OECS Energy Issues and Options

Report

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ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Energy Sector Management Assistance Program (ESMAP) is a global technical assistance partnership administered by the World Bank and sponsored by bi-lateral official donors, since 1983. ESMAP's mission is to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals. ESMAP interventions are knowledge products including free technical assistance, specific studies, advisory services, pilot projects, knowledge generation and dissemination, trainings, workshops and seminars, conferences and roundtables, and publications. ESMAP work is focused on four key thematic programs: energy security, renewable energy, energy-poverty and market efficiency and governance.

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FUNDING

ESMAP is a knowledge partnership supported by the World Bank and official donors from Belgium, Canada, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. ESMAP has also enjoyed the support of private donors as well as in-kind support from a number of partners in the energy and development community.

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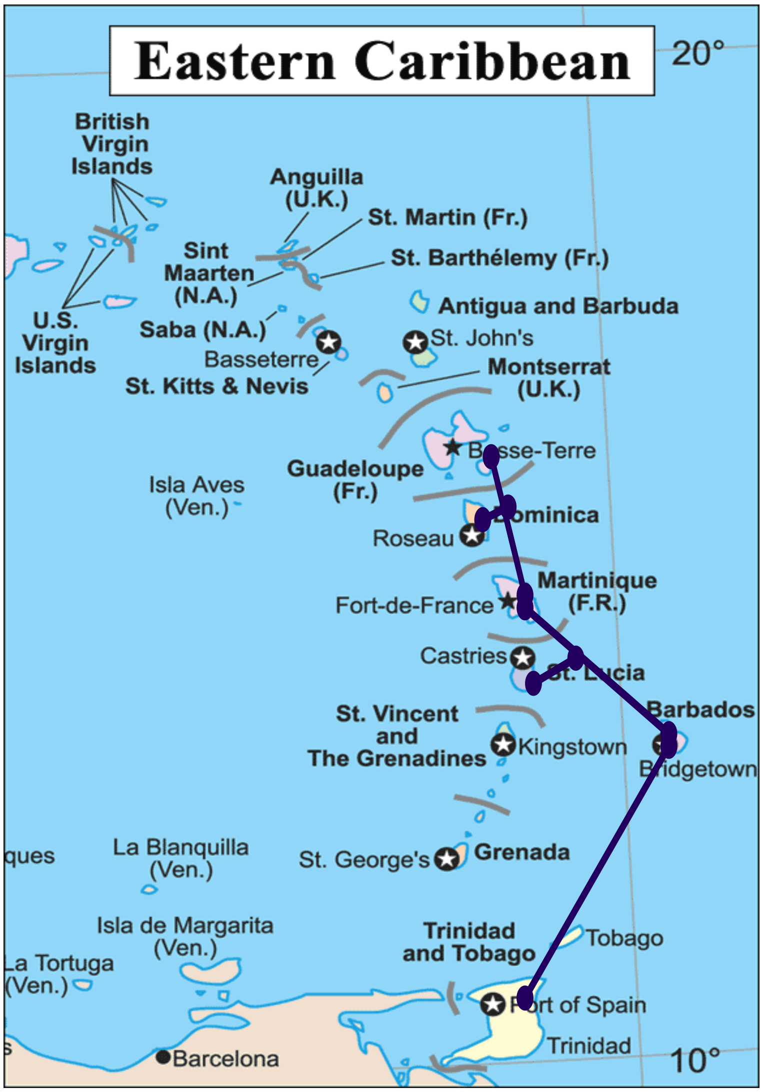

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Energy Sector Management Assistance Program
(ESMAP)

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Commonly Used Abbreviations

BAU	Business as usual
bbl	Barrel of oil (= 42 U.S. Gallons or 158.9 liters), 1 bbl/day for 1 year = 49.8 tons of crude oil per year
BTU	British thermal unit
BVI	British Virgin Islands
C°	Degrees Centigrade
CAEAL	Canadian Association for Environmental Analytical Laboratories
CARICOM	Caribbean Common Market
CARILEC	Caribbean Electric Association
CCGT	Combined Cycle Gas Turbine Power Plant
CEHI	Caribbean Environmental Health Institute
CEIS	Caribbean Energy Information Service
CIA	Central Intelligence Agency (U.S.)
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
CRDEP	Caribbean Renewable Energy Development Programme
DC	Direct current
Domlec	Dominica Electric Supply Company
ECD	Eastern Caribbean Dollar (= USD 0.3704)
ECGPC	Eastern Caribbean Gas Pipeline Company
EDF	Electricité de France
EH&S	Environmental Health and Safety
EIS	Environmental Impact Statement
ESA	Electricity Supply Act
ESMAP	Energy Sector Management Assistance Program
FSRU	Floating storage regasification unit
GBU	Gravity-based unit
GEF	Global Environment Fund
GHG	Greenhouse gas
Grenlec	Grenada Electric Supply Company
GtZ	Gesellschaft für Technische Zusammenarbeit

GW	Gigawatt ($1x10^9$ watts)
HAWT	Horizontal axis wind turbine
Heat rate	Thermal efficiency of a power plant, usually expressed in % (higher is better) or BTU/kWh (lower is better)
HECO	Hawaiian Electric Company
HELCO	Hawaiian Electric and Light Company
HVDC	High voltage direct current
IADB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development
IDP	Integrated development planning
IFC	International Finance Corporation, division of World Bank
Imp Gal	Imperial Gallon (= 1.201 US gallons or 4.54 liters)
IPP	Independent power producer
IUCN	International Union for Conservation of Nature
KV	Kilovolt
kWh	Kilowatt hour, a measure of actual power plant output (= 3412 BTU or 3.6 MJ)
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas, a mixture of propane and butane
Lucelec	St. Lucia Electric Supply Company
M^3 or cm gas	Cubic meter of gas (= 35.3 $ft.^3$)
MEA	Multilateral agreement
MECO	Maui Electric Company
mmbtu	Millions of British Thermal Units (=1,055 GJ)
mmcfd	Millions of cubic feet of gas per day (~= 1.02-1.05 mmbtu and 28,330 M^3/day)
MW, GW, etc.	Megawatt (10^6), Gigawatt (10^9); a measure of power plant output capacity
NEMS	National Energy Management Strategy
NGO	Non-governmental organization
NREL	National Renewable Energy Laboratory (US)
NRMU	Natural Resource Management Unit
NSDS	National Sustainable Development Strategy
O&M	Operations and maintenance

OAS	Organization of American States
OECS	Organization of Eastern Caribbean States
PGN	Perusahan Gas Negara (Indonesia)
PLN	Perusahan Umum Listrick Negara (Indonesia)
QBtu	Quadrillion Btus
RED	Red Eléctrica de España
SCC	Standards Council of Canada
scf	Standard cubic foot – a measure of natural gas value equivalent to 1020 BTU
STELCO	State Electric Company (Maldives)
SWERA	Solar and Wind Energy Resource Assessment
T&TEC	Trinidad and Tobago Electricity Commission
TOE	Ton of oil equivalent (~= 7.3 bbl of medium weight crude oil)
UN/DESA	UN Department of Economic and Social Affairs
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNSD	UN Dept. of Economic and Social Affairs, Statistics Division
US Gal	U.S. gallon (= 3.78 liters)
USDOE	U.S. Department of Energy
USVI	United States Virgin Islands (St. Thomas, St. Croix, St. John)
VAWT	Vertical axis wind turbine
WRAMS	Waste Reclamation and Management System

Preface

This paper was prepared as part of the Energy Sector Management Assistance Programme's (ESMAP) "OECS Large Scale Energy Options Study ", and forms part of ESMAP's ongoing commitment to renewable energy. The author, Donald Hertzmark, is an expert consultant on natural resource economics, and is based in Washington DC.

For ESMAP this project was managed by Olivier Frémond and Charles Feinstein of the Finance, Private Sector and Infrastructure (FPSI) Department in the World Bank Latin America and the Caribbean Region. Both provided conceptual guidance as well as editorial and substantive input into the draft report. The team consisted of three consultants, Donald Hertzmark (economist and team leader), David Saul (energy transmission and transportation), and Mark Hodges (environment, regulation and wind energy). Assistance with editing, communications, budget management and overall coordination was provided by Daniel Farchy and Smriti Goyal, both of the FPSI Energy team. The paper was internally peer-reviewed by Charles Feinstein and Subodh Mathur. Marjorie Araya and Daniel Farchy provided support for publication and dissemination.

On the OECS side, assistance with meetings and information was coordinated by Dr. Vasantha Chase of the OECS secretariat. Other assistance was provided by Mr. Andrew Satney and Mr. Keith Nichols of OECS. The OAS provided invaluable assistance and direction on the geothermal and electricity transmission aspects of the study. Mr. Mark Lambrides of OAS met with the team several times to provide direction and guidance. Dr. Frederick Isaac of Energy and Advanced Control Technologies Inc., St. Lucia gave generously of his time and expertise to the team. Executives of the OECS member state electricity companies provided their time and data to the team. Of particular importance was the assistance provided by LUCELEC (St. Lucia), DOMLEC (Dominica), and the St. Kitts and Nevis Electricity Company. The team also benefited from information provided by Caricom and Carilec. Other important assistance, data and guidance was provided by Électricité de France, The Intra-Caribbean Gas Pipeline Company (Trinidad), The Trinidad and Tobago Electricity Commission and Shell Trinidad, Ltd. A full list of persons met is given in Annex 1 of this report.

Executive Summary

1 This study evaluates the current energy situation in the OECS member states and identifies selected investment options and policy issues for new energy projects. The emphasis of the study is on large energy systems and ways to link one of more of the OECS countries. Complementary smaller-scale systems, in the form of wind, are also considered. This study is not intended to be an exhaustive survey either of each OECS member country or of all possible energy technologies for the OECS countries. Rather, it is intended to address the key energy-economy interaction in the electricity sector and to assess potential new supply investments. A key issue in this study is how to bring some of the benefits of larger scale, more efficient power generation technology to these small island systems.

2 The report begins with a summary of recommendations and findings for OECS policies and actions. Part I contains an assessment of the energy sector with two main components, a review of recent studies on energy in the OECS and a summary of current use of fuel and energy, primarily electricity in the OECS member states. Part II starts with a review of international experiences in island energy systems, including integration efforts. Both the large island systems of Indonesia and the Philippines and several small island systems are included.

3 Based on the review of previous work, ongoing efforts in the region and the energy needs of the OECS members, several options are discussed in Chapter 5 for both large and small-scale investments. These include (i) inter-island gas pipeline; (ii) LNG/CNG supply; (iii) geothermal development with cable links to other islands; and (iv) wind farms, linked to multi-island power systems. Chapter 6 highlights the costs associated with various options, and Chapter 7 shows the economic and financial aspects of the various options, as well as their compatibility with policy objectives extracted from OECS member country energy strategy documents.

Recommendations

4 Over the years a number of studies have focused on specific projects or supply strategies for OECS and other Caribbean countries. The new fiscal stringency in many OECS member states, along with high oil prices, has given new impetus to investment opportunities in the energy sector.

Criteria for Ranking Supply Options

5 This study considers the overall supply situation using a range of economic, technical, financial, security and environmental criteria. These criteria can be regrouped under three main headings:

1. **Security of supply/diversity of type and source** – how does a particular option improve or worsen the security of supply?

2. **Cost/impact on sector efficiency –** What is the unit cost of providing energy from a particular source and how will it affect the economy?
3. **Potential for leveraging private sector investment –** Who will pay for this option? Is a particular option more or less likely to generate net private investment inflows?

Summary of Recommendations

6 After considering a wide array of potential projects and investments, the following projects and policies have emerged as the most attractive in terms of both reduced supply costs and long-term sustainability:

1. **The OECS members St. Lucia and Dominica should participate in the Eastern Caribbean Gas Pipeline project.** This project will transform energy supply in the larger markets of Martinique, Guadeloupe and Barbados, and would likely lead to significant economies in St. Lucia and Dominica, reducing electricity costs by a significant margin.
2. **Developing Dominica's geothermal resources are a high priority that would benefit not only Dominica but also its neighbors through undersea power transmission cables.** This project complements the Eastern Caribbean gas pipeline project because there is not enough gas transmission capacity to meet the full electricity needs of the nations beyond Barbados. To expedite its resource development and to ensure that its citizens receive the fullest benefit from the geothermal resources, Dominica needs to work through the electricity and mining sector coordination and legal issues that currently retard resource development.
3. **Pooling wind and conventional resources in multi-island systems should be seen as a way for wind projects to effectively and economically complement the gas pipeline and power transmission projects**. **Conduct prefeasibility studies of multi-island wind systems.** However, wind farms can only complement fossil or geothermal resources, not replace them. The lack of good storage technologies for electricity limits sharply what can be expected from wind farms for the foreseeable future. Further studies on wind, especially with regard to multi-island transmission and grid integration, are warranted by the falling costs of wind power.
4. **LNG and CNG are costly substitutes for the gas pipeline and should only be considered if the gas pipeline project fails to take off, but may have a secondary supply role.** Since these options are more costly and not fully reliable for the hurricane season, this option has not been recommended as an alternative to the pipeline. However, CNG may prove to be relatively cost-effective as a means of supplying markets too small or remote for pipeline supply.

7 Table 1 ranks the projects using the three key criteria:

Table 1: Rankings of Proposed Projects by Key Attribute

Rank **Attribute**	**1**	**2**	**3**	**4**
Security of Supply	geothermal	LNG	gas pipeline	wind
Cost	geothermal	gas pipeline	wind	LNG
Investment	gas pipeline	LNG	geothermal	wind

8 Table 2 gives the details on how these rankings were constructed. In particular, the security of supply measure is a combination of three attributes: (i) pure physical and political risk; (ii) risk from reliance on one fuel type or technology (including inherent riskiness of that technology); and (iii) ability to source fuel and technology from new vendors, thereby diversifying the sources of fuel or technology.

Table 2: Summary of Key Project Attributes

	Gas Pipeline	**LNG/CNG**	**Geothermal**	**Wind**
1. Security of supply	Single supply source – exposure to geological risk (lower with Barbados routing than with Grenada routing)	Can be sourced from multiple suppliers, technology is fungible, potential for interruptions during hurricane season	Very high	Little risk of wind not blowing, but unable to substitute for existing electricity infrastructure, vulnerability to hurricanes
Fuel type diversification	Replaces reliance on diesel with reliance on gas fuel cycles	Supplements existing imports of diesel for power and transport sectors, and facilitates possible shift to CCGT technologies	High	Medium
Fuel source diversification	Low	Medium	High for supplier countries	High – multiple equipment vendors
2. Cost	Pipeline is costly, commodity cost is moderate, conversion is low	Infrastructure less costly than pipeline, commodity cost higher, conversion is low, may become feasible for supply to non-pipeline OECS customers	High on initial basis, low on continuing basis	Moderate on initial basis, low on continuing basis, requires continuing backup capacity
3. Leveraging private investment	Moderate	Significant	Significant (?)	Moderate

9 In addition to thee metrics noted above, the projects were evaluated according to environmental and energy policy criteria. See Chapter 7 for a full discussion.

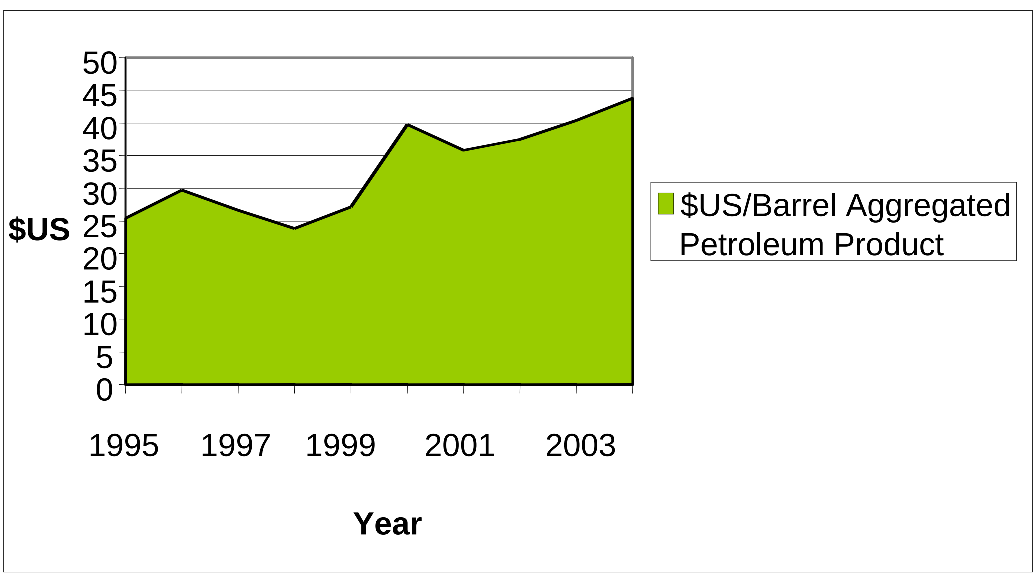
Key Features of OECS Energy Use

10 Energy use in the OECS countries is principally based on imported refined liquid fuels. These fuels are used both for transportation and electricity generation. Some hydroelectricity is used on Dominica and St. Vincent, but there and elsewhere in the OECS member states, diesel and gasoline dominate the energy consumption picture.

11 The current run-up in refined oil product prices (see graph 1), along with slowly rising demand, has increased sharply the foreign exchange drain represented by this pattern of energy use. In addition, a deteriorating fiscal situation in many of the OECS member states has led to import surcharges on refined product imports, further raising the costs to consumers.

12 Figure 1 shows the rising average price paid for oil product imports in the OECS member states. In addition to rising prices, rising use of oil relative to other goods has increased oil's share of total imports in every OECS member state since 1995. The increases have been dramatic. In Dominica, the share of oil in total imports more than doubled, from 5 percent to more than 11 percent. In St. Lucia the share of oil products rose from 6.1 percent in 1995 to 12.4 percent in 2004 (2004 figure estimated). The BVI had an even more dramatic proportionate increase, from 2.2 percent in 1995 to more than 8 percent in 2004. Even without the very high oil prices of the past 18 months, the share of oil in total foreign exchange earnings or imports has increased significantly.

Graph 1: Average Cost of OECS Oil Imports: $US/Barrel (Source: PETSTATS, 2004 and World Bank estimates)



13 The opportunities for new energy technology and investments must be assessed in the context of the following constraining factors:

- Small market size
- Low density of consumption
- High transportation or transmission costs for delivered energy
- Low purchasing power of local population
- Low level of industrial/processing demand
- Seasonal nature of electricity demand in tourism-dominated economies

14 These factors combine to create an overall situation where the appropriate technology for power generation is less efficient than is typical of larger markets, with higher fuel consumption per unit due to small generating engines, more costly fuels, given the islands reliance on smaller, less efficient delivery infrastructure, as well as lower utilization factors for the generating equipment due largely to low density of demand. Typical of this situation is Dominica, where electricity is transmitted at a relatively low distribution voltage (11 kV), leading to higher levels of technical losses than is the case in nearby St. Lucia, where the transmission occurs at a higher voltage.

15 Without significant industrial or processing demand, the load curve is sharply peaked, based on hotel and domestic use of electricity in the evening and late afternoon. In addition to the daily peaks in demand, there is also a seasonal peak, brought on by the tourism industry.

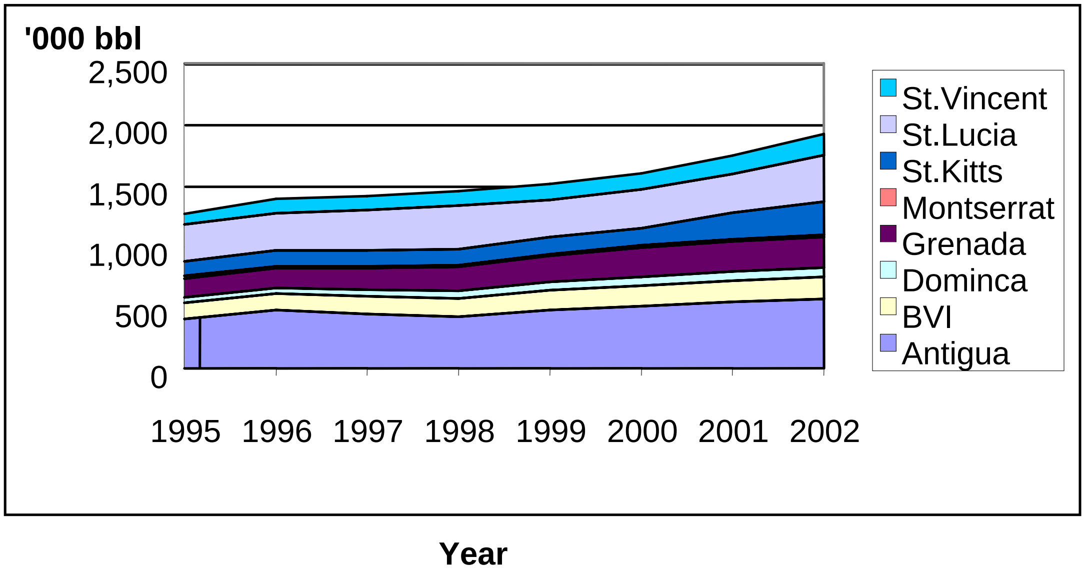
Energy Use and Power Generation in OECS Member States

16 Aggregated energy demand for the OECS remains small in spite of the large number of islands within the Commonwealth. To place the demand situation of the OECS member states into some perspective, consider the following facts:

- Total OECS fuel consumption for power generation is approximately 2,000 barrels/day. This is about 25 percent of the U.S. Virgin Islands (USVI) daily fuel demand for power generation, and 5 percent of Hawaii's power-related fuel consumption.
- Total generation in the OECS member states is about 300 GWh/y, compared with 1,040 GWh/y in the USVI. For most OECS members, electricity represents more than 40 percent of total primary energy use, compared with about 5 percent of the much larger USVI total energy consumption.
- Most OECS countries have significant energy use with members showing a range of between 7 and 14 mmbtu/$1,000 of GDP. This puts them generally at the higher end of typical industrialized country energy use (France's figure is 5.8 mmbtu/$1000; the USA's is 10.8 mmbtu/$1000), though the OECS states lack heavy industry and mechanized agriculture.

17 Figures 2, 3 and 4 illustrate the trends and distribution of fuel use, capacity and generation in the OECS electricity sector (note: excludes Barbados).

Graph 2: Fuel Use for Power Generation (Source: PETSTATS, 2004)

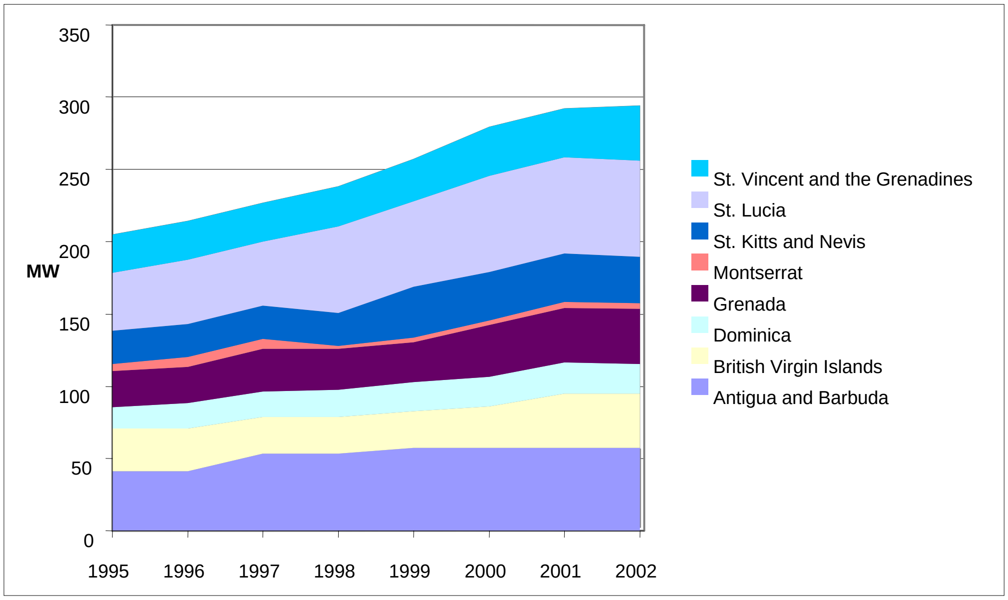


18 To put the generating capacity issue into some perspective, the annual growth in peak demand in Puerto Rico is greater than the total generating capacity of the OECS member states. Much of the power in Trinidad and Puerto Rico comes from natural gas, either domestic or imported as LNG. Because of their larger scales, Puerto Rico and Trinidad can make use of newer generation technologies.[1]

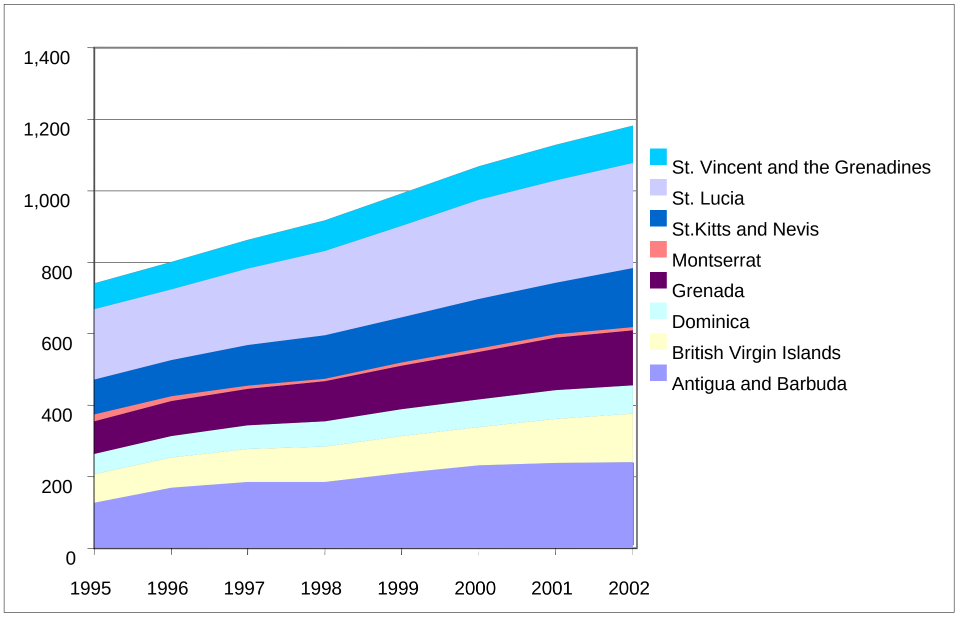
19 Despite the small sizes of the electricity generating systems in the OECS countries, there has been steady growth in capacity, generation and fuel consumption since the mid-1990s. These steady increases have resulted in greater electrification of the populace and reflect as well tourism industry expansion. The figures above also imply some improvements in energy efficiency and utilization of generation facilities (see Chapter 2) in the power sector of the OECS states overall.

1 In larger systems, employing better generation technology, the gas-based peak period generators are more efficient than the baseload diesel generators commonly used in the OECS countries, with the possible exception of the slow speed diesels in St. Lucia.

Graph 3: Installed Generating Capacity, 1995-2002 (Source: PETSTATS, 2004)



Graph 4: Electricity Generation in OECS States (GWh) (Source: PETSTATS, 2004)



Lessons from Other Island Systems

20 Other archipelagic or island nations face many of the same issues as the OECS member states. This study looks at the experience of two very large archipelagic nations, Indonesia and the Philippines, and several small systems, including Hawaii, Cape Verde, Maldives, and the Canary Islands. The examination of these systems is not meant to be either exhaustive or a complete diagnostic of their energy systems and policies. The intent, rather, is to extract relevant lessons, both positive and negative, from the experiences of others.

21 It is not possible to extract general principles from the experiences of larger and richer nations and apply them without modification to the Caribbean. However, some specific findings are still relevant for OECS member nations. The key areas of transferable findings include the following ones:

- **Regulation of the power sector –** decisions need to be made at the appropriate governmental levels; restructuring needs to be thought through, with appropriate sequencing of activities and "resting places" in between bursts of activity.
- **Investment climate for new generation –** decisions on pricing, licensing, etc. need to be assessed with regard to their impacts on investment.
- **Market size and importance of inter-island energy links –** where feasible, different island systems should be linked to take advantage of whatever scale economies and better technologies a larger market size might engender.
- **Data and analytical capabilities –** specific government or regulators offices should be responsible for different data and analytical activities. These activities should be reviewed periodically to ensure completeness and relevance of coverage.

22 These issues are explored in detail in Chapter 4.

23 **Questions for Policy Makers:** Applying the lessons of larger energy systems must be done judiciously. In particular, energy policy makers need to take into account the following considerations:

- What is the minimum market size needed for a given technology – how much does it rely on the coordination or backup facilities inherent in a larger system?
- Do the high costs of current generation options make room for generation technologies that might be sub-economic in larger, better-supplied systems?
- Are environmental considerations more important in the OECS than in some other markets, opening the door for cleaner, if less cost-efficient technologies?

OECS Supply Options

24 The following three potential ***large-scale*** options have been identified for consideration as alternatives to current generation systems. These options are:

1. Gas pipeline
2. LNG or CNG
3. Geothermal energy, with inter-island transmission of electricity

25 Where neither gas nor geothermal energy may be feasible, some options for ***wind energy*** were examined. The dry nature of most of the OECS islands precludes significant development of hydro and those areas with potential have already developed such capacity. The development of new supply projects was compared to incremental investment in the current electricity supply systems. That is examined below as the "Business as Usual" option.

Business As Usual – no new technologies or fuels

26 Before such large scale options can be considered, it is necessary to look at the current option – business as usual (BAU) – and what happens if no new technologies or fuels are introduced in the OECS member states. Sections 4 and 6.0 of this study address such matters in detail. Based on the existing data regarding current energy use and past growth rates, the general findings of this analysis can be summarized as follows:

- Without any major changes in technology or approach in the power sector, most of the OECS countries will have to incrementally increase their generation capacities by 25–35 percent on a net basis over the next 5–7 years, with an almost equivalent increase in distillate fuel utilization for power generation.
- The increase in net generating capacity on some of the islands will bring these systems to a point where larger scale, improved technology may become more appropriate for the power sector.
- The larger the total generation of the OECS member states, the more feasible power line linkages may be.

27 For most OECS countries, the BAU forecast means the following:

1. Continued reliance on diesel engines as the prime movers for power generation;
2. Little or no additional exploitation of hydro, geothermal, and wind resources; and
3. No imports of natural gas either in pipeline or LNG/CNG form.

28 The net increase in diesel generation capacity is expected to total 110–125 MW for 2005 through 2011. However, the acquisition of new diesels will be greater, probably in the range of 125–150 MW, given the need to replace worn out and obsolete generating capacity.

29 The BAU scenario provides for continuity and the use of well-understood technologies and fuels. On the down side of continuity, the recent increase in fuel prices has been especially difficult for small, poor islands. Not only have commodity prices gone up, but also the cost of transporting fuel to the power plants. Further, the small size of the diesel engines now used limits the efficiency of generation and forecloses other options, including micro-turbines and integrated wind systems.

30 As a result of the high cost of fuel, including government taxation, electricity prices for all consumers are high in OECS member states. Such a high price level has three primary effects on the economy and consumers. These are:

- Discouragement of industrial investment or any processing investment requiring significant electricity inputs;
- Competitive disadvantage for tourism and services business competing against larger islands with lower cost power; and
- Reduction in direct consumption of electricity by consumers, thereby reducing the overall benefits of electrification to civil society.

Large Scale Supply Options

31 For a number of years energy planners and suppliers in the OECS countries have considered a number of larger scale supply options. These options include:

1. Natural gas pipeline
2. LNG/CNG
3. Geothermal energy with inter-island power transmission (integration with Martinique and Guadeloupe)

32 The general features shared by each of these options are (i) they are highly disruptive with respect to existing power systems; (ii) they require a larger market than any OECS country can provide on a stand-alone basis; and (iii) they offer improved stability of electricity prices for the countries deploying the technology.

Natural Gas Pipeline

33 A new company, the Eastern Caribbean Gas Pipeline Company (ECGPC), formed in Trinidad and Tobago, proposes to send up to 140 million ft^3/d to the following Caribbean islands: Barbados, Guadeloupe, Martinique, St. Lucia, and Dominica. Following announcement of the project, ECGPC commissioned a pre-feasibility study, which was carried out by Doris Engineering (a US based engineering consultancy). This study proposed a pipeline with the following segments:

- Trinidad to Martinique and St. Lucia via Barbados
- Martinique to Guadeloupe via Dominica

34 The project is expected to cost over $500 million, including the spurs to St. Lucia and Dominica.

Key Considerations

35 The financial feasibility of this project depends almost entirely on the three large markets, Barbados, Martinique and Guadeloupe. These three islands are expected to take more than 70% of the pipeline capacity and will provide the steadiest demand profiles. With the OECS islands taking perhaps 12-14% of the pipeline throughput that leaves another 15% of spare capacity to provide for demand growth.

36 An alternative routing, which would have taken the pipeline through Grenada and St. Vincent has been dropped from consideration due to greater geological risk.

Assessment

37 The gas pipeline is considered a good alternative. The total volumes of gas to be supplied by Trinidad amount to less than 4 percent of the island's annual production, a highly sustainable figure. As Table 3 below shows, using gas, whether in a new Combined Cycle Gas Turbine ("CCGT") or in a repowered diesel plant,[2] is less costly than purchasing new diesel engines. As a part of a mixed generation system, the gas option is attractive. The feasibility of this mode of supply is dependent almost entirely on acceptance of the project by the three large markets, Barbados, Martinique and Guadeloupe. The other determining feature of the gas pipeline project is the promise from Trinidad to maintain a cost-based and relatively steady *real* price for the gas and its transmission over the life of the project, reducing the exposure of generating companies to oil price risk.

Table 3: Base Case Electricity Generation Costs, OECS

	$ US per MWh			**$ EC per MWh**
	Capital Cost	**Fuel + O&M Cost**	**Total cost**	**Total cost**
CCGT	$22.99	$51.18	$74.17	$200.25
Diesel (new)	$18.85	$91.06	$109.91	$296.76
Diesel (conversion to gas)	$3.77	$78.83	$82.60	$223.01
Geothermal	$32.68	$8.50	$41.18	$111.19
Wind (average)	$47.33	$9.50	$56.83	$153.44

Note that inclusion of power transmission costs will raise the delivered cost of electricity from geothermal by US$31.02 per MWh. For wind, transmission from offshore farms will cost an additional US$12-15 per MWh. See Chapter 6 for sources and details of calculations.

2 Repowering involves either replacing a diesel cycle with a spark ignition gas cycle or adapting the diesel cycle to the auto-ignition characteristics of natural gas rather than middle distillate fuel.

LNG/CNG

38 It is possible to supply some of the regional markets with gas using a decentralized option; either liquefied natural gas or compressed natural gas. This option is technically feasible, and Trinidad currently exports LNG from its Atlantic LNG facility to Puerto Rico, Spain, the U.S. Gulf Coast and New England. However, LNG supply to Caribbean islands is not viable because:

- One LNG tanker carries the equivalent of the total gas requirement for the islands for about 20 days. However, this option would require multiple visits to each island to unload unless gas storage for 20-30 days gas demand is available on each island, raising the variable costs of LNG use.
- Previous studies (see Sections 4, 6 and 7) indicate that, even for areas with large gas demand, pipelines are more economic than tanker transportation for sailing distances of less than 700 miles.
- Current tankers require a deep-water berth. St. Lucia has a deep-water berth but Grenada, Dominica, St. Vincent, Nevis and St. Kitts do not. Furthermore the St. Lucia deep-water berth might not be available for LNG unloading if it were utilized for other activities important to the island economy.
- Each island would require an unloading terminal and re-gasification plant to convert the LNG back to natural gas. This would require land and capital investment in equipment and operating costs (>$ 100 million for a small facility) far greater than that required for landing a sub-sea pipeline (~$5–10 million).
- LNG is a global commodity whose price is governed by the global market and is related to the price of oil.
- Continuity of supply is an issue during the hurricane season.

39 Despite the shortcomings of LNG, it may be worthwhile studying the potential for CNG supply from one of the OECS gas pipeline landing points, Dominica or St. Lucia, to other markets that the pipeline system cannot reach.

Geothermal

40 The OECS islands of Grenada, St. Vincent, St. Lucia, Dominica and Nevis and St. Kitts lie close to a tectonic plate boundary. This boundary is characterized by volcanic activity. The islands are therefore potential sites for geothermal energy exploitation.

41 Geothermal feasibility studies have taken place on a number of the OECS islands over many years but, to date, no commercial exploitation for power generation purposes has been achieved. However, the nearby island of Guadeloupe has had a successful 4MW geothermal plant at Brouillante since 1996.

42 The primary interest is in the potential geothermal resources of Dominica, believed by the Government of Dominica and the OAS to be capable of supporting 200–

300 MW of electricity generation capacity. With Dominica's geographical position between the French islands of Martinique and Guadeloupe, there is interest in developing this resource and forming a multi-island transmission grid. While no large-scale exploration and development work is currently being done, both Électricité de France (EdF) and its Dominican partner and the Organization of American States (OAS) have expressed interest in the economic exploitation of Dominica's geothermal resource. EdF has already conducted preliminary studies on plant capacity and undersea power transmission, as well as recent studies on environmental impacts and site specifics for drilling. The OAS is about to begin a project that will advance the understanding of the resource and provide a Risk Fund to encourage drilling exploration and development of a commercial project by local and regional exploration companies.

Assessment

43 As Table 3 shows, a medium-sized geothermal resource on Dominica would be able to supply the domestic market at prices that are attractive, about half that of diesel for repowered units burning gas and far less expensive than new diesel engines.

44 The key drawback is size. In order to develop this project a large market for the electricity is critical. Such a market can only be provided by sending most of the plant output to Martinique and Guadeloupe, with a total of 540 MW of generation capacity. The sub–sea transmission of electricity, expected to cost about $100 million, will still leave this geothermal project attractive relative to any other feasible and live alternatives.

Wind Energy

45 Wind energy systems could be used in OECS islands not readily connected to either the gas pipeline or the geothermal power grid. Islands are typically well suited for development of wind energy projects—at least from the perspective of having sustained winds of sufficient velocity to support generation of electricity. Small islands of the Caribbean, and elsewhere in the tropics and subtropics also typically have low energy demand. However, wind is a scalable resource and is well suited for distributed generation (provided demand is nearby) as well as grid interconnects.

46 The optimal size of an offshore wind farm in the OECS region would likely be one to 10 MW—with size limited primarily by demand, and ability and willingness of the utilities to accept a substantial volume of wind-supplied power. Distributed generation for resort and hotel cooperatives could justify smaller wind farms, say one to two MW capacity, depending on local demand and whether a special purpose company or cooperative could be formed to justify a larger project, entertaining better economies of scale (i.e., lower $US/MW installed, and lower operations and maintenance (O&M) costs per megawatt hour (MWh). However, such small generators might not be competitive with newer supply options, including geothermal or gas. In order to find a solution for wind energy that is competitive with gas and geothermal, it would be necessary to look for situations where economies of scale in turbine construction and efficiency can be realized.

Assessment

47 By the middle of the next decade wind energy in large turbine sizes is expected to fall into the approximate range for diesel engines and CCGT power plants on a unit investment (per kW) basis (see Chapter 6). Table ES 3 shows that wind on its own can provide energy at a rate below the variable O&M plus fuel costs for a diesel plant.

48 However, for small islands the wind option remains problematic. In particular, the reliability needs of modern tourism and commerce will almost certainly require some type of storage or backup, thereby negating much of the fuel cost advantage of wind energy. Additionally, wind turbines in large numbers present their own aesthetic and avian issues, since vacationers have consistently objected to the presence of large wind farms viewable from the shore. Bird kills remain an unresolved issue, though one that is probably not relevant for the types of wind generation schemes envisioned for the OECS member states.

49 The cost to back up a wind-based system involves creating a redundant capability to meet peak demand and continued servicing and staffing of the conventional power generation capabilities in the country. Among the OECS member countries, only Dominica and St. Vincent possess the type of hydro capacity that could serve to cost-effectively back up offshore wind generation. Developing a large-scale wind farm of 30 MW or larger would provide the lowest cost and most reliable wind energy. However, such an undertaking is too large for any of the individual OECS countries given the needs for backup and maintaining appropriate voltage and frequency for a modern economy.

50 The dilemma of wind development would seem to be the tradeoff between high cost wind on a scale small enough to be integrated in a single island system, and lower cost large scale wind energy that would require a multi-island transmission system. A proposal that is explored later in this report is the possibility of using a supra-national market to justify a larger scale wind farm, which might prove more competitive and reliable than a smaller one. In order to site such a project two elements are necessary, a good wind resource and proximity of several national or island markets, each of which maintains its own fossil-based generation. Where it is feasible to construct such a plant and where inter-island electricity transmission cables already exist or are in the planning stage, it might be economically attractive to supply multiple markets with wind energy and reduce fossil fuel costs in generation.

Key Energy and Development Policy Issues in Developing Large Scale Energy Projects

51 A final set of considerations involves the matter of policy formulation and coordination. Several key issues will need to be resolved in order to deploy new and larger scale technologies effectively. These include:

- The role of the current monopoly provider
    - How will stranded costs be resolved?

    - What rights will the incumbent provider have to invest in new technologies?
    - What is the role of smaller generation investors?
- What is the role of the government?
    - Development rights for geothermal energy
    - Setting prices for common services, including transmission
    - New regulatory oversight—what is needed? And should it be regional?

52 Over the next several months it will become necessary to establish some policies regarding these matters in the two OECS countries where development is currently contemplated, Dominica and St. Lucia. In addition, Grenada's prospective cable supply from Trinidad raises issues of stranded costs and regulated prices, both difficult to resolve without a reference point.

53 There are two or three competing potential projects for several of the OECS member states. These projects are concentrated on those islands where proximity to a larger market or supplier is proven. For the other islands, with small markets and at a greater distance from large suppliers or customers, new developments in CNG delivery may eventually provide some of the benefits of the larger-scale projects to such markets.

54 A key issue for consideration is the degree to which these larger projects are potential competitors for both investment and market share. As long as the French Départements of Guadeloupe and Martinique remain the anchor customers for both gas and geothermal electricity in the region, both the gas pipeline and the geothermal plant with undersea transmission will be feasible and will remain focused on these two large customers. Neither energy source can by itself meet the full demand of the two large markets.

55 As regards competition for capital, it appears from discussions with the pipeline company that funding for the pipeline will come from private international investors. Sources of funds for the geothermal project are likely to be more of a public-private mixture, which is not directly competitive with the pipeline funding.

1

Introduction

Background

1.1 The World Bank's Energy Sector Management Assistance Program (ESMAP) in coordination with the Environment and Sustainable Development Unit (ESDU) of the Organization of Eastern Caribbean States (OECS) has commissioned this study to assess the potential for regional coordination for energy policies and energy supply in the islands of Dominica, St. Grenada, St. Kitts and Nevis, St. Lucia and St. Vincent and the Grenadines.

1.2 Energy supply for the small island states of the Organization of the Eastern Caribbean States (OECS) is heavily dependent on imported fossil fuels. These countries have high levels of electricity coverage. However, operational efficiency and maintenance in some cases remain weak and tariffs are high. OECS members like many smaller island systems experience high energy supply costs because of limited load concentration, relatively high cost of low volume thermal plants and high fuel transport costs. All OECS islands have vertically integrated electricity utilities. They have handled their electricity needs individually. Because of their small size and limited institutional capacity, sector planning, management and regulation in OECS members remain elementary.

1.3 The governments of the abovementioned islands have requested the World Bank's assistance to assess alternative regional and island-specific approaches to improving the performance of their energy sectors. The principal policy goals of the OECS governments are to (i) improve sector efficiency; (ii) reduce burden of energy costs on economies; (iii) diversify fuel sources; (iv) leverage private capital; and (v) safeguard the environment.

Study Objectives

1.4 The objectives of this study are to:

1. Provide an overall assessment of the current situation and future prospects of the energy sector in the OECS.

2. Examine preliminary economic and technical aspects of alternative options for using large-scale projects for energy systems integration among the islands in the long term.
3. Identify the major policy issues for a regional approach that will benefit the OECS Member States collectively and individually.
4. Identify optimal solutions for the above-mentioned islands based on the policy goals listed above.

1.5 The study objectives as well as the following scope of work were addressed at both the country specific and at the subregional level.

Scope of Work

1.6 The study was divided into two parts, as outlined below.

Assessment of the Energy Sector

1.7 This Chapter takes stock of the present situation and existing work on the energy sector in the islands, identifies major issues, and develops demand projections for electricity and primary energy sources.

1.8 Tasks undertaken for this Chapter of the study include:

- A review of the available reports and studies of the last 3–4 years concerning the energy situation in the islands. This review includes a discussion on the most important issues, including high electricity generation costs, previous project experiences, and recommendations of previous analytical and actual work performed on the islands.
- Estimations of current levels of electricity demand for various sectors of the economies including use of fuels and technologies, projected demand growth for the next decades.

Identification and Evaluation of Long-Term/Large-Scale Options

1.9 This Chapter identifies energy supply options, evaluates them on the basis of the screening criteria set out above, and identifies the main energy policies necessary for their implementation. Specific tasks include:

- Review of international practices and experiences on the integration of energy systems of islands.
- Identify supply options for energy provision to the islands, including small-scale projects and large regional projects from within the OECS and/or outside the OECS.
- For each island, provide preliminary cost estimates for future plants based on representative energy transmission and power generation facilities.

- For each large-scale regional project (including but not limited to, large geothermal and thermal power generation projects, regional integrated transmission line, gas pipeline, LNG terminal, CNG barges), provide cost estimates (capital expenditure and operational costs), and identify the major technical issues.
- Preliminary assessment of environmental implications of large-scale solutions.
- Presentation of a table evaluating each option according to the following criteria: (i) security of supply and fuel diversification benefits; (ii) cost; (iii) impact on sector efficiency; (iv) source diversification; (v) potential for leveraging private sector capital; and (vi) safeguard of the environment.
- Identification of the main energy policies to implement the preferred option(s).

2

Part I: Assessment of the Energy Sector

2.1 This Chapter contains a brief listing of previous initiatives to assess OECS energy prospects along with a summary of the existing balance of supply and demand for conventional energy in the OECS member states.

Listing of Previous Studies

2.2 During the past 3–4 years several energy studies on the OECS and Caribbean Basin countries have been produced. In addition, a number of OECS member states have produced their own energy studies, as has the OECS Secretariat. A selection of the reports reviewed for this project are shown in Table 2.1 below:

Table 2.1: Summary of Energy and Environmental Reports Reviewed

Report Name	Author and or Agency	Supporting Organization	Date	Content or Conclusions	Recommendations
OECS Regional Reports					
Membership Listing 2004	An Association of Electric Utilities	Carilec	2004	Source of utility information and statistics	None
Country Analysis Brief	Energy Information Administration	U.S. Government	July 2004	Source of information on energy usage	None
Helping Antigua and Barbuda Develop an Electricity Strategy	The RAND Corporation	U.S. Government	2004	Energy Policy for 2 OECS member States	Establish benchmark electricity prices
Regional Symposium on Energy	OECS Natural Resources Management	OECS	2001		

Management and Energy Efficiency	Unit				
Eastern Caribbean Geothermal Development Project	M. Lambrides	OAS	2004	Proposal for geothermal development assessment	Establish drilling fund for geothermal exploration, legal basis for geothermal exploitation
PETSTATS	CEIS	CEIS, Jamaica	2003	Information on energy and oil demand and trade in the Caribbean Basin	N/A
Country-Specific Reports					
Dominica					
Domlec Annual Report 2002				Source of utility information and statistics	None
Domlec Annual Report 2003				Source of utility information and statistics	None
Dominica Sustainable Energy Plan	Organization of American States		Nov 2002	Source of information on current electricity demand and expected growth along with identification of alternative fuels and strategies for renewables.	None
Domlec Research Report	National Mortgage Finance Company Ltd		July 2003	Review of Domlec structure, operating regime, financial position	None
Grenada					
Grenlec Annual Report 2002				Source of utility information and statistics	None
Grenlec Annual Report 2003				Source of utility information and statistics	None
Grenada Sustainable Energy Plan	Organization of American States		Aug 2002	Source of information on current electricity demand and expected growth along with identification of	None

				alternative fuels and strategies for renewables.	
Nevis & St. Kitts					
No country-specific reports used					
St. Lucia					
Lucelec Annual Report 2002				Source of utility information and statistics	None
Lucelec Annual Report 2003				Source of utility information and statistics	None
Load Forecast 2004–2020	Lucelec		June 2004	Information on current load forecasts	None
St. Lucia Sustainable Energy Plan	Organization of American States		May 2001	Source of information on current electricity demand and expected growth along with identification of alternative fuels and strategies for renewables.	None
St. Vincent					
No country-specific reports used					
Energy Sources					
Geothermal					
Geothermal – An Assessment	World Bank			Description of geothermal risks, project costs and impacts	None
What is Geothermal Energy?	Instituto di Geoscienze, Pisa (Dickson & Fanelli)			Description of geothermal energy, exploration, utilization, and economics	None
Geothermal small power generation opportunities in the Leeward Islands of the Caribbean	Geothermal Management Inc., Colorado		June 1999	Overview of geothermal potential in Leeward Isles	

Sea					
LNG					
Introduction to LNG	Institute for Energy, Law and Enterprise		Jan 2003	Overview of LNG, properties, industry, safety considerations	None
HVDC					
HVDC Transmission	Manitoba HVDC Research Centre		Mar 1998	HVDC technology overview	None
Sustainable energy with HVDC transmission	ABB Power			Demonstration of need for HVDC transmission for small sustainable energy projects	None
HVDC Transmission System	World Bank			HVDC Technology review	None

2.3 These reports provide the basis of most of the analysis and discussion of energy projects and future demand contained in this study. Three distinct types of input were used in this study: (i) resource assessments and proposals for energy resource development; (ii) technology studies; and (iii) statistical studies.

2.4 It was found that little of the current impetus toward regional resource developments was fully described in the literature reviewed. This is not surprising, since the greatest portion of regional energy resource development remains in the hands of private investors who treat their investment plans as confidential.

2.5 In addition to the reports reviewed, there was a significant amount of verbal and interview data gathering in the OECS countries and new projects, primarily with three outside entities, Électricité de France (EdF), the Eastern Caribbean Gas Pipeline Company (ECGPC), and the OAS, each of which has a significant role in large project developments. These interviews were used as a means of testing the proposals suggested in the literature reviewed for the project. In addition, given the sensitive commercial nature of some of the information on new investment proposals, much important information has not yet been memorialized in public documents.

Current Use of Fuel and Energy in OECS Countries

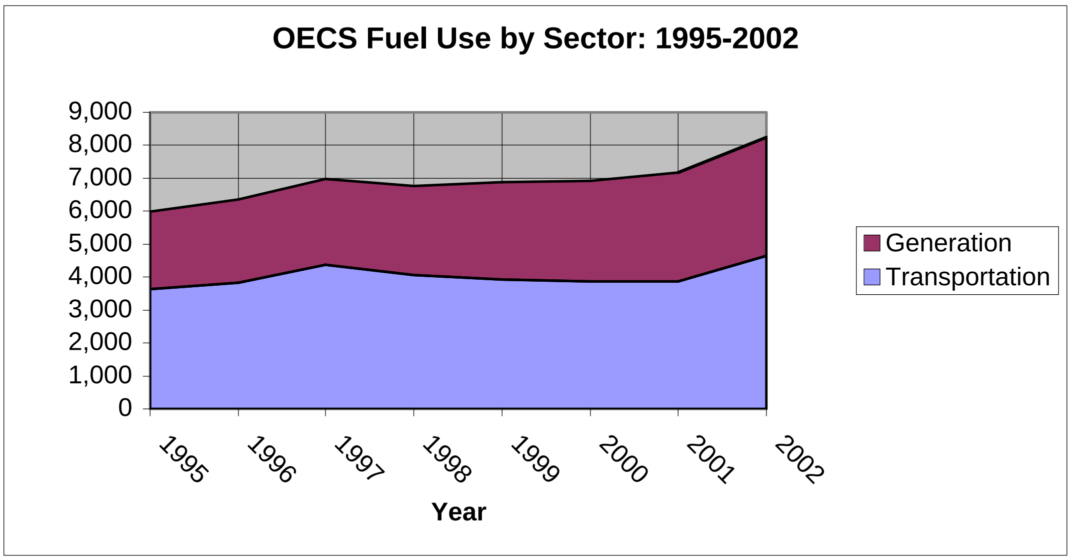
2.6 This Chapter contains a summary of PETSTATS and U.S. Department of Energy statistics on fuel use in OECS countries.

Current Use of Fuel and Energy in OECS Countries

2.7 Total energy consumption in the OECS member states was approximately 8.7 million U.S. barrels, equivalent to 23,000 b/d, almost all of it refined oil products. Only Barbados uses natural gas at present. Small amounts of hydropower are also used in Dominica and St. Vincent, primarily for the generation of electricity.

2.8 For the OECS member states approximately 41 percent of commercial energy is used in the electric power sector of the economy. Individual country figures (see Table 2.4) range from 31 percent for St. Lucia to 51 percent for St. Kitts. Figure 2.1 below shows energy use for electricity and overall consumption for the OECS member states.

Graph 2.1: OECS Total Energy Demand, 2002 (Sources: Petstats and DOE-EIA)



2.9 Among the larger consumer countries, only Barbados has more than 40 percent of its total commercial energy in the electricity sector. The other two larger energy users, Antigua and St. Lucia, both have significant energy use in commercial aviation and other transportation.

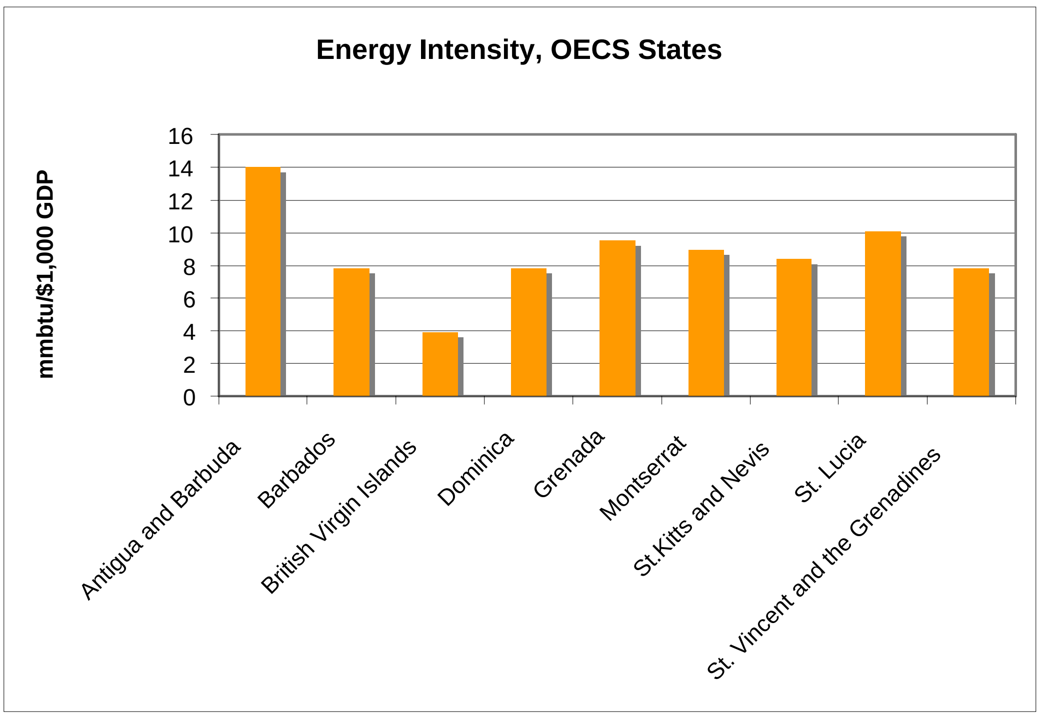
2.10 Over the period of 1985 to 2002, significant changes in energy consumption patterns have occurred in the Caribbean Region. Until 1991 the transportation sector was the largest consumer of petroleum products in the region. During the early to mid-1990s the electric utility sector became the major consumer in most Caribbean countries—though in the OECS this is not strictly the case—even as of 2002, when the transportation sector consumption still outstripped power generation in Antigua, BVI, Dominica, Montserrat and St. Lucia.

Energy Balances

2.11 Table 2.2 below shows the end uses for commercial energy in the OECS countries. The overall energy balances by fuel, for each of the OECS countries as summarized by the U.S Department of Energy (USDOE), Energy Information Agency (EIA) are presented in Annex 2. Table 2.3 shows a summary of the critical electricity sector and isolates fuel use and overall system losses (the difference between gross and net output). Summary data for Antigua are not presented in the Annex, as no data were reported to or available from USDOE-EIA. However, Antigua data were available from PETSTATS and are used in this Section. Data from Barbados have been removed from most figures to facilitate presentation and comparisons between the smaller islands.

2.12 The energy intensities of the OECS member states are shown in Figure 2.2 below:

Graph 2.2: Energy Intensities of OECS States (Sources: Petstats and CIA World Factbook)



2.13 The figure indicates a wide range of energy intensities, from the BVI low of less than 4 mmbtu/$1000 to Antigua's high of 14 mmbtu/$1000. Most of the other OECS member states range from 8–10 mmbtu/$1000. This range is typical for nonindustrialized countries[3] and is well below the 22 mmbtu for Indonesia and the 14 mmbtu for the Philippines. Since 1995 the energy use per $1,000 GDP has risen in all of the OECS countries, reflecting economic growth as well as a generalized substitution of

3 The figures for the Maldives and Puerto Rico in mmbtu/$1,000 GDP are 5.4 and 6.8, respectively.

electricity for kerosene and wood in the home and increased use of motor vehicles. The increases have generally fallen into the 5–10 percent range. The only decrease was for Antigua and Barbuda where, paradoxically, the heavy use of energy for transoceanic flights has so stimulated the economy that the rate of economic growth has risen faster than has energy demand.[4]

Detailed Assessment of Electricity Sectors, by Country

2.14 The primary source of data in the assessment of electricity sectors by capacity, fuels, prime movers, and structure of demand, by country, was the Jamaica Ministry of Science, Commerce and Technology, Scientific Research Council (SRC), in association with Sub-Regional and National contacts of the Caribbean Energy Information System (CEIS), Petroleum Statistics (PETSTATS) CD, Volume 1, as released January 2005. Other information was obtained from the U.S. Department of Energy's Energy Information Service Country Studies and from the CIA World Factbook. The tables below show overall oil use, as well as the breakdowns by economic activity. Trends in the electricity sector are shown in Tables 2.4–2.6 and summary statistics for 2002 power generation for all of the OECS members are given in Table 2.8.

2.15 The reader will note that some data anomalies remain in the Petstats and DOE-EIA statistics. This is probably inevitable when dealing with small systems. The primary areas of caution are electricity losses and sectoral allocation of energy use.

[4] The increasing use of more efficient airplanes since 1995 has also reduced somewhat the use of jet fuel, keeping it below the 1997 level for that sector.

Table 2.2: Total Petroleum Product Imports, 1995–2002 (1,000 Bbl.) (1)

Country	Year							
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Antigua and Barbuda	1,299.6	1,412.0	1,388.3	1,300.5	1,373.0	1,434.8	1,447.8	1,505.8
British Virgin Islands	316.9	368.6	387.4	409.3	438.9	471.9	507.3	527.5
Dominica (2)	219.5	252.7	278.7	264.3	272.0	316.9	339.5	353.1
Grenada	419.1	396.1	495.3	535.4	516.2	622.9	612.8	647.5
Montserrat	65.6	32.7	31.0	32.7	51.5	54.9	59.1	61.4
St. Kitts and Nevis	264.6	296.2	292.9	290.9	310.8	337.3	437.4	524.8
St. Lucia	867.2	886.5	1,017.6	1,003.3	1,006.8	1,007.3	1,029.9	1,235.8
St. Vincent and the Grenadines	362.8	352.9	357.6	356.9	445.9	420.4	429.7	477.4
OECS Total	**3,815.3**	**3,997.7**	**4,248.8**	**4,193.3**	**4,415.1**	**4,666.4**	**4,863.5**	**5,333.3**

(1) SRC CEIS PETSTATS 2004

(2) Fuel imports only, 1995 and 1996

Table 2.3: Energy Consumption by Sector, 2002 (1,000 bbl. Oil equivalent, excluding natural gas)

Country	Agriculture	Commercial	Transport	Cement	Government	Residential	Electric Utility	Tourism	Refining	Other Mfgr.	Construction	Sugar	Other	Total
Antigua	N/A	N/A	877	N/A	N/A	28.4	564.5	35.8	N/A	N/A	N/A	N/A	N/A	1,506
Barbados	23.9	47.2	1,299.00	73.7	27.5	225.8	1,678.10	22.7	N/A	136.7	0	2.4	4.7	3,542
British Virgin Islands	N/A	N/A	219.6	N/A	N/A	95.1	181.3	31.7	N/A	N/A	N/A	N/A	N/A	528
Dominica	1.7	2.4	168	N/A	12.3	14.1	79.8	12.5	N/A	13.4	9.9	N/A	0.1	314
Grenada	1.1	9.7	227.2	N/A	9.6	45.8	251.5	7	N/A	10.1	6.9	N/A	2.6	571
Montserrat	N/A	N/A	28.2	N/A	1.9	4.6	19.5	N/A	N/A	N/A	N/A	N/A	N/A	54
St. Kitts and Nevis	N/A	34.5	156.7	N/A	5.1	37.8	269.5	21.2	N/A	N/A	N/A	N/A	N/A	525
St. Lucia	1.2	44.8	672.5	N/A	7.3	56	380.9	53.8	N/A	10.1	N/A	N/A	0.5	1,232
St. Vincent and Grenadines	1	22.8	165	N/A	8	44	174.2	13.6	N/A	14.1	10	N/A	4.3	453
Total	**28.9**	**161.4**	**3813.2**	**73.7**	**71.7**	**551.6**	**3599.3**	**198.3**	**0**	**184.4**	**26.8**	**2.4**	**12.2**	**8,725**

Source: PETSTATS 2004, Volume 1, January 2005

Table 2.4: Trends in Electricity Generation Capacity, as Megawatts (MW) (1)

Country	Year							
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Antigua and Barbuda	41.3	41.3	53.3	53.3	57.4	57.4	57.4	57.4
British Virgin Islands	29.6	29.6	25.6	25.6	25.6	29.0	37.6	37.6
Dominica	14.8	17.6	17.6	18.7	19.9	20.4	21.7	20.4
Grenada	25.0	25.0	29.5	28.3	27.7	35.8	37.5	38.2
Montserrat	4.8	6.8	6.8	2.0	3.0	3.0	4.1	4.0
St. Kitts and Nevis	22.9	22.9	22.9	22.9	35.3	33.5	33.5	32.0
St. Lucia	40.2	44.5	44.5	59.9	59.0	66.4	66.4	66.4
St. Vincent and the Grenadines	26.3	26.6	26.6	27.5	29.4	33.9	33.9	38.0
OECS Total	**204.9**	**214.3**	**226.8**	**238.2**	**257.3**	**279.4**	**292.1**	**294**

(1) SRC CEIS PETSTATS 2004

Table 2.5: Trends in Electricity Generation as GWh (1)

Country	Year							
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Antigua and Barbuda	127.0	168.9	185.3	185.1	210.4	231.5	238.5	241.1
British Virgin Islands	80.4	85.0	92.3	98.9	103.7	107.1	122.9	135.0
Dominica	56.2	60.1	65.8	70.3	74.6	77.5	80.9	80.1
Grenada	91.8	98.0	102.8	113.0	122.2	133.6	146.4	153.3
Montserrat	19.2	13.8	9.1	6.7	8.4	8.9	9.0	9.6
St. Kitts and Nevis	97.5	100.4	113.4	121.6	126.5	139.1	145.0	164.2
St. Lucia	196.6	198.0	213.2	235.9	256.2	276.8	286.5	295.3
St. Vincent and the Grenadines	72.2	76.5	80.2	85.2	89.5	93.4	98.8	102.8
OECS Total	**740.9**	**800.7**	**862.1**	**916.7**	**991.5**	**1,067.9**	**1,128.0**	**1,181.4**

(1) SRC CEIS PETSTATS 2004

Table 2.6: Trends in Fuel Use in Power Generation (1,000 Bb. Eq.) (1)

Country	**Year**							
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Antigua and Barbuda	403.6	475.4	443.9	420.2	477.5	508.2	542.8	564.5
British Virgin Islands	132.1	136.6	146.4	152.7	159.1	166.9	174.3	181.3
Dominica	45.3	42.9	52.9	61.0	70.4	73.2	76.7	79.8
Grenada	152.3	163.8	175.0	193.5	210.7	240.2	241.8	251.5
Montserrat	22.9	15.0	15.3	15.7	17.3	18.2	18.7	19.5
St. Kitts and Nevis	117.9	129.5	130.4	131.0	138.0	144.8	224.6	269.5
St. Lucia	308.1	311.4	338.1	360.2	307.4	315.0	317.4	380.9
St. Vincent and the Grenadines	86.0	114.0	111.4	117.5	134.4	131.2	145.2	174.2
OECS Total	**1,268.2**	**1,388.6**	**1,413.4**	**1,451.8**	**1,514.8**	**1,597.7**	**1,741.5**	**1,921.2**

(1) SRC CEIS PETSTATS 2004

Table 2.7: Trends in Fuel Use in Transportation (1,000 Bbl. Eq.) (1)

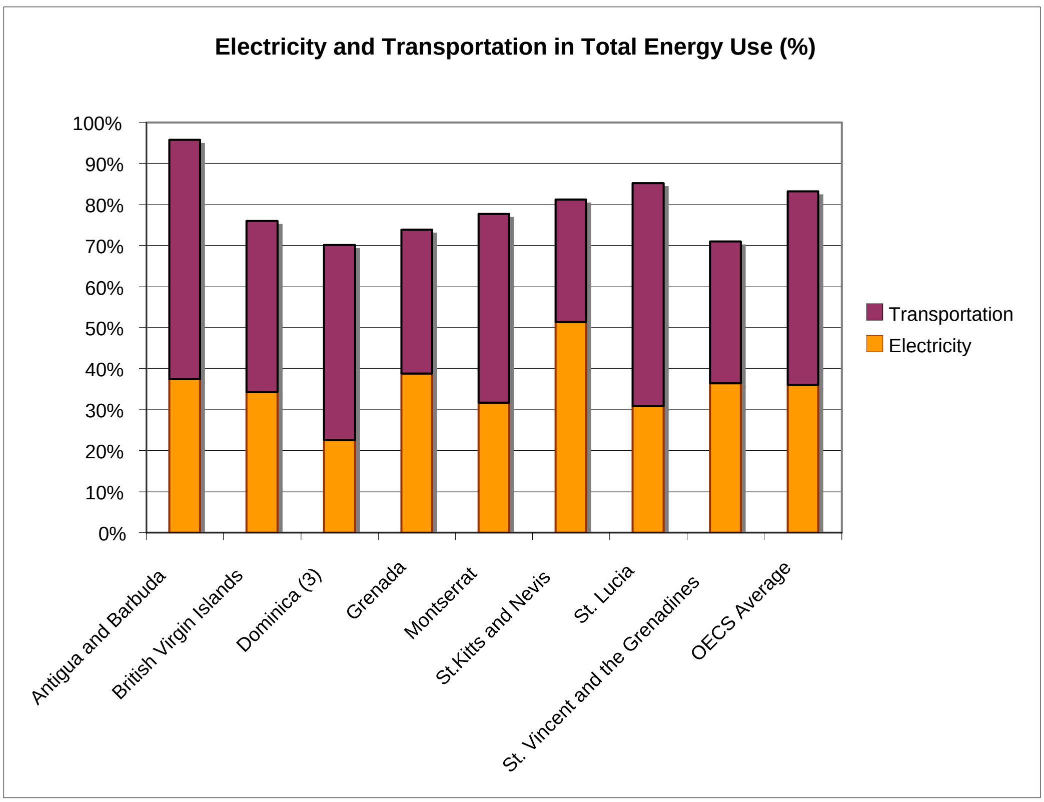
Country	Year							
	1995	1996	1997	1998	1999	2000	2001	2002
Antigua and Barbuda	842.1	860.9	910.9	831.6	848.4	871.2	843.3	877.0
British Virgin Islands	102.8	120.8	130.8	143.9	163.5	185.8	211.1	219.6
Dominica	114.9	128.3	135.8	128.0	143.5	147.2	161.6	168.0
Grenada	168.4	151.9	185.3	181.8	165.2	197.1	218.5	227.2
Montserrat	27.9	11.9	12.9	13.6	23.3	24.5	25.2	28.2
St. Kitts and Nevis	104.0	122.2	122.6	123.8	124.4	125.5	130.6	156.7
St. Lucia	402.7	409.8	496.0	426.9	512.2	553.1	560.4	672.5
St. Vincent and the Grenadines	158.3	152.2	151.4	166.0	167.4	160.3	152.5	165.0
OECS Total	**1,921.1**	**1,958.0**	**2,145.7**	**2,015.6**	**2,147.9**	**2,264.7**	**2,303.2**	**2,514.6**

(1) SRC CEIS PETSTATS 2004

2.16 Tables 2.2–2.7 above show the trends and composition of OECS energy demand over time since 1995. Total petroleum use has increased by more than 40 percent in the OECS member states. One of the most notable features of this trend is the rise in oil use almost regardless of the economic health of the country during that period. For example, St. Lucia saw an increase of about 42 percent with its healthy tourism-driven economy, while Dominica, facing adverse economic, demographic and financial trends, nevertheless managed an increase its oil use by 61 percent. These figures certainly show the importance not only of the local economy but also of remittances from overseas workers.

2.17 Two sectors account for most of the energy use in the OECS countries, electricity generation and transportation. The OECS average is just over 80 percent for these two sectors. Figure 2.3 below shows the role of these two sectors in overall energy demand in 2002. These shares have been remarkably stable over the period 1995–2002, varying by less than 2–3 percentage points per country. The figure also shows the significant differences in the electricity and transportation shares from one country to another.

Graph 2.3: Electricity and Transportation Shares of Total Oil Use (Source: Petstats)



2.18 The very high share of electricity and transportation in the Antigua/Barbuda economy (about 96 percent) is likely due to the large demand from transoceanic flights to and from the region. The two lowest shares for these sectors, Dominica and St. Vincent and the Grenadines, are both stable in the low 70 percent range, with relatively larger transportation use due to their hydro resources, as well as (relatively) significant commercial and manufacturing demand.

2.19 Table 2.8 below shows the 2002 summary electricity sector statistics for the OECS member states. Despite a few cautions regarding the quality of the statistics,[5] these numbers show that most of the OECS systems are quite small, indeed too small to make use of the best current technology for generation and distribution.

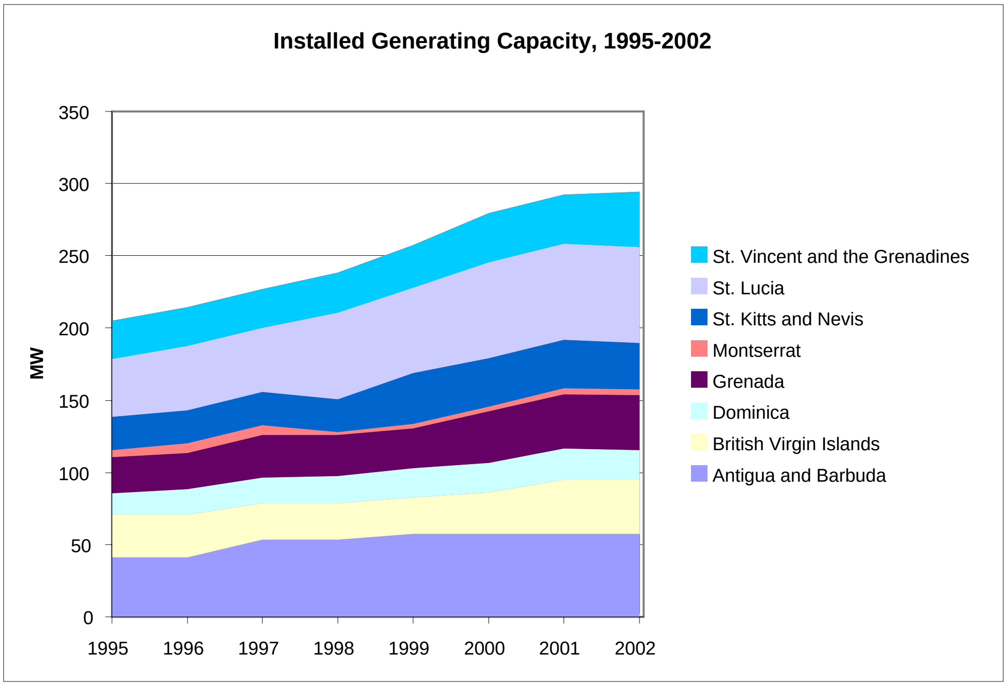
Table 2.8: Summary Electricity Generation Statistics by Country, 2002

Country	Installed Capacity (MW)	Peak Demand (MW)	Gross Generation (GWh)	Net Output (GWh)	Net Loss (GWh)	Net Loss (% Gross)
Antigua and Barbuda	57.4	37.3	241.1	219.4	21.7	9.0
British Virgin Islands	37.6	23.4	135.0	126.6	8.4	6.2
Dominica	20.4	13.0	80.1	65.8	14.3	17.9
Grenada	38.2	23.8	153.3	149.4	3.9	2.5
Montserrat	4.0	1.5	9.6	8.8	0.6	6.3
St. Kitts and Nevis	32.0	18.9	164.2	142.1	3.3	2.0
St. Lucia	66.4	46.5	295.3	260.3	35.1	11.9
St. Vincent and the Grenadines	38.0	19.1	102.8	100.4	2.4	2.3
OECS Total	294	184	1,181	1,073	90	8.4
Source: PETSTATS 2004, Volume 1, January 2005						

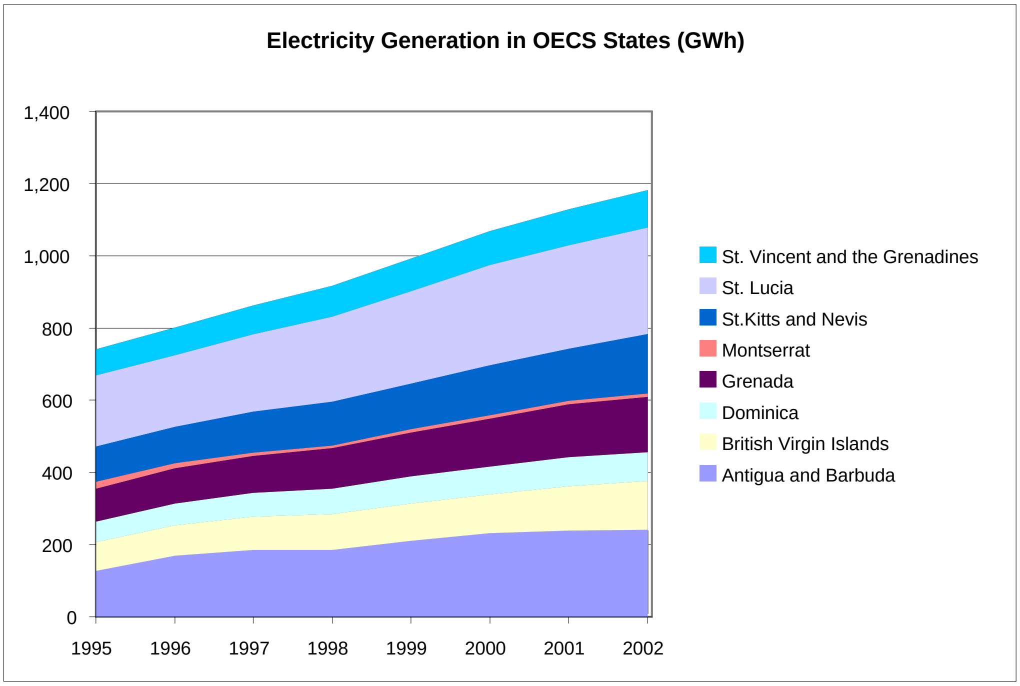
2.20 Figures 2.4–2.6 below show the trends in some of these electricity sector statistics from 1995–2002. For all three figures the sources was PETSTATS, 2004, Volume 1.

5 The loss figures for Grenada, St. Kitts and St. Vincent are too low, since they are well under the technical lower limit for losses in a system of this size (about 11–12 percent). These figures probably represent the difference between gross generation and station sendout.

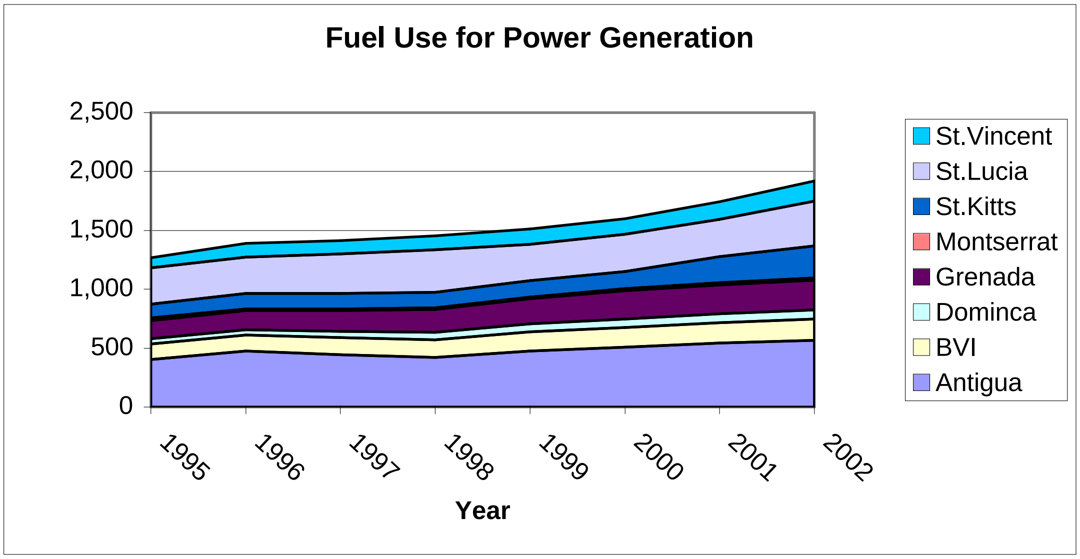
Graph 2.4 :



Graph 2.5:



Graph 2.6:



2.21 The data underlying these three figures indicates two positive trends in most of the OECS member states.

1. Load factors[6] have risen in most systems, reducing the capacity needed to meet generation targets; and
2. Fuel use in generation has fallen relative to 1995 for each kWh generated.

2.22 Since 1995, OECS generation capacity has risen by 43 percent, while generation has increased by 59 percent, implying better utilization of plant and equipment. Fuel use in generation has risen by 51 percent over that period, meaning the efficiency of generation itself has increased over the period. Most of this improvement came from St. Lucia and Antigua & Barbuda, where the energy to generate one kWh dropped by almost 20 percent from 1995–2002. In Grenada there were slight improvements, while Dominica, St. Kitts and St. Vincent all showed declines in electricity-generating efficiency.

Financial and Economic Aspects of Energy Use

2.23 As small consumers of electricity and overall energy, the OECS countries suffer from two handicaps that make imported energy even more costly. The first is the small and costly import infrastructure for oil products; the second is the reduced efficiency in the all-important power sector owing to reliance on small diesel engines, low voltage transmission and distribution. A final source of increased costs is the "peaky" pattern of demand that typifies most of the OECS countries.

6 The system load factor is the actual generation relative to potential generation from existing capacity.

2.24 **High Oil Import and Infrastructure Costs:** Oil product shipments are very sensitive to the size of the ship carrying the product. Larger ships use less fuel per unit of cargo, cost less to build per unit, and can discharge in larger, more efficient ports. For large consumers *The Oil and Gas Journal* estimates that a shipment of middle distillate (30,000 tons of cargo) from Trinidad to the U.S. Gulf Coast will cost about US$2.75 per barrel. For a 2,000-ton ship the much shorter delivery path to the OECS countries can easily be double or even triple the cost for the larger ship. The cost advantage of larger markets is repeated in the on-shore storage of refined products, where smaller tank sizes generally cost more per unit, once again raising the costs of oil product storage in the OECS markets.

2.25 Table 2.9, below, shows the costs of oil imports in the OECS member states.

Table 2.9: CIF Value of Total Imported Petroleum Products, OECS 1995–2004 ($US 1,000s)

Country	Year									
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Antigua and Barbuda	30,442	38,004	36,337	28,517	36,010	55,647	47,515	55,482	59,643	67,098
British Virgin Islands	8,536	11,804	11,508	11,045	12,750	18,981	18,412	20,537	22,078	24,837
Dominica	5,185	8,349	7,851	6,665	7,623	13,123	11,296	13,348	14,349	16,142
Grenada	11,559	12,838	12,352	11,572	14,778	26,860	22,911	23,840	25,628	28,832
Montserrat	1,616	1,162	572	885	1,582	2,719	4,014	3,594	3,863	4,346
St. Kitts and Nevis	7,879	8,578	8,021	6,551	7,807	14,097	16,256	19,706	21,184	23,832
St. Lucia	23,293	28,485	26,359	26,049	29,392	39,597	38,596	45,315	48,714	54,803
St. Vincent and the Grenadines	8,558	9,710	10,343	8,982	9,871	14,535	15,227	18,040	19,393	21,817
Total	97,067	118,930	113,343	100,265	119,812	185,559	174,226	199,862	214,851	241,708
Source: PETSTATS, Vol. 1										

2.26 **Less Efficient Electricity Conversion and Distribution:** The diesel engines used for electricity conversion in the OECS countries are less efficient than the larger, higher technology prime movers in the USA or other larger markets. Table 2.10 below shows approximate conversion efficiencies for a range of current electricity generation units.

Table 2.10: Conversion Efficiency of Current Power Generation Technologies (% on original fuel)

CCGT	52-56
Coal (clean)	40
Slow Speed Diesel	36-39
High Speed Diesel	28-34
Source: World Bank estimates and OECS Power company reports.	

2.27 Similarly, the most efficient transmission of electricity occurs at very high voltages. No OECS member state is large enough to justify the construction of a very high voltage transmission system. On many of the islands there is not even a formal transmission system, just a higher voltage component of the distribution system (usually 11 kV). The theoretical minimum loss in a system with 11 kV transmission/distribution is estimated to be approximately 11–12 percent. For system with very high voltage transmission systems, overall loss figures of 7–8 percent have been achieved for transmission and distribution. The additional losses act like a tax on generation, requiring, for example, generation of 1,000 MWh, in order to sell 850–875 MWh to consumers.

2.28 **Demand Patterns:** As a general rule, the more "peaky" the demand, the greater the cost will be to meet such a peak demand. If an electricity system has significant demand around the clock (called a high load factor), then it's large and expensive-to-build plants can operate continuously and power plant types that make use of low cost fuels (coal, uranium) can be used on a large scale. However, where the system load factor is low, demand is highly concentrated into just a few hours of the day and high investment cost/low fuel cost power plants cannot be used economically. It was noted above that the load factor has improved generally in the OECS countries since 1995. However, this improvement, from an OECS average of 44 percent in 1995 to 46 percent in 2002, is still far below the levels common to countries with significant industrial demand for electricity.

2.29 This latter pattern is typical of the OECS member states. With little heavy industry and a demand pattern that reflects the role of tourism as well as the even year-round climate and day length, demand will reliably peak in the late afternoon or early evening on a workday. To meet the demand of just a few hours per day utilities will generally build small units that are relatively inexpensive—high-speed diesel, for example. With the cost of diesel fuel well above the cost of coal per BTU[7] and with the conversion efficiency of a small diesel plant at just 75 percent of a modern coal plant, the unit cost of generation at peak times can easily run at 3–5 times that of a larger scale plant.

[7] Right now coal can be delivered for about $2.00/mmbtu v. $9–10/mmbtu for middle distillate delivered to an OECS island. However, facilities to receive coal at such a price are costly and are only practical where imports of the fuel are steady and substantial.

3

Part II: Identification and Evaluation of Long-Term/Large-Scale Options

3.1 This Chapter lays out the options and potential impacts of large-scale investment opportunities for the OECS nations. The key elements of this discussion include the following:

1. Examination of experiences in other countries with similar geography
2. Identification of supply options for energy provision to the islands.
3. Cost and economic assessment for electricity supply options for each identified distributed technology/option.
4. Preliminary assessment of environmental implications of large-scale solutions.

3.2 The review of experiences in other island systems is not intended to be an exhaustive review of the energy sectors of those countries. Rather, it is an effort to distill the essential lessons from the varied experience of these places. While there is no perfect analogy to the OECS states, and each of the island entities chosen has significant differences with respect to the OECS economies, certain lessons regarding regulation, pricing and energy information should prove useful to the OECS members both individually and in concert should a regional regulator come into existence in the next few years.

3.3 The review of energy options is designed around options that are already on the table in one sense or another. These options have been the objects of varying degrees of study over the past several years. The most important output of the technology or project-specific analysis is to assess the extent to which these technologies are complementary or exclusive.

4

Review of International Experiences on the Integration of Energy Systems of Islands

4.1 This Chapter provides a brief review of energy and electric power strategies and conditions in major archipelagic nations and small islands and groups of islands to assess the applicability of such precedents and approaches to OECS member countries addressed in this report.

4.2 The following island energy systems are examined:

- Indonesia
- Philippines
- Falklands
- Fiji
- Hawaii
- "Macronesia" (Azores, Cape Verde, Canary Islands and Madeira), and
- The Maldives

4.3 The primary focus of this comparative effort lies in the realm of institutional and regulatory arrangements. However, there are a number of technical elements of some island system that will be useful to discuss in the context of the OECS member states. In particular, there are very different degrees of national integration of the grid, diversity in prime movers and fuel sources as well as in policies toward new energy sources and private investment in the various systems examined. Table 4.1 below shows the variety of systems examined, with the OECS member states at the bottom of the table.

Table 4.1: General Characteristics of Selected Island-Based Electric Utilities

Country / Island	Utility	Ownership	MW Capacity	Technology and Fuels	Population *(millions)*	Annual Per Capita Gross Consumption (kWh)
Indonesia	PLN	State	21.5 +~9 of self-generation	Coal, gas, geothermal, oil, hydro	220	420
Philippines	NPC, Meralco, others	State, private investors	13.6	Coal, gas, geothermal, oil, hydro	87	529
Falklands			9	Diesel	0.002967	5,055
Fiji	Fiji Electricity Authority	T, G & D	199	Over 80% hydroelectric since installation of 80 MW Monasavu hydro-electricity scheme, located in the center of Viti Levu. Vanua Levu and all the other islands still dependent of electricity from diesel-fueled power stations. Additional power from bagasse at sugar mills, and wood and wood waste at sawmills.	0.881	749
Hawaii	Citizens Util. Co.	G&D	97	Port Allen power plant		
	Hawaiian Elect. Light Co. (HELCO)	G&D	265	Primarily oil, ~ 40% geothermal		
	Hawaiian Elect. Co. (HECO)	G&D	1,669			
	Kalaeloa Cogen. Plant	ABB Energy Venture	220			
	Maui Elect. Co., Ltd. (MECO)		273	Primarily oil fired		
Cape Verde	Electra	Parastatal (recently privatized, purchased by group of cities on Cape Verde)	7 MW	Diesel	0.415	94

Canary Islands	RED Electrica España	Publicly owned	2,084	Primarily thermal, with 130 MW in wind energy		
Maldives	State Electric Co., Ltd. (STELCO)	Joint Stock Company, 100% State-owned, G&D	21.5 MW on Male 14.7 MW between 18 additional stations throughout Maldives	Diesel	0.339	321
OECS Members						
Anguilla	Anguilla Elect. Co., Ltd.	40% Gov't / 60% public ownership	18.85	Diesel	0.013	3,275
Antigua and Barbuda	Antigua Public Utilities Authority		30 MW	Diesel	0.068	1,433
BVI	BVI Electricity Corp.		40 MW	Diesel	0.022	1,597
Dominica	Dominica Electricity Services, Ltd.		20 MW	60% Diesel, 40% hydroelectric	0.069	972
Grenada	Grenada Electricity Services, Ltd.	100% Private	37 MW	100% Diesel		
Montserrat	Montserrat Electricity Services, Ltd. (Monlec)		1 MW	Diesel, 1.8 MW to be installed by Monlec late 2004	0.0092	251
St. Kitts and Nevis	St. Kitts Electricity Dept.		20 MW	Diesel	0.0388	2,401
St. Lucia	St. Lucia Electricity Services, Ltd.	Publicly owned	70 MW	Diesel	0.164	681
St. Vincent and Grenadines	St. Vincent Electricity Services, Ltd.		20 MW	91% Diesel, 9% hydroelectric	0.117	734

Indonesia

4.4 Indonesia is comprised of more than 13,000 islands, covering 3,600 miles from the tip of Sumatra to the Papua New Guinea border in the East. With a total population of more than 220 million, the country has a vast diversity of resources, peoples and problems.

4.5 As a nation rich in energy resources, Indonesia, a founding member of OPEC, has been able to rely on these resources to spread both electricity and transportation throughout the archipelago. However, electricity access outside the main islands of Java-Bali and Madura (referred to as the Jamali system) is quite low in comparison with many other nations in the region.

4.6 Until 2001 three state enterprises, Pertamina (oil production and refining), PLN (electricity generation, transmission and distribution) and PGN (gas transmission) controlled virtually all of the production, transmission and final sale of energy throughout the country.

4.7 Indonesia has installed electrical generating capacity estimated at 21.4 gigawatts (GW), with 87.0 percent coming from thermal (oil, gas, and coal) sources, 10.5 percent from hydropower, and 2.5 percent from geothermal. The country produces just under 1 million b/d of crude oil, down from 1.2 million b/d in the late 1990s.

4.8 In 2003, about 65 percent of the country's installed power generating capacity was on the main Jamali grid. The remainder of the country has about 7 GW of generating capacity. Outside of a few major cities in the other provinces where large coal or gas plants were built and some geothermal and hydro plants in Sulawesi and Sumatra, the majority of generating capacity in the outer islands is diesel or small oil-fired steam turbines, a situation not dissimilar to that found in the OECS.

4.9 There are twelve PLN districts for electricity generation, transmission and distribution. These twelve districts are not interconnected, a fact that makes the Indonesian experience similar to that of the OECS countries. Even with the much larger volumes of electricity, it is still too costly to connect Sumatra to Java. It is feasible to connect the disparate regional grids in Sumatra, however, the national power company, PLN, has been starved for funds by low prices and cannot undertake such projects at present.[8]

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[8] Indonesia provides power by undersea cable to the islands of Madura and Bali. In both cases the distance traversed by the cable is short and the alternative investment in local generation is generally suboptimal in size and therefore more costly than the cable. For Sumatra three conditions hold which make a cable connection unappealing at this time: (i) Sumatra has considerable fuel production, and shipping fuel to Java and retransmitting the resulting electricity to Sumatra adds costs; (ii) Sumatra has a significant local market and full scale economies can be attained for power plants to serve the parts of Sumatra adjacent to the Sunda Strait; and (iii) the Sunda Strait is wider and deeper than either of the two cable traverses discussed above.

Note, however, that natural gas transmission under the Sunda Strait is likely to commence soon, to provide fuel for Java's new CCGT power plants.

4.10 Since the 1997–98 financial crises, regional economic recovery has led to sharp increases in demand for both electricity and oil products. Excess demand for oil products has been met though increased imports, both licit and smuggled. For electricity, unfortunately, the means to satisfy demand through a surge of imports is not possible. As a result, reserve margins for many of the grid systems, including Jamali, have become dangerously thin. Improved transmission, both within some regions and between and among regions is the most important short term means to alleviate the declining reliability of electricity supply.

4.11 Supply in the smaller grids relies heavily on diesel gensets. Such generators range in size from the 1–2 MW size common in the OECS states, to larger slow-speed diesel engines that supply significant load centers, primarily mines and plantations in the provinces. In the past PLN attempted to use grid extension, including inter-island cables, as a method of replacing its high-cost diesel units. When the grid can replace a small, isolated system, the generating equipment is generally moved to another island or another part of the country that remains without PLN-supplied electricity. Such a policy is still in effect today, although PLN suffers from a chronic and, indeed, worsening, financial situation.

4.12 As a general matter, the country has done a good job at exploiting its coal resources and geothermal energy. Exploitation of the country's abundant biomass energy resources has been far less aggressive. In the late 1980s and early 1990s there was some exploration of cogeneration of electricity from large plantation industries, especially sugar and palm oil. That interest waned with low oil prices in the late 1990s. However, the need to rebuild the grid of the tsunami-affected province of Aceh has rekindled interest in biomass-derived electricity in that region, where palm oil plantations are numerous.

Decision Making in Indonesia's Energy Sector

4.13 With the passage of new legislation in the early part of this decade, the formal monopolies of the state-owned enterprises, PLN, Pertamina and PGN, had come to an end. However, a lack of clarity on implementation of the new legal environment has essentially left the country with neither a private nor a public system, without the means to see new investments through to completion. A recent decision by the Constitutional Court in Jakarta has vacated the new Electricity Act and halted all restructuring activities while the government crafts a revised Electricity Act.

4.14 A key part of the new institutional environment is the decentralization of economic decision making. This means that each province is responsible for planning its own energy infrastructure needs, including transmission of gas and electricity. For most provinces this has meant a new burden, one that was both unanticipated and for which most local governments were unprepared. It is not clear at this time whether the

Constitutional Court's decision will affect the devolution of decision making in electricity, which is a part of a different legislative package.[9]

4.15 For the oil and gas sector, this decentralization has fostered a fragmented and incomplete institutional environment that has led to declining oil and gas investment in both exploration and production. In the electricity sector the institutional problems have reduced investment significantly, with the lights kept on largely through one-off improvements or power plant repairs.

Lessons of Indonesia's Experiences

4.16 Although the potential solutions are clear, the path of implementation remains difficult. Several years of an uncertain institutional environment have served to discourage investors, who now look elsewhere. Even in LNG, the crown jewel of the country's energy system, investment is headed to other regions and countries. Domestic gas prospects remain stunted despite considerable pent-up demand for gas, due in large measure to insufficient transmission of gas. Without the needed transmission capacity, private investors will not put new investments into gas production. Similarly, the lack of investment in transmission has discouraged new power plant investments, further reducing reserve margins and system reliability.

4.17 There is significant infrastructure investment that is needed in the country, but investors are fobbed off by the current institutional arrangements. The following key lessons can be learned from Indonesia:

1. Market liberalization, once started, must be completed down to the implementing of regulations and the establishment of new regulatory institutions; otherwise investors will be confused, key decisions will not be made and consumers will be left to fend for themselves; provisions must be made in the implementation for intermediate "resting places," where government and market participants can assimilate the changed rules of operation;
2. Decisions must be made at the appropriate governmental and geographic level; excessive devolution of decision making to local governments without requisite expertise will add new complications, slow down decisions and further discourage investment.
3. Key decision support capabilities must be maintained. PLN closed its system-planning department as a result of the PLN legal reform. Unfortunately, no other entity in the country was established to undertake electricity system planning, leaving the country institutionally incapable of determining the relative merits of competing investment proposals.

9 USAID has recently announced an initiative for small power generation by private suppliers. This project emphasizes the generation of electricity using biomass fuels and small hydro.

4. Transmission investments in gas and electricity, often the poor handmaidens of the integrated state-owned system, fare even worse in the fragmented one, with no institution able to champion large, trans-provincial projects.

4.18 Many of the key solutions to Indonesia's energy problems come down to simple findings:

- More internal transmission capacity for electricity and gas is needed
- Newer and more modern energy conversion plants (power plants, refineries, etc.) are critical to improved efficiency, living standards and investment competitiveness
- Inter-island links for gas and electricity are critical infrastructure

4.19 However, introducing these ameliorative measures is often made far more difficult by the country's institutional rigidities and lack of appropriate regulatory oversight.

Philippines

4.20 In sharp contrast to Indonesia, the Philippines possess modest energy resources. Its population of 86 million, spread across more than 6,000 islands, is experiencing a rebound in economic growth after many years of relative stagnation in the 1970s and 1980s.

4.21 Oil production of 24,000 b/d covers just 7 percent of current demand and the nation's gas reserves of 4 trillion cubic feet (tcf) allow current production of just under 200 million cubic feet per day. There is no imported gas and production started up in 2001.

4.22 Total installed electricity generating capacity is 13.6 GW, most of which is on Luzon and Cebu, the main centers of population and economic activity. Most new generation comes from either gas or coal-fueled plants. However, the country is one of the world leaders in the use of geothermal capacity. Its 1.9 GW of installed geothermal generating capacity is second only to the USA, and well ahead of Iceland, Indonesia, Italy and New Zealand, the other leading geothermal producers.

4.23 The two most economically advanced islands, Luzon and Cebu, both have integrated grid systems. The other islands are generally not connected in island-wide grids. Civil unrest in the large islands of Mindoro and Mindanao since the 1980s has impeded efforts to replace isolated grid generation and distribution with central station generation and inter-island transmission. Unlike Indonesia, most of the major Philippine islands are close enough to each other to make inter-island transmission technically and economically feasible.

4.24 For more than 20 years it has been the goal of the country's energy policy to unify the Visayas (Mindoro, Leyte, Cebu) with the transmission grid of Luzon. With growing civil calm (outside Mindanao) and with the formation of new electricity sector institutions, it may yet be possible to realize the unification of several major islands into one unified grid system. With an independent transmission entity responsible for new investments and for operation of the system and with a professional regulatory body, it may be possible to weigh local generation v. integration and transport of fuel v. transport of electricity with all of the considerations that such issues merit.

4.25 Unlike Indonesia in the 1980s and 1990s, the Philippines was a hotbed of technological and institutional experimentation, especially with regard to biomass energy. Several major initiatives were undertaken to grow energy crops for power generation and to encourage small farmers to plant tree species that were especially well suited to energy and feed production. The Maya Farms, an integrated pig farm, with biomass energy supplied internally, was a showcase of efforts to escape from the impacts of high energy prices and low investment in the country's electricity infrastructure. Several sugar producers generated electricity for sale to the grid or for distribution to the surrounding communities during the late 1980s, and there was a major interest in this form of energy supply, especially for the sugar-producing island of Mindoro, in the 1990s. In spite of these efforts, the country continued to rely primarily on coal and, more recently natural gas, for most of its new power output. During a power supply crisis in the early 1990s, the country was once again using diesel to supply its main grid, via a power barge in Manila harbor.

4.26 The biomass energy initiatives were largely abandoned as the 1990s wore on due to three main factors. The first was the falling real price of oil and other energy sources. A second was the falloff in interest after the discovery of the Palawan gas field. And, finally, many of these biomass production schemes had been associated with the corruption and personnel of the Marcos era, bogging some of the projects down in lengthy investigations of governance and making them unattractive to other investors or managers. Interest in small-scale energy has now shifted to wind. That energy form bears little taint from the Marcos era and the country has received considerable attention from the U.S. National Renewable Energy Laboratory for an accurate mapping of its wind resources. This project has resulted in new emphasis on wind energy investments, mostly in northern Luzon island, an area remote from the thermal power plants of the Manila metro complex.

Decision Making in the Philippines' Energy Sector

4.27 With the passage of major legislation in the late 1990s and in 2001, the country is committed to liberalization of both oil and electricity. The earlier liberalization of the oil sector was accompanied by a lifting of most price and import controls and a freeing of investment restrictions in the sector. Where oil supply was once dominated by four firms, there are now 62 companies supplying oil or oil products to the country.

4.28 Electricity reform legislation, passed in 2001, has established two transitional institutions to sell the government's interest in generation and transmission. An independent regulator will represent the public interest in adjudicating market matters.

4.29 Unlike the Indonesian situation, the regulatory body in the Philippines has already been functioning for more than five years, and the two transitional bodies were established prior to any significant crisis in the power sector.[10] Indonesia is still working with *ad hoc* arrangements.

Lessons Learned from the Philippines' Experience

4.30 If the experience of Indonesia represents the pitfalls of reform without consensus, then the Philippines shows just how long it can take to create such consensus. For more than 20 years the Philippines has attempted energy reform in various guises. In each case it failed due to a lack of consensus and appropriate institutional support. The only exception to this was the administration of President Ramos, who was able to forge a limited consensus to tackle the electricity supply crisis.

4.31 Key lessons from the experience in the Philippines include the following:

1. Institutions must be functioning before the reform act is fully implemented;
2. Implementing rules and regulations must be fully fleshed out before new institutions are empowered;
3. Sometimes moving slowly is the best tactic, especially if the worst aspects of the sector crisis have abated or have been mitigated by prior actions;
4. There is no cookie-cutter model of sector reform that will solve all of a country's problems; and
5. Inter-island energy transmission represents a serious investment, one that cannot be made without a supporting institutional environment.

Small Island Energy Systems

4.32 The large island systems discussed above are of some interest to the OECS nations. However, in such important considerations as average investment size, economics of interconnection and attractiveness to investors, there are distinct differences between larger island system and smaller ones.

4.33 Selected smaller islands or groups of islands considered are:

- Falklands
- Fiji
- Hawaii

10 The Philippines did have a power sector crisis in the 1980s and early 1990s. It was eventually resolved through resort to IPPs. However, private power plants with no real form of price discovery other than the power purchase agreement usually represent an unstable situation, and so they have proved in this instance as well. Unlike Indonesia's IPP crisis of 1999–2003, the prices were never as far out of line in the Philippines, permitting a softer landing subsequent to the passage of the reform legislation in 2001.

- Macronesia (Cape Verde, Canary Islands and Madeira), and
- The Maldives

4.34 In the cases of the three archipelagic entities, Hawaii, Fiji and the Maldives, there are considerable differences in the types of generation and transmission technologies used. The two largest population centers of Hawaii, Oahu and Hawaii, rely on single island grids fueled largely by oil. Maui is linked to the two nearby islands of Lanai and Molokai, permitting the use of larger, more efficient generation technology than would otherwise be the case for the smaller two islands. Geothermal generation is tapped on Hawaii and biomass energy from remaining sugar plantations is now being phased out on Kauai and Hawaii.

4.35 Fiji shows far more diversity and renewable energy (see table), but little integration of its various grid systems. The difficulty in linking together volcanic islands in the Pacific generally stems from ocean depth, making even large cables expensive on a unit basis.

4.36 Electricity systems in the Maldives generally rely on single island prime movers, largely due to the prices that tourist hotels are willing to pay for a high degree of reliability. There are more than 20 isolated systems, most of them very small, relying entirely on oil for the fuel source.

Successes, Failures and Lessons Learned

4.37 The per capita consumption of most of the OECS countries is significantly smaller than the island systems selected for comparison. Indeed, the consumption figures for the OECS discussed in Chapter 2 include resorts and hotels consumption, paying for demand patterns that are more similar to residential demand in U.S. and Europe than to other commercial or residential demand in the OECS countries. However, the increased use of electricity by hotels does enlarge the overall scale of operations on an island, giving rise to potential economies of scale and lower rates.

4.38 Most OECS countries have opted for private provision of electricity services. However, once privatization has been completed, the small market size can lead to difficult issues such as monopoly regulation and the incentives of providers to safeguard their ownership position. One downside of many small islands monopolies is that they may inhibit the emergence of and investment in Independent Power Producer (IPP) and Distributed Generation (DG) projects. Further, the local utility may have right of first refusal to take projects developed by developers, at the developer's expense – further discouraging proposal and development of projects.

4.39 Experiences of selected islands are discussed below:

4.40 **Hawaii:** This U.S. state has separate generation and distribution for each island, the waters between them being quite deep. However, the state has attempted to supplement diesel and oil-fueled steam generation with renewable energy sources. The state's **Biomass Conversion and Associated Distributed Generation Program** has been aimed at making use of agricultural residues or processing byproducts to sell excess capacity in to the grid. The program has been successful as a means of providing investment opportunities in clean energy to nonutility entities that generate sufficient agricultural-based fuel resources or residues to justify investment in power generation.

4.41 Three approaches have been tried in Hawaii: 1) co-firing of wastes for generation of process steam and reduction in fuel costs, 2) generating excess steam for the purpose of generating all or part of the electricity required by the plant or factory, and 3) installing excess generating capacity for the purpose of selling power on to the grid or local distribution system. The successful plants in Hawaii have used mostly sugar cane bagasse and Macadamia nutshells as the primary source of heat input in co-firing steam boilers for process steam and power generation thorough use of steam turbines.

4.42 The State and Federal governments have provided further incentives for development of such renewable sources of energy, including biomass, and offer a number of tax and policy incentives to advance the use of renewable energy. Tax incentives for alternative transportation fuels, which may also be produced from biomass, include a corporate income tax credit for ethanol production, an exemption from the 4 percent excise tax on retail sales of gasohol, and reduced tax rates for alternative fuels.

4.43 The state also provides generous business incentives for qualified high technology businesses in the area of “no fossil fuel energy-related technology,” and additional benefits for qualifying businesses located in Enterprise Zones.

4.44 One of the key pieces of Hawaii’s alternative energy development has been biomass energy. To this end the state has developed an inventory of its biomass resources. Hawaii’s initiatives include not only the inventory itself, but also the experience in Hawaii of making a detailed inventory of biomass potential, locations, logistical issues, seasonality of availability and possibilities of storage of biomass for future use—including possible conversion to ethanol or methane—which has been important to the success of the program.

4.45 **Electra (Cape Verde) Privatization** privatized its power system in the hope of providing better service at a reduced cost to the government. Three years ago 51 percent of Electra, the utility company, was sold to a Portuguese consortium. Thus far the effort has fallen short of expectations. Electricity bills have increased substantially, and Electra is apparently unable to make promised investments in infrastructure. As a result, municipalities have taken on greater responsibilities to increase access to electricity, through investment in distribution systems, an area that is supposed to be the business of Electra. Rates have continued to increase from an initially low base, giving Electra continuing public relations problems in its tariff setting.

Applicability to OECS-Member Countries

Biomass Inventory

4.46 With the currently elevated prices for petroleum products, the use of biomass energy becomes more attractive. At present, there is consideration of co-firing of bagasse on St. Kitts. The most likely candidates for further consideration of co-firing of agricultural wastes to offset fuel use and possibly generate electrical power are Dominica, where 24 percent of the labor force is engaged in agricultural activities, and the primary relevant crops are sugar cane, bananas and corn; St. Kitts and Nevis, where 3.5 percent of the labor force is engaged in agricultural activities, and the primary relevant crop is sugar cane; St. Lucia, where 21.7 percent of the labor force is engaged in agricultural activities, and the primary relevant crops are bananas and coconuts; and St. Vincent and the Grenadines, where 26 percent of the labor force is engaged in agricultural activities, and the primary relevant crops are also bananas and coconuts (U.S. Central Intelligence Agency World Factbook, 2004).

Privatization

4.47 Over the past 20 years, many governments have disengaged themselves from the business of electricity generation and sales. However, the vital importance of cost-effective power supply has given the government a continuing role in the regulation of that industry. Even where the domestic supply is completely in private hands, major decisions regarding transmission, new fuel sources and inter-island energy movements often involve input from governments.

4.48 Island countries with successful private utilities have generally found that providing an environment where basic business principles, including cost coverage, investments in new technology, and anticipatory capacity increments, can provide appropriate levels of service without economically damaging shortages and supply interruptions.

4.49 One key to managing the relationship with private electricity suppliers successfully is a realistic assessment of what small utilities can accomplish financially and technically. It is also important to note that the generally higher costs in small island systems may provide an opportunity for innovative investments that might not prove cost-effective in larger, mainland systems. Wholesale adoption of certain OECD-country investment incentives and regulations for new energy sources may or may not be appropriate to smaller, poorer island energy systems.

Applicability of Lessons from Other Countries to the OECS Member States

4.50 As was discussed in Chapter 4, the following factors characterize the energy sectors of the OECS countries:

- **Small geographic and market size** – none of the OECS countries has the minimal size for an efficient combined cycle power plant. The largest country, St. Lucia, has a population of fewer than 200,000, and the entire OECS has fewer than 500,000 people. Most OECS countries are not suitable for a competitive power supply system, which may also serve to discourage application of new or alternative generation technologies.

- **Reliance on diesel engine technology for power generation** – with the exception of Dominica and St. Vincent, virtually all power generation capacity in the OECS comes from diesel engines. In the larger markets, such as St. Lucia, the utility is able to use more efficient slow-speed diesel engines. In the smaller markets, most of the remainder other than Dominica, Grenada and Antigua, smaller, high-speed diesel engines must be used.
- **High Generation Costs –** the use of diesel engines and small-scale imports of diesel fuel combine to create a high cost basis for the power sector. The three factors primarily responsible for this situation are:
    1. Low efficiency of small diesel engines;
    2. High import costs for smaller markets, combined with high government taxes on fuels; and
    3. High distribution costs for electricity in mountainous, low-density systems.
- **Absence of compelling alternative power generation possibilities** – without significant investment in new technology, diesel will remain the dominant generation source for the foreseeable future. Even with admission of new generation technologies, the small market size inhibits economic deployment. For example, one large wind turbine (~1 MW) is large enough to destabilize system management in all but the largest OECS systems. Paradoxically, since unit generation cost is inverse to turbine capacity and reliability of wind output is directly proportional to turbine size, the more easily wind can be accommodated into the country's power system, the less compelling becomes the case for wind. On the other side of that statement is the fact that costs in all of the OECS countries from existing technologies are very high. (See Chapter 5 for a fuller explanation of this seeming paradox.)

4.51 Under such conditions, applying the lessons of larger energy systems must be done judiciously. In particular, energy policymakers must take into account the following considerations:

- What is the minimum market size needed for a given technology – how much does it rely on the coordination or backup abilities inherent in a larger system?
- Do the high costs of current generation options make room for generation technologies that might be subeconomic in larger, better-supplied systems?
- Are environmental considerations more important in the OECS than in some other markets, opening the door for cleaner, if less cost-efficient technologies?

4.52 The following Chapter shows how such considerations can be applied to the discussion of both large and small-scale energy investments for the OECS countries.

5

Identification of OECS Supply Options

5.1 Options for the supply of new energy sources in the OECS countries are based on the mix of the following factors in each of the member countries:

- Economic and population growth
- Changes in economic structure
- Trends in fuel prices and changes in relative costs of different supply options
- Emergence of new supply technologies or opportunities

5.2 The potential for emergence of alternative supply technologies also depends on such institutional factors as the legal right to develop new supply or transmission projects, availability of resources and opportunities to increase the effective scale of supply projects through inter-island transmission of fuel or electricity.

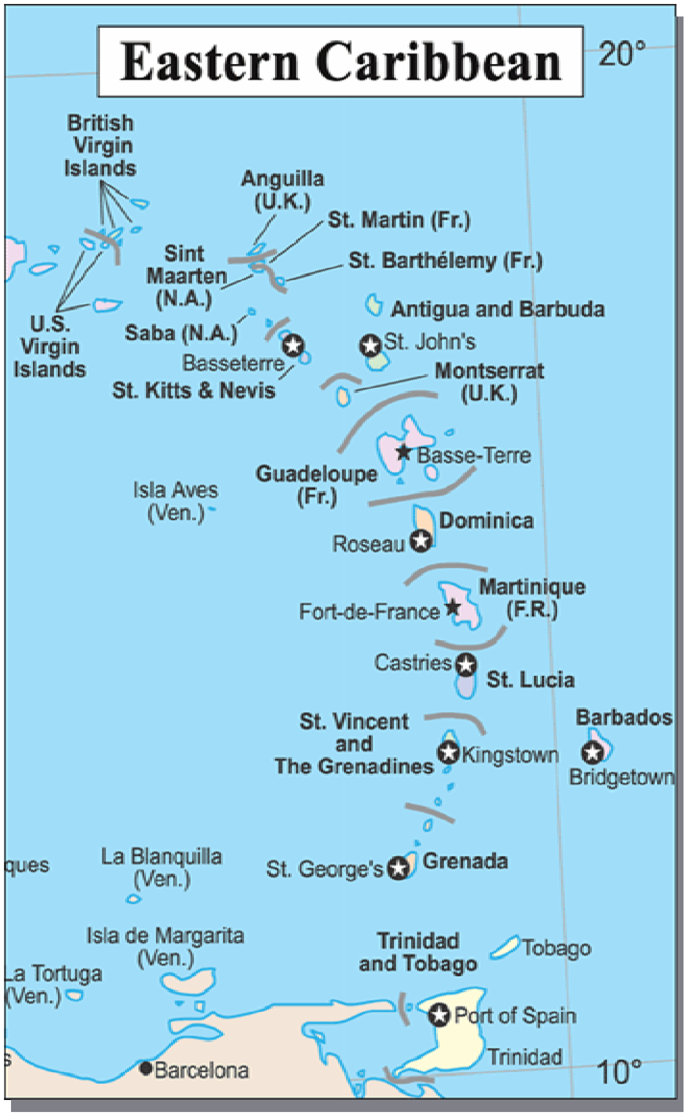
5.3 In order to examine these possibilities the report focuses on the power sector. Two main approaches have been considered for future electricity supply:

1. A business-as-usual (BAU) scenario with future supply using current technology;
2. A set of possible large-scale supply options featuring selected inter-island energy or electricity supply options,[11] and/or small scale distributed generation,[12] especially from wind, small hydro, and biomass.

5.4 The tables below indicate the projected BAU demand for diesel fuel in power generation for the OECS countries through the end of this decade.

[11] None of the options considered is capable of linking all of the OECS member countries.

[12] Distributed generation is the generation of electrical power at a location closer to the point of consumption, and may be located on the utility's distribution system for the purpose of substation level (local) peak loads or demand and/or eliminating the need to upgrade the local distribution lines. Distributed generation may also be off grid, self-generation for internal or local use. Ideally, non–utility-distributed generation would also be available for sale back on the grid though a power purchase agreement, thereby adding new capacity at no cost to the utility and providing revenue to the generator.



Business-as-Usual Electricity Forecasts for OECS Countries

5.5 Tables 5.1–5.3 below show the expected generation capacity and diesel fuel consumption in the OECS countries, based on current trends.[13] These forecasts are based on the business as usual scenario; that is, no gas pipeline, no geothermal, no large wind farms and no inter-island electricity transmission. In addition, it is assumed that those islands with current hydro resources, Dominica and St. Vincent, will not produce more electricity from hydro in the future, but instead will get all of their additional BAU electricity generation from diesel generators.

13 These forecasts were undertaken for this report and are based on the baseline data and growth rates calculated from PETSTATS data since 1995.

Table 5.1: OECS Thermal Generation Capacity (GW)

Country-	2001	2006	2011
Antigua-Barbuda	0.054	0.064	0.084
BVI	0.038	0.043	0.052
Dominica	0.012	0.014	0.017
Grenada	0.037	0.046	0.065
Montserrat	0.004	0.004	0.003
St. Kitts-Nevis	0.033	0.039	0.052
St. Lucia	0.066	0.085	0.129
St. Vincent	0.010	0.012	0.016
Total OECS	**0.254**	**0.306**	**0.419**
Note that Dominica and St. Vincent generate significant proportions of their electric power with hydro.			

Table 5.2: OECS Electricity Generation (TWh)

Country	2001	2006	2011
Antigua-Barbuda	0.105	0.145	0.247
BVI	0.038	0.049	0.076
Dominica	0.034	0.040	0.053
Grenada	0.143	0.185	0.283
Montserrat	0.003	0.002	0.001
St. Kitts-Nevis	0.100	0.130	0.200
St. Lucia	0.269	0.330	0.463
St. Vincent	0.064	0.076	0.103
Total OECS	**0.76**	**0.96**	**1.43**

Table 5.3: OECS Distillate Consumption for Electricity Generation ('000 b/d)

Country	2001	2006	2011
Antigua-Barbuda	0.88	1.04	1.38
BVI	0.20	0.23	0.31
Dominica	0.22	0.28	0.44
Grenada	0.63	0.81	1.23
Montserrat	0.16	0.15	0.13
St Kitts-Nevis	0.37	0.56	1.11
St. Lucia	1.33	1.48	1.76
St. Vincent	0.65	0.93	1.67
Total OECS	**4.44**	**5.49**	**8.05**
Note that this distillate fuel consumption figure is for the power generation sector only.			

5.6 As can be seen from the above tables, without any major changes in technology or approach in the power sector, most of the OECS countries will have to increment their generation capacities by 25–30 percent on a net basis over the next six years, with an equivalent increase in distillate fuel demand for power generation. Some nations, including Dominica and Grenada, are expected to show very small changes in generation and fuel demand, while others, including St. Lucia and St. Vincent, could face significantly higher imports of fuel in the future.

5.7 For the OECS countries listed above, the BAU forecast means the following:

1. Continued reliance on diesel engines as the prime movers for power generation;
2. Little or no additional exploitation of hydro, geothermal, and wind resources; and
3. No imports of natural gas either in pipeline or LNG/CNG form.

5.8 The net increase in diesel generation capacity is expected to total more than 110 MW for the period 2005 through 2011. However, the overall acquisition of new diesels will be significantly greater, probably more than 125–150 MW, given the need to replace obsolete units.

Strengths and Weaknesses of BAU Approach

5.9 The BAU forecasts show the likely evolution of generation and demand if current patterns of supply are maintained. As such, they have the advantage of familiarity. Continued reliance on diesel technology provides each island electricity system with a well-understood technology, capable of incremental augmentation, as demand requires.

5.10 In addition to the advantage of continuity and familiarity, a continuation of the current approach would avoid the costs of technology shifts, stranded costs for new capacity investments, and institutional uncertainty that often accompanies the emergence of new supply technologies. For some of the islands, incremental growth may finally provide a large enough demand to replace some of the high-speed engines with more efficient slower speed diesels, saving money on fuel and improving reliability.

5.11 On the down side of continuity, the recent increase in fuel prices has been especially difficult for small, poor countries. Not only has the commodity price gone up, but also the cost of transporting that fuel to the power plant. Further, the small size of the diesel engines now used limits the efficiency of generation and forecloses other options, including micro-turbines and integrated wind systems.

5.12 As a result of the high cost of fuel, including government taxation, electricity prices for all consumers are quite high in OECS member states. Such a high price level has three primary effects on the economy and consumers. They are:

- Discouragement of industrial investment or any processing investment requiring significant electricity inputs;
- Competitive disadvantage for tourism and services business competing against larger islands with lower cost power; and
- Reduction in direct consumption of electricity by consumers, thereby reducing the overall benefits of electrification to the society.

5.13 The following two sections lay out a number of possible alternative investments for the power sector. They are grouped roughly as follows:

Large-scale options – inter-island gas pipeline, LNG/CNG, Geothermal

Small-scale options – wind

Inter-island electricity transmission – based on geothermal or wind generation.

Large Scale Energy Supply Options

5.14 For a number of years energy planners and suppliers in the OECS countries have considered a number of larger-scale supply options. These options include:

1. Pipeline natural gas
2. LNG/CNG
3. Geothermal energy with inter-island power transmission (integration with Martinique and Guadeloupe).

5.15 The general features shared by each of these options are (i) they are disruptive with respect to existing power systems; (ii) they require a larger market than any OECS country can provide; and (iii) they offer improved stability of electricity prices for the countries deploying the technology.

Inter-Island Gas Pipeline

Background

5.16 Trinidad and Tobago has significant reserves of natural gas and is a major global exporter of LNG and gas-based chemicals. In August 2002, Prime Minister Patrick Manning of Trinidad and Tobago announced his support for a gas pipeline to supply natural gas to neighboring Caribbean states, which were reliant on diesel fuel for electricity generation. At the time it was estimated that the use of natural gas would cut the energy costs of these islands by about 30 percent.

5.17 Following this announcement, a pre-feasibility study was carried out by Doris Engineering (a U.S.-based engineering consultancy) on behalf of the Intra Caribbean Pipeline Company. This study proposed a pipeline with the following sections:

- Trinidad to Martinique via Grenada, St. Vincent and St. Lucia
- Martinique to Barbados
- Martinique to Guadeloupe via Dominica.

5.18 The proposed pipeline would provide an economic and sustainable gas supply to seven islands on the route. Encouraged by the favorable results of the pre-feasibility study, private investors were encouraged to back the project and the Eastern Caribbean Gas Pipeline Company (ECGPC) has been set up to develop, construct and operate an Eastern Caribbean gas pipeline. ECGPC commissioned a full feasibility study, which was completed in September 2004. Table 5.4. lists the costs for the pipeline:

Table 5.4: Gas Pipeline Costs for Eastern Caribbean Gas Pipeline System (US$ millions)

Pipeline Segment	Capacity (mmcfd)	Cost (USD M)
Phase I: Trinidad to Barbados	45	140
Phase II: Barbados to Martinique and St Lucia	100	204
Phase III: Martinique to Guadeloupe and Dominica	40	140
Total	**140**	**504**
Source: Eastern Caribbean Gas Pipeline Company		

Feasibility Study

5.19 The major gas markets on the originally proposed pipeline are Barbados, Martinique and Guadeloupe, which are expected initially to consume approximately 100 mmcfd (million cubic feet per day) of gas.[14] If the pipeline was built, the OECS islands that might get gas are expected to consume the following quantities:

- St. Lucia 10 mmcfd
- Dominica 1.5 mmcfd

5.20 This gas consumption is based on gas supply for power generation only as there are no existing gas distribution systems on any of the islands and the pipeline project does not propose to build any gas distribution infrastructure. Hence, consumers on the islands will only benefit from the gas supply by expected lower electricity prices.

5.21 St. Kitts and Nevis are north of Guadeloupe and it is not proposed that the gas pipeline would deliver gas to these islands, as it will terminate at Guadeloupe.

5.22 The full feasibility study has recommended a different pipeline route to that proposed in the pre-feasibility report for the following reasons:

- The route from Trinidad to Martinique via Grenada, St. Vincent and St. Lucia is along an area where the Caribbean and Atlantic Tectonic plates meet. This area is geologically unstable and the feasibility study recommends that this route had too many geological risks of damage to the pipeline.
- Because the major gas markets were Barbados, Martinique and Guadeloupe, the original route required the maximum size pipe from Trinidad to Martinique and on to Barbados. The feasibility study recommends a more economic route, in terms of pipeline capital cost, which allows the pipe to be reduced in diameter onwards from Barbados.

5.23 For these reasons, the proposed pipeline will follow a more easterly route from Trinidad to Guadeloupe via Barbados and Martinique with spurs to St. Lucia and Dominica. Following this route, the islands of Grenada and St. Vincent will not be supplied with gas from the proposed pipeline.

Description of Project

5.24 The pipeline will be designed to supply 130–140 mmcfd of gas, which represents only about 3 percent of Trinidad's production and is therefore considered as sustainable for the foreseeable future. The pipeline will be built in three phases as follows:

- Phase I: Trinidad to Barbados (approximately 180 miles)

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14 At approximately 14 mmcfd per 100 MW of CCGT capacity, 140 mmcfd is enough gas to supply approximately 700 MW of CCGT generation capacity. If generation on St. Lucia were simply converted to gas firing, then the total potential installed capacity would fall to roughly 660 MW for the entire pipeline throughput.

- Phase II: Barbados to Martinique with spur to St. Lucia (approximately 130 miles)
- Phase III: Martinique to Guadeloupe with spur to Dominica

5.25 Due to the estimated gas demand for both commercial/domestic distribution and power generation in Barbados, Phase I is economically viable as a standalone pipeline. The Barbados demand requires an 8-inch diameter pipe and this will be built if gas contracts can be agreed with Barbados. The maximum expected throughput of a Barbados-only 8 inch pipeline would be about 45 mmcfd, enough gas to fuel roughly 325 MW of CCGT (combined cycle gas turbine) power plant capacity. The present needs for gas in Barbados require about 20 mmcfd to fuel its 170 MW of CCGT capacity.

5.26 The remainder of the pipeline depends on gas contracts being agreed with the islands of Martinique and Guadeloupe. If these contracts are signed the pipeline will be designed as a 12-inch diameter pipe from Trinidad to Barbados, a 10-inch diameter pipe from Barbados to Martinique and an 8-inch diameter pipe from Martinique to Guadeloupe.[15]

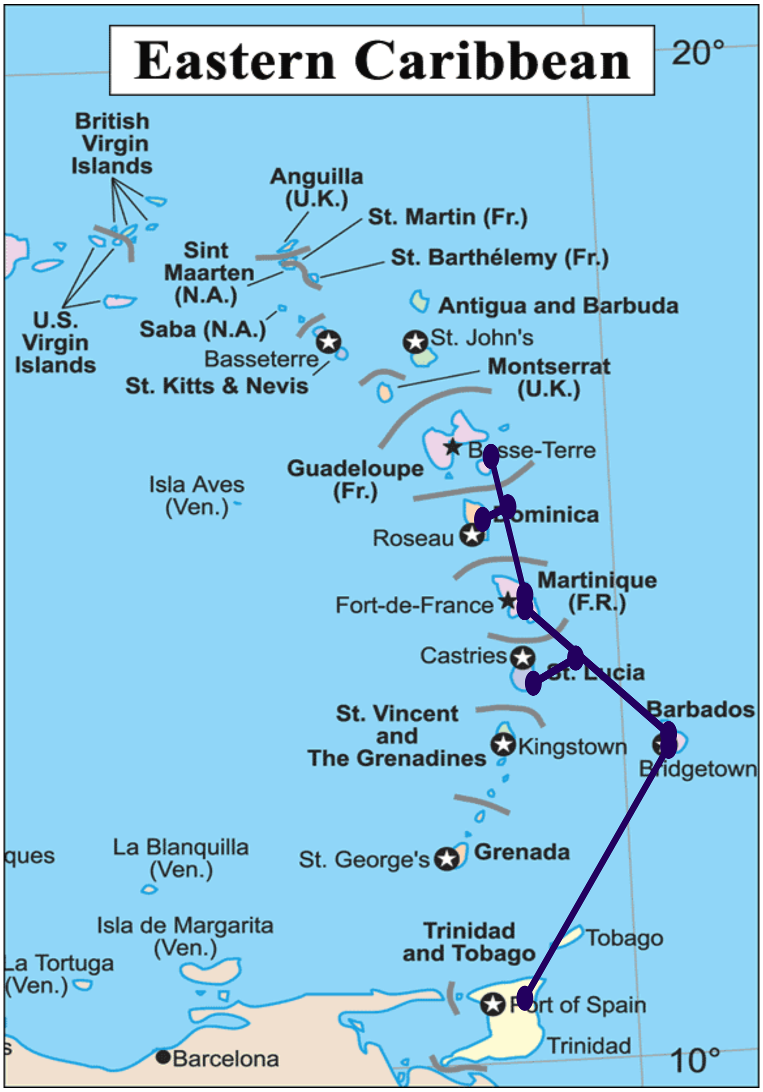
5.27 The pipeline will be designed to lie at depths no greater than 2,000m, which is possible throughout the chosen route. This means that standard pipeline technology may be employed, keeping capital cost to a minimum. The pipeline will also be designed to withstand “hurricane” waves, which might affect the pipe to depths of 100m.

5.28 Pipeline construction may only take place during the months of November through May, outside the “hurricane” season. The pipeline company has taken this into account and has developed a project schedule that completes Phase I with supply of gas to Barbados by 2007 with sections 2 and 3 complete and supplying gas by 2008. This means that St. Lucia and Dominica could have economic gas supplies by 2008.

5.29 The map below shows the proposed routing of the gas pipeline from Trinidad to Guadeloupe. There are two spurs, one to St. Lucia and the other to Dominica, to serve the OECS market.

15 Martinique and Guadeloupe now have a total of 540 MW of generation capacity (120 and 450 respectively, provided almost entirely by diesel engines). A complete replacement of this capacity by high efficiency gas-fired CCGTs would require almost 80 mmcfd, a figure within the probable supply profile of the proposed pipeline system. Each 100 MW of firm geothermal energy from Dominica, if it is developed, can replace approximately 14 mmcfd as used in a CCGT power plant.

Figure 5.1: Proposed Gas Pipeline Routing



Outstanding Issues

5.30 The project schedule is very aggressive and there are many remaining outstanding issues. Some of the main issues are outlined below

<u>Gas Contracts</u>

5.31 The agreements to take gas are keys to this project. As described above, the main gas markets are Barbados, Martinique and Guadeloupe. The pipeline to Barbados could be built and operated economically if gas contracts are signed with the appropriate authorities in Barbados, but this will not supply any gas to the OECS islands that are the subject of this study. Furthermore the pipeline will not be built beyond Barbados without agreement from Martinique and Guadeloupe to take gas.

5.32 These agreements must be in place before any construction may commence, so delay to signing contracts directly impacts the completion and gas supply dates.

Pipeline Design

5.33 The diameter of pipe directly affects the capital cost of the project. The gas demand from Barbados requires only an 8-inch diameter pipe, but if the islands of Martinique and Guadeloupe agree to take gas, then the pipe diameter for Phase I must be increased to 12 inches. Assuming that Barbados agrees to take gas, then, to meet the current project schedule of earliest supply to Barbados in 2007, Martinique and Guadeloupe must sign agreements to take gas by July 2005 so that the Phase I design can be completed.

Land and Right of Way Agreements

5.34 The pipeline will start at a terminal on shore in Trinidad and be routed across the seabed, landing on each of the islands en route. At the landfall on each island, a receiving terminal may be required on or near the coast, and the pipeline will then continue across the land to the power plant. To successfully build this pipeline, the company will require the necessary land and Rights of Way as follow:

- The pipeline will cross the territorial waters of at least 6 (six) island states and will require Rights of Way to cross the seabed from the relevant state governments.
- The pipeline will land on the coast of each island. It is assumed that the state government owns the land between the high and low water mark and the pipeline company will require a Right of Way to cross this land.
- The pipeline will cross the land from the High Water Mark to either a receiving terminal, which is likely where the pipe is traveling onto another island, or directly to the power plant. The pipeline company will need to purchase land for the receiving station from the relevant landowner and will also require a Right of Way across any land traversed by the pipe. The pipeline may cross the land of many different owners and a Right of Way will be required from each owner.

5.35 As this project is likely to give substantial benefits to the economy of each island, it may be assumed that the state governments will cooperate with each other and with the pipeline company and expedite the legal processes to provide the necessary Rights of Way for the sea crossing and island landings.

5.36 Purchasing land and land-based Rights of Way from landowners may not be straightforward, as they may not be willing to sell their land, especially if there may be a more lucrative market for hotel development at a later date. Alternatively land prices have been known to rise dramatically in affected areas once details of the project are known. Landowners may also refuse to grant Rights of Way for the pipeline as a bargaining ploy when negotiating to sell land.

5.37 Right of Way Agreements normally attract either a one off payment for a permanent Right of Way or an annual rental payment for which the Right of Way may be terminable. Either payment is negotiable with landowners, which could be a protracted business. In extreme cases where landowners continue to object to the project, there may be recourse to the law for compulsory land purchase or Rights of Way. This process often puts major delay into infrastructure projects of this type.

Environmental Issues

5.38 At present, seabed surveys have not been conducted, and therefore maps of the proposed undersea routing options under consideration are not available. Depending on routing, primary environmental concerns will likely include impacts in coastal areas and shallow waters. Impacts that must be considered include those on seagrass, mangroves, sensitive habitats and marine protected areas, coral reefs, marine water quality in general, beaches and coastlines, fisheries and aquaculture operations.

5.39 Current plans call for installation of the pipeline in three sections, as detailed below.

5.40 Phase I: Trinidad to Barbados (approximately 180 miles). The pipeline will start from the existing terminal on the east coast of Trinidad and land on the southeast coast of Tobago at a point called Cove Estate. This is an area designated for Light Industrial development. This will be the site for the main compressor units to compress gas from 1,800 psi to 3,750 psi for onward transmission.

5.41 From Tobago the pipeline will be routed to Barbados. There will be two landfalls on Barbados. The main landfall will be at Checker Hall, on the northwest coast of the island. From Checker Hall there will be a subsea lateral pipe to the southwest of the island, landing at Spring Garden. The Spring Garden area has some major industries and some key critical infrastructure. For example, the main generating facility of Barbados Light and Power is located in this area. There is currently one marine park on Barbados, at Folkestone Marine Park, which is located on the middle of the west coast of Barbados, near Holetown. A second marine park, Northeast Marine Park, is proposed, but based on its location, it does not appear to be near a point of landfall.

5.42 Phase II: Barbados to Martinique with a spur to St Lucia (approximately 130 miles). From Barbados (Checker Hall) the pipe will be routed to Martinique, landing at the southern tip, at Pointe Pimantee. At present there are no marine protected areas on Martinique.

5.43 From Martinique, there will be a lateral pipe to St. Lucia landing on the northwestern side at Cul de Sac bay, close to the Cul de Sac power plant. There are currently 21 marine protected areas on St. Lucia. However, none are located in the vicinity of Cul de Sac Bay (also the location of the Hess Oil terminal), south of Castries.

5.44 Phase III: Martinique to Guadeloupe with a spur to Dominica. On Guadeloupe there will be two landfalls, at Sainte Marie on the southeast of the island and at Pointe a Pitre, which is near the airport. There are no marine protected areas on Guadeloupe. From Guadeloupe there will be a lateral pipeline to Dominica landing at *Prince Rupert Bay*, near Portsmouth. There is one marine protected area on Dominica, Cabrits National Park, and a second currently proposed on and around the wreck of the Bianca C. Cabrits National Park is located immediately northwest of Portsmouth, and forms the northwest boundary of Prince Rupert Bay. Routing of the pipeline and location of the terminal will require consideration of impacts on Cabrits National Park.

Alternatives Considered

Gas Pipeline from Trinidad to Grenada and St. Vincent

5.45 Chapter 6 sets out the reasons for realigning the pipeline route to the east so that Grenada and St. Vincent will not be supplied with gas if the pipeline goes ahead. The principle behind the pipeline is to supply as many islands as possible with an economic and sustainable supply of gas, so the full feasibility study studied the possibility of supplying Grenada and St. Vincent with a dedicated small diameter pipe, from Trinidad to St. Vincent via Grenada, to meet their gas demands. The feasibility study was based on a total demand from these two islands of 8 mmcfd. However, the small volumes of gas required by these islands made this proposed pipeline uneconomic and this option has been rejected at this time.

LNG/CNG

5.46 At the present time there are no LNG or CNG receiving facilities in the region that are small enough to fit within the demand profiles of the OECS countries.[16] However, recent cost reductions in small-scale LNG regasification facilities, along with continued progress in offshore unloading technology. call for continued observation of cost and scale trends.

5.47 CNG has not yet proved to be a commercial technology for large-scale seaborne transport, though again, there are improved designs and costs are expected to fall in the future.

Liquefied Natural Gas (LNG)

5.48 LNG is natural gas that has been cooled to the point (-256^{o}F) that it condenses into a liquid at atmospheric pressure. Liquefaction reduces the volume of the gas by about 600 times, making it much more economical to transport.

16 Promising new transport and liquefaction technologies for gas at higher pressures than currently used may provide economic supplies for smaller markets. None of these has reached fruition yet, though the companies backing such technologies, ExxonMobil and ConocoPhillips, are enthusiastic about the prospects.

5.49 LNG is a major global commodity transported in bulk around the world to large demand centers. Trinidad and Tobago is a major exporter of LNG and so has the infrastructure in place to produce LNG and deliver it onto tankers for transportation.

5.50 LNG tankers are double-hulled vessels specially designed and insulated to prevent leakage or rupture in an accident. LNG is stored in a special containment system that maintains the LNG in liquid form at atmospheric pressure and -256^{o}F. An LNG tanker is typically 900 ft. long, 140 ft. wide, has a draft of about 36 ft., and is designed to transport 125,000–138,000 cm of LNG, which provides 3,600–3,800 mmcf of natural gas. The vessels are large, and getting larger, to take the benefits of economies of scale that have made LNG a more competitive fuel for large markets. The typical cost of an LNG tanker of this size is $160m (2002).

5.51 A dedicated deep-water berth and unloading terminal is required for LNG discharge and storage onshore. The terminal must contain LNG unloading and handling equipment, storage facilities, regasification equipment, gas pressure regulation equipment and connections to the gas distribution main.

5.52 For storage, a large double-walled storage tank is required into which the liquid is discharged and stored at atmospheric pressure and -256^{o}F. When required for use it is turned into gas by warming in a controlled environment and regulated for pressure before being discharged, as a gas, into the distribution main. It is estimated that costs for storage and regasification is US$0.3–US$0.5/10^{6}btu, although this is based on modern large-scale plants with economies of scale. It is expected that a small plant with small volumes would be more expensive than this.

5.53 LNG storage and regasification is a hazardous process because LNG is usually transported and stored in large quantities, and the liquid gas is volatile and flammable. Furthermore, cryogenic temperatures and processes are involved, which are hazardous by nature. Modern safety standards may be applied to the terminals but the facilities should be located far from populated areas and other port activities. On small islands, this may be difficult to achieve without considerable objection from the local population.

5.54 Unless the LNG terminal is directly adjacent to the power plant, a gas pipeline distribution system will be required to transfer the gas from terminal storage to the power plant. The overland pipeline will require Rights of Way over the land that it crosses, which will have the same issues over obtaining Rights of Way discussed earlier in this Chapter.

Why was LNG Not Chosen As A Supply Alternative For The Eastern Caribbean?
LNG supply to other Caribbean islands was considered during the feasibility study but rejected because: • This proposed gas pipeline is designed to provide 6 islands with up to 140 mcf/day. One current LNG tanker carries the equivalent of the total gas requirement for about 20 days, but would require multiple visits to each island to unload unless gas storage for 20–30 days gas demand is available on each island. • Previous studies indicate that, even for areas with large gas demand, pipelines are more economical than tanker transportation for sailing distances of less than 700 miles. • Current tankers require a deep-water berth. St. Lucia has a deep-water berth but Grenada, Dominica, St. Vincent, Nevis and St. Kitts do not. Furthermore, the St. Lucia deep-water berth may not be available for LNG unloading if it is utilized for other activities important to the island economy. • Each island would require an unloading terminal and regasification plant to convert the LNG back to natural gas. This requires land and capital investment in equipment and operating costs far greater than that required for landing a subsea pipeline. • LNG is a global commodity whose price is governed by the global market and is related to the price of oil. One objective of the pipeline project is to provide low cost energy at stable prices and to reduce the vulnerability of the Caribbean state economies to rising or unstable oil prices. • Continuity of supply is an issue during the hurricane season.

Compressed Natural Gas (CNG)

5.55 This technology takes natural gas and compresses it at high pressure (1,000–3000 psi) into a liquid at about 0°C. It is possible by this means to compress large volumes of gas into small containment areas without the huge investment in cryogenic plants necessary for LNG.

5.56 Unfortunately CNG technology is not yet well developed, but it is expected that CNG tankers could be loaded offshore by direct connection to buoy-type transfer systems attached directly to the gas production platforms by short pipelines, and could be unloaded in a similar manner. The ships themselves will act as the storage vessels so that large onshore unloading and storage facilities are not necessary, as the ships will be directly connected to the gas distribution system. This system significantly reduces the capital investment required at the terminals for loading and unloading gas, and removes many of the objections encountered during planning a new LNG facility.

5.57 The cost of CNG tankers is expected to be similar to LNG tankers, but CNG tankers will carry a significantly smaller volume of natural gas. A similar sized tanker is expected, depending on the technology chosen, to carry between 30 mmcf and 1,500 mmcf compared to the 3,000 mmcf carried by an LNG tanker.

5.58 As the ship acts as the storage vessel, multiple ships are required to maintain supply to each island on a continuous basis. As the pipeline cost is estimated at about $500 m, the comparative capital cost of dedicated vessels for CNG transport does not provide a competitive economic solution to the energy needs to the major markets at this time. For the short distances involved and the small gas volumes required, it is unlikely to become a competitive technology for these islands.

5.59 Once pipeline gas supply is established for St. Lucia and Dominica, it may become possible to compress gas there and ship onward to other OECS states with similarly small markets. Whether this is feasible will depend in large measure on future oil prices and the degree of progress in CNG transshipment technology.

Geothermal

Background

5.60 The OECS islands of Grenada, St. Vincent, St. Lucia, Dominica, and Nevis and St. Kitts lie close to a tectonic plate boundary. This boundary is characterized by volcanic activity and the islands are therefore potential sites for geothermal energy exploitation.

5.61 Geothermal feasibility studies have taken place on a number of the OECS islands over many years but, to date, no commercial exploitation for power generation purposes has been achieved. However, the nearby island of Guadeloupe has had a successful 4 MW geothermal plant at Brouillante since 1996. This plant produces about 23 GWh annually with availability of about 8,000 hours per year (91 percent). Figure 6.2.1 below addresses costs of geothermal resource development.

5.62 The status of geothermal development in the OECS islands is set out below.

Grenada

5.63 Some pre-feasibility studies show that there may be small geothermal potential on Mt. St. Katherine. There is also a large subsea volcano about 5 miles off Grenada’s north coast which indicates that the area between it and Grenada might have geothermal potential, but there have been no attempts to develop these possibilities.

St. Vincent

5.64 La Soufrière volcano on St. Vincent has erupted three times in the last one hundred years, indicating that there is at least a possibility of geothermal potential on St. Vincent.

St. Lucia

5.65 Investigations into geothermal potential on St. Lucia have been ongoing intermittently since the 1950s, the last real effort being in about 1991. However earlier in 2004, the Government of St. Lucia signed a Memorandum of Understanding with a

Canadian company to investigate geothermal potential on the island. It is not believed that any work has started at the date of writing this report. Furthermore, the electricity utility (Lucelec) have adopted a target of providing 10 percent of generated power from renewable sources by 2007. This policy is based on development of wind power technology only, so Lucelec does not appear to have plans of its own to develop geothermal resources.

Dominica

5.66 To date, only preliminary feasibility work has been carried out to determine the true geothermal potential in Dominica.[17] However, it is reputed that Dominica has the greatest geothermal potential among the OECS islands, variously reported at between 100 MW_e (MW electrical) and 300 MW. With Dominica's geographical position between the French islands of Martinique and Guadeloupe, there is interest in developing this resource and forming a multi-island transmission grid. No work is currently being done to explore or exploit this potential but both Électricité de France and its Dominican partner, and the Organization of American States (OAS), seriously intend to exploit the Dominican geothermal resource. EdF has already conducted preliminary studies on plant capacity and undersea power transmission, and the OAS is about to begin a project that will:

- Carry out a desktop feasibility exercise both of power production and electricity transmission
- Provide a Risk Fund to encourage drilling exploration and development of a commercial project.

5.67 The proposed Risk Fund will enable developers to access drilling capital in a manner that encourages competition for drilling rights while reducing the riskiness of such drilling for smaller companies. Local firms may be able to participate in the development of Dominica's geothermal resources through the operation of such a fund. Indeed, there is already at least one drilling consortium that has planned to develop at least some of the geothermal field, once the appropriate legislative environment is created.

5.68 The figure below shows the expected costs of developing 100 MW of geothermal energy, including the drilling and exploration components. Assuming that the resource exists, even a worst case scenario would result in generation costs below $70/MWh, less than half the current costs in the Caribbean, using internal combustion technology. For the expected 300 MW geothermal resource in Dominica, the predicted exploration costs should range from $10–40 million, about 10–15 percent of expected total project costs.

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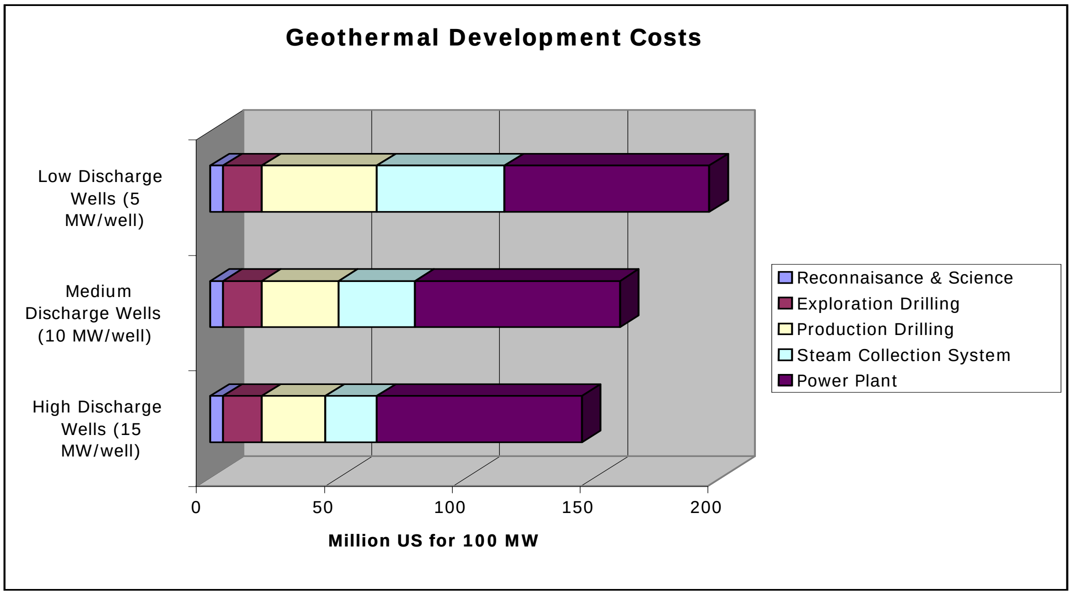
17 Recently, two scientific teams from EdF were in Dominica to assess the geothermal potential and environmental aspects of development.

St. Kitts and Nevis

5.69 There are numerous sites on Nevis, in particular, and St. Kitts with geothermal potential but no work is currently being undertaken to exploit this potential.

Figure 5.2: Source: The World Bank, 2003, *Geothermal Energy: an Assessment*



Role of Geothermal Energy and Transmission Grid for Martinique/Dominica/Guadeloupe

Integration of OECS member Dominica with the French islands of Guadeloupe and Martinique has long been seen as one of the keys to rational geothermal energy development. This integration of the two French Departments with the OECS countries could provide a basis for other forms of cooperation in the energy sphere as well.

Dominica has an installed capacity of around 22 MW, of which 7.6 MW is hydro and, therefore, relatively cheap. This leaves about 14 MW of diesel-fueled generation that could potentially be displaced by geothermal power. Hence, although a small geothermal plant might benefit Dominica, exploitation of the estimated large-scale geothermal resources is irrelevant to Dominica's energy needs except as a potential energy export and producer of income to the economy.

Martinique and Guadeloupe, on the other hand, have much greater power needs, with combined installed capacity of about 750 MW (see statistics below) and, like most of the islands, they are mainly dependent on imported diesel as fuel for their generators. Furthermore, consumers on the island benefit from a uniform Electricité de France (EDF) tariff, which means that the island consumers are heavily subsidized by consumers in mainland France. EDF in Martinique and Guadeloupe therefore has great incentives for reducing the cost of generation in the islands and hence reducing the overall level of subsidy.

As mentioned above, EDF already owns and operates a geothermal plant of approximately 4 MW at Brouillante on Guadeloupe and has plans in progress to increase this capacity to 14.5 MW. EDF, therefore has the experience and the incentive to develop Dominica's geothermal potential.

Small-Scale Supply Options

5.70 Small scale, distributed generation in the OECS region will likely be limited to additional diesel capacity, mini combustion turbine[18] and perhaps isolated wind and solar photovoltaic energy. Small-scale hydro may have limited potential on Dominica, but is not likely to be significant elsewhere. Solar photovoltaic is probably not yet inexpensive enough, though given the high fuel and generation costs, along with probable cost reductions in PV itself, the technology will likely become attractive sooner than in larger countries with much lower fuel, generation, and, especially electricity distribution costs.

5.71 In most cases, distributed generation is likely to be implemented by nonutility entities, most likely the hotel industry, as electricity bills are an ever-increasing proportion of the operating costs of such facilities. The primary difficulty encountered will be the lack of incentive for utilities to buy excess capacity or peak generation. In some of the islands, the current institutional arrangements leave a self-generating customer entirely vulnerable to technological risk, permitting the utility to reduce or terminate service altogether. Synchronization at interconnects between self-generators and the grid will also be a contentious and potentially costly problem to resolve.

5.72 The reader will note that offshore wind farms have been included as the sole small-scale option. This is due to two factors: (i) it is likely that large wind farms (>50 MW) are probably inappropriate for the local market conditions, so smaller scale options are the ones most likely to be considered; and (ii) small scale hydro is not promising on most islands due to the lack of adequate rainfall.

Offshore Wind Farms

5.73 Islands are typically excellently suited for wind energy projects because they enjoy sustained winds of sufficient velocity to support generation of electricity. Small islands in the Caribbean, and elsewhere in the tropics and subtropics, also typically have low energy demand. However, wind is a scalable resource and is well suited for distributed generation (provided demand is nearby) as well as grid interconnects.

5.74 There are many operational large-scale offshore wind farms around the world at present and many more under consideration (see Table 5.5 below).

18 Mini combustion turbines run in the general capacity range of 500–1,500 kW, and will use natural gas, middle distillates or naphtha as fuel.

Table 5.5: Selected Island-Based Wind Farm Projects

A total of 10 offshore projects are currently operational worldwide: the early projects were relatively small scale and shallow or sheltered waters. Not until Blyth Offshore came online, exposed as it is to the full force of the North Sea, could any be described as truly offshore. The newly completed Horns Rev is the largest offshore project in the world.

Location	Country	Online	MW	No	Rating
Vindeby	Denmark	1991	4.95	11	Bonus 450kW
Lely (Ijsselmeer)	Holland	1994	2.0	4	NedWind 500kW
Tunø Knob	Denmark	1995	5.0	10	Vestas 500kW
Dronten (Ijsselmeer)	Holland	1996	11.4	19	Nordtank 600kW
Gotland (Bockstigen)	Sweden	1997	2.5	5	Wind World 500kW
Blyth Offshore	U.K.	2000	3.8	2	Vestas 2MW
Middelgrunden, Copenhagen	Denmark	2001	40	20	Bonus 2MW
Uttgrunden, Kalmar Sound	Sweden	2001	10.5	7	GE Wind 1.5MW
Yttre Stengrund	Sweden	2001	10	5	NEG Micon NM72
Horns Rev	Denmark	2002	160	80	Vestas 2MW
Frederikshaven	Denmark	2003	10.6	4	2 Vestas 3MW,1 Bonus 2.3MW, and 1 Nordex 2.3MW
Samsø	Denmark	2003	23	10	Bonus 2.3 MW
North Hoyle	U.K.	2003	60	30	Vestas 2MW
Nysted	Denmark	2004	158	72	Bonus 2.3MW
Arklow Bank	Ireland	2004	25.2	7	GE 3.6 MW
Scroby Sands	U.K.	2004	60	30	Vestas 2 MW
Totals			**587**	**316**	

Many other countries are also expressing serious intent in developing their offshore resource. Proposed projects include:

Horns Rev II, Denmark, 200 MW + similar project, location to be decided.
Mouth of the Western Scheldt River, Holland, 100 MW
Ijmuiden, Holland, 100 MW
Lillgrund Bank, Sweden, 48 MW
Uttgrunden II, Sweden, 72 MW
Barsebank, Sweden, 750 MW
Kish Bank, Ireland 250 MW+
Cape Wind, USA, 420 MW
Long Island, USA, 140 MW
Arklow II, Ireland, 500 MW
Cape Trafalgar, Spain, 500 MW
Thornton Bank, Belgium, 200 MW

There are also large projects in various stages of development in German waters. Total planned projects are in excess of 30 GW. France also has 500 MW under consideration.

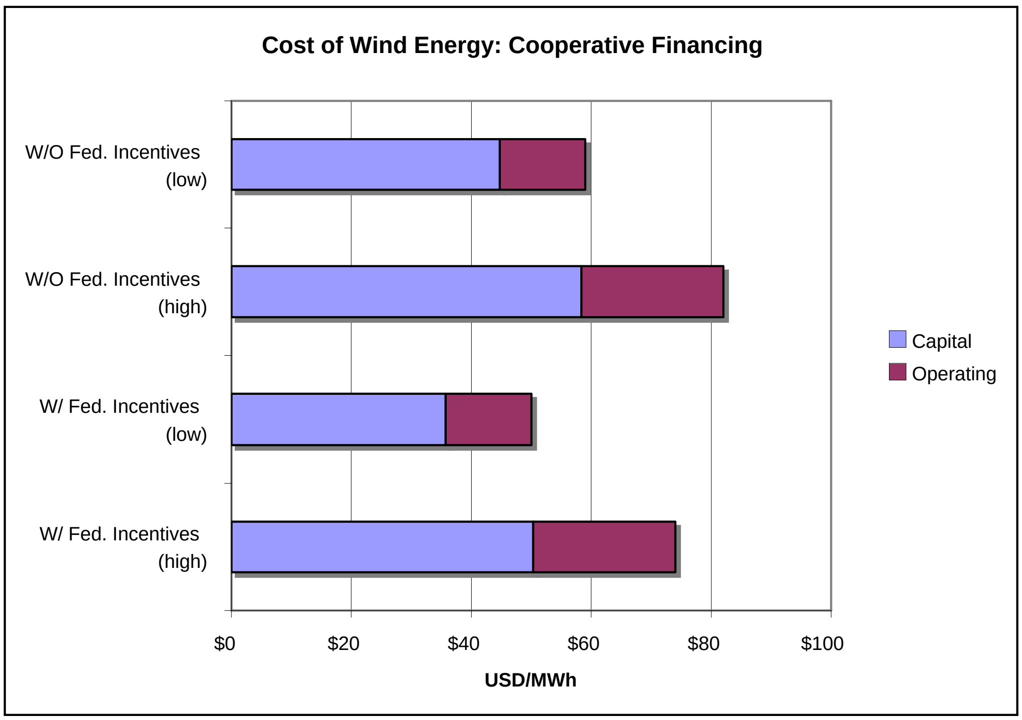
Utilizing megawatt-plus class machines, these projects will generate higher volumes of electricity from the more constant wind regimes experienced at sea and are likely to play a major role in power generation in the future.

The EWEA have estimated that 5 GW of the 60 GW predicted for 2010 will be coming from the offshore sector.

5.75 As can be seen in the preceding table, projects range from two to well over 150 MW, depending on the number of horizontal axis wind turbines (HAWT) installed. Most of the wind turbines have generating capacities at peak in excess of 500 kW.

5.76 The optimal size of an offshore wind farm in the OECS region would likely be one to 10 MW – with size limited primarily by demand, and ability and willingness of the utility to accept a substantial volume of wind-supplied power. Distributed generation, for resort and hotel cooperatives could justify smaller wind farms—say one to two MW capacity, depending on local demand and whether a special purpose company or cooperative could be formed to justify a larger project, entertaining better economies of scale (i.e., lower $US/MW installed, and lower operations and maintenance (O&M) costs per Megawatt hour (MWh).

Graph 5.3: Source: U.S. DOE (2004)



5.77 With the continued development of technology, the cost of wind energy-derived electricity has fallen by over 80 percent during the past 20 years for large scale machines, from approximately US$0.30/kWh to US$0.04–0.06/kWh in 2000, to the current range of $US0.03–0.045/kWh, for large wind farms and US$0.045–0.060 for smaller or stand-alone units, also depending in large part on the source of financing. Installed costs are currently between approximately US$800,000 and 1,000,000 per MW capacity. The installed cost is now reasonably competitive with the current alternative, diesel power.

5.78 The following figures illustrate the general range of wind energy costs as well as the influence of scale and financing structure on production costs. The first chart also shows the variability resulting from subsidies typical of those found in the USA.

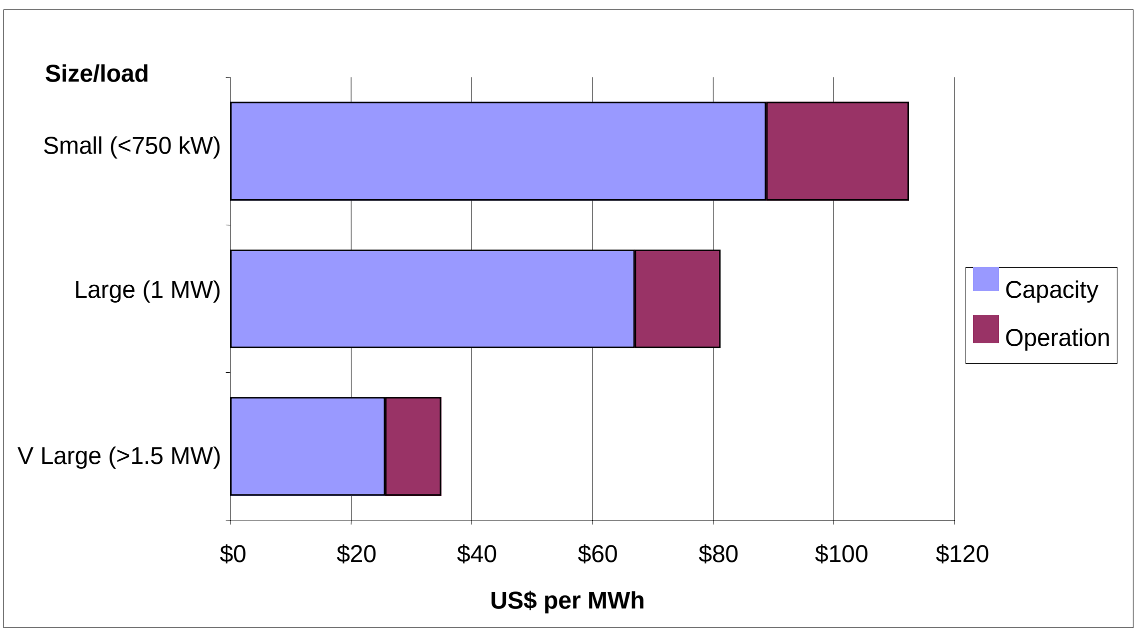
5.79 Generation costs for a medium-sized project cost roughly $60–80/MWh without federal incentives, when financed cooperatively. IPP financing structure for such a project will be found at the high end of this range. However, IPP financing of very large turbines, the type now more typically installed at offshore wind farms, will result in total generation costs below US$50/MWh, a very competitive price (see Figure 5.4).

5.80 A comparison of current ranges of generation costs also reveals that wind energy is indeed now a reasonable energy-only alternative, provided wind speeds are at or above 5 to 6 meters per second (mps), sustained. Capacity credits for wind remain elusive, and require high sustained wind speeds, some type of storage capacity in the form of batteries or other means of accommodating short-term reductions in output, and longer-term storage as pumped water or flywheel energy or some other approach.

5.81 Much work has been done in the OECS region on characterizing wind fields and potential for development. Among the most notable recent activities are the conference organized by Caribbean Renewable Energy Development Program (CREDP) in Jamaica, and the ongoing attempt to establish a wind farm project off the southern tip of St. Lucia, to service the tourist resort industry there. The later has been stalled for some time, though now LUCELEC is planning to develop a small demonstration project there.

5.82 As regards offshore wind farms, given the costs of civil works, grid interconnects and other civil works required, a certain threshold of size, with respect to nominal MW output is typically required. That threshold is currently in the range of 0.5 to 2 MW. Such projects, though large relative to many island systems in the OECS, are quite modest in development terms.

Graph 5.4: Capital and Operating Costs for Wind: IPP Financing (Source: see Figure 5.3)



Inter-Island Electricity and Gas Transmission

Electricity Transmission: Dominica to Martinique and Guadeloupe

5.83 The following discussion is based on a potential geothermal power plant on Dominica, with power offtake by Guadeloupe and Martinique, as an example.

Development of Geothermal Resources on Dominica

5.84 The likely geothermal sites are to the South and center of Dominica. The project is straightforward in that it will consist of exploration and development of the geothermal field and construction of a power plant and connection to the Transmission Grids of Dominica, Martinique and Guadeloupe. It is likely that HVDC transmission will be used for the submarine connection to the remote islands.

5.85 For the purposes of this report the following assumptions have been made:

- Power plant output: 100–300 MW
- Distance from Dominica to Guadeloupe: 25 miles
- Distance from Dominica to Martinique: 25 miles
- Dominica island length: 29 miles
- Submarine transmission cable:
  - Dominica power plant to Guadeloupe sea landing: 40 miles
  - Dominica power plant to Martinique sea landing: 40 miles
  - Monopole (single cable) with power transfer capability 50–150 MW to Martinique and Guadeloupe

Outstanding Technical and Economic Issues

Geothermal Exploration

5.86 Only desktop studies have been completed, though initial scientific investigations are now under way by EdF. Detailed exploration and ground assessment must be carried out to determine the geothermal reserves and sustainability of the resources to determine the overall viability and economics of the project.

5.87 The institutional environment for such exploration does not yet exist. Numerous issues remain to be resolved, including:

- The rights of the current Dominican electricity producer, Domlec, to participate in such a project;
- Resolution of existing contracts on geothermal exploration, production and offtake purchase;
- Interconnection construction and operation;

- Resolution of potential stranded generation costs in the Domlec system.

5.88 On the economic side, any reasonable quality of geothermal resource would easily become the least-cost electricity generation resource wherever the competing generation source was small-scale internal combustion, the dominant technology not only in Dominica, but also in Martinique, Guadeloupe and throughout the OECS.

5.89 Based on the World Bank's geothermal assessment, even a worst-case scenario would result in generation costs below $70/MWh, less than half the current costs in the Caribbean, using internal combustion technology. For the expected 300 MW geothermal resource in Dominica, the expected exploration costs should range from $10–40 million, about 10–15 percent of expected total project costs.

5.90 The key variable factors in geothermal costs are the production drilling and the steam collection systems. Both of those costs vary inversely with the quality of the resource. Initial exploration and the power plant itself are not greatly affected by the quality of the resource, thought smaller power plants or lower utilization rates will clearly increase costs of electricity generated in the plant.

Terrain

5.91 Dominica is very mountainous and consequently most of the existing settlements and infrastructure lie on the coast. New roads and power transmission infrastructure may be required to develop and sustain this power plant. However, most geothermal projects are situated in relatively difficult terrain, owning to the nature of the resource. Therefore it is difficult to say, a priori, that development and infrastructure costs in Dominica will be high relative to other geothermal projects.

Transmission Link Power Transfer

5.92 This report assumes that the power plant will have an output of at least 50MW and that the link has a power transfer capability of 50MW to both Martinique and Guadeloupe. The transmission system design and power transfer to each island must be established as it has significant effect on the capital cost of the project. Recent inferences about this geothermal prospect put the potential size at 200–300MW. In such a case, the unit costs for both the resource development and the transmission to Martinique and Guadeloupe might be lower. However, the larger resource size might also call for a double cable to each island, offsetting some or all of the net cost advantages of larger size.[19]

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19 With geothermal a larger component of the total power supply of the two islands, the developer might find it prudent to provide two cables to each island, minimizing the potential of serious disruption of electricity supplies in the event of a cable outage.

Transmission Cable Routes

5.93 No cable routing has been carried out and no cable landing sites have been determined. The land terminations are not know as no sites have been chosen for the converter stations and transmission routes to the power plant have not been determined. It is also not determined whether the land transmission route will be overhead or underground. For the purposes of this report it has been assumed that the land transmission will be by cable to a converter station at the power plant.

Benefits of Inter-Island Transmission

5.94 An inter-island transmission system is attractive to Martinique and Guadeloupe because they may be able to develop geothermal resources on Dominica to their own benefit. There is also a significant benefit for Dominica from the inter-island transmission. Such a project, by providing a bidirectional DC line, would permit Domlec to retire most of its thermal plants, except those required for system ancillary services, since backup supplies from Martinique and Guadeloupe could be provided as part of the transmission services agreement for Domlec.

5.95 Another key benefit of the geothermal supplies for both Dominica and the two French Départements is the possibility of reducing overall reserve requirements in the three systems, and hence future capital investments in capacity by considering the three islands as one transmission system. It may also be beneficial as an insurance against the effects of hurricanes, as the generation on all three islands is unlikely to be equally affected by the same storm, so an inter-island transmission system may help in restoring consumer supplies following a serious storm. The figure below shows the proposed routing from Dominica to Guadeloupe and Martinique, and from Trinidad to Grenada.

Figure 5.5: Proposed Electricity Transmission Cables for Trinidad-Grenada and Dominica Geothermal Projects

Submarine Transmission Connection from Trinidad to Grenada

Background

5.96 In 1999, Trinidad and Tobago Electricity Commission (T&TEC) carried out a feasibility study into the possibility of supplying electricity from Trinidad to Grenada via a submarine transmission cable. The feasibility study also investigated the possibility of continuing the cable onto St. Vincent but this was not considered to be an economical proposition due to the small demand and distance involved. The results of this study were sent to Grenada but the project has not proceeded. Following the devastation on Grenada caused by Hurricane Ivan, T&TEC have been asked to review their previous study and make a revised proposal to the Government of Grenada.

Description of Project

5.97 The electricity system in Trinidad has a frequency of 60 Hz whereas the system on Grenada is 50 Hz. It is therefore proposed that the transmission link will be a High Voltage Direct Current (HVDC) transmission system comprising:

- AC-DC converter station in Trinidad
- DC subsea cable – Transfer capability 35MW
- AC-DC converter station in Grenada

5.98 Trinidad has transmission voltages of 132kV, 66kV, 33kV and 11 kV. It is expected that the connection in Trinidad will be at either 132kV or 66kV whereas the connection in Grenada will be to the 11 kV system, as they do not currently have transmission voltages above this level.

5.99 The distance from Trinidad to Grenada is approximately 90 miles and the feasibility study proposed that the link should be a single bipole arrangement with only one fully rated cable. The expected capital costs and economics of the project are based on budgetary quotations received from manufacturers in 1999. However, HVDC technology is continually developing and this may not be the most cost effective solution today.

Outstanding Issues

<u>Technology Issues</u>

5.100 HVDC converter technology is well developed and has been in service with high reliability and availability throughout the world for over 30 years.

5.101 For the low power transfer capability required of this link, a modern modular HVDC system may be employed. These designs of converter stations are mostly assembled and tested in the factory, which makes field installation and commissioning very rapid and mainly fault free. The schedule time for design, manufacture and installation of these systems is short and may be a little as 18 months, so this project could be implemented very quickly once all agreements are in place.

5.102 Submarine cable technology is also well developed and modern extruded cables are very reliable. The HVDC link may be monopolar or bipolar, although some modern low power HVDC systems require bipolar arrangements, which require twin cables and possibly some increase in cost.

5.103 There are no outstanding technology issues with the link.

<u>Operational Issues</u>

5.104 T&TEC already own and operate a 20MW submarine link from Trinidad to Tobago so there are no major operational issues for this link.

5.105 There will need to be close operational cooperation between the utilities on Trinidad and Grenada and the owners of the link, in particular in scheduling of outages for maintenance of the link and utility equipment at the terminal points. There will also need to be close cooperation in power dispatch and energy metering and billing. All these issues should be established in the relevant contractual arrangements.

Project Design

Grenada System Design

5.106 Grenada currently generates power for the entire island demand from one power station at Queen's Park. Power is distributed from this power plant via seven 11kV distribution feeders. Installed capacity on Grenada, which is all diesel fueled, is 40MW with a peak demand of 25.5MW (2003). System studies have not been carried out but it is expected that the best location for connection of the cable to the system will be at Queen's Park, which may require on land transmission by cable or overhead line.

5.107 Any other location is expected to require extensive system reinforcement or re-configuration to transfer the power throughout the island. The local electricity company (Grenlec) has recently revealed plans to introduce a transmission system with higher system voltages onto the island by 2010, and to replace five of its existing diesel power generators by 2013. It would be beneficial to factor the proposed cable link to Trinidad into the system options at this early stage of design.

Power Supply Backup

5.108 This feasibility study shows that the link offers the possibility of cheaper power supplies for the island of Grenada. T&TEC expect to be able to supply power to the island at less than 50 percent of the current average selling price per unit on the island. However, the Grenada government may not want to rely entirely on power supplied over a single cable submarine link because:

- Each pole of the link will be required to be out of service periodically for maintenance. Assuming only one pole as currently proposed, this means an annual period with no power transfer to Grenada.
- The link and/or T&TEC system may be subject to periodic faults

5.109 It will therefore be necessary for Grenada to:

- Ensure the appropriate level of reliability and availability are written into the commercial agreements
- Make provision for loss of supplies by maintaining their own generation on the island.
- Consider need and economics of a bipolar arrangement to increase availability of power transfer.

Cable Route

5.110 Seabed surveys have not been carried out so the precise details of the cable route have not been established. Furthermore, landing points for the cable and sites for the converter stations have not been identified at this time. The converter stations each require a site land area of approximately $800m^2$ and there may be outgoing transmission lines or cables to make the Grid connection.

5.111 The cable route will cross at least two governmental jurisdictions and the converter stations will require land acquisition and possibly rights of way for the outgoing feeders. This will require the cooperation of Governments and landowners to ensure a successful conclusion to the project.

6

Cost Assessments for *non*-Business-as-Usual Electricity Supply Options

Preliminary Cost Analysis

6.1 The output from this subtask provides a set of comparable cost estimates for the alternative supply options laid out in Chapter 2. These estimates are preliminary and are based on typical design, installation and use conditions. Two large-scale options are considered, geothermal and gas via pipeline. In addition, the cost of generating electricity via wind farms is also provided.

Gas Pipeline and Power Plant Fuel Conversion Costs

Gas Pipeline Costs

6.2 The company developing the Eastern Caribbean Gas Pipeline Company (ECGPC) has already estimated that it is feasible to construct the initial portion of the pipeline system from Trinidad to Barbados. Consequently, those costs will not be assigned to the extensions of such a line to Martinique, Guadeloupe, St. Lucia and Dominica, if completed. The table below shows the probable costs.

6.3 The estimated capital costs of the pipeline were shown in Table 5.4 to total US$504 million, according to the developers of the project.

6.4 Total estimated gas throughput for the pipeline system from Barbados to Martinique, St. Lucia, Guadeloupe and Dominica is about 100 mmcfd; Phase II will need to carry about 30 mmcfd on its own if Phase III is not built.

Investment in New Power Plants and Conversion of Existing Generation Stations

Combined Cycle Power Plants

6.5 New gas fired combined cycle power plants (CCGT) can be constructed for approximately $600,000 per MW if infrastructure already exists, rising to about $850,000 or more per MW for a locale with no current gas and CCGT plant infrastructure. The latter figure will be the appropriate one for the OECS and French islands. The minimum reasonable size for a single CCGT unit is about 80 MW, of which 50 MW is the combustion turbine and 30 MW the heat recovery steam generator.[20] For such a small unit the cost per MW is likely to rise to over $1 million per MW for a single plant.

Diesel Plant Conversion to Gas Firing

6.6 Conversion of an existing medium-speed or low speed diesel plant to natural gas firing has been estimated by Lucelec to cost approximately $100,000 per MW for its 8 generating stations at Cul de Sac.[21] There is not expected to be a change in the net power output or heat rates of these plants under the proposed conversion plans.

Geothermal Costs

6.7 Using information from a World Bank Study (***Geothermal Energy, an Assessment***, 2003), the probable costs of a large-scale geothermal development in Dominica lie in the following range:

Table 6.1: Geothermal Project Cost Development for 100 MW Output ($ million)

Cost Element	High Discharge Wells (15 MW/well)	Medium Discharge Wells (10 MW/well)	Low Discharge Wells (5 MW/well)
Reconnaissance & Science	5	5	5
Exploration Drilling	15	15	15
Production Drilling	25	30	45
Steam Collection System	20	30	50
Power Plant	80	80	80
Total	**145**	**160**	**195**

6.8 Within each category there are levels of uncertainty, especially with regard to drilling, steam collection and the power plant. Taking full account of such uncertainty, the upper range of cost estimates would likely rise to as much as $220 million for a 100 MW plant.

6.9 In order to make the geothermal electricity useful for Dominica, Domlec would need to connect the geothermal plant to its existing distribution system with a transmission cable rather than through 11 kV distribution. Such an investment would probably cost about $10 million. To transmit electricity from Dominica to Guadeloupe and Martinique will probably cost an additional $100 million, bringing total project costs to about 245–295 million for a 100 MW project.

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20 Such a minimum size probably puts CCGT out of the range of feasibility for any of the OECS islands, given the small generating capacities in their systems and general rules regarding spare generating capacity.

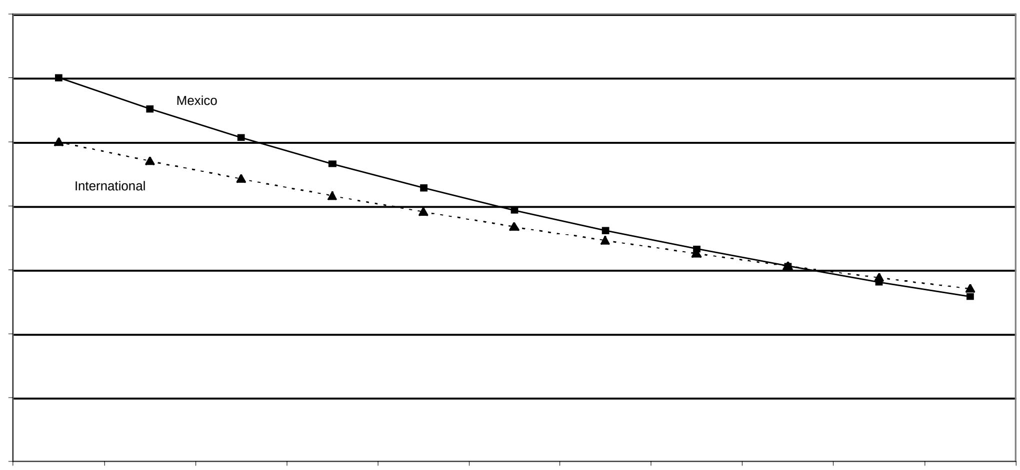
21 This figure is based on discussion with Lucelec of their plans for conversion to gas firing of existing slow-speed diesel power plants.

Wind Energy

6.10 The conversion of wind energy to electricity has shown considerable progress over the past 10–15 years. The progress in wind technology has consisted primarily of two related phenomena; the first is the increased size of individual wind turbines, with average size increasing from 250–500 kW in the mid-1990s to 750–1,200 kW currently. Concomitantly, the installed cost per kW for wind has fallen from approximately $2,000 in the early 1990s to about $1,200 today, with expected reductions to less than $1,000/kW within the next year. A 10 MW wind farm constructed offshore containing ten 1 MW machines could probably be constructed for $10,000,000.

6.11 Smaller wind turbines have not seen the kind of cost reduction that characterizes the larger machines, and will probably still fall into the $1,250–1,500 per kW range. The following figure, taken from an internal World Bank report on wind energy in Mexico, shows the general trend in future wind energy investment costs.

Graph 6.1: Expected Improvements in Wind Energy Costs in Mexico: 2003-2013, Source: World Bank Estimates from D. Papathanasiou, Cost Dynamics for Wind Power in Mexico, 2003



6.12 By the middle of the next decade wind energy in large turbine sizes should fall into the approximate range for diesel engines and CCGT power plants on a unit investment (per kW) basis.

6.13 For small islands the wind option remains problematic. In particular, the reliability needs of modern tourism and commerce will almost certainly require some type of storage or backup, thereby negating much of the fuel cost advantage of wind energy. Additionally, wind turbines in large numbers present their own aesthetic and avian issues, since vacationers have rather consistently objected to the presence of large wind farms viewable from the shore.[22] Bird kills remain an unresolved issue.

6.14 The cost to back up a wind-based system involves essentially a redundant capability to meet peak demand and continued servicing and staffing of the conventional power generation capabilities in the country.

6.15 For the OECS countries wind remains a paradoxical source of generation. At a small-scale wind energy will not be disruptive even to a small system, such as the one on Dominica. However, small turbines are relatively costly per unit, and with the reduced wind constancy at lower tower heights, reliability of the wind energy supply is further reduced. Under such conditions, wind is hardly likely to be attractive as an alternative power supply source.

6.16 Larger wind farms, with higher towers, can take advantage of greater wind constancy at such heights, as well as the greater overall plant factor that comes from dispersal of the turbines. However, this increased plant factor comes with two important caveats for the OECS countries:

1. The wind farm size required to gain such economic benefits (>30 MW) would be greater than what could be absorbed readily by any single OECS country; and
2. There is no adequate backup system on any of the islands, except possibly Dominica, for mitigating the fluctuations in power output.

6.17 The resolution of the wind paradox probably awaits the fate of the geothermal drilling trials. If these are successful and if undersea transmission to Guadeloupe and Martinique can be built, then a large wind farm can be tied into such a transmission system. The overall level of demand in the two French Départements is great enough to absorb some fluctuations in output from the wind farm, and the geothermal and hydro plants on Dominica can accommodate very short-term output fluctuations if managed properly.

Electricity Costs for Large Scale Options

6.18 In the previous sections the cost and size parameters for various large-scale energy options has been shown. Using these cost figures it is possible to estimate the likely range of unit electricity supply costs for the following large-scale options:

- Gas pipeline and CCGT generation
- Gas pipeline and diesel plant conversion

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22 A famous case involves the Nantucket Sound in the U.S., a favorite of high-income vacationers. The rapid fall in the sea floor around the OECS countries will generally preclude establishing a wind farm at a great enough distance from the shore as to be unobtrusive visually, unlike the situation the rather shallow North Sea areas.

- Geothermal energy development with inter-island electricity transmission

6.19 The total investment costs and comparisons of alternative energy development scenarios will be presented in a subsequent section.

6.20 Levelized costs for each investment options were constructed using standard discounting methods and the unit costs are based on the investment costs given in the 'large scale energy supply options' section above. Table 6.2 shows the key assumptions of the unit cost calculations:

Table 6.2: Key Parameters for Economic and Financial Analysis

Parameters	Value	Unit/note
Discount rate	12%	
Plant Lifetime (diesel)	10	year
Plant Lifetime (CCGT)	20	year
Plant Lifetime (geothermal & wind)	20	year
Oil Cost (crude)	40	per bbl
Oil cost (diesel)	46	per bbl
Heat rate (diesel)	33%	btu/scf
Heat rate (CCGT)	52%	
Heat content of diesel	140,000	btu/bbl
Heat content of gas	1,020,000	btu/scf
Gas Price	4.694	per mmbtu
Gas Discount from landed LNG price	35%	
MD Price	7.84	per mmbtu
Cost overrun factor	1	
Investment costs ($/MW)		
CCGT	850,000	
Diesel	500,000	
Diesel Conversion	100,000	
Geothermal	1,450,000	
Wind	1,050,000	
Plant Factors		
CCGT	75%	
Diesel	65%	
Geothermal	90%	
Wind	45%	
Gas Pipeline Throughput	35,000,000,000	scf/year
Gas Pipeline Cost to Dom, St. L, M & G	$345,000,000	
Power transmission cable	1,150,000	per MW

Exchange rate	2.7	$EC per $US

6.21 Based on these parameters, the calculated costs of electricity supply are shown in Table 6.3:

Table 6.3: Base Case Electricity Generation Costs, OECS

	$ US per MWh			$ EC per MWh
	Capital Cost	**Fuel + O&M Cost**	**Total cost**	**Total cost**
CCGT	$22.99	$51.18	$74.17	$200.25
Diesel (new)	$18.85	$91.06	$109.91	$296.76
Diesel (conversion)	$3.77	$78.83	$82.60	$223.01
Geothermal	$32.68	$8.50	$41.18	$111.19
Wind (average)	$47.33	$9.50	$56.83	$153.44
Note that inclusion of power transmission costs will raise the delivered cost of electricity from geothermal by US$ 31.02 per MWh. For wind, transmission from offshore farms will cost an additional US$12–15 per MWh.				

6.22 The costs shown for generation of electricity indicate the clear advantage of geothermal and CCGT under normal investment and operating conditions. Transmission of electricity between Dominica and the French islands would add another $31.02 per MWh (EC$ 83.77) to the cost of geothermal energy, bringing the total delivered cost to $72.20 per MWh or EC$ 142.21 per MWh, still far less expensive than any other option. In order for Dominica to realize the full benefits of geothermal energy, it would have to participate in the power transmission investments so that its own diesel generation capacity could be minimized. The new diesel plant is shown for the purposes of comparing the business as usual scenario with three alternatives.

6.23 Conversion of existing diesel units appears to be relatively attractive, with an overall cost slightly higher than the CCGT cost. In this case, the higher unit fuel costs are offset by the lower investment costs. The lower conversion efficiency of the diesel engines (33% v. 52%) results in fuel + O&M costs per MWh for diesel conversion that are 50% higher than for CCGT. However, even though CCGT investments are probably not appropriate in any of the OECS countries, substantial savings from gas conversion may still be realized.

6.24 Wind energy costs will tend to be low on a direct basis. That is, the pure investment and operating costs for wind energy fall into the range of $50–60 per MWh, just above the cost of geothermal. However, unlike geothermal energy, wind-generated electricity is not firm, requiring some method of storage or backup. That is because wind energy is available at best about 45 percent of the time. For the rest of the year, some other form of storage or primary energy would be required to provide electricity. Without large hydro reservoirs to back up intermittent supplies, the responsibility for providing continuity of service would likely fall to diesel engines. Backup engines used in this manner would cost more per unit than would diesels used as baseload supply.[23] The average delivered cost of a diesel-wind electricity system at the HV level would still be high (see footnote below) and would be uncompetitive for those islands with opportunities to invest in gas conversion, geothermal energy or purchased power from a larger, lower cost neighbor.

Gas and Electricity Transmission

6.25 The cost of energy transmission for the OECS countries was calculated using the same types of DCF techniques and was estimated at:

Gas Transmission: $1.96/mmbtu

Power Transmission: $31.02/MWh

6.26 More than 85 percent of the power transmission cost consists of investment and fixed costs. A similar factor holds for the gas transmission line. It may be possible to reduce the costs of transmission if lower cost funds are available to transmit the gas and electricity. The above costs were based on a 17 percent return on 100 percent equity. Use of debt plus equity, with an overall cost of 12 percent, would yield the following costs for transmission:

Gas Transmission: $1.54/mmbtu

Power Transmission: $21.63/MWh

Sensitivity to Fuel Prices and Operating Conditions

6.27 The investment options identified for large-scale power supply are sensitive to several key parameters. These include:

- Cost overruns in investment (especially for geothermal)
- Plant factors (Hours/year of operation)
- Fuel costs

6.28 The geothermal electricity costs used the lower end of the range estimated in the World Bank report as well as the lower end of the OAS preliminary estimates. The gas commodity cost was based on assurances from Trinidad of "cost-plus" conditions for gas supply, and oil prices are assumed to remain very high. In addition, the geothermal plant is assumed to enjoy the same type of plant factor (90 percent) that is characteristic of such plants elsewhere.

6.29 Table 6.4 gives an assessment based on more pessimistic assumptions for the selected technologies:

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23 The lower plant factor would probably raise the capital charge to $24–26 per MWh, up from the estimated $18.85/MWh used for calculations above. The average cost of electricity for a blended wind-diesel system would be: 0.45 x 56.83 + (1-0.45) x 115.57 = $89.13.

Table 6.4: Sensitivity of Future OECS Electricity Generation Costs to Key Assumptions

	$ US per MWh			$ EC per MWh
	Capital Cost	**Fuel + O&M Cost**	**Total cost**	**Total cost**
CCGT	$22.99	$51.18	$74.17	$200.25
CCGT - High Gas Cost	*$22.99*	*$60.66*	*$83.64*	*$225.84*
Diesel (new)	$18.85	$91.06	$109.91	$296.76
Diesel – new + $30/bbl oil price	*$3.77*	*$77.89*	*$81.66*	*$220.49*
Diesel (conversion)	$3.77	$78.83	$82.60	$223.01
Diesel conversion - High Gas Cost	*$3.77*	*$93.76*	*$97.53*	*$263.33*
Geothermal	$32.68	$8.50	$41.18	$111.19
Geothermal – high plant costs	*$41.70*	*$8.50*	*$50.20*	*$135.53*
Wind	$47.33	$9.50	$56.83	$153.44
Wind (low plant factor, high plant costs)	$67.00	$9.50	$76.50	$206.56
Note that inclusion of power transmission costs with a 25% cost overrun will raise the delivered cost of electricity from geothermal by US$38.78 per MWh (EC$104.71 per MWh). Similar cost overruns on the pipeline will increase the gas transmission cost from $1.93 to $2.39 per mmbtu.				

6.30 This sensitivity analysis indicates that conclusions and findings are highly sensitive to entirely plausible parameter changes. In order to avoid the downside risks associated with these changes, OECS investors and bankers will need to lay out carefully the key contract terms for gas supply, transmission systems and plant operation.

6.31 For example, cost overruns in the geothermal plant and in the transmission line could bring the delivered cost of geothermal energy to a level above the delivered price of electricity from CCGT units. Similarly, the conversion of power plants to gas could become uneconomical if the commodity cost of gas were linked to oil products, rather than being sold on a cost-plus basis.

Key Energy and Development Policy Issues in Developing Large Scale Energy Projects

6.32 The discussion of new energy projects above has focused largely on the mechanics of the technology and unit cost of deployment. However, several key policy matters should be highlighted as a part of the overall technology assessment process. These policies concern the roles played by incumbent electricity and fuel providers and the rights, roles and responsibilities of various private and public parties in the implementation and development of new energy approaches. Key issues include the following ones:

- The role of the monopoly electricity provider, including resolution of stranded costs that may arise as a result of adoption of new energy technology and access of new suppliers to the energy network
- The role of the government in securing development rights and permits for new technologies, including the use of government revenues from development of new resources.

Role of the Monopoly Electricity Provider

6.33 In each of the OECS countries there is a single private or governmental electricity provider. These monopolies normally have wide discretion over their operations and investments, and may enjoy certain regulatory responsibilities as well. Bringing in a new fuel source, such as pipeline gas, may provide opportunities for the incumbent to save money, but it may also allow existing customers to make use of the new fuel to cogenerate heat and electricity.

6.34 The existing legal framework for electricity supply in St. Lucia and Dominica generally restricts the ability of third parties to generate electricity. These aspects of the existing electricity supply acts (ESA) may need to be reexamined in light of new technologies.

6.35 Also, where the ESA does not mandate the least-cost supply of electricity, the government or its advisors may want to look at enacting new measures to ensure that cost-saving fuels and technologies are used and that these are deployed in the most effective and least costly manner possible.

6.36 Areas of legislative and regulatory concern include the following:

- Access to the transmission and distribution systems for self-generators and third party suppliers
- Adoption of least cost generation strategies by incumbent providers
- Resolution of stranded cost issues
- Pass through of savings to electricity consumers
- Pricing of new fuel or supplies of electricity.

6.37 Current efforts are under way in Dominica to address the roles and responsibilities of potential new electricity suppliers, with particular attention to the role of geothermal energy development. These efforts include amendments to the current ESA to permit new suppliers into the system where there is a clear public benefit.

6.38 As a part of the legislative effort in Dominica new clauses have been added to an amended ESA to include least cost supply planning as an annual feature of the regulatory process. This is an effort to ensure that (i) new, lower cost technologies are included in supply planning; and (ii) the incumbent supplier considers such new technologies in his own investment planning. With regard to the latter feature, it is important that both consumers and incumbent suppliers understand the future planning for system supply early enough to make sure that unneeded investments in other supply technologies are not made and hence do not become stranded costs. Specific measures to resolve whatever stranded costs may arise as a result of new supply technologies cannot be predetermined, though a functioning regulatory body is certainly a great facilitator of such resolution.

6.39 Finally, new technologies must offer clear financial benefits to both consumers and suppliers in order to be attractive investments. The legal framework in the OECS countries needs to ensure that cost savings in electricity supply be passed on to electricity users. The current tariff structure in most OECS countries provides no such assurance. Adoption of a more transparent electricity tariff will make apparent the potential savings from new technologies and may help to facilitate their more rapid adoption. Another new legal feature that could promote adoption of new generation technology is the permission for the incumbent supplier to take a role in the new technology as a minority investor. In Dominica, for example, the proposed geothermal development is far greater than the needs of the domestic market and is well beyond the financial capabilities of Domlec. However, a role for Domlec in geothermal development and power transmission offers the best hope of encouraging rapid development of the geothermal resources while discouraging redundant capacity from the conventional diesel system.

Role of the Government

6.40 The government needs to play a significant role in securing development rights and permits for new technologies. At the same time, certain new technologies, especially geothermal energy, may provide for new government revenues in the form of royalties.

6.41 The government will have a critical role in providing an appropriate legal and regulatory environment for the development of new energy resources and projects. Key considerations include appropriate assignment of responsibilities. For example, is geothermal energy primarily an electricity activity or a mining activity? Which laws should govern the ESA or the Mining Act? A failure to resolve such issues could retard the crucial investments by clouding the legal environment.

6.42 All new electricity and fuel technologies carry implications for government revenues. On the positive side is the potential for additional revenues from royalties, as in the case of geothermal energy. On the other side is the potential loss of revenue from fuel taxes as gas and other electricity sources replace fuel oil in prime movers. The fiscal implications of lower fuel tax receipts will need to be assessed against higher receipts of other taxes as a consequence of increased economic activity.

Environmental Implications of Large-Scale Options

Options with Significant Environmental Impacts

6.43 All of the large-scale options considered, i.e., gas pipelines, geothermal, offshore wind farms, and inter-island power transmission, have environmental impacts—effects which must be addressed to comply with host-country environmental requirements, and with those of development banks and lending institutions, because external financing or cofinancing will likely be required for any of the large scale projects. Details of likely impacts, by technology, follow.

Natural Gas Pipeline

6.44 The Eastern Caribbean Gas Pipeline project, currently under consideration, is the most likely medium-term alternative to the business as usual (BAU) scenario. The primary environmental concerns of this option are seabed disturbances in laying the pipeline, damage to sea-grass beds, coral reefs in shallower waters, possible impacts on marine protected areas, and disturbances associated with onshore facilities such as receiving terminals, compressor stations, and rights of way and pipelines to the power plants if not located at the landfall or receiving terminal. Emissions from compressor stations, if required, should be minimal as compressors would likely be run off of natural gas from the pipeline.

6.45 The current routing is assumed to be from Trinidad to Guadeloupe by way of Martinique and Barbados, between which approximately 80 percent of the delivered gas is to be used. Spurs of smaller diameter would be extended to St. Lucia and Dominica. Grenada and St. Vincent would not be supplied with gas from the pipeline. Subsequent redistribution by shipment of CNG from one of the countries served remains a possibility, and would result in secondary environmental effects in those markets.

6.46 In all markets served, the cleaner burning fuel would result in lower emissions of air pollutants (most notably, particulate matter of primarily respirable diameter) and less water pollution from effluents containing grease and oily wastes, than are produced by diesel generators.

6.47 The Caribbean Gas Pipeline is proposed to serve only power generation facilities, and therefore does not contemplate further onshore distribution. Additional shore facilities and inland distribution, if undertaken by local governments or project developers, would require development of pipelines and associated rights-of-way, which can be problematic when crossing forests, estuaries, rivers and protected areas.

Geothermal

6.48 Geothermal resources exist on the islands of Grenada, St. Lucia, Dominica, St. Kitts and Nevis, and Montserrat. However, to date, no project has been undertaken to develop geothermal power on those islands. Successful operations have, however, been undertaken on Guadeloupe, where a 4 MW plant is running successfully with a 91 percent reported plant factor.

6.49 The primary concern regarding the environmental impacts of geothermal energy projects relates to water. Environmental impacts can result from extracted hot water and steam used to generate electricity. This meteoritic or geological water often contains many dissolved and potentially toxic compounds, such as silica compounds, chlorides, arsenic, mercury, nickel, and other heavy metals, which are then concentrated in the sludge generated by an open-loop system. Gases such as hydrogen sulfide, sulfur dioxide, carbon dioxide, ammonia, nitrogen and methane also typically occur in various concentrations.

6.50 Groundwater contamination is also an important concern. Generally, groundwater pollution can be prevented if the wastewater is disposed of by reinjection, and this approach is usually employed because the water can then potentially be reused once the earth has reheated it. It is critical that waste waters be reinjected in a way that ensures groundwater and aquifers are not polluted.

6.51 Large amounts of fresh water are needed for cooling and other purposes in most geothermal plants. The resultant heated waters should not be discharged at temperatures that cause temperature increases above World Bank guideline limits beyond the mixing zone. Where water is not plentiful there is also the potential for conflict with other water users for water resources, and these concerns must be contemplated and addressed.

6.52 The amount of air pollution and solid waste resulting from geothermal energy production depends on the type of system employed, and the characteristics of geothermal steam. Closed-loop systems, which reinject the extracted water, are more expensive than conventional open-loop systems, but do not require scrubbers or solid waste disposal (sludges)—which may provide long-term economic advantage. Open-loop systems can generate large amounts of solid waste, noxious fumes and toxic gases (see above), and steam vented at the surface can contain any or all of the gases listed above.

6.53 However, there are many environmental benefits to be gained by using geothermal energy. Carbon dioxide emitted at geothermal plants is about 5 percent of that emitted by coal- or oil-fired power plants per kilowatt-hour of energy generated. Geothermal plants emit no nitrogen oxides and low amounts of sulfur dioxide. According to the U.S. Department of Energy, electricity produced from geothermal resources in the U.S. currently prevents the emission of 22 million tons of carbon dioxide, 200,000 tons of sulfur dioxide, 80,000 tons of nitrogen oxides, and 110,000 tons of particulate matter every year compared to coal-fired plants. An entire geothermal field uses 1–8 acres per megawatt, versus 5–10 for nuclear and 19 for coal.

6.54 If an open-loop system is used, scrubbers can also reduce air emissions, but they produce a sludge that is high in sulfur and the heavy metal vanadium. Current research is looking into the possibility of treating the waste with microbes that would recover commercially valuable metals, and render the waste nontoxic. Another approach is to redissolve solids so that they can be reinjected.

Offshore Wind Farms

6.55 Wind energy is generally seen to be a benign method of capturing and converting energy. It is largely free of visible air and water pollution. The emissions due to the manufacture of the wind turbines themselves are minimal relative to the energy generated. The main objections to wind energy fall into two possible categories: aesthetic and wildlife.

6.56 Understanding that wind farms may in many instances be developed to service the tourism industry, the visual impacts may in fact be undesirable. The most recent well-known instance of strong public objection to visual impacts of horizontal axis wind turbines is the case of Nantucket Sound, where a major project has been substantially delayed and may be brought to a halt through public protest and pressures. Such objections may also arise in the OECS nations, particularly where scenic vistas are part of the natural resource imparting higher value and desirability to resorts and hotels.

6.57 The only significant wind farm project under consideration at present is a 5 MW (nominal) facility proposed by LUCELEC, but at this writing no substantive progress appears to have been made. The U.S. DOE (Department of Energy)'s National renewable Energy Laboratory (NREL) is currently engaged in work on a regional wind resource assessment, in collaboration with the UNEP-sponsored Solar and Wind Resource Assessment (SWERA) and using the Wind Resource Assessment mapping System (WRAMS), which will provide a more complete database of wind energy data for use by wind project developers in future.

6.58 Environmental impacts may significant, ranging from increased bird and bat kills (this can be a major problem if the farm is situated on or near a migratory route or interferes with a wild or endangered species of bird, mammal or fish.) Additional impacts may include low-frequency blade noise, disruption of fisheries, and significant disturbance of the sea-grass beds and coral during the construction phase.

6.59 Additional impacts may include hazard to ships, if in or near shipping lanes or anchorage areas, and interference with radar, which may result in shipping mishaps which could have far-reaching impacts on the environment. Further, the wind farms themselves are susceptible to damage from tropical storms and hurricanes, which are frequent in the region.

6.60 In the case of wind farms and geothermal energy, the net reduction of greenhouse gas emissions should also be considered, as sale of carbon dioxide–equivalent credits could add significantly to plant revenues.

Inter-Island Undersea Transmission Lines

6.61 Two possible projects fall under this category. The first is transmission of power from possible geothermal power plants on Dominica to Martinique and Guadeloupe by way of high voltage direct current (HVDC) undersea cables.

6.62 The second involves HVDC transmission from Trinidad to Grenada.

6.63 In both cases, environmental impacts would include those of laying cable in shallow water, the onshore transformer and inverter substations, and of onward power transmission lines and associated rights of way. However, most of these concerns will fall outside the OECS nations and, strictly speaking, are not part of this study.

Impacts of Expansion of Business As Usual Scenario

6.64 Environmental impacts of expansion of BAU are incrementally small as future growth, at least in the near-term, will involve installation of additional capacity on existing plant footprints and will utilize existing (though possibly upgraded) transmission and distribution systems. Increased emissions of air pollutants will be proportional to fuel consumption, though likely a little lower per MW hour out as newer, higher efficiency generators go into service, replacing older, more polluting machines.

Regulatory Policies Required for Continued Environmental Compliance

6.65 Regulatory polices required for continued environmental compliance under BAU, i.e., continued reliance primarily in diesel power, with small amounts of hydroelectric, geothermal and solar power, where it exists, are as discussed below.

6.66 There are many resources for development of and access to energy and environmental data in the Caribbean. These sources of information and data should be well integrated into the development and review of policies and planning for environmental compliance of energy projects in the OECS region. For example, much work is being done by the Caribbean Energy Information Service (CEIS) to coordinate efforts and data. A well-organized renewable energy promotion program, the Caribbean Renewable Energy Development Program (CRDEP), is headquartered in Guyana, and is supported by United Nations Development Program (UNDP), Germany's Gesellschaft für Technische Zusammenarbeit (GtZ) and Global Environment Fund (GEF). "The Caribbean Community (CARICOM) Secretariat's Environment in Figures 2002," prepared by UN Dept. of Economic and Social Affairs, Statistics Division (UNSD) and the Caribbean Community Secretariat, is also a useful resource for data and contacts throughout the region.

Business-As-Usual

6.67 No specific changes in environmental regulatory policies should be required if the BAU option of continued and increased diesel power generation is pursued. All countries have reasonably responsive regulations regarding noise and air pollution. As regards the later, in the case of air pollution, excessive emissions are typically a result of inefficient operation. Given the cost of diesel oil it is likely that utilities will optimize engine performance and thereby reduce air pollutant emissions. As island countries, there is also persistent ventilation of the power plant sites by the prevailing maritime winds. Adverse impacts of air pollution are likely occur only in the case of plant upset, inappropriately designed exhaust stacks or nearby structures (where stack or building downwash might occur under certain meteorological conditions), air stagnation or inversions (unlikely in the island environment), or where residences or other structures have been constructed on elevated terrain that is affected by the plume during certain conditions.

7

Options and Policies for the OECS Nations

7.1 This Chapter provides a comparison of the various investment options for the electricity sector. Following the comparisons, a set of recommended policy initiatives is discussed.

Key Attributes of Selected Energy Technologies

7.2 In the previous two sections of this study, the cost, feasibility, environmental impacts, and general suitability of each of the potential supply options were discussed individually. This Chapter compares these key sector considerations in a manner that facilitates direct comparisons between one option and another.

7.3 The following criteria have been chosen as the basis of inter-project evaluation and analysis:

1. **Security of supply** – how does this option raise or lower the likelihood of supply reductions?
2. **Fuel type diversification –** how does this option change the fuel mix used in the power sector?
3. **Fuel source diversification –** how does this option reduce the exposure of the electricity sector to a given supplier of fuel or technology?
4. **Cost –** What is the unit cost of providing energy from this source?
5. **Impact on sector efficiency** – How does adoption of this option affect the management of electricity generation, distribution and regulation in the country?
6. **Potential for leveraging private sector investment –** Who will pay for this option? Is this choice more or less likely to generate net private investment inflows? and
7. **Safeguarding the environment** – What are the important adverse (or positive) environmental impacts from this technology?

7.4 Table 7.1 below summarizes the report's findings on these issues:

Table 7.1: Summary of Key Project Attributes

Attribute	Gas Pipeline	LNG/CNG	Geothermal	Wind
Security of supply	Single supply source – exposure to geological risk (lower with Barbados routing than with Grenada routing)	Can be sourced from multiple suppliers, technology is fungible, potential for interruptions during hurricane season	Very high	Little risk of wind not blowing, but unable to substitute for existing electricity infrastructure, vulnerable to hurricanes
Fuel type diversification	Replaces reliance on diesel with reliance on gas fuel cycles	Supplements existing imports of diesel for power and transport sectors, and facilitates possible shift to CCGT technologies	High	Medium
Fuel source diversification	Low	Medium	High for supplier countries	High—multiple equipment vendors
Cost	Pipeline is costly, commodity cost is moderate, conversion is low	Infrastructure less costly than pipeline, commodity cost higher, conversion is low	High on initial basis, low on continuing basis	Moderate on initial basis, low on continuing basis, requires continuing backup capacity
Impact on power sector	Significant—requires new technologies, new companies and poses new regulatory issues	Significant—requires new technologies, new companies and new regulatory issues	Significant—requires new technologies, new companies and new regulatory issues	Moderate—requires decisions on backup power supply and rights of various parities to participate in system
Leveraging private investment	Moderate	Significant	Significant (?)	Moderate
Environment	Replaces diesel exhaust with gas emissions, pipeline may case adverse impacts during construction but net environmental impacts lower over life of project	Replaces diesel exhaust with gas emissions, terminals may case adverse impacts during construction, possibility for accidents but net environmental impacts lower over life of project	Low if managed and controlled properly, replaces more polluting electricity sources	Low, if visual impacts are minimized or not important, and if low noise blades are required.

Comparison of Selected Options

7.5 The table above permits direct comparison across a range of important project attributes. Perhaps the most important of these are cost, security of supply and ability to leverage new private investment. All of the feasible options can meet current environmental standards for emissions, though it is easier for some (e.g., wind and gas) than for others (e.g., oil and, possibly, geothermal). Diversification for fuel sources and types is a desirable, if secondary, attribute. Power sector governance impact can be considered either positive or negative, depending on implementation issues. Therefore it is not considered except in a qualitative sense.

7.6 For the three key attributes, the proposed projects rank as follows in Table 7.2:

Table 7.2: Rankings of Proposed Projects by Key Attribute

Rank Attribute	**1**	**2**	**3**	**4**
Security of Supply	geothermal	LNG	gas pipeline	wind
Cost:	geothermal	gas pipeline	wind	LNG
Investment	gas pipeline	LNG	geothermal	wind

7.7 The geothermal project will provide the lowest cost energy, though to a limited OECS market, while limiting the supply exposure to outside forces and events. Both of the gas projects are likely to prove highly financeable by private investment, while geothermal energy may well require some type of public-private partnership.

7.8 Investments in wind should be entirely financeable from private sources. However, it is not clear how the transmission system for large wind farms or the backup system to maximize the capacity contribution will be paid for.

7.9 The overall evaluation of the three key attributes indicates that geothermal and the gas pipeline prospects are the best ones for the OECS countries that are able to take advantage of such energy sources. LNG, though desirable based on supply flexibility and investment stimulation, is the costliest of the four options.

Implementation Issues

7.10 In addition to normal concerns over cost, security of supply, diversification, etc., these projects present an issue of implementation that goes to the heart of regional energy sector cooperation. There are three key concerns on the implementation side:

1. Are the projects complementary or exclusive?
2. Can a project be implemented by one OECS member on its own or will supra-national issues come to the fore?
3. Will domestic energy regulatory institutions be capable of a smooth and beneficial implementation?

Complementarity

7.11 The two gas projects certainly aim at the same market of prime movers in generation and the region will not be able to support both LNG and a gas pipeline. However, both the geothermal and gas projects can be implemented at the same time, since neither one can fully supply the main market for such energy, the two French Départements of Guadeloupe and Martinique.

7.12 Wind is generally complementary to other electricity sources, especially hydro and geothermal, since both of the latter power plants can accommodate the normal fluctuations of wind energy better than can a thermal-based system. In addition, the HV transmission line that would need to be built for the geothermal project could also benefit a wind energy project if properly situated.

Multi-country Implementation

7.13 With the exception of small scale wind energy projects, each of the proposed energy options requires some degree of coordination with other jurisdictions. In particular, the gas options will require a regional regulatory approach to transport, safety, tariffs for transmission, etc. The gas pipeline will require discussions with Trinidadian, Barbadian and French authorities by at least two OECS members, St. Lucia and Dominica.

7.14 Geothermal energy in Dominica, though it can be implemented in just one OECS country, will require significant coordination with Guadeloupe and Martinique for sizing and operational issues. In addition, most of the money for the power plant and transmission line(s) is expected to come from France.

Institutional Issues

7.15 Most of the important regulatory matters are identified below. As a general matter, though, successful implementation of the gas pipeline or geothermal energy projects will entail a degree of coordination among OECS members that is unprecedented. Key regulatory matters on which coordination will be required include:

- Undersea rights-of-way for pipelines and transmission cables;
- Tariffication of electricity and gas
- Structural impacts on existing electricity systems of new, large investors
- Rights of third parties (especially wind generators) in such systems
- Gas system safety standards and enforcement mechanisms

7.16 Recommendations for policies to ease implementation problems are found the next section.

Identification of Key Policy Initiatives

7.17 A final set of considerations involves the matter of policy formulation and coordination. Several key issues need to be resolved in order to deploy new and larger scale technologies effectively. These include:

- The role of the current monopoly provider
  - How will stranded costs be resolved?
  - What rights will the incumbent provider have to invest in new technologies?
  - What is the role of smaller generation investors?
- What is the role of the government?
  - Development rights for geothermal energy
  - Regulating and awarding rights-of-way for gas and electricity transmission lines
  - Setting prices for common services, including transmission.

7.18 Over the next several months it will become necessary to establish some policies regarding these matters in the two OECS countries where development is currently contemplated, Dominica and St. Lucia. In addition, Grenada's prospective cable supply from Trinidad raises the issues of stranded costs and regulated prices, both difficult to resolve without a reference point. However, the types of issues that must be resolved for Dominica and St. Lucia are relevant to other OECS members as well, especially if wind energy projects covering more than one island system look attractive to investors.

7.19 The telecommunications sector in the OECS countries provides one model of regional regulation that has worked to bring new investments to the sector. Indeed, the certainty of competent and fair regulation has apparently outweighed the possible benefits (from the supplier's viewpoint) of more intrusive oversight. The result has been a burst of new investment in wireless systems.

7.20 For electricity, a regional regulatory system might first focus on common issues. These issues are identified above with regard to both the government side and the investor side. They include resolution of stranded costs, transmission tariffs for gas and electricity and the rights of third part investors in existing power systems.

7.21 While geothermal development rights will certainly remain a strictly national issue for Dominica, international transmission of both gas and electricity will raise issues that might best be resolved in a regional regulatory context.

7.22 A regional oversight and regulatory system need not be overly complicated and costly. The initial tasks should be limited to those that call for a regional solution. Such issues, identified above as transmission pricing and rights-of-way, resolution of stranded costs and the rights of third party power investors, can be addressed with a small commitment of staff and should cost less and provide greater assurance for investors than will an extension of the current national approach to significantly larger investment matters.

7.23 Key environmental implications for each of the investment options have been discussed in paragraph 6.43. For geothermal projects the key regulations include water treatment and protection of water sources from potential contamination. For gas projects, the key regulations involve safety at the landing or regasification point. For wind projects, the key regulatory elements include pricing, and the protection of coral reefs and birds, both of which can be damaged by unsound offshore wind farm development.

Annex 1

Persons Contacted for This Project

Table A.1.1: Persons Contacted - OECS Energy Strategy and Planning Project

Organization	Person	Title	Purpose	Location	E-mail	Telephone/ Fax
Barbados, Ministry of Energy and Public Utilities	Mr. Richard Goddard		E-mail inquiry on energy and electricity supply, Barbados	Barbados	energydiv@sunbeach.net	
Caribbean Hotels Association	Ms. Berthia Parle	President	Project background and request for information on and energy plans and experiences of the Caribbean Hotel Association	Castries, St. Lucia	baygardens@candw.lc	758-4528060 (tel) 758-4528059 (fax)
CARICOM Secretariat, Caribbean Renewable Energy Development Programme (CREDP)	Roland Clarke, Ph.D.	Project Manager	Project description and request for data and information on renewable energy activities in OECS member countries	Georgetown, Guyana	rclarke@caricom.org	592-2269281 X2631 (tel)
CARILEC	Mr. Victor Poyotte	Exec. Director	Project background and determine information available from or through CARILEC	Gros Inlet, St. Lucia	vpoyotte@carilec.org	758-4530140 (tel) 758-4580702 (fax)
DOMLEC	Mr. Rawlins Bruney	Chief Engineer, power production	Discuss geothermal project & cable connection with Guadeloupe and Martinique	Roseau, Dominica	rawlins.bruney@domleconline.com	767-448-2681

Energy and Advanced Control Technologies Inc.	Dr. Frederick Isaac	Exec. Chairman	ibid.	Castries, St. Lucia	isaacf@candw.lc	758-4537844 (tel) 758-4853144 (fax) 758-4853144 (cell)
Intra-Caribbean Gas Pipeline Co.	Mr. Clyde Williams	Technical Coordinator	ibid.	Port of Spain, Trinidad		868-6288814 (tel)
Intra-Caribbean Gas Pipeline Co.	Mr. Gregory Rich	Project Coordinator	ibid.	Port of Spain, Trinidad		868-6288814 (tel)
Intra-Caribbean Gas Pipeline Co.	Mr. Trevor Byer	Director	Project description and request for data and information on development of the ICP	Port of Spain, Trinidad		868-6846630 (tel)
LUCELEC	Mr. Duleep Cheddie	Financial Controller	Project background and determine information available from or through LUCELEC	Castries, St. Lucia	dcheddie@lucelec.com	758-4574402 (tel) 758-4574409 (fax)
LUCELEC	Mr. Trevor M. Louisy	Managing Director	Project background and determine information available from or through LUCELEC	Castries, St. Lucia	tlouisy@lucelec.com	758-4574400 (tel) 758-4574409 (fax)
LUCELEC	Mr. Victor Emmanuel	Chief Engineer	Project background and determine information available from or through LUCELEC	Castries, St. Lucia	vemmanuel@lucelec.com	758-4574400 (tel) 758-4574409 (fax)
Min. of Planning, Dev. Env. And Housing, Sust. Dev. and Env. Section	Dr. Bishnu Tulsie	Chief	Project background and request for energy, environmental and renewables data and information.	Castries, St. Lucia		
Nat'l Insurance Property Dev. and Mgt. Co. (NIPRO)	Dr. Frederick Isaac	CEO	Project background and determine information available from building managers, developers and based on recent prior experience as head of T&D for LUCELEC.	Castries, St. Lucia	fisaac@nipro.org	758-4515100 (tel) 758-4853144 (cell)

OAS, Unit for Sustainable Development and Environment	Mr. Mark Lambrides	Geo-Caribe Project Manager	Project description and request for data and information on geothermal projects in OECS, particularly on Dominica, with interconnect to Martinique and Guadeloupe	Washington, D.C.	mlambrides@oas.org	202-4586262
OECS	Mr. Andrew O. Satney	Senior Programme Officer	Project kick-off and request for information	Castries, St. Lucia	asatney@oecs.org	758-4522537 X2157 (tel) 758-4531628 (fax)
OECS, Environment and Sustainable Dev. Unit	Dr. Vasantha Chase	Head of Unit	Project kick-off and request for information	Castries, St. Lucia	vchase@oecs.org	758-4536208 X26 (tel) 758-4522194 (fax)
OECS, Environment and Sustainable Dev. Unit	Mr. Keith E. Nichols	Programme Officer	Project kickoff, request for information and coordination of request for data and information from OECS points of contact throughout OECS	Castries, St. Lucia	kenichols@oecs.org nicholsk@candw.lc	758-4536208 X30 (tel) 758-4522194
Scientific Research Council (SRC), Caribbean Energy Information Services (CEIS)	Ms. Roselyn Fisher	General Manager, Marketech	Request for PETSTAT CDs (Energy production and use, Caribbean Region)	Kingston, Jamaica	RoselynF@src-jamaica.org	876-9271771-4 (tel) 876-9772192 (tel) 876-9776000 (fax)
Shell Trinidad Ltd.	Mr. Nicholas Shorthose	Chairman	Project background and request for views on energy alternatives and solutions in OECS Region	Trinidad	nicholas.shorthose@sagl.simis.com	246-4314810 (tel) 246-4297766 (fax) 246-2333150 (cell)
St. Lucia Distillers	Mr. Laurie M. Barnard	CEO	Project description and request for data and information on impacts of fuel and energy costs on manufacturing and industries on St. Lucia.	Castries, St. Lucia	lmd@sludistillers	

St. Lucia Transportation Board, Transportation Dept.	Mr. Melvin Williams	Information Technology Mgr.	Project background and request for transportation related data and information.	Castries, St. Lucia		
Sust. Dev. and Econ. Office	Ms. Judith Ephraim	Technical Spec.	ibid.	Castries, St. Lucia	jephraim@planning.gov.lc	
The Voucher Co. (TVC)	Mr. Everist Jn Marie	Managing Director	Project background and request for information on experience of independent fuel retailers on St. Lucia and throughout OECS	Castries, St. Lucia	everist@candw.lc	758-4532601 (tel) 758-4516690 (fax)
Trinidad & Tobago Electricity Commission (T&TEC)	Mr. I Singh	Assistant General manager	Discuss undersea cable from Trinidad to Grenada	Port of Spain, Trinidad	indar@ttec.co.tt	(office): 1-868-662-4268 (mobile): 1-868-680-8362

Annex 2

OECS Study Country 2001 Energy Balances

From: U.S. Department of Energy
Energy Information Agency

Antigua and Barbuda

Year:
2001

Energy Production (Quads) = **0.0000** **Energy Consumption (Quads) =** **.0072**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	0.00		0.00	0.00	0.00	0.00
NGLs	0.00		0.00	0.00	0.00	0.00
Other Oils	0.00		0.00	0.00	0.00	0.00
Refinery Gain	0.00					
Gasoline		0.00	.79	.12	0.00	.68
Jet Fuel		0.00	1.48	0.00	0.00	1.48
Kerosene		0.00	0.00	0.00	0.00	0.00
Distillate		0.00	.92	.04	0.00	.88
Residual		0.00	.29	0.00	0.00	.29
LPGs		0.00	.06	0.00	0.00	.06
Unspecified		0.00	.12	0.00	0.00	.12
TOTALS	0.00	0.00	3.66	.16	0.00	3.51

(Billion Cubic Feet and Quadrillion Btu)

Natural Gas

Gross Production	(Billion Cubic Feet)	0.00	**Dry Imports**	(Billion Cubic Feet)	0.00
Vented and Flared	(Billion Cubic Feet)	0.00	**Dry Exports**	(Billion Cubic Feet)	0.00
Reinjected	(Billion Cubic Feet)	0.00			
Marketed Production	(Billion Cubic Feet)	0.00			
Dry Production	(Billion Cubic Feet)	0.00	**Dry Production**	(Quadrillion Btu)	0.0000
Dry Consumption	(Billion Cubic Feet)	0.00	**Dry Consumption**	(Quadrillion Btu)	0.0000

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		**Imports**		**Exports**		**Stock Build**	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0.0000	0	0.0000	0	0.0000
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads) =**	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	Generation				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.007	
Thermal	.027	.105				
Totals	**.027**	**.105**	**Consumption**		**.098**	

Barbados

Year: 2001

Energy Production (Quads) = 0.0038 **Energy Consumption (Quads) = 0.0229**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	1.27		0	1.27	0	0
NGLs	0		0	0	0	0
Other Oils	0		0	0	0	0
Refinery Gain	0					
Gasoline		0	1.94	0	0	1.98
Jet Fuel		0	3.3	0	0	3.3
Kerosene		0	0.05	0	0	0.05
Distillate		0	1.49	0	0	1.49
Residual		0	2.87	0	0	3.14
LPGs		0	0.25	0	0	0.3
Unspecified		0	0.12	0	0	0.12
TOTALS	1.27	0	10.02	1.27	0	10.38

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	1.03	**Dry Imports**	(Billion Cubic Feet)	0
Vented and Flared	(Billion Cubic Feet)	0	**Dry Exports**	(Billion Cubic Feet)	0
Reinjected	(Billion Cubic Feet)	0			
Marketed Production	(Billion Cubic Feet)	1.03			
Dry Production	(Billion Cubic Feet)	1.03	**Dry Production**	(Quadrillion Btu)	0.0011
Dry Consumption	(Billion Cubic Feet)	1.03	**Dry Consumption**	(Quadrillion Btu)	0.0011

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		**Imports**		**Exports**		**Stock Build**	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0	0	0	0	0
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads)** =	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	**Generation**				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.055	
Thermal	.166	.780				
Totals	**.166**	**.780**	**Consumption**		**.725**	

Virgin Islands, British

Year: 2001

Energy Production (Quads) = 0 **Energy Consumption (Quads) = 0.0008**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	0		0	0	0	0
NGLs	0		0	0	0	0
Other Oils	0		0	0	0	0
Refinery Gain	0					
Gasoline		0	0.19	0	0	0.19
Jet Fuel		0	0	0	0	0
Kerosene		0	0.02	0	0	0.02
Distillate		0	0.2	0	0	0.2
Residual		0	0	0	0	0
LPGs		0	0	0	0	0
Unspecified		0	0	0	0	0
TOTALS	0	0	0.41	0	0	0.41

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0	**Dry Imports**	(Billion Cubic Feet)	0
Vented and Flared	(Billion Cubic Feet)	0	**Dry Exports**	(Billion Cubic Feet)	0
Reinjected	(Billion Cubic Feet)	0			
Marketed Production	(Billion Cubic Feet)	0			
Dry Production	(Billion Cubic Feet)	0	**Dry Production**	(Quadrillion Btu)	0
Dry Consumption	(Billion Cubic Feet)	0	**Dry Consumption**	(Quadrillion Btu)	0

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		Imports		Exports		Stock Build	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0	0	0	0	0
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads)** =	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	Generation				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.003	
Thermal	.013	.038				
Totals	**.013**	**.038**	**Consumption**		**.035**	

Dominica

Year: 2001

Energy Production (Quads) = 0.0003 **Energy Consumption (Quads) = 0.0018**

Oil

(Thousand Barrels per Day)

	Production	**Refinery Output**	**Imports**	**Exports**	**Stock Build**	**Consumption**
Crude Oil	0		0	0	0	0
NGLs	0		0	0	0	0
Other Oils	0		0	0	0	0
Refinery Gain	0					
Gasoline		0	0.42	0	0	0.42
Jet Fuel		0	0	0	0	0
Kerosene		0	0.02	0	0	0.02
Distillate		0	0.22	0	0	0.22
Residual		0	0.02	0	0	0.02
LPGs		0	0.06	0	0	0.06
Unspecified		0	0	0	0	0
TOTALS	0	0	0.74	0	0	0.74

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0	**Dry Imports**	(Billion Cubic Feet)	0
Vented and Flared	(Billion Cubic Feet)	0	**Dry Exports**	(Billion Cubic Feet)	0
Reinjected	(Billion Cubic Feet)	0			
Marketed Production	(Billion Cubic Feet)	0			
Dry Production	(Billion Cubic Feet)	0	**Dry Production**	(Quadrillion Btu)	0
Dry Consumption	(Billion Cubic Feet)	0	**Dry Consumption**	(Quadrillion Btu)	0

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		Imports		Exports		Stock Build	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0	0	0	0	0
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads) =**	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	Generation				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	.008	.032	.0003	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.005	
Thermal	.011	.034				
Totals	**.019**	**.066**	**Consumption**		**.062**	

Grenada

Year: 2001

Energy Production (Quads) = 0 **Energy Consumption (Quads) = 0.0032**

Oil

(Thousand Barrels per Day)

	Production	**Refinery Output**	**Imports**	**Exports**	**Stock Build**	**Consumption**
Crude Oil	0		0	0	0	0
NGLs	0		0	0	0	0
Other Oils	0		0	0	0	0
Refinery Gain	0					
Gasoline		0	0.57	0	0	0.57
Jet Fuel		0	0.11	0	0	0.11
Kerosene		0	0	0	0	0
Distillate		0	0.63	0	0	0.63
Residual		0	0	0	0	0
LPGs		0	0.19	0	0	0.19
Unspecified		0	0.11	0	0	0.11
TOTALS	0	0	1.61	0	0	1.61

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0	**Dry Imports**	(Billion Cubic Feet)	0
Vented and Flared	(Billion Cubic Feet)	0	**Dry Exports**	(Billion Cubic Feet)	0
Reinjected	(Billion Cubic Feet)	0			
Marketed Production	(Billion Cubic Feet)	0			
Dry Production	(Billion Cubic Feet)	0	**Dry Production**	(Quadrillion Btu)	0
Dry Consumption	(Billion Cubic Feet)	0	**Dry Consumption**	(Quadrillion Btu)	0

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		**Imports**		**Exports**		**Stock Build**	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0	0	0	0	0
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads) =**	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	**Generation**				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.010	
Thermal	.027	.143				
Totals	**.027**	**.143**	**Consumption**		**.133**	

Montserrat

Year: 2001

Energy Production (Quads) = 0 **Energy Consumption (Quads) = 0.0007**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	0		0	0	0	0
NGLs	0		0	0	0	0
Other Oils	0		0	0	0	0
Refinery Gain	0					
Gasoline		0	0.19	0	0	0.19
Jet Fuel		0	0	0	0	0
Kerosene		0	0.02	0	0	0.02
Distillate		0	0.16	0	0	0.16
Residual		0	0	0	0	0
LPGs		0	0	0	0	0
Unspecified		0	0	0	0	0
TOTALS	0	0	0.37	0	0	0.37

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0	**Dry Imports**	(Billion Cubic Feet)	0
Vented and Flared	(Billion Cubic Feet)	0	**Dry Exports**	(Billion Cubic Feet)	0
Reinjected	(Billion Cubic Feet)	0			
Marketed Production	(Billion Cubic Feet)	0			
Dry Production	(Billion Cubic Feet)	0	**Dry Production**	(Quadrillion Btu)	0
Dry Consumption	(Billion Cubic Feet)	0	**Dry Consumption**	(Quadrillion Btu)	0

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		**Imports**		**Exports**		**Stock Build**	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0	0	0	0	0
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads)** =	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	**Generation**				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.000	
Thermal	.001	.003				
Totals	**.001**	**.003**	**Consumption**		**.003**	

Saint Lucia

Year: 2001

Energy Production (Quads) = 0.0000 **Energy Consumption (Quads) = .0049**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	0.00		0.00	0.00	0.00	0.00
NGLs	0.00		0.00	0.00	0.00	0.00
Other Oils	0.00		0.00	0.00	0.00	0.00
Refinery Gain	0.00					
Gasoline		0.00	.93	0.00	0.00	.93
Jet Fuel		0.00	0.00	0.00	0.00	0.00
Kerosene		0.00	.02	0.00	0.00	.02
Distillate		0.00	1.33	0.00	0.00	1.33
Residual		0.00	.02	0.00	0.00	.02
LPGs		0.00	.10	0.00	0.00	.10
Unspecified		0.00	.04	0.00	0.00	.04
TOTALS	0.00	0.00	2.44	0.00	0.00	2.44

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0.00	**Dry Imports**	(Billion Cubic Feet)	0.00
Vented and Flared	(Billion Cubic Feet)	0.00	**Dry Exports**	(Billion Cubic Feet)	0.00
Reinjected	(Billion Cubic Feet)	0.00			
Marketed Production	(Billion Cubic Feet)	0.00			
Dry Production	(Billion Cubic Feet)	0.00	**Dry Production**	(Quadrillion Btu)	0.0000
Dry Consumption	(Billion Cubic Feet)	0.00	**Dry Consumption**	(Quadrillion Btu)	0.0000

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		Imports		Exports		Stock Build	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0.0000	0	0.0000	0	0.0000
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads)** =	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	Generation				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	0.000	0.000	0.0000	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.019	
Thermal	.066	.269				
Totals	**.066**	**.269**	**Consumption**		**.250**	

Saint Vincent/Grenadines

Year: 2001

Energy Production (Quads) = .0003 **Energy Consumption (Quads) = .0027**

Oil

(Thousand Barrels per Day)

	Production	Refinery Output	Imports	Exports	Stock Build	Consumption
Crude Oil	0.00		0.00	0.00	0.00	0.00
NGLs	0.00		0.00	0.00	0.00	0.00
Other Oils	0.00		0.00	0.00	0.00	0.00
Refinery Gain	0.00					
Gasoline		0.00	.44	0.00	0.00	.44
Jet Fuel		0.00	0.00	0.00	0.00	0.00
Kerosene		0.00	0.00	0.00	0.00	0.00
Distillate		0.00	.65	0.00	0.00	.65
Residual		0.00	0.00	0.00	0.00	0.00
LPGs		0.00	.10	0.00	0.00	.10
Unspecified		0.00	.04	0.00	0.00	.04
TOTALS	0.00	0.00	1.23	0.00	0.00	1.23

Natural Gas

(Billion Cubic Feet and Quadrillion Btu)

Gross Production	(Billion Cubic Feet)	0.00	**Dry Imports**	(Billion Cubic Feet)	0.00
Vented and Flared	(Billion Cubic Feet)	0.00	**Dry Exports**	(Billion Cubic Feet)	0.00
Reinjected	(Billion Cubic Feet)	0.00			
Marketed Production	(Billion Cubic Feet)	0.00			
Dry Production	(Billion Cubic Feet)	0.00	**Dry Production**	(Quadrillion Btu)	0.0000
Dry Consumption	(Billion Cubic Feet)	0.00	**Dry Consumption**	(Quadrillion Btu)	0.0000

Coal

(Thousand Short Tons and Quadrillion Btu)

	Production		**Imports**		**Exports**		**Stock Build**	
	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)	(1000 Tons)	(Quads)
Hard Coal			0	0.0000	0	0.0000	0	0.0000
--- Anthracite	0	0.0000						
--- Bituminous	0	0.0000						
Lignite	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Coke			0	0.0000	0	0.0000	0	0.0000
Total Coal	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Consumption (1000 Tons):	0		**(Quads) =**	0.0000				

Electricity

(Million Kilowatts, Billion Kilowatt Hours, and Quadrillion Btu)

	Capacity	**Generation**				
	(Million kw)	(Billion kwh)	(Quads)		(Billion kwh)	(Quads)
Hydroelectric	.006	.025	.0003	**Total Imports**	0.000	0.0000
Nuclear	0.000	0.000	0.0000	**Total Exports**	0.000	0.0000
Geothermal and Other	0.000	0.000	0.0000	**Losses**	.006	
Thermal	.010	.064				
Totals	**.016**	**.089**	**Consumption**		**.083**	

Annex 3

Environmental Resources for Geothermal, Gas and Wind Projects

The following sources may be useful to obtain guidelines for new energy projects:

Geothermal

The International Finance Corporation (IFC) has produced Environmental Health and Safety (EH&S) guidelines for Geothermal Projects, found at:

http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_geothermal/$FILE/geothermal.pdf

These guidelines may be seen as the minimum requirements for management and control of potential environmental impacts of geothermal energy projects. These requirements are similar to the general standards laid out by The World Bank, as presented in the Bank's Pollution Prevention and Abatement Handbook (PPAH, 1998), which can be viewed and downloaded at

http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_99040905052283.

Wind

The International Finance Corporation IFC) Environmental Health and Safety (EH&S) provides guidelines for Wind Energy Conversion Systems. These guidelines may be found at:

http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_windenergy/$FILE/windenergy.pdf

Such guidelines should be adopted as the minimum requirements for management and control of potential environmental impacts of a wind energy projects. These requirements are similar to the general requirements of The World Bank, and as presented in WB's Pollution Prevention and Abatement Handbook (PPAH, 1998), which can be viewed and downloaded at http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_99040905052283.

Business-as-Usual Expansion

Large-Scale Options

Large-scale options are de facto new developments, such as pipeline gas, geothermal, and wind as discussed above. In the interest of attracting investment, and satisfying the requirements of development banks, such as IBRD and the Inter-American Development Bank (IADB), it recommended that either an OECS-wide environmental guideline be adopted for major projects, and incorporated by reference in to the environmental guidelines of all member countries. Such a measure would facilitate development of projects that would satisfy development banks, if accessed for financing or cofinancing. Such a measure would serve the same purpose for commercial banks that are signatory to the Equator Principles

http://www.equator-principles.com/

which essentially require compliance with IFC EIA standards for projects greater than US$50 million. For reference, the IFC guidelines, which are substantially similar to the WB guidelines presented in the Pollution Prevention and Abatement Handbook (PPAH)

http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/06/03/000094946_99040905052283/Rendered/PDF/multi0page.pdf ,

are available at

http://ifcln1.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines/

and cover sector-specific requirements for a wide range of development projects, including electric power generation, transmission, gas terminals, geothermal energy, and wind energy projects.

A region-wide guideline and requirement would assure that, given all other considerations are equal (demand, fuel supply, etc.), project developers would not seek out the country having the least stringent environmental requirements.

Any such guideline should also include details that would facilitate the identification, validation and certification of CO_2 equivalent credits, for subsequent sale. Along those lines, OECS countries should be cautious about including renewable energy or GHG-reducing projects in their national plans or strategies, because including them would indicate the planned development of such projects. Therefore, they would not meet the test of “additionality,” so by current interpretations, GHG emission reductions could not be quantified and sold as CO_2 equivalent credits.

It should also be noted that endangered species of flora and fauna occur on each of the OECS islands considered in this report, and as such, screening for impacts on IUCN

Species Survival Commission “Red Book”-listed species should be conducted very early in the project screening process.

Annex 4

Environmental Aspects of LNG and CNG

LNG

The LNG option is rendered unlikely due to size and cost, unless an LNG terminal were to be constructed at a logistically desirable location for onward shipment of CNG to smaller and more distant markets.

Environmental concerns of an LNG terminal project include all of those typically associated with port and harbor projects—e.g. dredging, disposal of spoils, alteration of current and tidal impacts, disturbance of coastal zones and indigenous species, and the implicit danger of catastrophic failure of the LNG Tanker vessel and or the degasification plant. Coral, sea-grass beds, mangroves, and complex shoreline ecosystems may also be adversely affected. However, it should be noted that new and refined technologies are now making it possible and practical to construct smaller LNG gasification, and receiving terminals and regasification facilities. Further, various types of offshore receiving terminal and regasification facilities have been conceptualized, and include:

- Floating storage regasification units (FSRU)
- Converted LNG carriers (with submerged or turret mooring)
- Offshore gravity based units (GBU)
- Platform-based import terminals.

While none of these offshore facilities have been built to date, they are based on proven technologies, and siting, design and permitting work is underway for several such projects.

Such an approach obviates the need for bringing the LNG tanker into port and modifying port facilities to accommodate the tanker, and reduces safety concerns with respect to catastrophic failures. The downside of the approach is that the LNG tanker would need to remain anchored for the duration of discharge of LNG over time, necessitating substantial capital investment in additional tankers.

Should an LNG terminal and transshipment project be contemplated, the oil terminal near Castries, St. Lucia would be a likely candidate, as the deep-water harbor facility is already in place, sufficient land area may be available for regasification facilities, storage and distribution works, and it is logistically well-placed for onward redistribution of CNG and NG by smaller vessels. Use of LNG would result in lower emissions from power plants, and could also serve as an alternate source of cleaner fuel for vehicles.

The International Finance Corporation IFC) Environmental Health and Safety (EH&S) guidelines for Gas Terminal Systems, found at:

http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_gasterminal/$FILE/gasterminal.pdf

should be adopted as the minimum requirements for management and control of potential environmental impacts of a LNG receiving terminal and regasification facility. These requirements are similar to the general requirements of The World Bank, and as presented in WB's Pollution Prevention and Abatement Handbook (PPAH, 1998), which can be viewed and downloaded at

http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000094946_99040905052283

CNG

The CNG option is similar to the LNG option, but is a less well-developed technology at present, and represents a far lower energy density than LNG. Onshore storage, less complex regasification, pipelines and rights of way for delivery to power plants, and additional distribution systems for other uses, if desired, would be required. Again, use of CNG would result in lower emissions from power plants, and could also serve as an alternate source of cleaner fuel for vehicles.

The approach of offshore anchoring and discharge to shore-based compressor stations, power plant and onward distribution as described for LNG can also be applied to CNG.

As above, the International Finance Corporation (IFC) Environmental Health and Safety (EH&S) guidelines for Gas Terminal Systems, found at:

http://ifcln1.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_gasterminal/$FILE/gasterminal.pdf

should be adopted as the minimum requirements for management and control of potential environmental impacts of a CNG receiving terminal and redistribution facility. These requirements are similar to the general requirements of The World Bank, and as presented in WB's Pollution Prevention and Abatement Handbook (PPAH, 1998), which can be viewed and downloaded at

Joint UNDP/World Bank
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercilizing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
	Africa Gas Initiative – Main Report: Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
	Ministerial Workshop on Women in Energy	10/01	250/01
	Energy and Poverty Reduction: Proceedings from a Multi-Sector And Multi-Stakeholder Workshop Addis Ababa, Ethiopia, October 23-25, 2002.	03/03	266/03
	Opportunities for Power Trade in the Nile Basin: Final Scoping Study	01/04	277/04
	Énergies modernes et réduction de la pauvreté: Un atelier multi-sectoriel. Actes de l'atelier régional. Dakar, Sénégal, du 4 au 6 février 2003 (French Only)	01/04	278/04
	Énergies modernes et réduction de la pauvreté: Un atelier multi-sectoriel. Actes de l'atelier régional. Douala, Cameroun du 16-18 juillet 2003. (French Only)	09/04	286/04
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshops held in Africa	01/05	298/05
	Power Sector Reform in Africa: Assessing the Impact on Poor People	08/05	306/05
	The Vulnerability of African Countries to Oil Price Shocks: Major Factors and Policy Options. The Case of Oil Importing Countries	08/05	308/05
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
	Africa Gas Initiative – Angola: Volume II	02/01	240/01
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU

Region/Country	Activity/Report Title	Date	Number
Burundi	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cameroon	Africa Gas Initiative – Cameroon: Volume III	02/01	240/01
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessment (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95
	Africa Gas Initiative – Côte d'Ivoire: Volume V	02/01	240/01
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
	Africa Gas Initiative – Gabon: Volume VI	02/01	240/01
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
	Corporatization of Distribution Concessions through Capitalization	12/03	272/03
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84

Region/Country	Activity/Report Title	Date	Number
Kenya	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
	Strategic Gas Plan	02/04	279/04
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	-
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	-
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE

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Senegal	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution System Technical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84

Region/Country	Activity/Report Title	Date	Number
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
Zimbabwe	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Pre-feasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--
	Rural Electrification Study	03/00	228/00

EAST ASIA AND PACIFIC (EAP)

Region/Country	Activity/Report Title	Date	Number
Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/99
	Air Pollution and Acid Rain Control: The Case of Shijiazhuang City and the Changsha Triangle Area	10/03	267/03
	Toward a Sustainable Coal Sector In China	07/04	287/04
	Demand Side Management in a Restructured Industry: How Regulation and Policy Can Deliver Demand-Side Management Benefits to a Growing Economy and a Changing Power System	12/05	314/05
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Mongolia	Energy Efficiency in the Electricity and District Heating Sectors	10/01	247/01
	Improved Space Heating Stoves for Ulaanbaatar	03/02	254/02
	Impact of Improved Stoves on Indoor Air Quality in Ulaanbaatar, Mongolia	11/05	313/05
Myanmar	Energy Assessment (English)	06/85	5416-BA

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Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
	Strengthening the Non-Conventional and Rural Energy Development Program in the Philippines: A Policy Framework and Action Plan	08/01	243/01
	Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits	05/02	255/02
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
	Why Liberalization May Stall in a Mature Power Market: A Review of the Technical and Political Economy Factors that Constrained the Electricity Sector Reform in Thailand 1998-2002	12/03	270/03
	Reducing Emissions from Motorcycles in Bangkok	10/03	275/03
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
	An Overnight Success: Vietnam's Switch to Unleaded Gasoline	08/02	257/02
	The Electricity Law for Vietnam—Status and Policy Issues—The Socialist Republic of Vietnam	08/02	259/02
	Petroleum Sector Technical Assistance for the Revision of the Existing Legal and Regulatory Framework	12/03	269/03
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Pre-feasibility Study (English)	12/88	--
	Reducing Emissions from Baby-Taxis in Dhaka	01/02	253/02

Region/Country	Activity/Report Title	Date	Number
India	Opportunities for Commercialization of Non-conventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
	Energy Strategies for Rural India: Evidence from Six States	08/02	258/02
	Household Energy, Indoor Air Pollution, and Health	11/02	261/02
	Access of the Poor to Clean Household Fuels	07/03	263/03
	The Impact of Energy on Women's Lives in Rural India	01/04	276/04
	Environmental Issues in the Power Sector: Long-Term Impacts And Policy Options for Rajasthan	10/04	292/04
	Environmental Issues in the Power Sector: Long-Term Impacts And Policy Options for Karnataka	10/04	293/04
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
Pakistan	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
	Clean Fuels	10/01	246/01
Regional	Toward Cleaner Urban Air in South Asia: Tackling Transport Pollution, Understanding Sources.	03/04	281/04
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86
	Sustainable Transport Options for Sri Lanka: Vol. I	02/03	262/03
	Greenhouse Gas Mitigation Options in the Sri Lanka Power Sector: Vol. II	02/03	262/03
	Sri Lanka Electric Power Technology Assessment (SLEPTA): Vol. III	02/03	262/03
	Energy and Poverty Reduction: Proceedings from South Asia Practitioners Workshop How Can Modern Energy Services Contribute to Poverty Reduction? Colombo, Sri Lanka, June 2-4, 2003	11/03	268/03

Region/Country	Activity/Report Title	Date	Number
	EUROPE AND CENTRAL ASIA (ECA)		
Armenia	Development of Heat Strategies for Urban Areas of Low-income Transition Economies. Urban Heating Strategy for the Republic Of Armenia. *Including a Summary of a Heating Strategy for the Kyrgyz Republic*	04/04	282/04
Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
	Energy Environment Review	10/02	260/02
Central Asia and The Caucasus	Cleaner Transport Fuels in Central Asia and the Caucasus	08/01	242/01
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
Central and Eastern Europe	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union (English and Russian)	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
	Private Sector Participation in Market-Based Energy-Efficiency Financing Schemes: Lessons Learned from Romania and International Experiences.	11/03	274/03
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00
	Energy and Environment Review: Synthesis Report	12/03	273/03
	MIDDLE EAST AND NORTH AFRICA (MNA)		
Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96

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Tunisia	Rural Electrification in Tunisia: National Commitment, Efficient Implementation and Sound Finances	08/05	307/05
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91
	Household Energy Supply and Use in Yemen. Volume I: Main Report and Volume II: Annexes	12/05	315/05

LATIN AMERICA AND THE CARIBBEAN REGION (LCR)

Region/Country	Activity/Report Title	Date	Number
LCR Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshop held in Bolivia	06/05	202/05
	Power Sector Reform and the Rural Poor in Central America	12/04	297/04
	Estudio Comparativo Sobre la Distribución de la Renta Petrolera en Bolivia, Colombia, Ecuador y Perú	08/05	304/05
	OECS Energy Sector Reform and Renewable Energy/Energy Efficiency Options	02/06	317/06
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Pre-feasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
	Oil Industry Training for Indigenous People: The Bolivian Experience (English and Spanish)	09/01	244/01
	Capacitación de Pueblos Indígenas en la Actividad Petrolera. Fase II	07/04	290/04
	Estudio Sobre Aplicaciones en Pequeña Escala de Gas Natural	07/04	291/04
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
	Reducing Energy Costs in Municipal Water Supply Operations "Learning-while-doing" Energy M&T on the Brazilian Frontlines	07/03	265/03
Chile	Energy Sector Review (English)	08/88	7129-CH

Region/Country	Activity/Report Title	Date	Number
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
Colombia	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Mini-hydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
	Health Impacts of Traditional Fuel Use	08/04	284/04
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
Jamaica	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comisión Nacional para el Ahorro de Energía (CONAE) (English)	04/96	180/96
	Energy Environment Review	05/01	241/01
Nicaragua	Modernizing the Fuelwood Sector in Managua and León	12/01	252/01
	Policy & Strategy for the Promotion of RE Policies in Nicaragua. (Contains CD with 3 complementary reports)	01/06	316/06
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--

Region/Country	Activity/Report Title	Date	Number
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

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Region/Country	Activity/Report Title	Date	Number
	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99
	A Review of the Renewable Energy Activities of the UNDP/ World Bank Energy Sector Management Assistance Programme 1993 to 1998	11/99	223/99
	Energy, Transportation and Environment: Policy Options for Environmental Improvement	12/99	224/99

	Privatization, Competition and Regulation in the British Electricity Industry, With Implications for Developing Countries	02/00	226/00
	Reducing the Cost of Grid Extension for Rural Electrification	02/00	227/00
	Undeveloped Oil and Gas Fields in the Industrializing World	02/01	239/01
	Best Practice Manual: Promoting Decentralized Electrification Investment	10/01	248/01
	Peri-Urban Electricity Consumers—A Forgotten but Important Group: What Can We Do to Electrify Them?	10/01	249/01
	Village Power 2000: Empowering People and Transforming Markets	10/01	251/01
	Private Financing for Community Infrastructure	05/02	256/02
	Stakeholder Involvement in Options Assessment: Promoting Dialogue in Meeting Water and Energy Needs: A Sourcebook	07/03	264/03
	A Review of ESMAP's Energy Efficiency Portfolio	11/03	271/03
	A Review of ESMAP's Rural Energy and Renewable Energy Portfolio	04/04	280/04
	ESMAP Renewable Energy and Energy Efficiency Reports 1998-2004 (CD Only)	05/04	283/04
	Regulation of Associated Gas Flaring and Venting: *A Global Overview and Lessons Learned from International Experience*	08/04	285/04
	ESMAP Gender in Energy Reports and Other related Information (CD Only)	11/04	288/04
	ESMAP Indoor Air Pollution Reports and Other related Information (CD Only)	11/04	289/04
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshop on the Pre-Investment Funding. Berlin, Germany, April 23-24, 2003.	11/04	294/04
	Global Village Energy Partnership (GVEP) Annual Report 2003	12/04	295/04
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshop on Consumer Lending and Microfinance to Expand Access to Energy Services, Manila, Philippines, May 19-21, 2004	12/04	296/04
	The Impact of Higher Oil Prices on Low Income Countries And on the Poor	03/05	299/05
	Advancing Bioenergy for Sustainable Development: Guideline For Policymakers and Investors	04/05	300/05
	ESMAP Rural Energy Reports 1999-2005	03/05	301/05
	Renewable Energy and Energy Efficiency Financing and Policy Network: Options Study and Proceedings of the International Forum	07/05	303/05
	Implementing Power Rationing in a Sensible Way: Lessons Learned and International Best Practices	08/05	305/05
	The Urban Household Energy Transition. Joint Report with RFF Press/ESMAP. ISBN 1-933115-07-6	08/05	309/05
	Pioneering New Approaches in Support of Sustainable Development In the Extractive Sector: Community Development Toolkit, also Includes a CD containing Supporting Reports	10/05	310/05
	Analysis of Power Projects with Private Participation Under Stress	10/05	311/05
	Potential for Biofuels for Transport in Developing Countries	10/05	312/05

Last report added to this list: ESMAP Formal Report 317/05