

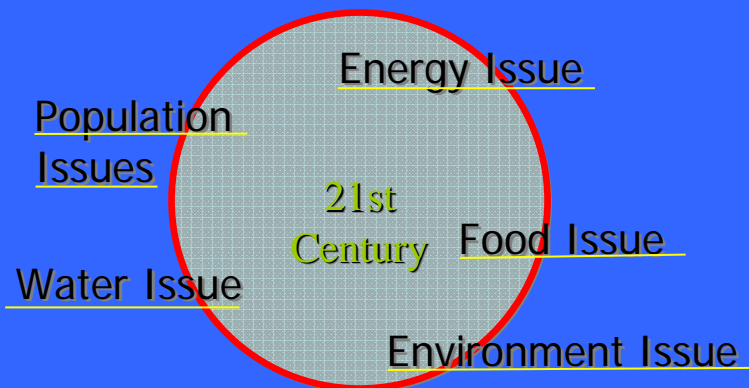
SUSTAINABLE DEVELOPMENT IN SMALL ISLAND DEVELOPING STATES THE ENERGY CHALLENGE

Presentation to
Many Strong Voices Workshop
Belize

27- 30 May 2007

Al Binger

Development Issues



How does Energy affect development?

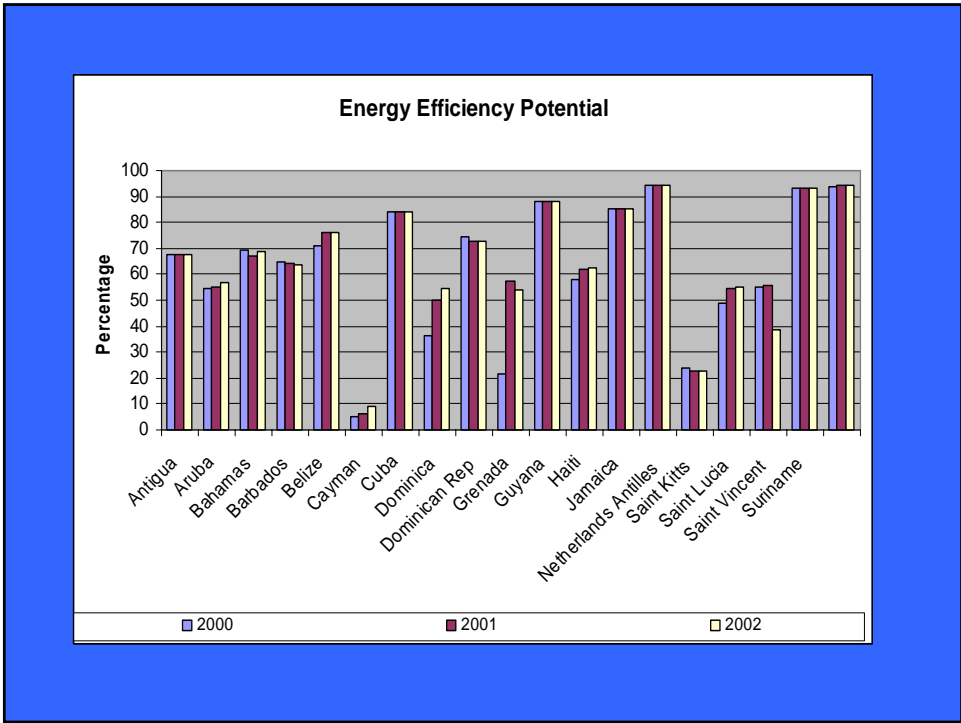
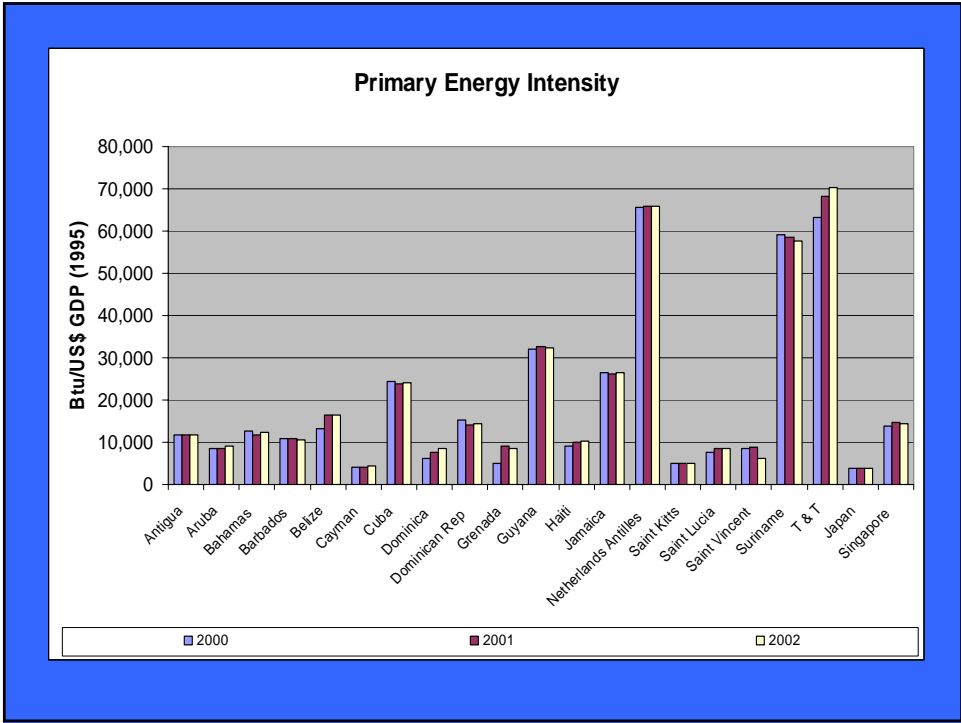
- Factors of Production
 - Energy
 - Finance
 - Raw material
 - Labor

The quality of life of society is directly proportional to the availability of energy and the efficiency to which it is converted into goods and services.

Prof. Even Sund -- Norway

Energy Imports for the Caribbean.

YEAR	1985	1990	1995	2000	2001	2002	2003	2004
TOTAL (000'S BARRELS)	116,605.5	107,521.5	91,911.1	126,195.8	122,180.5	138,200.4	165,327.6	163,287.6



ENERGY SOURCES

- Fossil
 - Lignin
 - Coal
 - Petroleum –LNG
- Special Sources
 - Nuclear
 - Waste
 - Energy Efficiency
- Renewable Sources
 - Wind
 - Solar
 - Photovoltaic
 - Heating – Direct Solar
 - Biomass
 - Geothermal
 - Ocean Energy
 - Wave
 - Tidal
 - Thermal

RENEWABLE ENERGY SOURCES ...1

- Wind
 - Electricity
 - Water pumping

Technology well developed
e.g. 4 m/sec electricity
US\$0.07/kwh

Not base load power –
require storage or
complimentary system
- Solar
 - Water heating proven
application – Barbados
 - Photovoltaic –for
electricity costly –
US\$0.40/kwh

Good for remote and
special applications but
cannot be base load
power.

RENEWABLE ENERGY SOURCES ...2

- Biomass
 - Linked with the production of plants of animals
 - Potential to provide multiple energy services –cooking, heating, electricity, transportation
 - Production potential limited by land space – similar to wind and solar
 - Economies of scale
- Geothermal
 - Linked to volcanic activities –
 - It use if for electricity generation

RENEWABLE ENERGY SOURCES ...3

- Wave Energy
 - Electricity
 - Generated by the conversion of the kinetic energy in wave ?
- Tidal Energy
 - Electricity
 - Generated by the difference in height of the tides (high and low)
- Ocean Thermal Energy Conversion
 - Electricity
 - Water
 - Chemicals
 - Food
 - Fuel for Transportation

SPECIAL SOURCES

- Waste
Generated daily and requires Management –
Public health and environment
High BTU value
Economic synergy
Toxic and Hazardous Material --
- Energy Efficiency
Lowest cost energy efficiency
Save foreign exchange
Improves the compositeness of the economy – goods and services
Environmental benefits

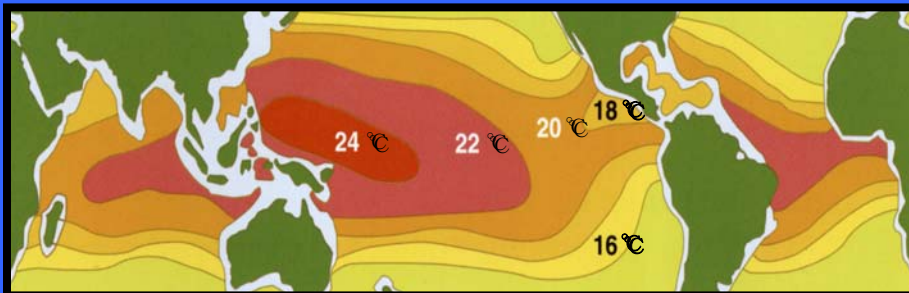
What is OTEC
— Principle of OTEC —
Reverse Refrigeration
1888

Characteristics of OTEC

- **Clean & Renewable Energy**
OTEC uses only seawater as energy resource.
- **Inexhaustible Energy**
25-30k barrel of oil eq per hectares of sea surface in the tropics
- **Stable Energy**
Generate base load day and night though the year.
- **Zero Emission**
No CO₂ & other Green house gas, SO_x, NO_x and any wastes.

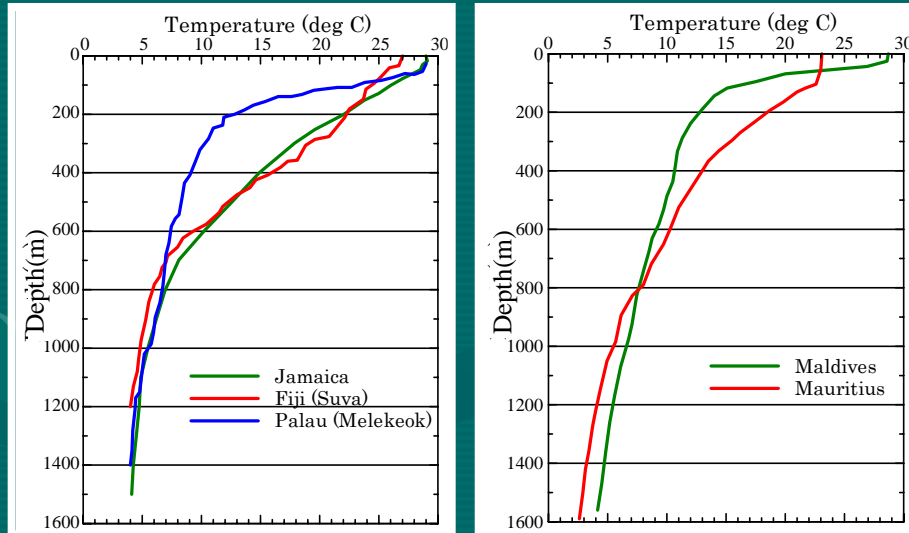
Potential Area for OTEC

Best Sites for OTEC.

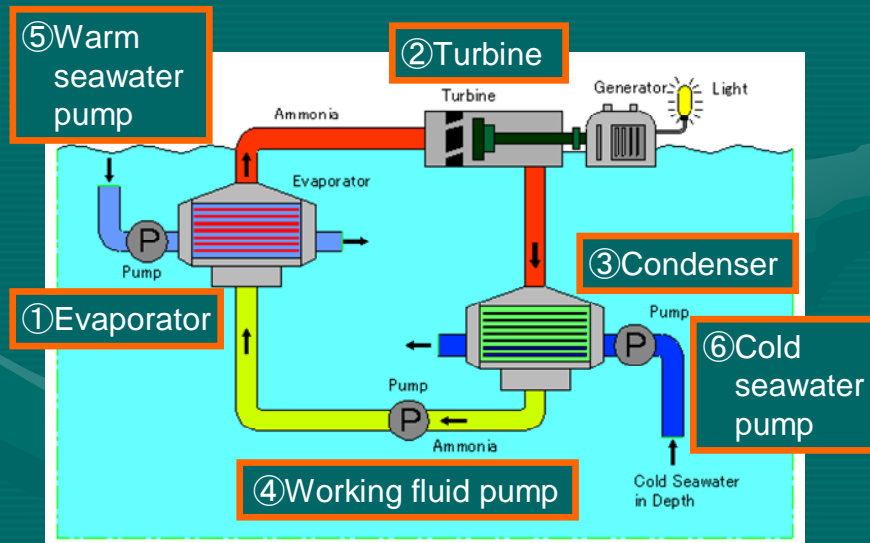


Temperature Difference between Surface and 1000m Depth

Temperature Profile



Principles of OTEC technology



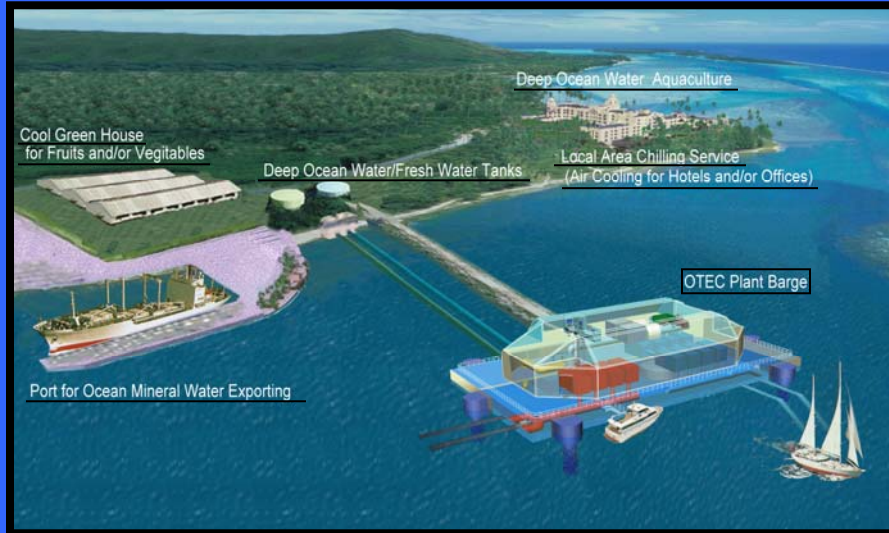
Water Production Cost by Hybrid OTEC Plant

OTEC size		1MW	10MW	100MW
Unit price of power generation	US\$/kWh	0.189	0.089	0.068
Scale of water production	m³/day	1,200	12,000	120,000
Flow rate of raw water (surface warm water)	m ³ /h	4,000	40,000	400,000
Flow rate of cold water (deep sea cold water after OTEC use)	m ³ /h	4,000	40,000	400,000
Temperature difference for seawater desalination	°C	15		
Required electric power	kW	230	2,300	23,000
Annual operating ratio	Day	335 (continuous operation on 24 hours)		
Annual amount of gross water production	x 10 ³ m ³	402	4,020	40,200
Annual amount of power consumption	MWh	1,850	18,500	185,000
Construction cost	Million yen	650	4,100	26,000
Period of amortization	Year	20		
Residual value (10%)	Million yen	▲65	▲410	▲26,000
Annual amortization cost	Million yen	29	185	1,170
Annual running cost	Million yen	39	185	1,480
Annual cost	Million yen	78	370	2,650
Water production cost	US\$/m³	1.75	0.82	0.51

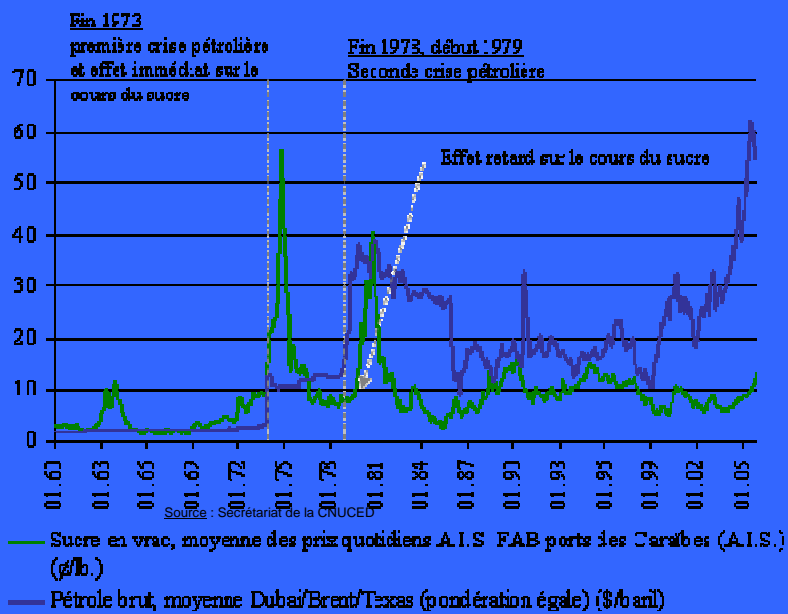
Comparison of CO₂ Emission per 1kWh by LCA Method

Method	Kg-CO ₂ /kWh
Coal fired power plant	0.916
Thermal power plant	0.756
LNG power plant	0.563
Hydro-electric power plant	0.017
OTEC – 2.5 MW	0.119
OTEC – 100MW	0.014
Solar Cell	0.153

Concept of OTEC Plant



Sugar prices versus Oil prices 1960 – 2005

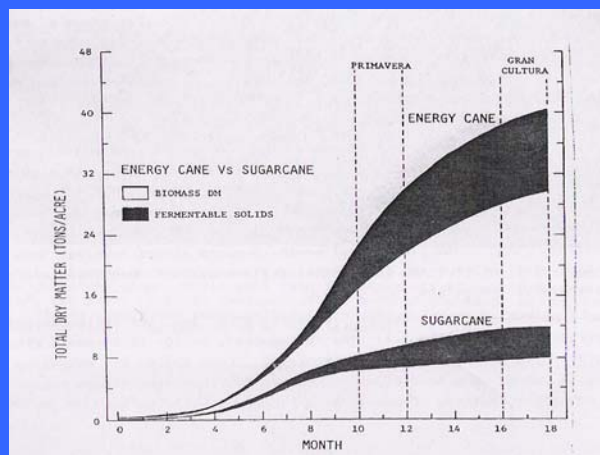


Value of 2004 sugarcane crop as a mix of sugar, ethanol and electricity .

SUGAR & ELECTRICITY (US\$ million)			SUGAR, ETHANOL & ELEC (US\$ million)		
		Crude oil @ 70 US\$/barrel		Crude oil @ 70 US\$/barrel	Crude oil @ 100 US\$/barrel
electricity	Electricity	1,526	Electricity	1,526	2,180
Sugar	Sugar	824	Sugar	412	412
Molasses	Molasses	69	Molasses	34	34
TOTAL	TOTAL	2,418	Ethanol	770	1,100
US\$/tc	US\$/tc	63	TOTAL	2742	3726
			US\$/tc	72	98

ETHANOL & ELECTRICITY (US\$ million)		
	Crude oil @ 70 US\$/barrel	Crude oil @ 100 US\$/barrel
electricity	1,526	2,180
Ethanol	1,540	2,200
TOTAL	3,066	4,380
US\$/tc	80	115

Comparative Growth of Sugarcane and Energycane



A Different Paradigm

- Based on the concept of Energy Services rather than energy supply
- Minimizes the dependence on imported Petroleum
- Has synergy with other sectors --- water, waste, agriculture, tourism, industry

Major Challenges to Development and Implementation

- Limited human capacity (technological as well as entrepreneurial) in SIDS especially within the energy sector
- Attitude of the financial institutions (both local and foreign)
- Energy policies and sometimes tax policies