CONTENTS

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MALEIC ANHYDRIDE

EXPANDING INTO THE DOWNSTREAM ENERGY SECTOR

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In keeping with Government's focus to develop the downstream energy sector, one of the projects currently under development is an integrated Maleic Anhydride (MA) Complex. The focus on downstream opportunities and development of the downstream manufacturing and related sectors of the economy will become more robust with the realization of this project venture. The products of this plant will contribute to the evolution of the local energy manufacturing industry by creating employment, business opportunities and allowing for the sustainability of the energy sector.

There are currently several projects under development, as Government through their related state agencies work towards the development of a sustainable energy-based manufacturing sector. The emergence of this new phase of development will use the merits of the energy industry as the building block and use non-traditional raw materials through projects to develop the local downstream manufacturing sector.

The Maleic Anhydride Project

In March 2007 ISEGEN, a South African based company signed an MOU with NGC and NEC for the development of an integrated maleic anhydride manufacturing facility in Trinidad. The facility is expected to produce approximately 20,000 tonnes of maleic anhydride per annum along with a further 23,000 per annum of other products, such as malic acid, fumaric acid and tartaric acid.

The main feedstock for the process is normal butane (n-butane), of which approximately 700 barrels per day will be required. The feedstock will be sourced from Phoenix Park Gas Processors Limited (PPGPL) which is in the process of installing a butane splitter. The iso-butane component will be sold to Petrotrin for refinery operations.

Construction is proposed to begin in Q4 2009 and employment during this phase of the project has been estimated at 600 at peak...

ISEGEN is a global manufacturer of Food Additive Chemicals via the Maleic Anhydride route and exports product to 41 countries throughout the world. Maleic anhydride is an intermediate chemical which is used to manufacture specialty chemicals for applications such as food products, pharmaceuticals, resins, oil additives, detergents and agricultural products. These food additive chemicals are used in beverages, confectionery, jams, jellies, wine, baking, dairy products, canned foods, frozen foods, sauces, meat, etc.

ISEGEN's major clients include: Pepsi Cola, Coca Cola, Cadbury Schweppes, Unilever Bestfoods, Kraft, Arcor and many other multinational food manufacturers.

The proposed project in Trinidad and Tobago will comprise of five production plants. These will include:

- Maleic Anhydride
- Malic Acid
- Fumaric Acid
- Tartaric Acid
- Fruitaric Acid

Some of the products from these plants will be consumed internally in manufacturing processes. Ultimately, the products from the plant that would be available for sale include:

	Tonnes per annum (approximate)
Maleic Anhydride	2,000
Malic Acid	7,000
Tartaric Acid	2,000
Fruitaric Acid	12,500

The raw material requirements for the production of these chemicals are:

- n-butane
- hydrogen peroxide
- caustic soda
- sulphuric acid
- demineralized water
- natural gas for fuel
- water
- nitrogen

The estimated Capital Expenditure for the project is US$135MM and the site for the project is the new Point Lisas South and East Industrial Estate, which is currently being developed by NEC.

Construction is proposed to begin in Q4 2009 and employment during this phase of the project has been estimated at 600 at peak, while permanent employees will be on the order of 30-40 persons. Production is expected to commence approximately 12-18 months after the start of construction.

Production of Maleic Anhydride

Maleic Anhydride can be made from benzene and n-butane. For environmental reasons most new production plants use n-butane. Fluid bed and fixed bed reactor processes can be used. The fluid bed process will be described in this article.

The first stage of this process is where n-butane and air are fed separately into the fluid-bed catalytic reactor to produce maleic anhydride. The exothermic heat of reaction is removed by generating saturated high pressure steam. After cyclone separation of the elutriated solids, the reactor effluent is cooled, filtered and fed to the absorber. The most common catalyst used in this process is vanadium pentachloride.

In the absorber, a proprietary, patented solvent is used to selectively remove maleic anhydride from the cooled reactor effluent. The offgas is exhausted to an incinerator for recovery of its heating value. The bottoms are fed to a stripper where crude maleic anhydride is separated as distillate from recirculated solvent.

The crude maleic anhydride is fed to the light ends column where a small quantity of by-product light ends is separated as distillate and sent to the incinerator. The bottoms are fed to the product column where maleic anhydride product is recovered as distillate and the bottoms are recycled back to the stripper.

A small slip stream of the circulating solvent is purified to remove solvent degradation products in order to prevent the build-up of impurities in the solvent recycle loop.

The absorber offgas is combined with the light ends column distillate and vacuum system exhausts and fed to the incinerator, where unreacted butanes and reaction by-products (carbon monoxide, acetic and acrylic acids) are burnt. The waste heat is recovered as saturated high pressure steam, which is combined with the steam from the reactor and super heated. A portion of this steam can be used to drive the air compressor, with the excess exported or used to generate electric power.

The n-butane process is considered to have superior economics, and is therefore the preferred route.

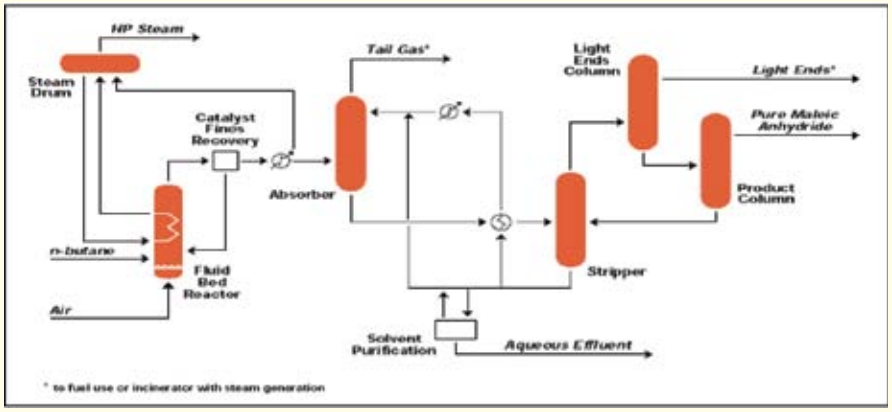

Figure 1: Maleic Anhydride Production Process
Source: ABB Lummus Global

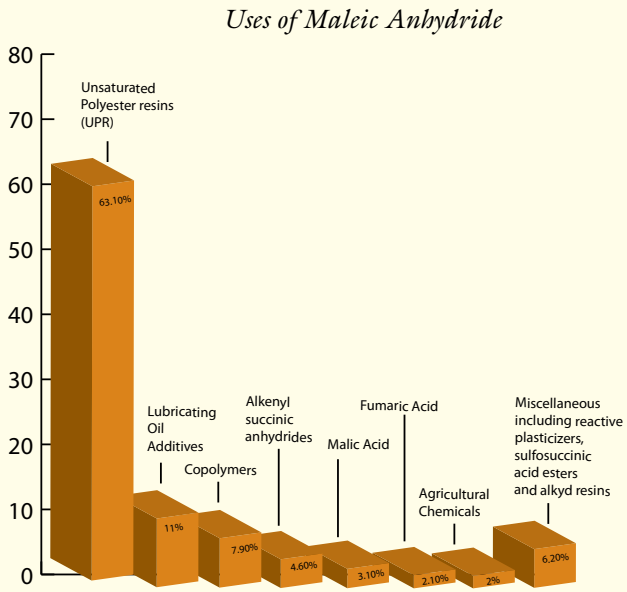

Figure 2: Uses of maleic anhydride
Source: European Chemical News

The diagram above provides an illustration of the fluid bed process used to produce Maleic Anhydride.

Uses

Maleic anhydride is mainly used in unsaturated polyester resins (UPR) which accounts for about 50% of consumption. UPR resins are consumed in the construction, marine and automotive industries.

The other main use is for the production of 1,4 butanediol (BDO) and its derivatives tetrahydrofuran (THF) and gammabutyrolactone (GBL).

Other uses include manufacturing of plasticizers, surface coatings, agrochemicals, lubricants, fumaric acid and malic acid.

MA is also a base chemical used in automotive manufacturing, ship building, paint and varnish, construction, agricultural chemistry and other industries.

Global MA consumption was 1.5mmtpy in 2006. This represented a 6.7% increase from the previous year.

Projected Growth Rate

In several countries, the demand for maleic anhydride is expected to grow in line with GDP. Growth is estimated at 1.5 - 2.0% per year in Western Europe, approximately 4.0% per year in Eastern Europe and 3.0% per year globally up to 2010. Growth will be slower in Western Europe and the USA but higher in Eastern Europe, Latin America and Asia, particularly in China.

Prices

Prices of maleic anhydride in the USA during the period April 2006 - April 2007 ranged from US$1,474 - $1,628 per tonne (fob). European third quarter prices range from US$1,520 - 1,610 per tonne.

Suppliers sought an increase in prices in Q4 2007 as butane prices continued to rise. Analysts also indicated that margins which improved in 2006 have dropped in 2007 and prices have failed to keep pace with record-high butane values.

In 2007 spot prices have remained relatively stable at £1,340- £1,420 per tonne.

Developments in the Maleic Anhydride Industry

New investment in the maleic anhydride industry is focused in Asia, with developments being concentrated mainly in China. In the Western Hemisphere, Huntsman is building a 45,000 tpy plant in Lousiana, which is expected to start production in early 2009.

Russia's OAO Acrylat is also in discussions with relevant parties to build a 30,000 tpy, which may come on stream in 2009.

The table that follows shows the current maleic anhydride plants in operation throughout the world.

Table 1: Maleic Anhydride Plant Capacities ('000 tonnes per year)

Company	Location	Capacity
Bartek Chemical	Stoney Creek, Ontario, Canada	25
BASF	Feluy, Belgium	115
Compania Espanola de Petroleos (CEPSA)	Algeciras, Spain	12
Cray Valley	Drocourt, France	15
Derivados Maleicos	Puebla, Mexico	7.5
DSM Fine Chemicals	Linz, Austria	36
Elekeiroz	Varzea Paulista, Brazil	30
Flint Hills Resources	Joliet, Illinois, US	50
Hungarian Oil and Gas (MOL)	Szazhalombatta, Hungary	20
Huntsman	Pensacola, Florida, US	110
Koksno Hemijski Kombinat	Lukavac, Bosnia	10
Lanxess	Baytown, Texas, US	75
Novomoskovsk Orgsyntez	Novomoskovsk, Russia	12
Marathon Ashland Petroleum	Neal, West Virginia, US	45
Orgachim JSC	Ruse, Bulgaria	1
Polynt	Bergamo, Italy	36
Repsol YPF	Ensenada, Argentina	18
Sasol-Huntsman	Moers, Germany	60
Zaklady Azotowe Kedzierzyn	Kedzierzyn-Kozle, Poland	8

Source: ICIS

Benefits to Trinidad and Tobago

1. The maleic anhydride project would represent a significant diversification in chemical production away from primary petrochemicals into specialty chemical products.
2. The manufactured products would create substantial value added to the n-butane from the PPGPL.
3. There will be an opportunity for the development of food manufacturing industries as well as other specialty chemicals.
4. In terms of the potential benefits of developing a specialty chemicals industry in Trinidad and Tobago, minimal resources of natural gas, power and land will be required for the project.

The new wave of downstream industrial expansion holds favourable for derivative chemicals such as maleic anhydride. Products derived from this chemical can provide the platform for a host of new industries in Trinidad and Tobago.

Additionally, export and sales of such derivatives will increase the revenue and foreign exchanges earnings of the country. The establishment of value-added downstream industries will also help to create and foster entrepreneurship and develop the local skill base of Trinidad and Tobago for a manufacturing industry that has been generated by the energy sector.

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ENVIRONMENTAL WASTE MANAGEMENT BEYOND COMPLIANCE

By MARIO SINGH,
Community Relations Officer

The National Gas Company of Trinidad and Tobago Limited (NGC) has over the years exhibited a commitment to preserving the natural environment. This commitment has its grounding in the Company's Corporate Environment, Health and Safety (EHS) Policy which states:

"The NGC is committed to responsible environmental stewardship, health and safety. This corporate value is strategic to our business success and will be merged with all of our business processes and accountabilities".

NGC has in place an Integrated Waste Management Plan which seeks to reduce the risks posed to NGC's employees, contractors ...

NGC's Environment Management System (EMS)

In delivering on this Corporate EHS Policy, NGC has developed and implemented an Environmental Management System (EMS) which provides the framework for:

- Developing a system that will consistently address and resolve environmental issues;
- Establishing environmental objectives and targets and;
- Demonstrating continual improvement of the system and our environmental performance

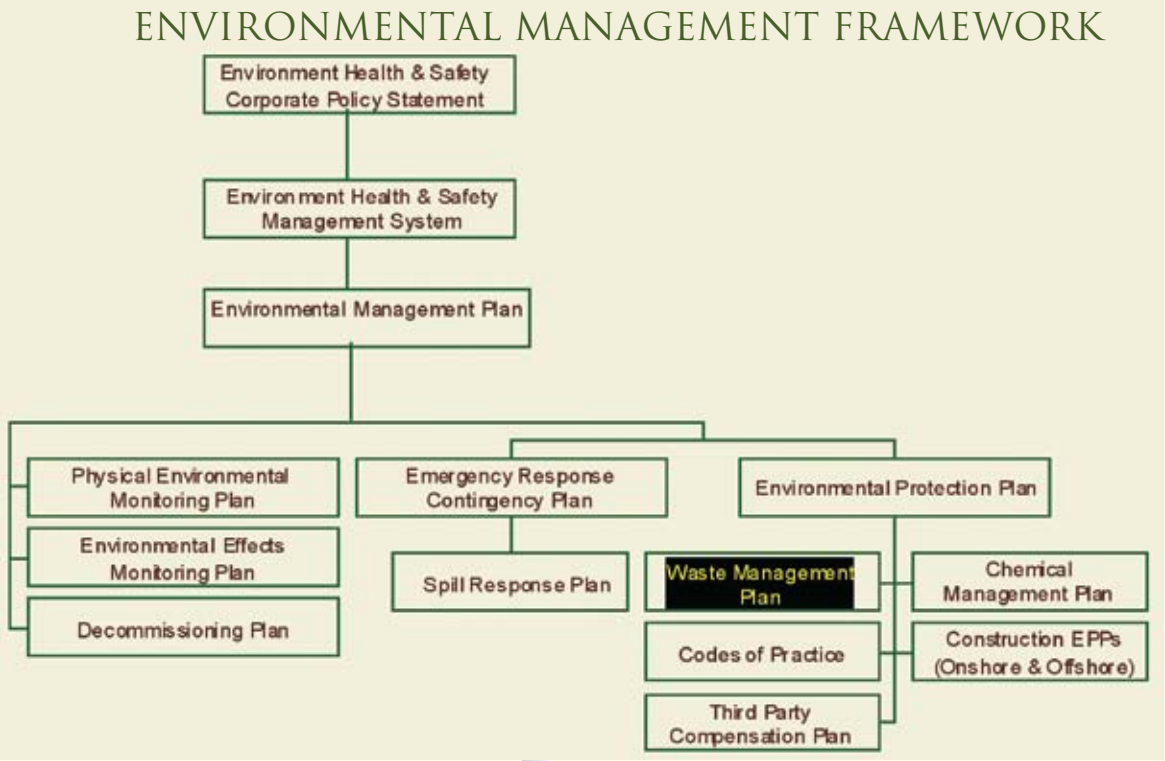
The major elements of NGC's EMS include and Environmental Policy, Planning, Implementation and Operation, Checking and Corrective Action and Management Review. Through these elements NGC has sought to integrate its environmental objectives into all its business processes and systems.

NGC's Corporate EHS Policy also speaks to waste management and reduction whereby it is the Company's Policy to:

"Minimise the generation of waste, and thereby prevent pollution at source and, conserve natural resources".

NGC's Integrated Waste Management Plan

NGC has in place an Integrated Waste Management Plan which seeks to reduce the risks posed to NGC's employees, contractors, communities and natural surrounding environment as a result of improper waste disposal. Apart from



reducing risks, the Integrated Waste Management Plan also assists NGC in attaining legal compliance and reducing costs of its operations.

NGC's Integrated Waste Management Plan adopts the principles of the Waste Management Pyramid which has as preferred waste management methods, prevention, minimisation, reuse and recycling as opposed to incineration and physical disposal which have the highest environmental impacts among the various waste management techniques.

Under the Integrated Waste Management Plan three main categories of waste are identified in accordance with the USEPA' s Resource Conservation and Recovery Act:

- Municipal solid waste;
- Industrial non-hazardous and special wastes and;
- Hazardous waste

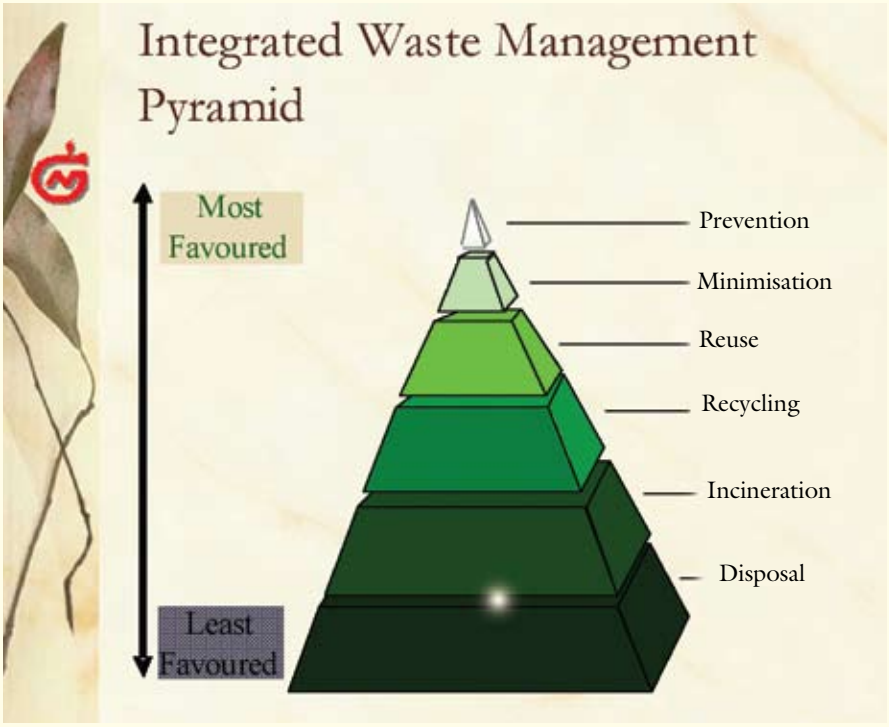
Non-hazardous waste streams at NGC are currently separated for recycling, reuse on site and reuse by third parties. Examples of non-hazardous waste generated by the Company's operations include:

- Ballast tiles
- Bottles (plastic and glass)
- Cables
- Food
- Furniture
- Paper
- Print cartridges
- Sanitary waste-water
- Yard trimmings

Hazardous waste on the other hand is described as any waste with properties which render it dangerous or potentially harmful to human health or the environment. The characteristics of hazardous waste include:

- Corrosiveness
- Ignitability
- Infectiousness
- Reactivity
- Toxicity

At NGC hazardous waste is identified through the use of the:



1. Material Safety Data Sheets (MSDS).
2. Product suppliers and manufacturers.
3. Product labels.
4. Local, regional and, or international legislation.
5. Lab testing where the above information may be deficient.

Some examples of hazardous waste generated at NGC include:

- Asbestos
- Batteries
- Biological waste
- Chemicals
- Fluorescent light bulbs
- Waste electronic and electrical equipment

NGC's Environment, Health, Safety and Security (EHSS) Handbook clearly outlines procedures for the management of hazardous materials and waste. Aspects such as proper storage, labelling, handling (inclusive of required Personal Protective Equipment) and disposal are all detailed. Both employees and contractors must adhere to these procedures.

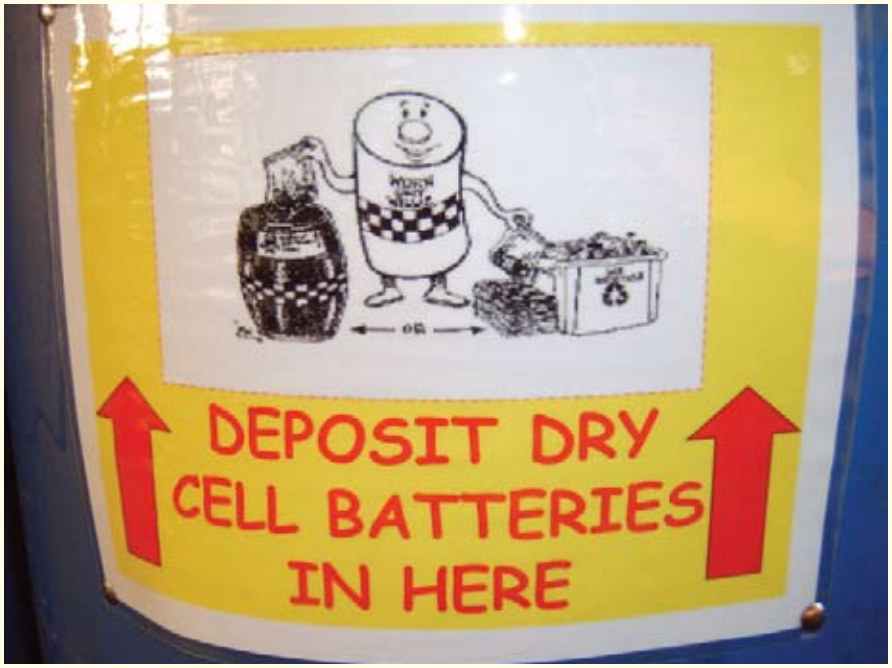
Environmental management beyond compliance

Apart from the policies and procedures built-in to NGC's operations (aimed at environmental management geared towards meeting legal requirements such as the Environmental Management Act (2000) and the Occupational, Safety and Health Act (2006)) NGC through its Environment, Health and Safety (EHS) Department has spearheaded several new environmental waste reduction initiatives.

In July 2007 a Battery Disposal Programme was launched for staff. In this programme staff is encouraged to collect from their homes and work, dry cell batteries for proper disposal. NGC has at present an arrangement with the Solid Waste Management Company Limited (SWMCOL) for proper disposal. Other areas covered by the Programme include:

- Educational awareness – staff are informed of the importance of

proper disposal of dry-cell batteries through emails, the Company's intranet, electronic newsletters and during orientations
- Collection bins – collection bins are strategically placed at locations throughout NGC accessible to all staff
- Packaging of collected batteries – all batteries collected are double-packaged in heavy-duty plastic bags before delivery to SWMCOL
- Transportation to SMWCOL – all collected and packaged batteries are transported safely to SWMCOL for final disposal at approved, designated sites.



More recently in January 2009, Glass Recycling and Print Cartridge Recycling Programmes were launched by the EHS Department. Here both staff and maintenance contractors are encouraged to dispose of glass bottles in specially labelled bins placed throughout NGC. An arrangement is in place to have all collected bottles taken to the Carib Glassworks Limited where they are purchased from NGC for recycling.

With respect to the recycling of print cartridges, each department is encouraged to place all spent cartridges in marked recycling bins. The spent cartridges are taken to PIRANHA International Limited where they are recycled. Staff is also allowed to bring their cartridges from home.

NGC's ECO Phoenix Club

The above waste reduction activities which are considered as voluntary and spearheaded by NGC's EHS Department all fall under the ambit of a new initiative titled the "Eco Phoenix Club". The Club has as its vision:

"To empower employees and their families to become active agents of sustainable and equitable development; promote an understanding that each employee is pivotal to changing attitudes towards environmental issues; and advocate partnerships, which will ensure our nation enjoys a safer and more prosperous future."

The Eco Phoenix Club has set itself several objectives which include and extend beyond waste reduction as follows:
- Minimize the generation of waste (reduce and reuse initiatives)
- Minimize the impact of waste generation (recycling projects)
- Reduce air emissions (tree planting exercises)
- Reduce releases to water sources (clean-ups)
- Reduce energy consumption (educational promotions)
- Gain appreciation for our local wildlife (hikes and nature tours)
- Promote eco-learning and growth (competitions, movies and fun events)

The Eco Phoenix Club also has a built-in element of self-sustainability whereby the revenue generated from the Glass Recycling Programme will be used to partially fund the activities of the club.

All of the policies, procedures and voluntary initiatives at NGC with respect to environmental waste management, strive to ensure that the Company continues to act as a responsible corporate citizen, reducing where practicable, its environmental impact or footprint and going beyond minimum required compliance levels.

ECOLOGICAL RESTORATION OF MANGROVES

By Dr. Reeza Mohammed, PhD.
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Shazam Edoo, DipNEBOSH

The Government of the Republic of Trinidad and Tobago has embarked on a new thrust in downstream gas-based expansion requiring port development to serve the new gas-based industrial estates. The construction of such ports, particularly on the western seaboard, requires sea bed and coastal reclamation in order to create the land space necessary for port construction. These ports are designed so that there is minimum impact on the coastal mangrove ecosystems. However, wherever mangrove is to be impacted, the National Environmental Policy of Trinidad and Tobago makes provision for these impacts through the "No Net Loss of Wetlands Policy". In this regard, port developers are required to restore and/or establish a minimum of the total amount of mangrove impacted by port construction.

National Energy Corporation (NEC), the company mandated to undertake the development of new gas-based industries, is aware of the impacts this could have on the natural environment, and will be prepared to replace mangrove destroyed during its construction activities.

In keeping with the no net loss policy for wetlands, the company has projected that 4 hectares of mangrove will be removed during its activities and in accordance with CEC requirements would undertake to replace what has been lost through a restoration programme.

This paper therefore presents Best Practices and Advances in Wetland Restoration Technology to create a fully functioning mangrove ecosystem which will compensate for any short term ecological, social and economic disruption that can result from port construction. The first of two segments is reproduced for the interest of readers.

What are Mangroves?

The term "mangrove" refers to an assemblage of tropical trees and shrubs that grows in the intertidal zone. Mangroves include approximately 16 families and 40 to 50 species. Mangrove forests develop in areas where high energy waves are absent and sediments accumulate and are hence adapted to survive highly saline environments, water saturated soils and periodic tidal submergence. Mangrove ecosystems are comprised of plants, animals and micro-organisms that have adapted to life in the dynamic environment of the tropical inter-tidal zone. The complex and dense root systems encourage sedimentation and development of a mud substrate that enables more mangroves to spread and expand their range.

Globally, mangroves are distributed along coastlines 30° north and south of the equator. At one time, 75% of the world's tropical coastlines were dominated by mangroves. Unfortunately, mangrove extent has been significantly reduced due to human activities in the coastal zone. There are two centres of mangrove diversity: the Eastern group (Australia, Southeast Asia, India, East Africa, and the Western Pacific) where the total number of species is approximately 44 and the Western group (West Africa, Caribbean, Florida, Atlantic South America, and Pacific North and South America) where the number of species is only seven.

In Trinidad, mangrove ecosystems occur on all coasts with the greatest development being along the sheltered, low-energy Gulf of Paria shoreline. There are seven mangrove species in Trinidad & Tobago: *Rhizophora mangle, R. harrisonii, R. racemosa, (red mangrove) Avicennia germinans (black mangrove), A. Schaueriana, Laguncularia racemosa, (white mangrove) and Conocarpus erectus (button mangrove)*. *R. mangle* is the most widespread species. In general, *R. harrisonii* and *R. racemosa* are more abundant in the east coast swamps, *Rhizopora* species are found along the margins of tidal channels, sometimes mixed with Avicennia germinans, which is also found in pure stands in basins behind levees.

Figure 1: Red Mangrove Prop Roots

Characteristics and Adaptations of Mangroves

Root Adaptations

Mangrove species possess root adaptations to increase their stability in the soft sediments along shorelines. This is especially well developed in red mangroves which have "prop roots" *(See Figure 1)* descending from the trunk and branches providing a stable support system. Other such support adaptations include shallow wide spreading roots which surround the trunks of black mangroves, adding to the structural stability of the tree. Other species such as the white mangrove grow at higher elevations, in drier soils and hence do not require specialized root structures.

Salt Tolerance Adaptations

Mangroves possess physiological adaptations for salt exclusion or salt excretion to allow them to withstand high saline environments. Red mangroves occur where soil salinities range from 60-65 parts per thousand (ppt) while black and white mangroves are found in soils with over 90 ppt salinities. Mangroves exclude salts through the filtration at the surface of the root membranes which prevent salt form entering while allowing the water to pass through. The red mangrove is an example of a salt-excluding species. Black and white mangroves remove salt through glands located on each leaf, and are hence referred to as salt excreters.

Reproductive Adaptations

All mangroves share two reproductive adaptations - viviparity and propagule dispersal. Similar to terrestrial plants, mangroves reproduce by flowering with pollination occurring via wind and insects. The seeds remain attached to the parent tree and germinate into *propagules (See Figure 3)* before dropping into the waters below. Germination of seeds while still attached to the mother plant is called viviparity. The classic example of vivipary is *Rhizophora mangle*, which is able to traverse broad ocean regions by producing large seedlings that float horizontally, undamaged by salinity. These seedlings can be washed up on sand or mud flats, where they settle to establish new populations.

Figure 3: Rhizophora mangle propagules

Figure 2: White Mangrove Flowers

Breathing roots

Mangroves possess specialized root structures to allow them to live in anaerobic (oxygen-poor) sediments. In contrast to most plants, mangrove species have roots growing out of the soil and into the air to remain above the tide levels, so that the connection between the submerged part of the root system and the atmosphere is maintained and continuous supply of air is received by the roots when flooded. Such a mechanism is well exhibited by the black mangrove, the black mangrove possesses numerous vertical pneumatophores *(See Figure 4)* which tip through the

mud from its shallow root system above the average spring tide level (highest monthly tide) and have lenticels on their tips for breathing. The white mangrove also has pneumatophores which are smaller diameter (often pencil diameter and less abundant than those of the black mangrove).

Zonation

Mangrove trees have different degrees of tolerance for exposure and submergence of their roots to seawater, thus the tidal fluctuation results in Zonation of mangrove species. The red mangrove *(Rhizophora mangle)* is the pioneer mangrove in the Caribbean (first to grow in newly exposed muddy shore). It grows as a dense tangle in the water along the edge of the shoreline. Their arching prop roots provide an excellent habitat for many invertebrates. Shoreward from the red mangroves, but still in damp soil, are the black mangroves *(Avicennia spp.)*. The black mangrove fares best where there is occasional inundation, but not by diurnal tides. They are characterized by prop roots that extend from the lateral branches but do not produce the tangle of roots seen in the red mangroves. They also have many pneumatophores that extend upward from the roots around the base of the trunk. The white mangrove is found the furthest inland.

Rationale for restoration

Mangroves in Trinidad & Tobago have been severely impacted due to reclamation of land for port and industrial development, changes in water quality due to fresh water influx and pollution and extreme natural events such a coastal erosion.

In order to sustain the benefits derived from these ecosystems, these systems should be conserved and restored where necessary in an ecologically sound manner. The preceding paragraphs outline the social, economic and ecological functions of mangrove ecosystems.

Figure 4: Pneumatophores of Black Mangrove (Avicennia)

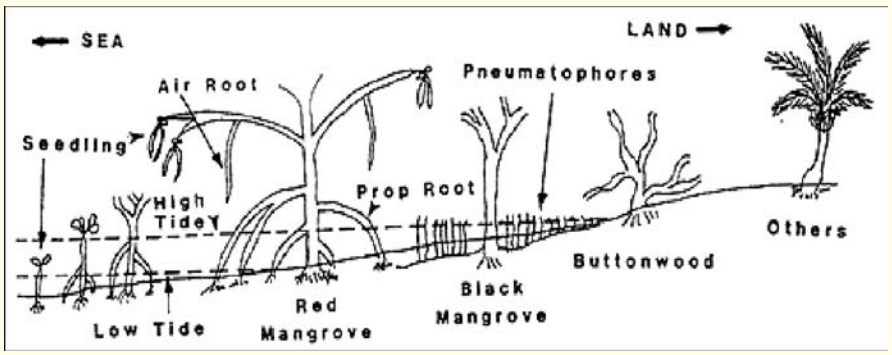


Figure 5: General Zonation Pattern of Mangroves in Caribbean and North America

Shoreline stabilization and Protection

Located along the coastline, mangroves play a very important role in soil formation, shoreline protection, and stabilization. The mangrove forest's extensive, aboveground root structures (prop roots, drop roots, and pneumatophores) act as a sieve, reducing current velocities and shear, and enhancing sedimentation and sediment retention. The intricate matrix of fine roots within the soil also binds sediments together. Not only do mangroves trap sediments, they also produce sediment through accumulated, mangrove-derived organic matter by enhancing sedimentation, sediment retention, and soil formation. Mangroves stabilize soils, which reduce the risk of erosion, especially under high-energy conditions such as tropical storms.

Animal Habitat and Food Source

Mangroves provide both habitat and a source of food for a diverse

animal community that inhabits both the forest interior and the adjacent coastal waters. Some animals depend on the mangrove environment during their entire lives while others utilize mangroves only during specific life stages, usually reproductive and juvenile stages Mangroves' intricate aerial root system, which is most highly developed within the lower intertidal zone, provides a substrate for colonization by algae, wood borers, and fouling organisms such as barnacles, oysters, mollusks, and sponges. From the diverse group of invertebrates found in mangroves, arthropods, crustaceans, and mollusks are among the most abundant and have a significant role in mangrove ecosystems.

As mentioned earlier, some species of crabs, recognized as propagule or seedling predators, can influence mangrove forest structure as may seedling predation by beetles or other insects. Crabs and snails, important components of the detritus food chain, help break down leaf litter through grazing. Shrimp, an important fisheries resource, find food and shelter in mangrove forests.

Likewise, commercially important bivalves such as oysters, mussels, and clams are commonly found in and around mangrove roots. Mangroves are also recognized as essential nursery habitat for a diverse community of fish, which find protection and abundant food in these environments, especially during juvenile stages. Many animals found within mangroves are semi-aquatic or derived from terrestrial environments.

Numerous insect species are found in mangrove forests; some play critical roles as mangrove pollinators, herbivores, predators, and as a food source for other animals. Amphibians and reptiles such as frogs, snakes, lizards, and crocodiles also inhabit mangrove forests. Birds use mangroves for refuge, nesting, and feeding. In Florida and Australia, up to 200 species of birds have been reported around mangrove communities. Most of these birds do not depend completely on mangroves, and use these habitats only during part of their seasonal cycles.

Water Quality Improvement

Mangrove habitats maintain water quality. By trapping sediments in the mangrove root system, these and other solids are kept from offshore waters, thereby protecting other coastal ecosystems such as oyster beds, seagrasses, and coral reefs from excessive sedimentation. This process can also remove agrochemical and heavy-metal pollutants from the water, since these contaminants adhere to sediment particles. Mangroves also improve water quality by removing organic and inorganic nutrients from the water column. Through denitrification and soil-nutrient burial, mangroves lower nitrate and phosphorus concentrations in contaminated water, preventing downstream and coastal eutrophication. However, the potential of mangroves to "clean" water is limited and depends on the nature of the inputs, and the surface area and nutrient biochemistry of the mangrove forest.

Mangrove Economic Value and Uses

There are many mangrove products and services, not all of which are easily quantified in economic terms. Mangrove products can be obtained directly from the forest (wood) or from a derivative, such as crabs, shrimp, and fish. The most common uses of mangrove wood are as a source of fuel, either charcoal or firewood, and as the primary material for the construction of boats, houses, furniture, etc. Given these uses, commercial mangrove production (especially of *Rhizophora spp.)* is common around the world, primarily in Asia.

Besides wood, other mangrove products have been exploited commercially.

Mangrove bark has traditionally been used as a source of tannins, which are used as a dye and to preserve leather. The pneumatophores of different mangrove species are used in making corks and fishing floats; some are also used in perfumes and condiments. The ash of *Avicennia* and *Rhizophora* mangle is used as a soap substitute. Other mangrove extracts are used to produce synthetic fibers and cosmetics. Mangroves are also used as a source of food (mangrove-derived honey, vinegar, salt, and cooking oil) and drink (alcohol, wine). For example, the tender leaves, fruits, seeds, and seedlings of *Avicennia*.

Mangrove forests have been widely recognized for their role in maintaining commercial fisheries by providing nursery habitat, refuge from predators, and food to important species of fish and shrimp. Demonstrating a statistical relationship between mangroves and fishery yields has proven difficult, however, because mangroves, sea grasses, and other nearshore habitats are closely linked, and all provide nursery habitat and food for fish. Mangrove ecotourism is not yet a widely developed practice, but seems to be gaining popularity as a nondestructive alternative to other coastal economic activities. Mangroves are attractive to tourists mostly because of the fauna that inhabit these forests, especially birds and reptiles such as crocodiles.

Carbon Sequestration

Mangroves play a role in sequestering carbon dioxide from the atmosphere. Mangroves have been reported to sequester approximately 1.5 tonnes carbon dioxide per hectare per year. **(www.mangroveaction.project)**

The socio-economic and ecological values of mangrove ecosystems provide a powerful rationale for their preservation. The restoration of degraded mangroves and creation of new habitat would indeed contribute towards the overall goal of sustainable development whereby development meets the needs of the present without compromising the ability of future generations to meet their own needs.

Note that Part II will be published in the next issue and references/sources will be cited at the end of Part II.

Update on Union Industrial Estate Pipeline

The proposed alternate route for the pipeline to tenants on the Union and La Brea Industrial Estates has been revised. The route will begin from a tap off the 56-inch-diameter Cross-Island Pipeline near Rousillac and follow a route westwards before turning north to Union Industrial Estate along a new Right of Way (ROW). The total length of the pipeline has been reduced from 8km to 5km.

A modification to the CEC for this project was submitted to the EMA in September 2008, and further documentation was submitted in December 2008 in support of the modifications to the route. The first customer expected to tap the line is Trinidad Generating Unlimited, which has been contracted to supply power for Alutrint's operations. Initial demand to the estates is expected to be 165 MMscf/d of which 8 MMscf/d is earmarked for use by small consumers at the La Brea Industrial Estate.

Additional proposals include the construction of an 8-inch-diameter low-pressure, high-density polyethylene line to small customers on the La Brea Estate and a 16-inch distribution line with service connections for tenants at Union's Site B. The 16-inch-diameter distribution line to Site A terminates at the Gas Facilities planned.

A contract to supply line pipe was finalized in December 2008 with Tubacero of Mexico and tenders were received in December for site preparation of the storage yard at Union Industrial Estate. First gas is projected by the end of March 2010.

Transmission and Distribution Network Expands

Between September and December 2008, designs, pre-commissioning and commissioning works were completed on a number of facilities. These included:

- The installation of a 50-mm-diameter tie-in valve and gas main along Ajax Street and a 152-mm-diameter line across Richmond Street to the Government's Campus Plaza. A combination of open cut and horizontal drilling techniques were used to minimize public inconvenience;
- The 6km, 36-inch-diameter 'pipeline loop to Ring Main' at the corner of Atlantic and Pacific Avenues on the Pt Lisas Industrial Estate;
- The 66km, 36-inch-diameter BUD Offshore/onshore Pipeline was pre-commissioned. The 66km line runs from bpTT's Cassia Platform to NGC's Beachfield Facilities at Guayaguayare;
- The metering station at the MHTL AUM on Caribbean Drive, Point Lisas Industrial Estate;
- Engineering designs for the replacement of the 4-inch-diameter natural gas pipeline to Longdenville with a combination of 4-inch and 8-inch-diameter pipelines.

Pipelaying – hoop to ring main

Liquid Fuels Pipeline & Ancillary Facilities Project On-stream

Works on the Liquid Fuels Pipeline & Ancillary Facilities intended to improve security of fuel supply and reduce Road Tank Wagon congestion on the roads of Trinidad and Tobago are 58% complete as of December 2008. The project consists of the construction of a Multifuels Pipeline from Petrotrin, Pointe-à-Pierre to a Road Tank Wagon Loading Terminal at Frederick Settlement, Caroni and a Jet A1 fuel pipeline from the Frederick Settlement Loading Terminal to NP's Terminal at Piarco.

For the period covered PIDs have been signed off and returned by the

three stakeholder groups Petrotrin, NP and NGC to the Design and Engineering Contractors, Kellogg Brown & Root (KBR). HAZOP studies were performed for Process and Instrumentation Diagrams (PIDs) specific to pipelines and the Frederick Settlement Facility with HAZOPS outstanding for Main Pump and Petrotrin Facilities.

Final construction and specification drawings for pipeline construction have been completed. Tenders for pipeline Construction Services have also been invited and reviewed. Tenders have been invited for earth fill at the Caroni Site.

In addition to constructing the Liquid Fuels Pipeline, NGC will construct a 4-inch-diameter Isobutane line for Petrotrin, from Pointe-à-Pierre to PPGPL, within the existing NGC Right of Way. Mandatory public consultations were held as part of preparatory work in the EIA process. An EIA has been submitted to the EMA by contractors, KAIZEN, and stakeholders are awaiting results of the EMA review process. The first shipment of 10 containers of line pipe will arrive in Trinidad in the first quarter 2009 with the containers stored at the NEC yard.

NEO/Tobago Pipeline Project Completion Date Extended

NGC has extended the completion date of this project from January 2010 to January 2011, and a revised project construction plan is being prepared. In the last quarter of 2008, Public Consultations were held for residents of Tobago and Mayaro likely to be impacted by construction activities. Meetings have also begun with Tobago Fisheries, the Tobago House of Assembly and the Divers Association of Tobago.

Environmental Services Limited, a local service provider, conducted two EIAs and submitted them to the EMA in October, 2008. CECs are expected by the end of February 2009. Tenders have been invited for construction of civil and structural works for the Gas Metering Facility at Cove Estate.

The pipe manufacturing mills – Tennaris of Mexico for the 12-inch pipe and Welspun of India for the 36-inch pipe – were reviewed, and pipe manufacturing has begun with the first shipment expected in mid-February 2009. Bredero Shaw, the subcontractor working with Weldspun and Tenaris to concrete coat the pipe to Tobago has mobilized at La Brea and it is anticipated that the coating process will begin by the end of March. Casbarian Engineering and Associates Limited have been contracted as certification agent for the project.

Phoenix Park Valve Station

Phoenix Park Station Upgrade in Train

Site preparation works for the upgraded valve station were completed in the last quarter of 2008, inclusive of drainage, underground duct banks, fencing to enclose the site and first grade roadways within the compound. High tension poles located on the site were moved and low voltage poles replaced with low voltage underground duct band. Piling works for more than 40 light poles on the site have been completed. Piling and foundation works have commenced under contractor Gordon Winter Construction Limited, with "spread-footing" foundations being constructed and two of five test piles bore holes completed. Control valves and pressure safety valves have been received, and 'in-service' welding in preparation for hot taps of the 30-inch, 36-inch, and 48-inch inlet piping to Phoenix Park Gas Processors begun.

TD Williamson will perform the large bore hot-taps in January 2009. Tenders for mechanical, structural, electrical and instrumentation works on the main site as well as tender submissions for a Certification Verification agent are under review. Procurement for the project is 70 percent complete and design optimisation for the project is being undertaken to ensure that maximum value is derived.

Construction is still in its early stages and is 10 percent complete with an anticipated completion date of second quarter, 2010.

Pt Lisas Industrial Estate Expansion Update

The project scope for the expansion of the Pt Lisas Industrial Estate now includes 50 five-acre plots for light industrials, a road network and storm water management systems. Project consultant Blake, Beston, François and Loquan (BBFL) is working with a Canadian consulting firm to develop designs, and has presented detailed plans, which are under evaluation.

Designs of the road package are 90 percent complete and the infrastructure design is 80 percent complete. The traffic study, which analyses existing traffic flows and future routing to compensate for post-development traffic has been completed. Proposals for a highway overpass and Southern Main Road intersection, allowing access to the new port area are being studied. The corridor linking the port area to the estate will accommodate heavy estate traffic loads, specifically truckloads of up to 100 tons.

The spectrum of investment for support services is widening, and proposals for hotels, restaurants, recreation and conference facilities are being considered.

In addition there has been new interest in the construction of smaller, high-tech support service industries on the estate and planning is being adjusted to accommodate this profile of interest in estate occupancy.

Drainage is a key part of the planning process and water management strategies are focused on separating and conserving pure water supplies from contaminated water destined for treatment. The consultant has been tasked with planning appropriate waste disposal systems, a key component in the overall project planning. A proposal to manage this aspect of the project was submitted by BBFL for the completion of the EIA study.

Oropouche Bank Study

Technital is at the start of a projected 30-month study of the Oropouche Bank and has completed its first preliminary report and a review of the data collected. Based on this report, some early issues have been identified, particularly the need to comply with environmental preservation criteria.

NEC is now able to respond to the EMA queries that arose from the CEC application in December 2005. Questions to be addressed based on the preliminary report include dredging and reclamation methodology and related issues, fill sourcing, hydrodynamic modeling and economic feasibility modeling.

Initial findings from the report:

- Reclamation will protect the Mosquito Creek Roadway from coastal erosion and flooding;
- Outfall from the Godineau River and hydraulic connectivity of the wetlands and the Gulf of Paria will be investigated thoroughly to ensure that there are no undue impacts on the ecology and coastal morphology;
- Preliminary hydrodynamic analyses have been validated and used to model the shape, location and coastal protections for the proposed island;
- Socioeconomic studies will evaluate the impact on the area's fishing industry.

In accordance with statutory requirements, a programme of public consultations and community involvement is planned. Technital is now preparing a second technical report with an emphasis on hydrodynamic modeling to analyze wet and dry season data and provide predictive information on development outcomes. A comprehensive study of the fish resources of the Gulf of Paria commenced in August 2008.

Pt Lisas South and East Port Expansion Updates

The Pt Lisas Port Expansion Project is designed to extend the capacity of the existing port facilities, add 700 metres of dock face, and eight hectares of port storage. The facility will be Panamax rated, with a draft of 12.8 metres. Saipem of France has been awarded the contract to design and construct the facility.

Detailed designs have been completed and are being reviewed by NEC. Saipem is awaiting certification of their design from Bureau Veritas, an engineering classification society based in Paris.

Procurement of materials has commenced for circular steel and sheet piles, tie rods and anchor wall. A five-acre storage yard has been constructed, and 9,000 tons of steel piles are now onsite. Nine containers of small tools and equipment have also been landed and in storage. The procurement of local materials and the contracting of local suppliers have also been completed and this represents significant local value added, or ten percent of the overall contract.

CEC approval to start is now expected in March 2009. The delay was occasioned by NEC's decision to modify the design concept to remove 450 hectares of reclamation from the project scope to minimize the potential loss of sea floor. This also means that overall hydrodynamic and coastal morphological impacts will be significantly improved with these design modifications. Fieldwork for data to support and validate the design and planning are ongoing.

Aerial of La Brea Industrial Estate and Brighton Port in background.

Pipe Coating Begins at La Brea Estate

The La Brea Industrial Estate now has 95 percent occupancy of its 55 lots. A major pipe coating project has been started on Union Estate by Shaw Pipe Protection Ltd.

Average monthly employment for the first ten months of 2008, inclusive of the Fabrication Yard, Alutrint Dock Construction and Port operations, was 901 persons with 353 or 39 percent of those employed, drawn from La Brea and its environs.

Key highlights of the Port of Brighton operations included the fabrication and load out of the Savonetta Jacket and Poinsettia Production Deck by TOFCO and the harbour dredging to the Panamax depth of 12.8 metres.

Alutrint Materials Handling Facility Contract Awarded

This facility is being handled with an EPC turnkey contract with Grandi Lavori Fincosit, signed and awarded November 2008. The project is expected to run for 25 months. Preliminary designs are ongoing and construction is expected to commence in the second quarter of 2009.

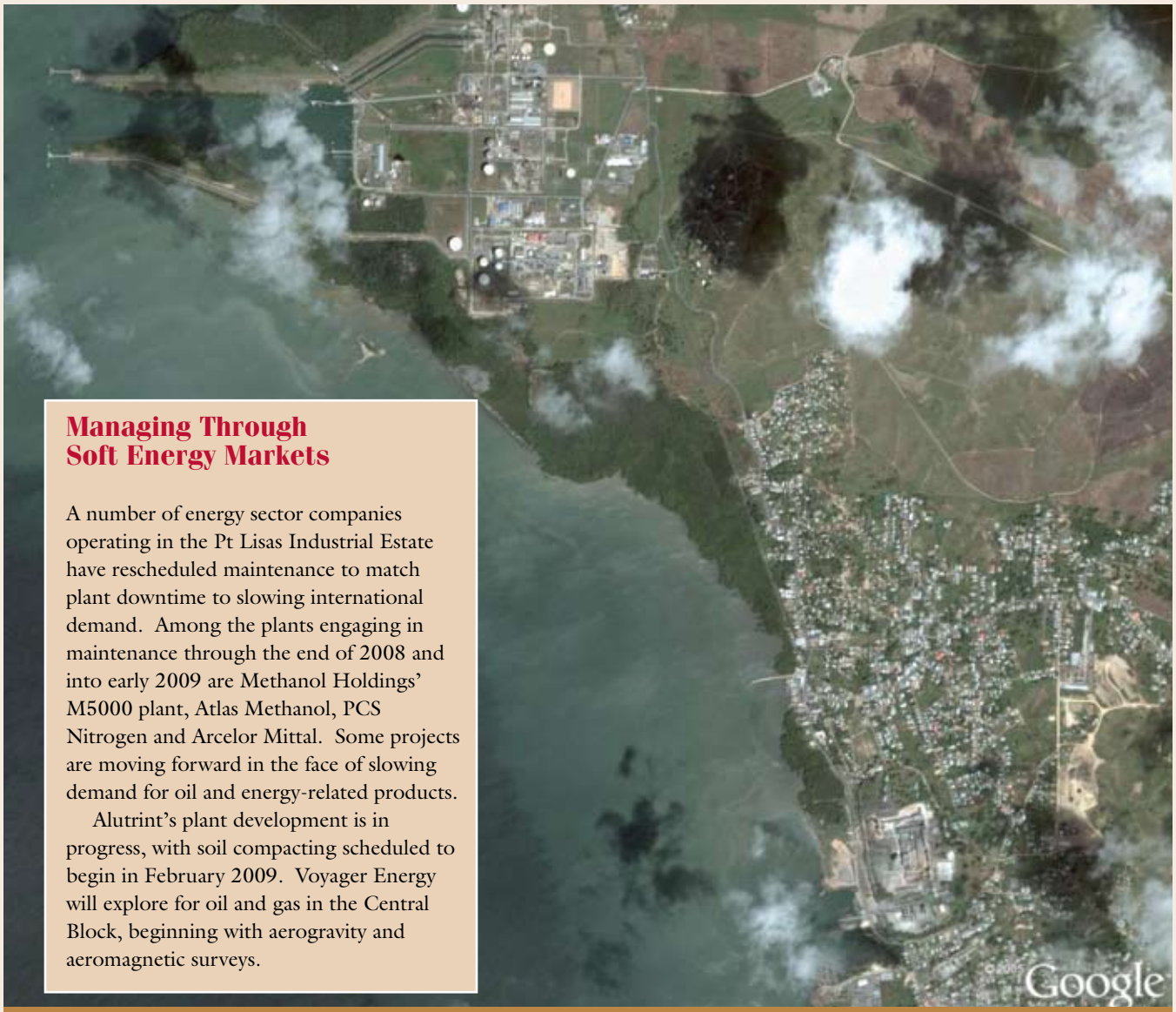
Capital and Maintenance Harbour Dredging Completed

Maintenance dredging has been completed by the contractor, Boskalis. Capital dredging for the project requires a CEC, which is expected by the second quarter of 2009.

Alutrint Dock and Storage Yard Construction in Progress

The CEC for the project was awarded in June 2008 and construction is in progress. Site reclamation is 50 percent complete and pile installation for the key wall iss 20 percent complete. Construction, managed by contra00ctor Pihl Besix, is expected to be completed by the last quarter of 2009. The project includes appropriate local content participation.

Earthworks have been subcontracted to Namalco, a local contractor, with 60 percent of the daily paid workforce coming from La Brea and its environs.



Managing Through Soft Energy Markets

A number of energy sector companies operating in the Pt Lisas Industrial Estate have rescheduled maintenance to match plant downtime to slowing international demand. Among the plants engaging in maintenance through the end of 2008 and into early 2009 are Methanol Holdings' M5000 plant, Atlas Methanol, PCS Nitrogen and Arcelor Mittal. Some projects are moving forward in the face of slowing demand for oil and energy-related products.

Alutrint's plant development is in progress, with soil compacting scheduled to begin in February 2009. Voyager Energy will explore for oil and gas in the Central Block, beginning with aerogravity and aeromagnetic surveys.

Satellite view of Pt Lisas

Senator Conrad Enill

Energy Minister Certain of Price Rebound

Minister of Energy and Energy Industries, Senator Conrad Enill expressed his confidence in Trinidad and Tobago in spite of the market instability in the larger world economies. Speaking at the signing ceremony for a new Product Sharing Contract for Block 2 in the North Coast Marine Area (NCMA) for ONGC Mittal Energy and Petrotrin, the Minister noted that the signing was indicative of Trinidad and Tobago's continued capacity to attract investment in the midst of the negative global outlook for energy and energy related markets.