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OTEC in Africa and Commercializing/Financing OTEC

Dr. Gunnar (Ted) Johnson, Executive Director and VP of OTEC/SDC

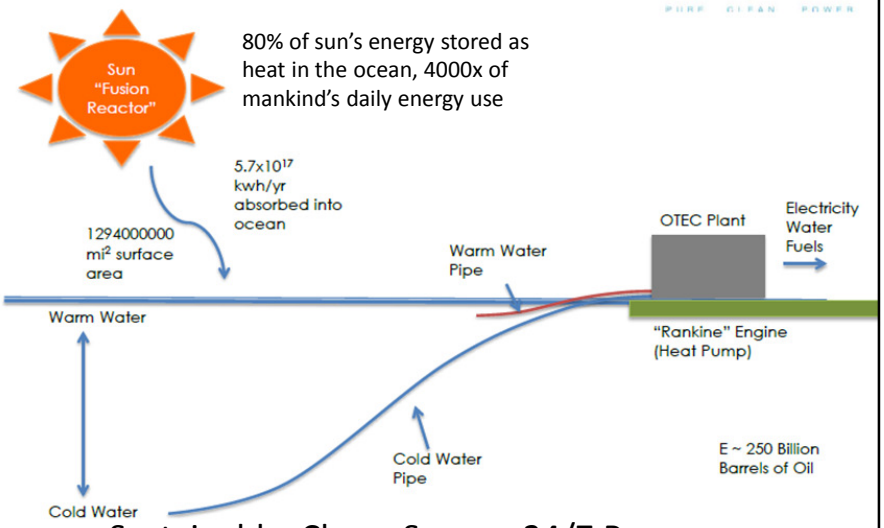
United States/United Kingdom/Bahamas/ US Virgin Islands

www.otecorporation.com Updated October 2013

OTEC: Turning Water into Energy

OCEAN THERMAL ENERGY PLC

PURE CLEAN POWER



Sustainable, Clean, Secure, 24/7 Power

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OTEC History

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Conceived in late 1800s – First tested in 1900s – Implemented in 2000s, OTEC technology has been proven for commercial applications

1974: Hawaii Established Natural Energy Laboratory Authority (NELHA)

1975: NSF OTEC Studies (Lockheed/TRW)

1979: 50 kW Mini-OTEC (Lockheed/MAKAI)

1981: OTEC-1 Test (TRW/DoE)

1981: 100 kW OTEC Nauru Plant (Toshiba)

1983: CWP at Sea Test (TRW/DoE)

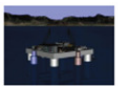
1993: 250 kW Open Cycle OTEC (PICHTR/NELHA)

1996-2000: 50 kW Heat Exchanger Testing (NELHA)

2000: India 1 MW OTEC Plant (NIOT)

2005: Diego Garcia Feasibility (OTE/OCEES SBIR)

2006: OTEC Study (Makai/OTE/OCEES SBIRs)



2007-Present: Pilot Plant Design (Lockheed Martin/OTE)

SEAWATER COOLING

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Countries and Territories With OTEC Potential

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The Americas		Africa		Middle East	Pacific and Indian Oceans	
Antigua	Guyana*	Aldabra	Sierra Leone*	Iran*	American Samoa	Northern Marianas
Aruba*	Haiti	Angola*	Somalia*	Oman	Australia*	Okinawa
The Bahamas	Honduras*	Ascension	Tanzania	UAE*	Brunei*	Pakistan*
Barbados	Jamaica	Benin*	Togo*	Yemen	Burma*	Palau
Barbuda	Martinique	Cameroon*	Zaire*		Cook Islands	Papua New Guinea
Belize*	Mexico*	Cape Verde			Diego Garcia	Philippines
Brazil*	Montserrat	Comoros			Fiji	Samoa
Cayman Islands	Nicaragua*	Congo*			French Polynesia	Seychelles
Colombia*	Panama	Equatorial Guinea*			Guam	Solomon Islands
Costa Rica*	Puerto Rico	Gabon*			Hawaii	Sri Lanka*
Cuba	Saint Kitts*	Ghana*			India	Taiwan
Curacao	Saint Lucia	Guinea*			Indonesia	Thailand*
Dominica	Saint Vincent	Ivory Coast*			Kiribati	Tonga
Dominican Republic	Suriname*	Kenya*			Malaysia*	Tuvalu
El Salvador*	The Grenadines	Liberia*			Maldives	Vanuatu
French Guiana*	Trinidad & Tobago	Madagascar			Marshall Islands	Vietnam*
Grenada	United States*	Mozambique*			Mauritius	Wake Island
Guadeloupe	US Virgin Islands	Nigeria*			Nauru	Wallis & Futuna
Guatemala*	Venezuela*	São Tomé & Príncipe			New Caledonia	

*offshore/floating OTEC applications only, all other OTEC applications are land-based

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Onshore OTEC Plant

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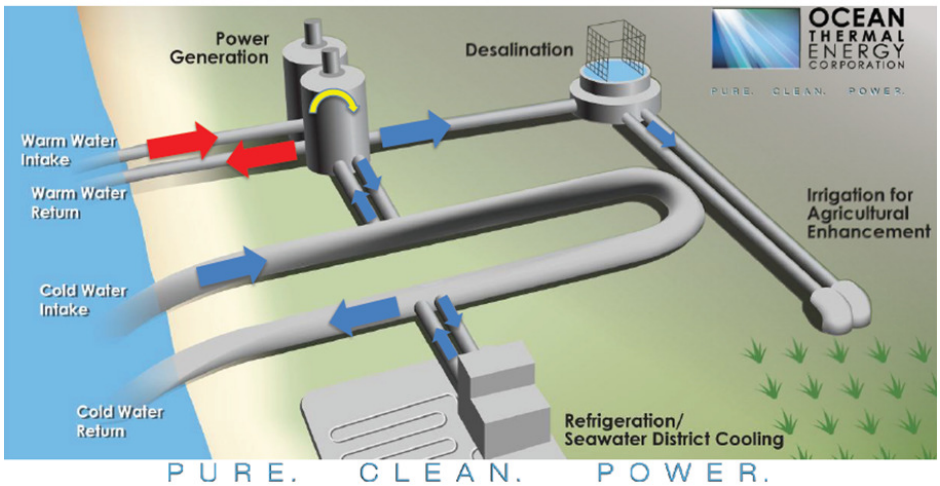
Using the temperature difference of sea water found in tropical climates, land-based OTEC plants produce fossil-fuel free electricity, potable water and opportunities for sustainable food production



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Seawater District Cooling

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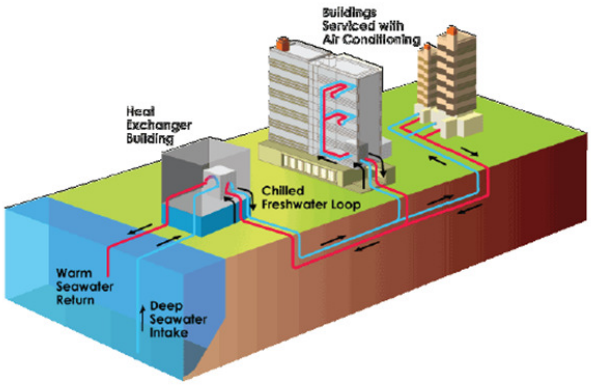
SDC systems can save up to 90% in electricity costs when compared to traditional air conditioning systems. SDC systems range in size from 400 to 80,000 tons of cooling capacity and use millions of gallons of seawater. Once the seawater has been used for air conditioning it can be desalinated for potable water



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OTEC and SDC Provide Opportunities for Sustainable Technologies

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Give a man a fish, you feed him for a day. Teach a man to fish, and you feed him for a lifetime.
– Chinese Proverb

Fish Hatcheries

Shellfish Production

Cyanotech (Algae) Production

Seed Growing Methods

Bottled Water

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Each 100 MW OTEC Plant

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OTEC plants can provide sustainable clean power without harming the environment

- Provides Base-Load **Electricity for 100,000 people**
- Produces **800 Million kWh per year**
- Saves **1.3 million barrels of oil each year**
- Produces **no Carbon Dioxide** (avoiding the generation of up to 800 thousand tons of CO_2)
- Can be designed to co-produce **120 million liters of fresh water** per day
- Moves four cubic km of high-nutrient deep water per year (1 square kilometer 11.5 meters deep each day, enough to grow 70 tons of shellfish meat per day)

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The Many Benefits of OTEC

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"The potential of OTEC is great. The oceans are the biggest solar collector on Earth, and there's enough energy in them to supply a thousand times the world's needs. If you want to depend on nature, the oceans are the only energy source big enough to tap."

Dr. Joseph Huang – Senior Scientist, NOAA and DOE, USA

Economic Benefits

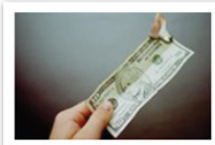
- Base-load Power: Available 24/7
- Reduced fuel imports
- Stable utilities pricing
- Reduced capital expense to Power Company and Government
- Affordable incremental power capacity increase
- Reduced burden on existing utilities
- Life cycle cost savings

Environmental Benefits

- Inexhaustible renewable energy from local resources
- Fossil fuel avoidance
  - ~15,000 bbls oil per year per MW
- Zero emissions
  - Saves nearly 7,000 tons CO_2 per year per MW
- Sustainable fresh water supply
- Energy conservation (SDC)

Social Benefits

- Affordable fresh water and power
- New industries/jobs/export opportunities (aquaculture)
- Increased fuel flexibility and energy security
- World leadership role in eco-awareness



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Africa Continent Overview

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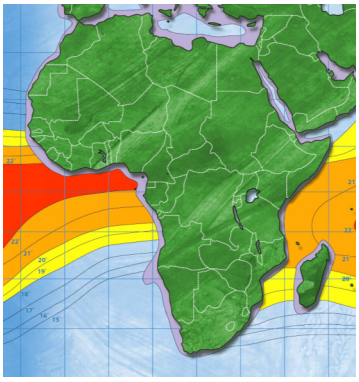

- Over 500M people
- Highest birthrate of any continent with population expected to reach 2B by 2050
- Fastest growing region on earth – facing most serious problems of food and water
- High potential for commercial OTEC plants

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Courtesy of GMU

Land-Based OTEC Plants for Africa

East and West African Countries

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- **African States use *liquid-petroleum* fuels for power generation**
- **Crude oil price continues to rise and refining of *heavier crude oils* is becoming bottleneck**
- **Diesel-engine power: Fuel cost alone is between *$0.25 and $0.33* per kWh at engine efficiency of 12 to 16 kWh per gallon and diesel at ~ $4.0/gallon (delivered to the African countries)**
- **Some African states are facing scarcity of *fresh water for human consumption***

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Possible OTEC Locations

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	Criteria	Max ΔT @ 1000 m (°C)		Min Depth for ΔT=20° (m)		Established Power Distribution System (Y/N)		Installation Facilities Available (Y/N)		Political Stability		GDP (2008 est.)		Sea Stability (Pirating)		Final
	Weight	20%		15%		15%		15%		15%		10%		10%		100%
Rank	Location	Criteria	Val	Criteria	Val	Criteria	Val	Criteria	Val	Criteria	Val	Criteria	Val	Criteria	Val	Score
1	**Lagos, Nigeria**	**22.0**	**3.0**	**700**	**3.0**	**Yes.**	**2**	**Yes.**	**2**	**Yes. Democratic**	**3**	**$336.2 billion 5.3% annual growth**	**3**	**Pirating in Niger Delta Region**	**1**	**2.5**
2	Dar es Salaam, Tanzania	20.5	2.0	1000	2.0	Yes. Tanzania Electric Supply Company, (TANESCO).	2	No.	0	Yes. Democratic	3	$20.7 billion 7.1% annual growth	1	Medium. High Drug Trafficking Trade.	2	**1.75**
3	Darkar, Senegal	18.0	1.0	1500	1.0	Yes	2	Yes. Established Captial City of Dakar	2	Varying. High Illegal Drug Trade	1	$13.4 billion 2.5% annual growth	1	No.	3	**1.5**
4	Maputo, Mozambique	19.0	1.0	1100	1.0	Yes. Primary - Electricidade de Mozambique (EDM).	2	No.	0	Yes. Democratic.	3	$9.9 billion 6.8% annual growth	1	Medium. High Drug Trafficking Trade.	2	**1.4**
5	Walvis Bay, Namibia	13.0	0.0	14 deg C @ 1500m	0.0	No. Very Fragmented.	0	Possible Yes. Well established port city.	2	Yes. Democratic. Good U.S. relations	3	$13.2 billion 2.9% annual growth	1	No.	3	**1.15**

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Courtesy of GMU

Zanzibar OTEC Plants

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Memorandum of Understanding (MoU) signed with the Zanzibar Electricity Corporation (ZECO) to introduce OTEC and ancillary technologies to Tanzania

- Power outages are commonplace as electrical supply is intermittent. Water is scarce and is imported to Zanzibar
- Zanzibar depends entirely on power energy through 132 kV submarine cable connected from the Tanzania Mainland with a capacity of 45 MW
- Zanzibar Electricity Corporation (ZECO) is the sole power utility in Zanzibar empowered to generate, transmit, distribute and sell electric energy to the country

Note:
*Based on pricing model for a 17.2 MW OTEC Plant

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Overview of Land Based Plant

Zanzibar North Point

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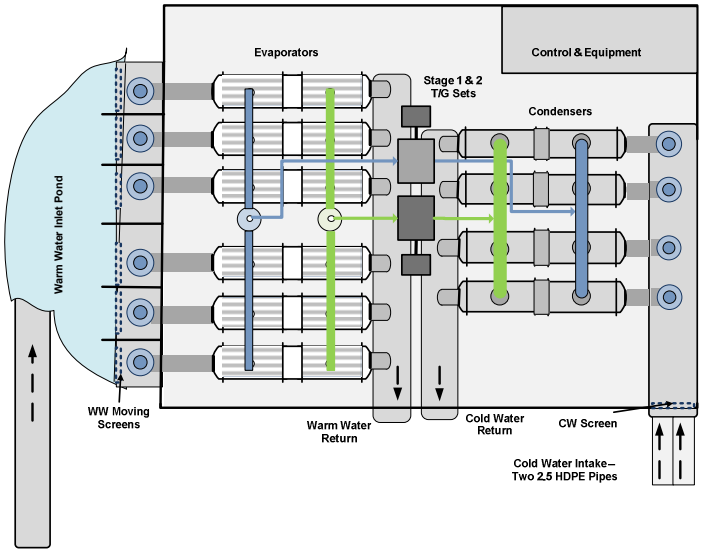
Typical Plant Layout



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Design Parameters

	Nigeria	Zanzibar
Warm Water Inlet / Outlet Temp, C	27.5 / 23.1	27.5 / 23.4
Cold Water Inlet / Outlet Temp, C	5.5 / 13.1	7.0 / 14
Warm Water Flow, kg/s	33,416	42,350
Cold Water Flow, kg/s	19,620*	23,593*
Power Generation, kW		
Gross Power	17,759	19,504
Parasitic Power	6,021	7,642
I &C, Chlorinator, Line Losses	721	727
Net, kW	11,017*	11,134*

* Although Delta-T for Nigeria is greater than that for Zanzibar, net power is comparable for both sites due to pressured drop limitation of HDPE pipes that limits flow rate of cold water for Nigeria plant with longer cold water pipe as compared to the plant at Zanzibar site

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Design Basis of Lagos Floating OTEC Plant

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- Site: Offshore of the Coast of Lagos, Nigeria
- Average Seawater Temperatures: Warm 27.5°C, Cold 5.5°C, Delta-T 22°C
- Cold Water intake: 1,000 m depth
- Cold water intake pipe: Three 3.0-M High Density Poly-Ethylene (HDPE) pipes bundled together as demonstrated by OTEC-1 project
- Mixed water return at depth of 200 m
- Heat exchangers: shell-and-tube (enhanced titanium tubes) with 30-year service life (8 evaporators and 6 condensers per stage)
- Platform: Ship-shape (OTEC-1) or Barge

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OTEC Lagos Plant Layout

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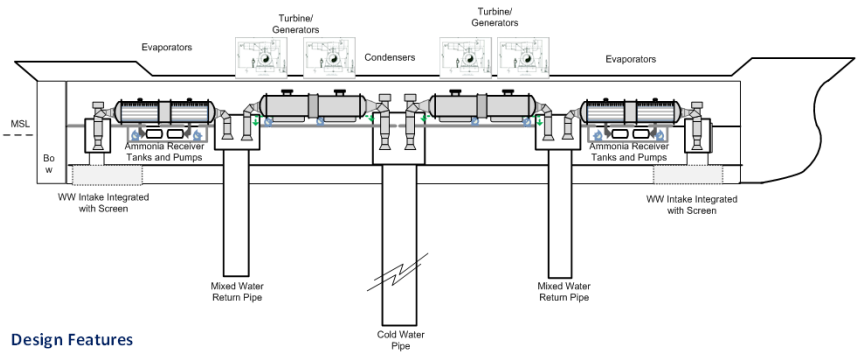

Design Features

- Heat exchangers in mid-deck just above mean sea level
- Turbine/Generator sets on upper deck for ease of maintenance/replacement
- Water pumps accessible from main deck for maintenance/replacement
- Ammonia pumps and reservoir tanks in ventilated compartment

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Baseline Design Parameters

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Gross Power generation	**39,077**	**kW**
Parasitic Power		
➢ **Warm seawater pumps**	**7,305**	**kW**
➢ **Cold seawater pumps**	**5,214**	**kW**
➢ **Ammonia pumps**	**1,653**	**kW**
➢ **Chlorinator + I&C + Line losses**	**1,520**	**kW**
Net Power to Grid	**23,385**	**kW**

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ALFA Laval Heat Exchanger (Sweden) Large Water Pipes (Norway)

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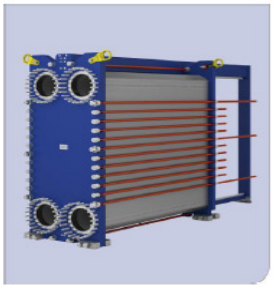

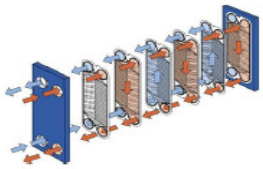

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Production of Fresh Water

RO-Based Desalination of Cold Seawater

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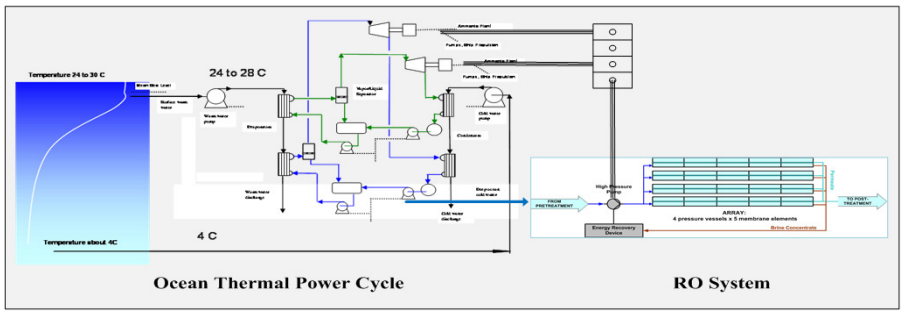
- **Commercially ready with known performance and costs**
- **1 MWe OTEC power can produce 6.7 million liters per day of fresh water**
- **RO system can be integrated with OTEC power system by utilizing a small fraction of cold seawater downstream of condensers**
- **By mixing concentrated seawater (with higher concentration of salt) with returning cold seawater minimizes environmental impact of returning concentrated brine seawater encountered in conventional RO plants**



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Ocean Thermal Energy Corporation

"Committed to a Sustainable Future"

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GOAL – BLUE CHIP OCEAN ENERGY COMPANY WITH OUTSTANDING SHAREHOLDER RETURNS

Growth of Developing Nations with Massive Infrastructure and Economic Development Needs

Increasing Water and Food Scarcity

Rising and More Volatile Energy Costs

Escalating Pollution and CO_2 Levels

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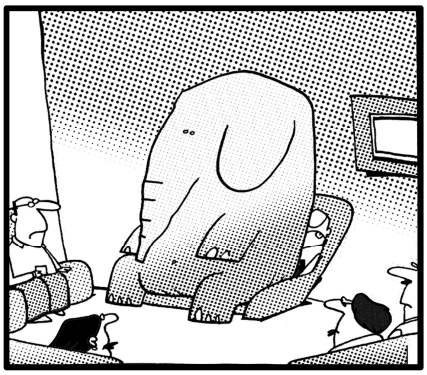
Developer Financing



"Historically, developer financing has been the OTEC "Elephant in the Room"

OTE Corp, founded by venture capital investors, has developed an investor/finance driven business architecture for the commercialization of OTEC, SDC, WATER, and DOWNSTREAM PRODUCTS

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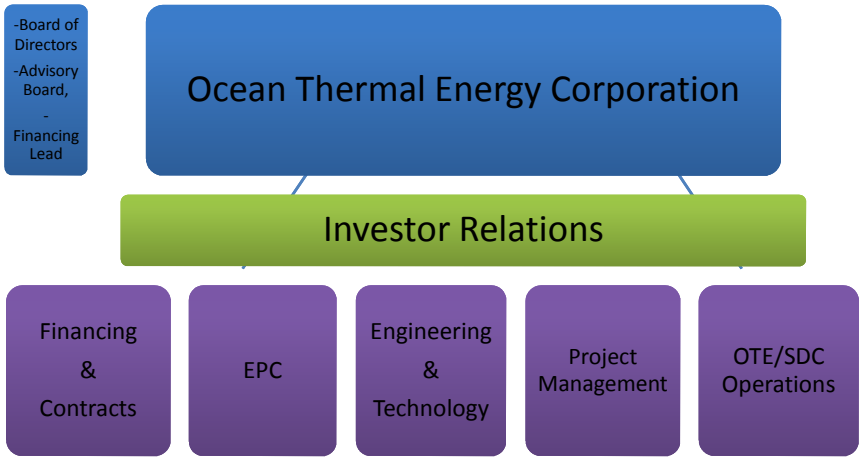
Role of the Developer



Design, Build, Own, Operate, and Finance

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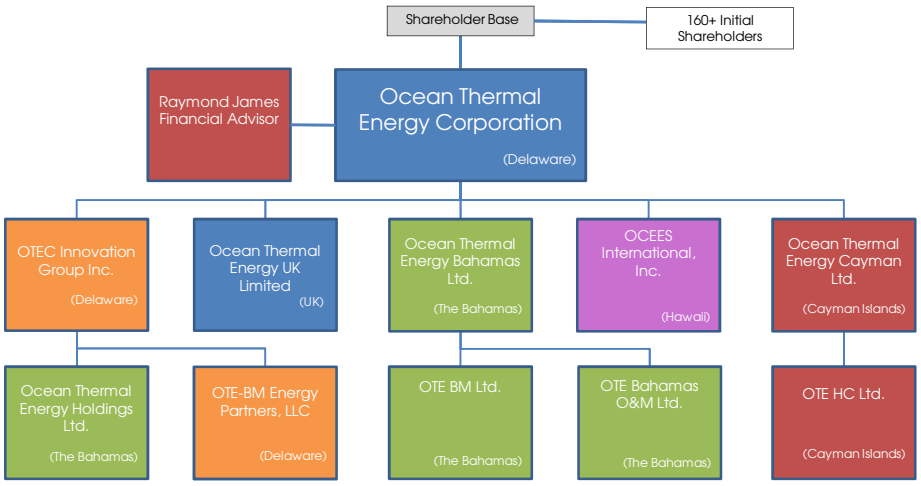
OTE Corporation Structure (Pre IPO)



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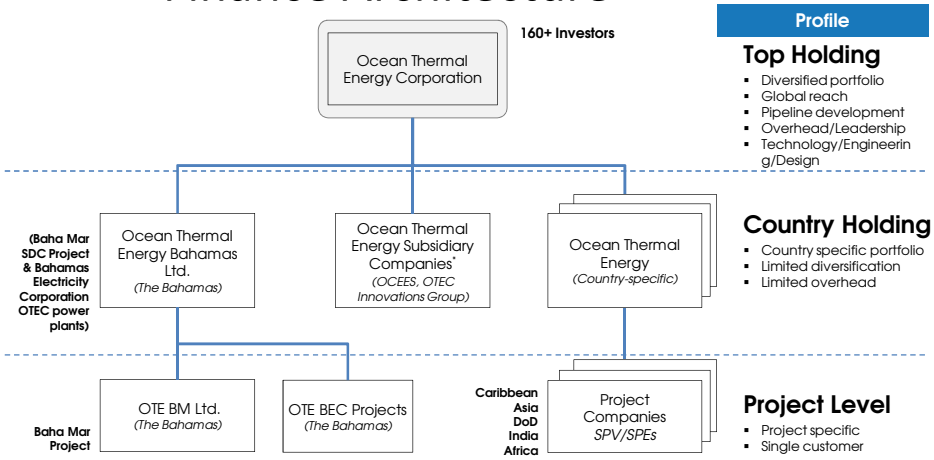
OTE Holding Companies/ Project Finance Architecture



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First Stage Projects Example: 1. Baha Mar SDC Plant

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The resort will enjoy in excess of 80% energy savings compared to conventional central air systems for air conditioning

BAHA MAR
THE BAHAMIAN RIVIERA

- Baha Mar is a multi billion dollar resort/entertainment complex in the Caribbean half way thru construction
- OTE is building the large scale seawater district cooling facility in The Bahamas for the Baha Mar resort
- In-service date scheduled for January 2016
- DCO Energy is the lead EPC contractor for OTE
- OTE estimates its SDC system will reduce Baha Mar's energy consumption by 50-60,000 bbl. oil (equivalent to ~42,000 tons CO_2) per year, reducing electricity consumption by over 80%
- Energy Services Agreement (ESA) is to build, own and operate a 9,800 ton SDC system
- ESA generates $530 Million in revenue for OTE

Construction Progress April 2013

Design Rendering

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Baha Mar SDC Intake Pipeline Route

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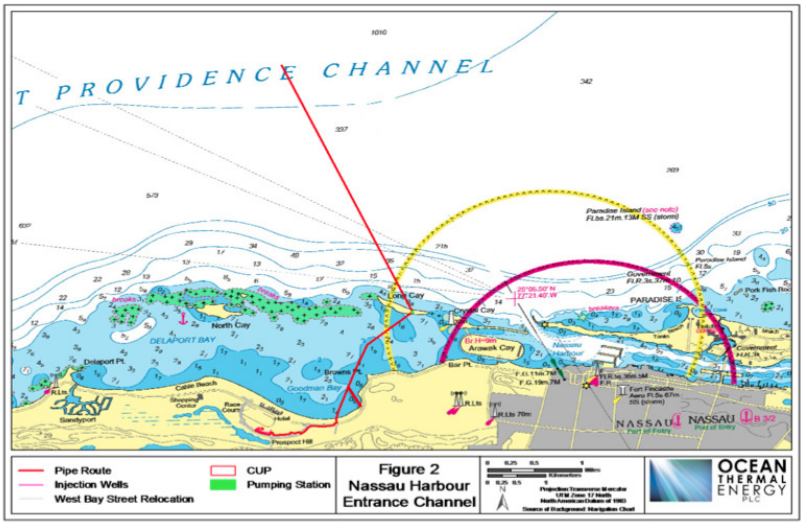

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DCO Energy, Baha Mar EPC

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- DCO is an investor in OTE and Frank DiCola, DCO's Chairman and CEO, serves on OTE's Board of Directors
- DCO Energy, LLC (NJ, USA) is a proven leader in the development of Central Energy Cooling, Combined Heat and Power facilities, Landfill Gas to Energy and Biomass projects
- Through 2012, DCO's portfolio of projects includes 185 MW of electric, 332 MMBtu/hr of Heat Recovery, 1,866 MMBtu/hr of Boiler Capacity and over 141,210 tons of chilling capacity
- DCO provides EPC partnership and independent engineering services to OTE and has been working with OTE on SDC and OTEC for three years

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Financial/EPC/Technical Liaisons

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OTE has strategic and teaming relations with multi national companies who have key experience in project finance and ocean engineering, construction and project finance including professionals with excellent credentials in providing legal advice and listing companies.

DCO Energy
Crowe Clark Whitehill
LennoxPaton — LEGAL SOLUTIONS. OFFSHORE FOCUS.
Cairn
KBR Corporate Finance
IDB
DAC beachcroft
MAKAI OCEAN ENGINEERING — Innovation in the Ocean World
PROVIDENCE ADVISORS
KPMG
RAYMOND JAMES
WEEKS MARINE
OPIC
HDR
AMERESCO — Green • Clean • Sustainable
INTECSEA — WorleyParsons Group
KONGSBERG
DCNS
PIPELIFE

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Europe

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- Norway
  - MoU with Kongsberg on joint OTEC/geothermal power development
  - Leverages Norway's deep water expertise, large cold water pipes, and floating platforms
- France
  - MoU signed with DCNS/France for OTE to be lead project developer in key markets
  - Joint development of selected OTEC technology
  - Joint OTE/France marketing council formed
- Sweden
  - Alfa Laval joint OTEC heat exchanger design
  - Discussions planned with Sweden's deep water technology companies

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OTE Markets (Contracts/MoU's)

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Our Angle

First to Market – Land based systems evolving to floating systems; (Energy, Cooling, Water, Aquaculture, Farming, Minerals)

Global Leader

Markets

Bahamas – OTEC, SDC, Potable Water, Aquaculture

US Virgin Islands – OTEC, Potable Water

Cayman – OTEC/SDC

Pacific Islands – OTEC, Potable Water

Caribbean – OTEC, SDC, Potable Water, Aquaculture, Agriculture

US DoD – OTEC, SDC, Potable Water

Asia/India – OTEC, SDC, Potable Water

Africa – OTEC, SDC, Potable Water (ZECO MoU)

Technology

~10+ MW Land Based Plant

100+ MW Floating Plants

Funding

Building Infrastructure
Pipeline Development

Continuous Sustainable Growth
Blue-Chip Renewable Listed Company

Today → 3 Years → 5 Years

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Educating the World About Ocean Thermal Energy Conversion (OTEC)

OCEAN THERMAL ENERGY CORPORATION

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OTEC is a global game changer. The ON Project is an educational program from Ocean Thermal Energy Corporation (OTE). The project seeks to educate and inform the public of the considerable benefits of the technology and its positive effect on millions of people worldwide.

Click in center of graphic to play movie. Go to next slide when done.

View this video online at http://www.youtube.com/watch?v=bMhbyPai2uY

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