

Power and Economic Development

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Presented to: IEEE
April 24, 2008

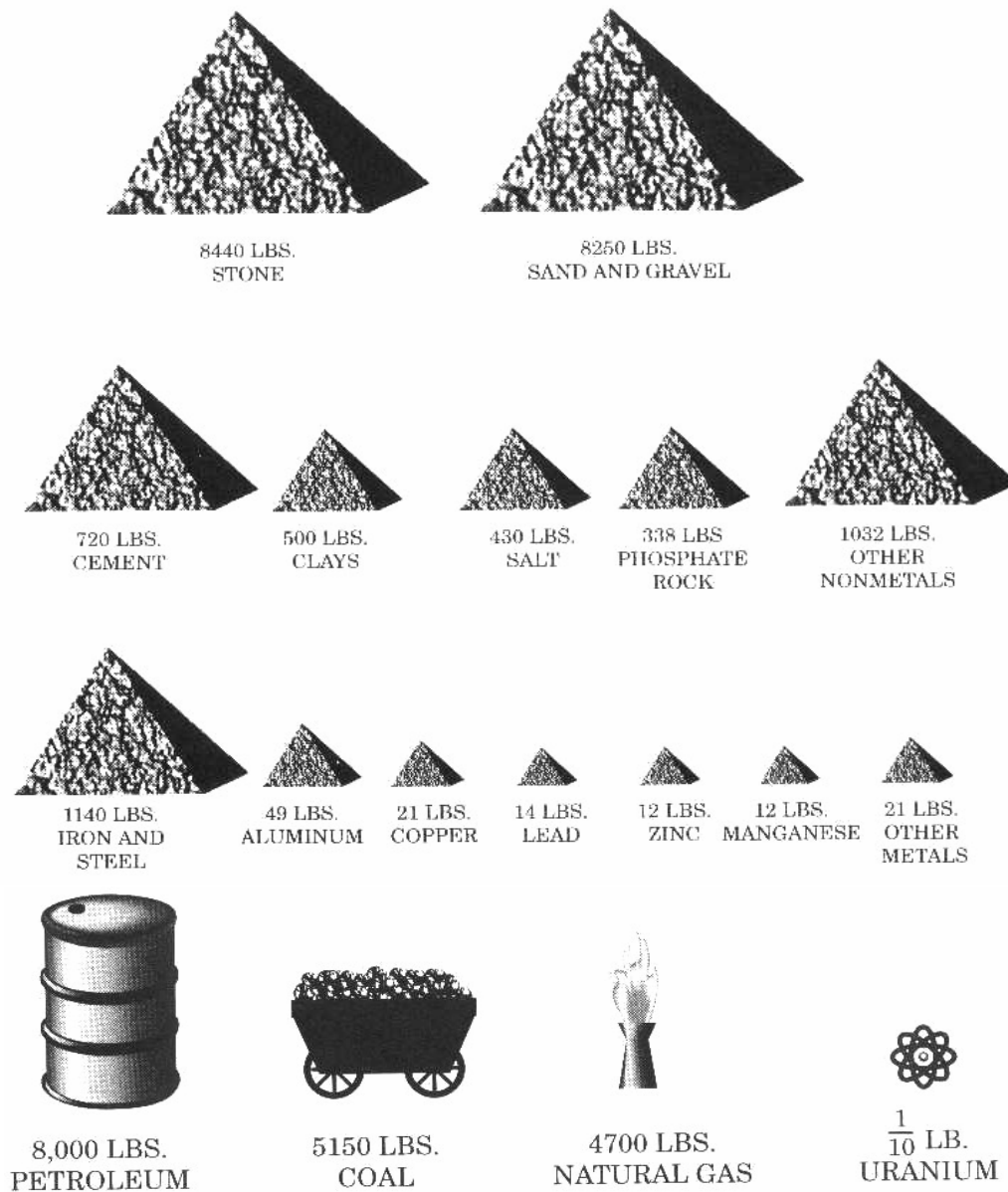


Energy and Our High Standard of Living

- *With high energy consumption goes a high standard of living.* Thus the enormous fossil energy which we in this country control feeds machines which make each of us master of an army of mechanical slaves.
- Man's muscle power is rated at 35 watts continuously, or one-twentieth horsepower.
- **Machines** therefore furnish every American industrial worker with energy equivalent to that of **244 men**.
- **2,000 men** push his **automobile** along the road.
- His family is supplied with **33** faithful **household helpers**.
- **Each locomotive** engineer controls energy equivalent to that of **100,000 men**;
- **Each jet** pilot controls energy equivalent to that of **700,000 men**.

“Energy Resources and Our Future,” Admiral Hyman Rickover, May 14, 1957

EACH U.S. CITIZEN USES ANNUALLY:



Energy is the key to unlock all other physical resources

US = 1100 lbs of iron & steel per capita
 3rd world = 50 lbs of iron & steel per capita

Current US energy use is equivalent to having 300 people working around the clock for each citizen

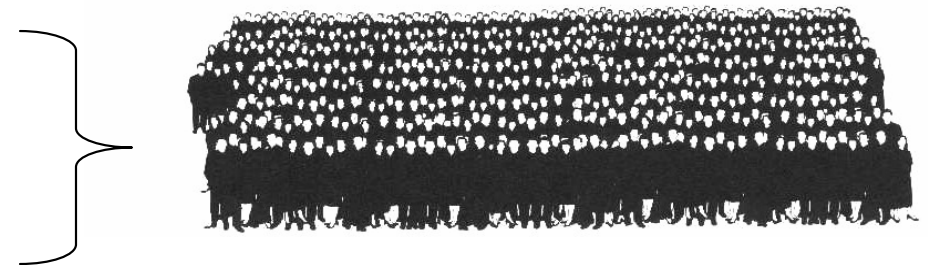


Figure 2. U.S. per capita annual mineral consumption

(Source: U.S. Bureau of Mines, 1990)

Every person in Puerto Rico consumes an average of 2.5 Gallons of oil per day

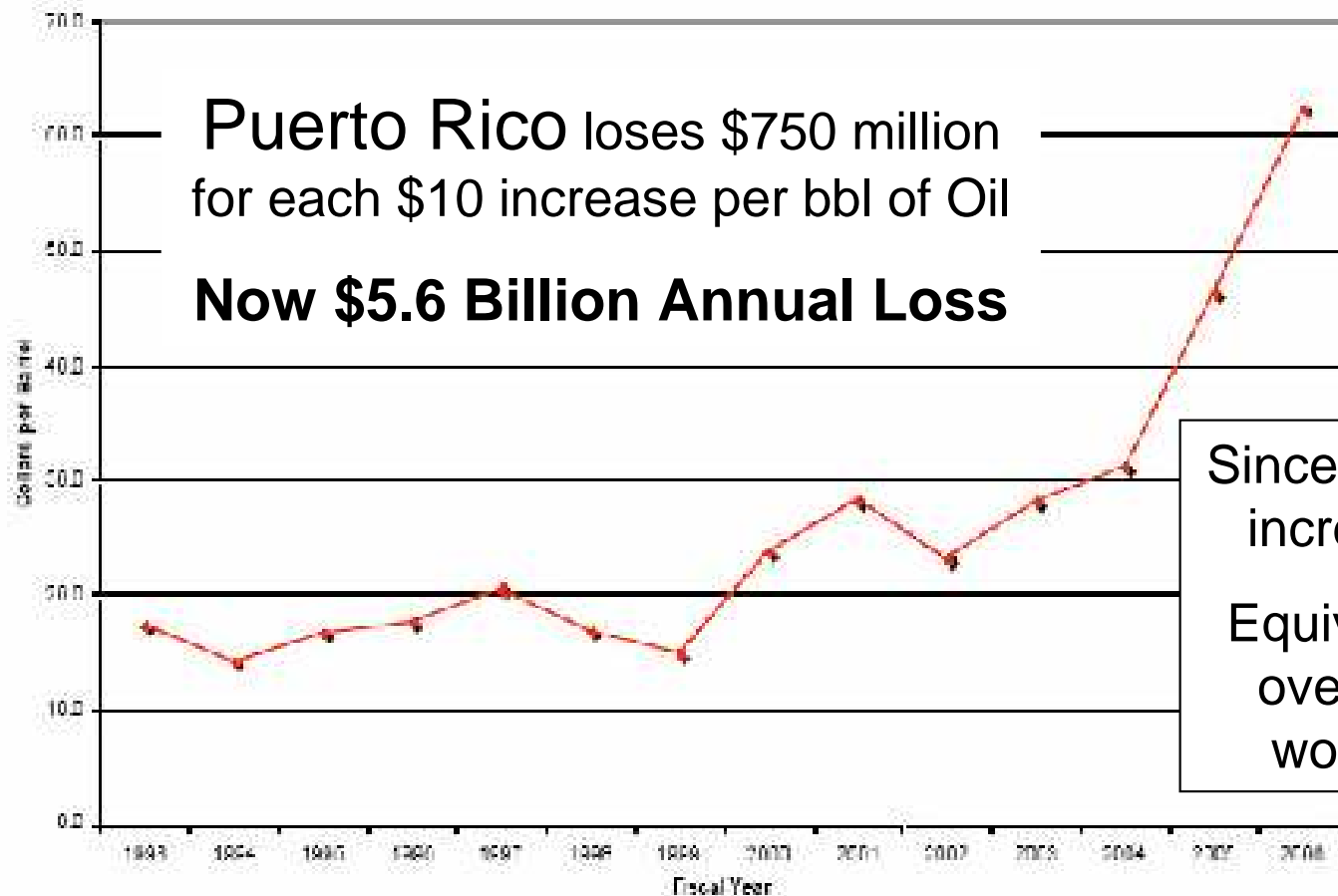
Energy and Civilization

- **Whether this Golden Age will continue depends entirely upon our ability to keep energy supplies in balance with the needs of our growing population.**
- ...Possession of surplus energy is, of course, a requisite for any kind of civilization, for if man possesses merely the energy of his own muscles, he must expend all his strength - mental and physical - to obtain the bare necessities of life.
- ...A reduction of per capita energy consumption has always in the past led to a decline in civilization and a reversion to a more primitive way of life.
- Examples: Mayan, India, China, Middle East

“Energy Resources and Our Future,” Admiral Hyman Rickover May 14, 1957

Puerto Rico suffers terribly from Oil Dependency

Average Price of Imported Crude Oil (dollars/barrel)

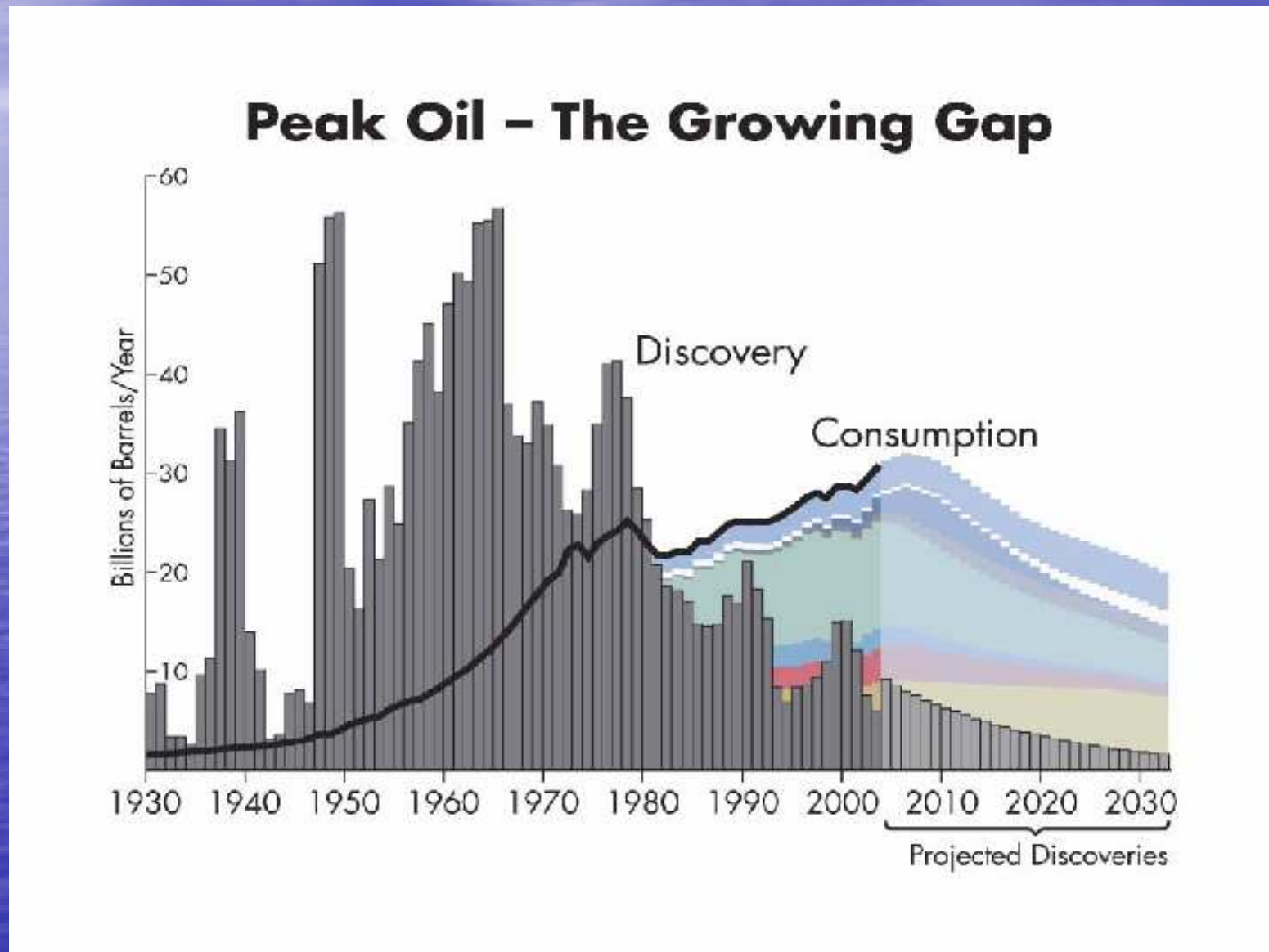


Puerto Rico loses \$750 million for each \$10 increase per bbl of Oil
Now \$5.6 Billion Annual Loss

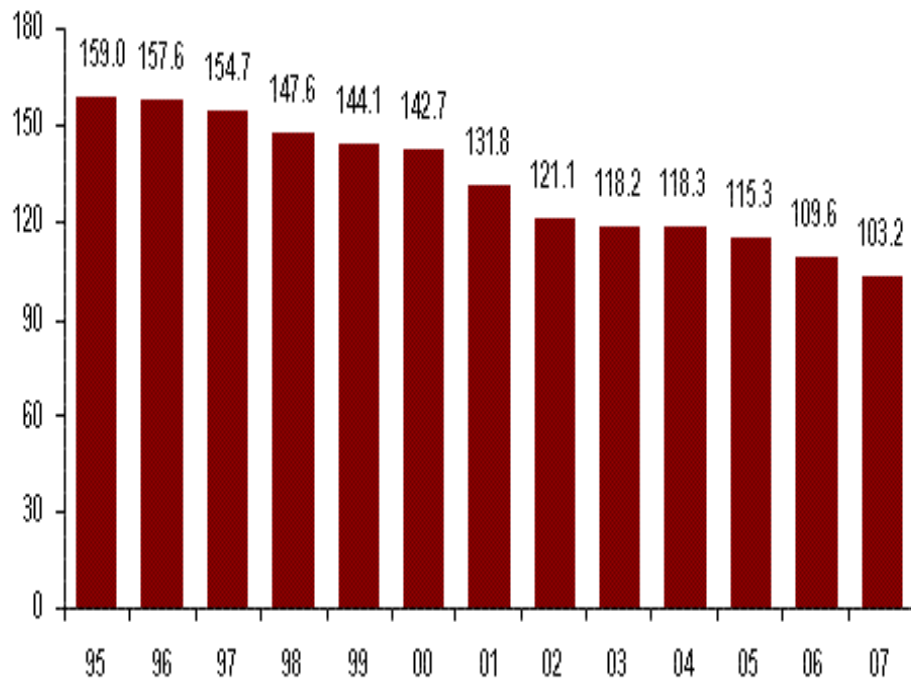
Since 1999 Oil Prices have increased by \$75/barrel
Equivalent to a pay cut of over \$2.30/hr for every worker in Puerto Rico



And it's is not going to get better

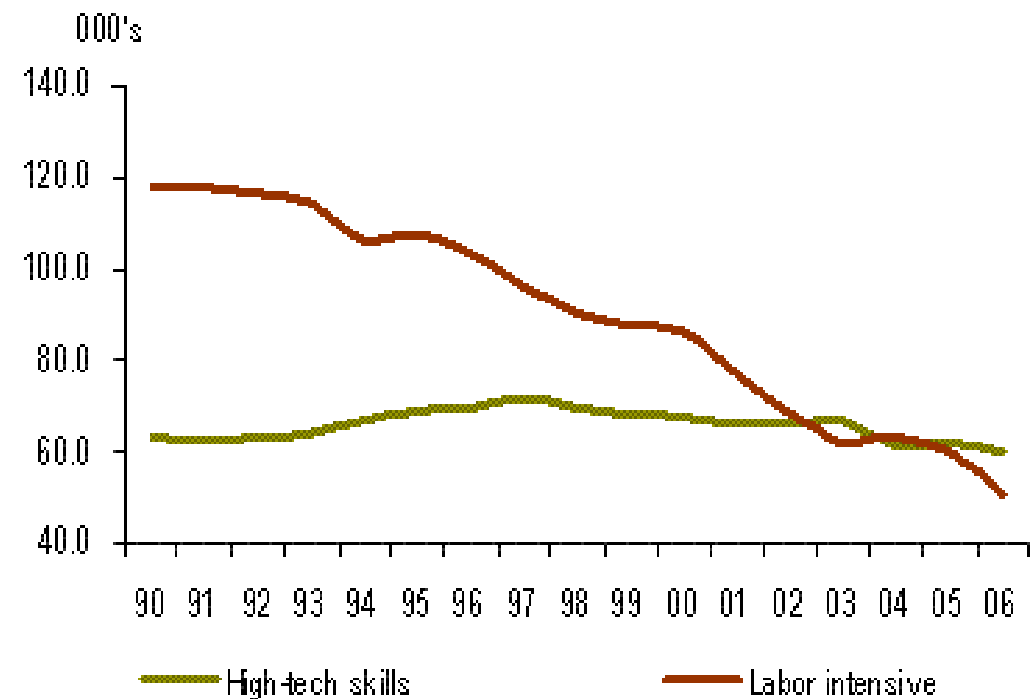


Puerto Rico has lost 35% of its manufacturing jobs since 1995



Source: Puerto Rico Department of Labor

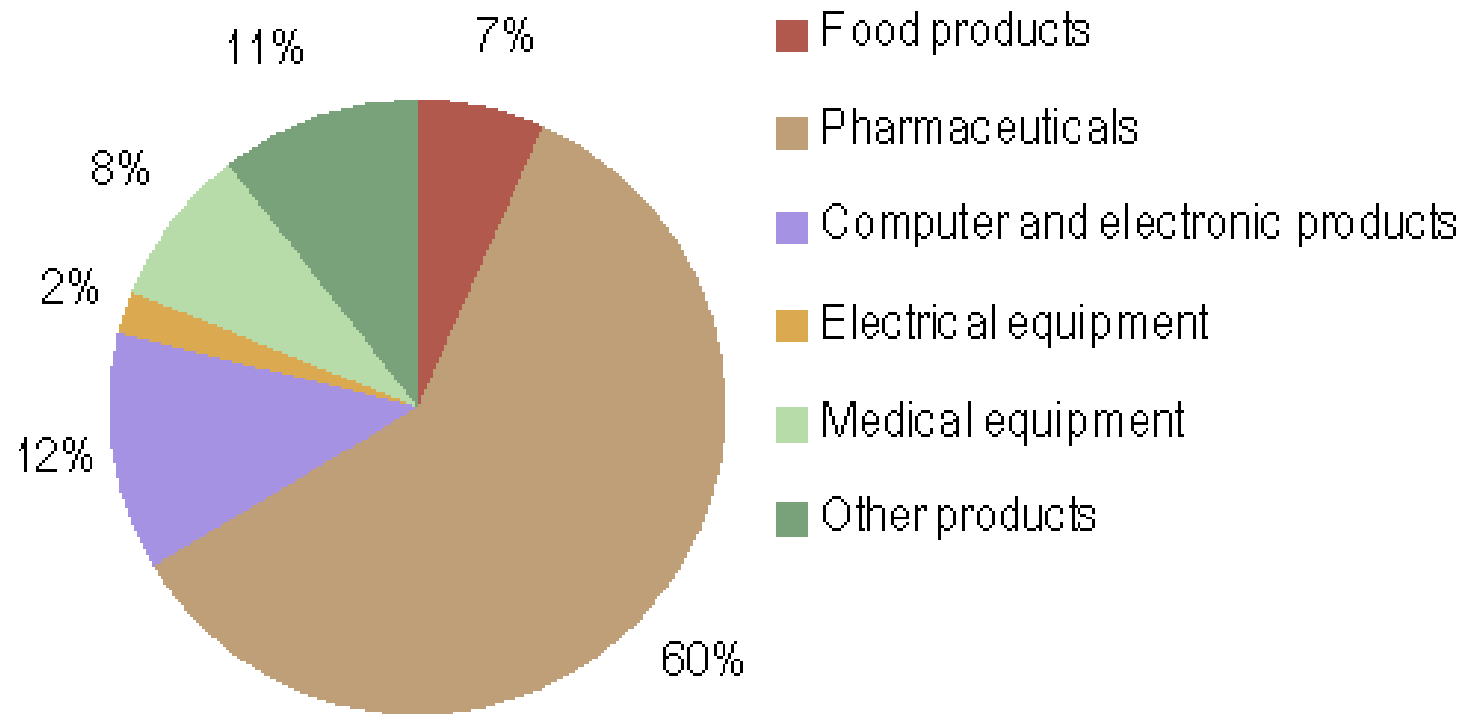
Average employment in 2007 estimated with data until September 2007.



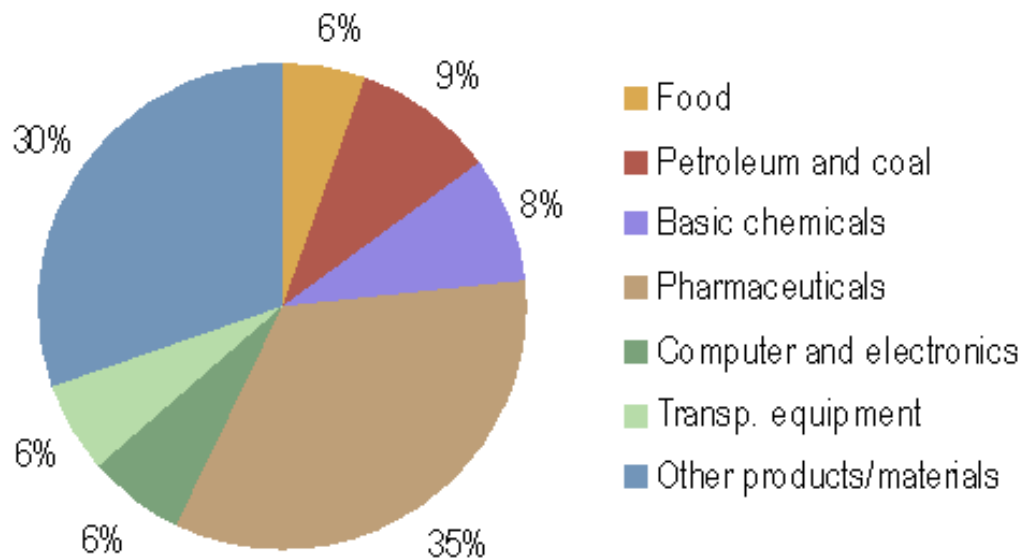
Source: Bureau of Labor Statistics.



MAIN EXPORT PRODUCTS, 2006



MAIN IMPORTS PRODUCTS, 2006



Most of the major patented pharmaceuticals will come off patent by 2011



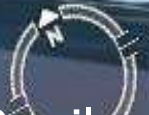
Many Critical OTEC Elements can be Manufactured and Assembled in Puerto Rico

- Power System - commercially available
 - Turbines
 - Heat Exchangers
 - Pumps
- Vessel – commercial design & construction
- CW Pipes – commercially proven to 2 M dia. Larger field tested but not in full size
- Moorings – same as for deepwater oil rigs

San Juan

UPR Humacao

Roosevelt Roads 10 miles to Deep Water



Port Yabucoa 3.5 miles to Deep Water

Abandoned Sugar Cane Fields

Resources that could employ thousands of People in OTEC

Playita

Maunabo

Faro de Punta Tuna 1.5 miles to Deep Water

An Employment Solution

Image © 2007 DigitalGlobe
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Image NASA

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My original plant started 1968 stopped in 2003

An Energy & Employment Solution

Jamaica

Nassau,
Bahamas

Hispaniola

Monariff

Caribbean plate

Puerto
Rico

PUERTO RICO

Punta Tuna

Virgin Islands

North American Plate

**THE BEST LOCATION IN THE WORLD
FOR RENEWABLE ENERGY
FROM DEEP OCEAN WATER**

OTEC

Base Load Electrical Power



- No Land Use
- No Fuel Use
- No Environmental Impact
 - Little or No visibility
- Co-Production of Fresh Water
- Adaptable to Assembly Line Production

Lockheed
Spar Design



Each 100 MW OTEC Plant


Provides Base Load Electricity for 100,000 people

- Produces 800 Million kWh of electricity 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 CO₂)
- Can co-produce 200 million liters of fresh water per day (50 million gallons 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) costing ~\$200 million per year at the current pumping cost for NELHA in Hawaii.

Unique Puerto Rico Assets

- The deep ocean resource near to land
- Large electrical demand on one island
- A highly educated and capable workforce of more than 1.4 million
- Facilities able to build the OTEC units
- A strong and stable financial, political and economic infrastructure with great tax benefits
- A Biotechnology capability that can revolutionize microalgae & ocean based products
- Puerto Rico can readily become the World's "Center of Excellence for Ocean Thermal Energy"





Deep Ocean Water can provide the
foundation for an

Algae & Aquaculture Industry

built on pure, high nutrient
discharge water from OTEC

- * Bio Fuels
- * Pharmaceuticals
- * Specialty Chemicals
- * Food

Open Pond Production System

Oil Yield

Cultivating Algae for Liquid Fuel Production

(http://oakhavenpc.org/cultivating_algae.htm)

Gallons of Oil per Acre per Year

Corn 15

Soybeans48

Safflower. 83

Sunflower . . . 102

Rapeseed. . . 127


Oil Palm 635

Micro Algae . .1850 [based on actual biomass yields]

Micro Algae . .5000-15000 [theoretical laboratory yield]

There are estimated to be between 1 million and 10 million undiscovered algae in the oceans. few have been characterized.

Use of local indigenous species can eliminate environmental risks – oils can be extracted with the remainder used for feed



NEWS RELEASE

▶ **EMBARGOED UNTIL: 09:00 GMT TUESDAY 11 DECEMBER 2007**
10:00 CET, 01:00 PST, 03:00 CST, 04:00 EST (23:00 10 DEC HAWAII)

SHELL AND HR BIOPETROLEUM BUILD FACILITY TO GROW ALGAE FOR BIOFUEL

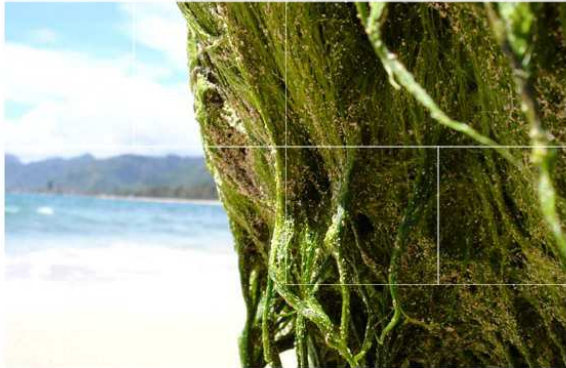
Doyal Dunch, Shell plc, and HR Bio Petroleum today announced the construction of a pilot facility in Hawaii to grow marine algae and produce vegetable oil for conversion into biofuel.

The announcement is a further step in Shell's ongoing effort to develop a new generation of biofuels using sustainable, non-food crop materials. Algae have great promise because they grow very rapidly, are able to regenerate oil and can be harvested in ponds of seawater, maintaining the use of fertile land and fresh water.

August 2006

Production of Micro algae-based Products

A map of available production methods for micro algae and market opportunities for algae-based products as a basis for establishing commercial operations.




Author: Jan Berg-Nilsen

DOW
Deep Ocean Water as Our Next Natural Resource

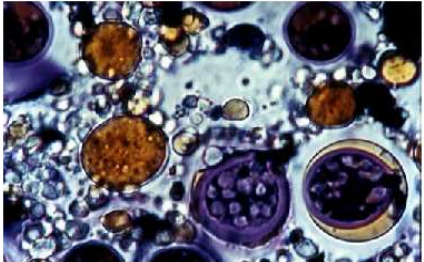
Microbiology 2006-2008

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A Look Back at the U.S. Department of Energy's Aquatic Species Program:



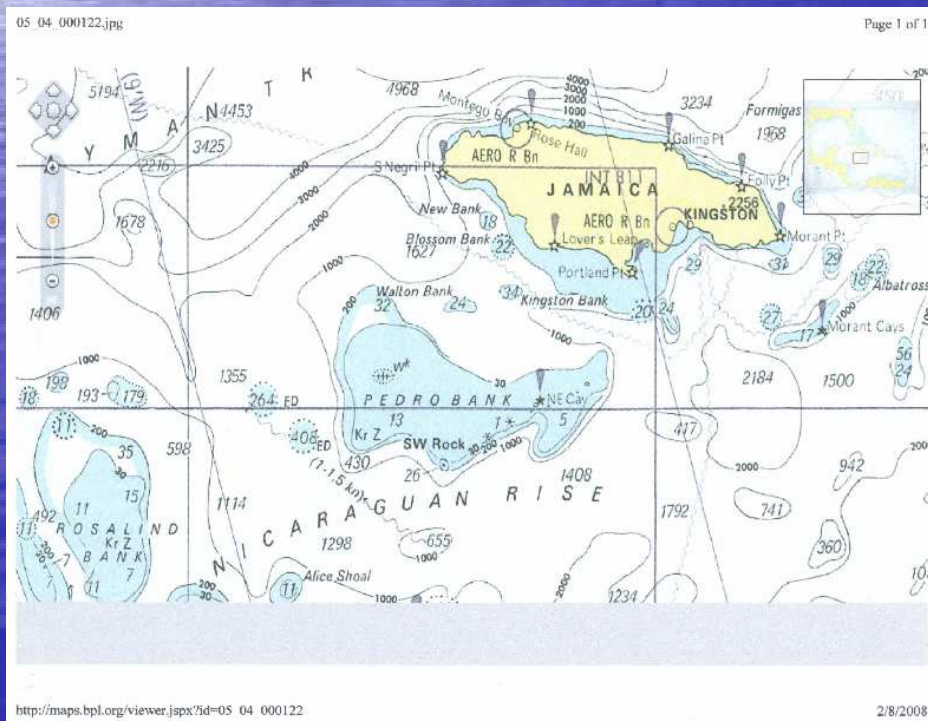
Biodiesel from Algae

*Part I:
Program Summary*

Algae can produce up to 20 times the oil that can be obtained from the highest yielding land plants and does not require fertile land.

Open Ocean Algae-culture and Aqua-culture is possible throughout the tropics

-The deep high nutrient water from a 100 MW OTEC Plant would cost \$200 million to pump without OTEC



Many shallow areas in the Caribbean and Pacific such as the < 30 m deep 8,000 sq KM Pedro Bank off Jamaica, the thousands of km of shallows off Cuba and the atolls of the Pacific would keep the high nutrient discharge water available to grow algae and sea food from the Sun, just as occurs with natural upwelling

Atolls can provide natural containment — over 20,000 atolls in the Pacific





Dallas
Houston
San Antonio

Gulf of Mexico

Nassau
The Bahamas

Turks and Caicos Islands
Cockburn Town

La Habana (Havana)

Cuba

Dominican Republic
Santo Domingo
Port-au-Prince

Charlotte Amalie
San Juan
The Valley
Saint John's

Basseterre
Basse-Terre
Roseau
Fort-de-France

Cayman Islands

Navassa Island
Jamaica
Kingston

Bridgetown
Kingstown
Saint George's

Caribbean Sea

Oranjestad
Willemstad

Caracas

Venezuela

Guyana

Belmopan
Belize

Guatemala
Tegucigalpa
El Salvador
San Salvador

Honduras
Nicaragua
Managua

San Jose
Ciudad de Panama (Panama City)

Bogota

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Pointer 17°28'27.32" N 76°56'28.26" W

Streaming ||||| 100%

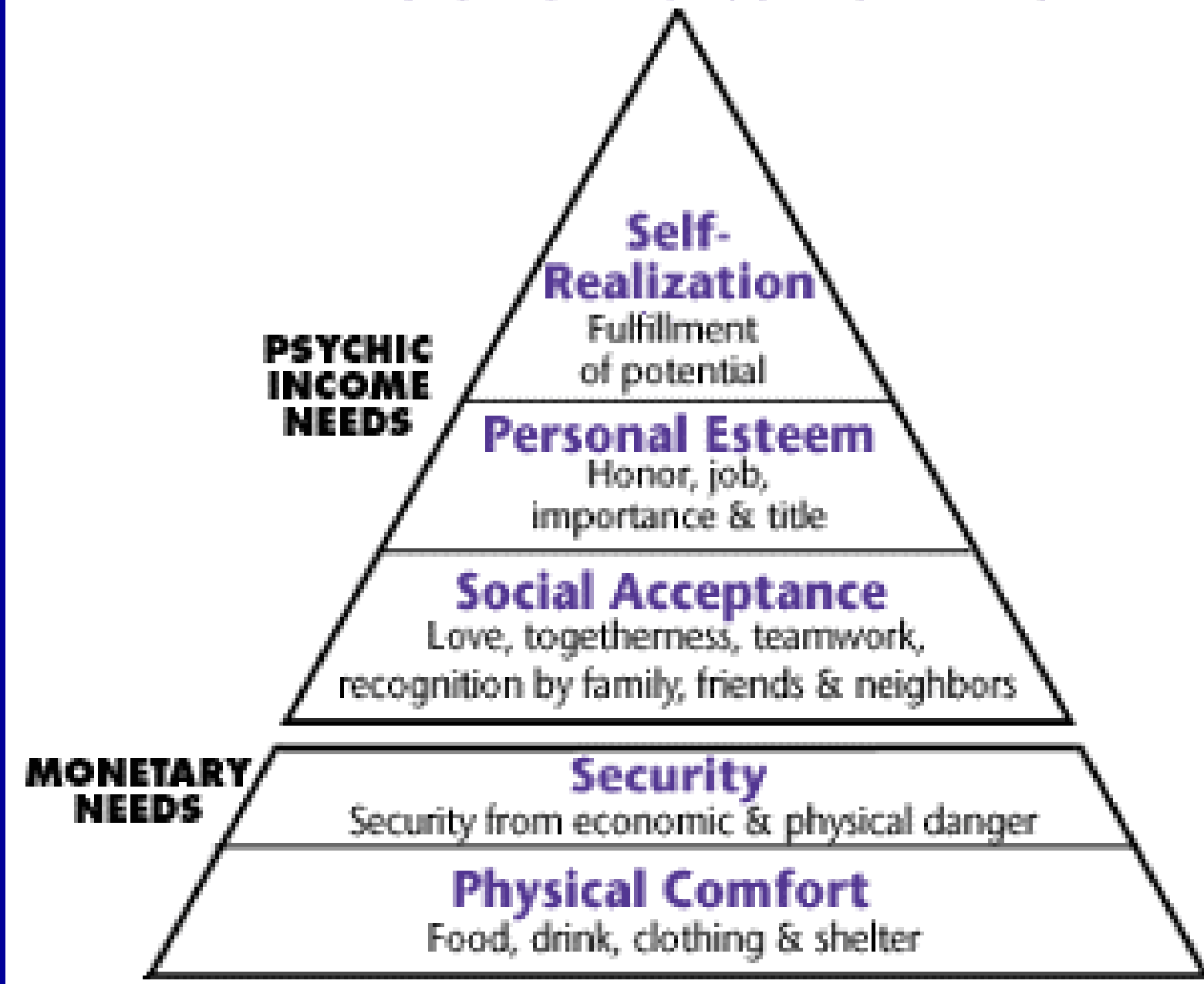
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The Deep Ocean can place
Puerto Rico's future
in its own Hands

This is real the real power
of OTEC



MASLOW'S HIERARCHY OF NEEDS



The OTEC Island Strategy

The most effective path to
Sustainable Economic & Human Growth
for the Tropics



Thank You

