HYDROGEN ECONOMY:
BASIC COMPETENCIES AND INVESTMENT OPPORTUNITIES
IN NIGERIA

BY

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INTERNATIONAL CONFERENCE ON HYDROGEN FUEL CELLS AND
ALTERNATIVES IN THE TRANSPORT SECTOR
MAASTRICHT, NETHERLANDS

7-9 NOVEMBER 2005
KEY TOPICS

- What we know about Hydrogen
- Fuel Cells
- Skepticisms on use of Hydrogen
- Why Hydrogen?
- Sources of Hydrogen

- NNPC Group & JV Partners
- Hydrogen Production at EPCL
- Our Competencies & Investment Opportunities
## WHAT WE KNOW ABOUT H2

<table>
<thead>
<tr>
<th>WE KNOW THAT HYDROGEN</th>
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<tbody>
<tr>
<td>NONMETALLIC, MONOVALENT ELEMENT</td>
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<tr>
<td>LIGHTEST OF KNOWN ELEMENTS</td>
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<tr>
<td>SIMPLEST STRUCTURE</td>
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<td>MOST ABUNDANT ELEMENT ON EARTH</td>
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<th>BUT</th>
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<tr>
<td>NOT FOUND IN UNCOMBINED STATE</td>
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<tr>
<td>MUST HAVE TO BE EXTRACTED</td>
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<td>CHOICE FUEL FOR FUEL CELLS</td>
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FUEL CELLS

Electrochemical devices which convert chemical energy of fuel oxidation directly to electricity without combustion.

Relatively light, efficient and quiet source of power.

Classified by type of electrolyte employed, which depends on:
- kind of chemical reaction, catalyst required, temp range, fuel required, etc.
Each type has its own advantages, limitations and potential applications. The technology is said to be highly efficient with low emissions. Can be used for almost everything from powering vehicles to stationary applications and to man space flights. Most fuel cells are powered by Hydrogen.
SKEPTICISMS ON USE OF HYDROGEN

- Safety and Efficiency
- Weight and Volume of H2 storage systems
- Cost and Time of refueling
- Electricity required produce H2

- May need to be compressed or kept at low temps
- Infrastructure required to produce, transport and store large quantities of Hydrogen
WHY HYDROGEN?

The concept of H2 power has become increasingly important in recent years.

H2 has the highest energy content per unit mass of any known fuel.

Once separated, the ultimate clean energy carrier.

H2 fuel cells work like batteries, and the only byproduct is water unlike toxic chemicals and greenhouse gases emitted by burning fossil fuels.
WHY HYDROGEN? cont’d

The technology has the potential to cut both pollution and global dependence on oil.

Space shuttles use H2-powered fuel cells and the key emission, water, is consumed by the crew.

Experts believe H2 is safer than gasoline or diesel if used properly.

H2, like any fuel, store energy.

Handling requires certain safety precautions.

H2 disperses and floats skywards when leaked [so light].
Spilled H2 won’t soak into clothing, and will not ignite like gasoline or soak into earth and pollute ground water or cause environmental disaster.

Carbon-based fuels burn with glowing hot soot particles radiating heat to you and surroundings.

Even if H2 ignites, it burns cleanly with no residue of hot soot, producing little radiant energy.

You will have to practically be in the flame in order to get burned.
Pressurized H2 tanks can explode but so also can our gasoline tanks
- H2 tanks are made to withstand enormous impacts
- H2 infrastructure includes a system of detectors to pinpoint leaks, alarms to notify of leakage and a system of cut-off points all regularly tested

Natural gas is reformed to produce H2 for industrial use in refineries, petrochemical plants, food processing etc
- These industries have already resolved the safety issues around the storage and transportation of H2
# SOURCES OF HYDROGEN

- Water Electrolysis
- Photo Electrolysis
- Biomass Gasification
- Coal Gasification
- Methanol Dissociation
- Ammonia Dissociation
- Partial Oxidation of Hydrocarbons
- Refinery & Chemical Off-Gases
- Steam-Methane Reforming [SMR]
WATER ELECTROLYSIS

Passing electric current through water \([H_2O]\) to separate it into \(H_2\) and \(O_2\).

\[
H_2O \leftrightarrow H_2 + \frac{1}{2}O_2
\]

Requires electricity which ideally should come from renewable sources like solar, wind or hydro.

70°C
PHOTOELECTROLYSIS

- Uses sunlight to split water via a semiconductor material.
- Incoming light stimulates the semiconductor to split $\text{H}_2\text{O}$ into constituent gases.
- Promising but has not evolved beyond the laboratory.
BIOMASS GASIFICATION

- H2 can be extracted from H2-rich biomass sources like wood chips and agric waste
- When heated in a controlled atmosphere, biomass converts to synthesis gas
- Hurdles have been economic rather than technical

- Increasing demand for Hydrogen may make biomass gasification economically viable in future
COAL GASIFICATION

- Hydrogen is made from coal by reacting it with steam.
- Techniques are being developed to sequester the remaining carbon: CO$_2$ is re-injected or mineralized via carbonates.

- Burning coal produces many harmful emissions.
- Coal mining spoils the landscape.
Almost all H₂ used worldwide today comes from natural gas reforming.

Natural gas is made to react with steam in a 2-step process producing H₂ and CO₂.

\[
\text{CH}_4 + \text{H}_2\text{O} \leftrightarrow 3\text{H}_2 + \text{CO}
\]

\[
\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{H}_2 + \text{CO}_2
\]

Relatively efficient and inexpensive process.

Produces moderate emissions of CO₂ …
CO$_2$ emission need not be pumped into the atmosphere
Can be profitably re-sequestered at wellhead for greater yield

SMR is affected by fluctuating price of natural gas which is still being flared in Nigeria
OUR VISION

NNPC WILL BE A WORLD-CLASS OIL AND GAS COMPANY DRIVEN BY SHARED COMMITMENTS TO EXCELLENCE
NNPC IS AN INTEGRATED OIL AND GAS COMPANY, ENGAGED IN ADDING VALUE TO THE NATION’S HYDROCARBON RESOURCES FOR THE BENEFIT OF ALL STAKEHOLDERS
NNPC GROUP

Platform for Nigeria’s participation as a major player in the global oil industry

Vehicle for actualizing national aspirations in the oil and gas sector

HAS MANDATE TO:

- Build our crude oil reserves from 33b barrels now to 40b barrels by 2010
- Increase production from 2.7mbpd now to 4.5mbpd by 2010
NNPC MANDATE CONT’D

- Commercialize our vast natural gas resources estimated at 168 TCF, through the development of domestic and international markets

- Facilitate local participation in the industry by fast-tracking technology transfer and harnessing linkages with other sectors of the economy
NNPC MANDATE CONT’D

- Maintain domestic self-sufficiency in the supply and distribution of petroleum products and derivatives through a market oriented downstream sector

- Transform our country from an oil dependent mono-cultural economy to an industrial poly-cultural economy using the industry as the basis for our industrial take-off.
NNPC is undergoing a transformation process aimed at repositioning the Corporation towards fully realizing its vision and mission [PROJECT PACE]

NNPC has opened its operations to private sector investments in line with modern trends in global business and govt policy of deregulation, liberalization and privatization
NNPC STRUCTURE

NNPC is involved in exploration, production, refineries, petrochemicals, transportation and marketing activities.

10 SBUs, 2 partly owned SBUs and 16 associated companies.

Group Managing Director’s Office
4 Directorates: E&P, R&P, F&A and CS
NAPIMS in E&P directorate monitors and supervises government investments in the Joint Venture, Production Sharing and Services Contract agreements.
POSITIONING AND ALIGNING NNPC FOR HIGHER PERFORMANCE CREATING APPROPRIATE PROCESSES AND SYSTEMS FOR GLOBAL COMPETITIVENESS ENABLING AND EMPOWERING OUR PEOPLE
ELEME PETROCHEMICAL COMPLEX

OLEFINS 997 K T/Y (May 1995)
- PRF ex PHRC 98 K T/Y
- NGL ex NAOC 899 K T/Y
- FUEL GAS ex NAOC

ETHYLENE
- Kellogg Brown & Root
- Chiyoda

BUTENE-1 22 K T/Y (September 1996)
- Kobe Steel Ltd.

POLYETHYLENE 270 K T/Y (September 1996)
- Kobe Steel Ltd.

POLYPROPYLENE 80 K T/Y (August 1995)
- Technimont & JGC

PE RESINS
- HDPE – 162 K T/Y
- LLDPE – 108 K T/Y

PP RESINS 80 K T/Y

VIRGIN C5+ 80 K T/Y

PRF ex PHRC 98 K T/Y
NGL ex NAOC 899 K T/Y
FUEL GAS ex NAOC

Ethylene Make 300,000 MT/Y

Propylene Make 126,000 MT/Y

(POWER & UTILITIES 1994)

(Nigeria National Petroleum Corporation)
H2 PRODUCTION AT EPCL

- NGL
- FRACTIONATION
- QUENCHING
- CRACKING
- PRODUCT SEPARATION
- PG COMPRESSION
- DRYING
- CHILLING
- PSA
- H2 [99.99 mol %]
- FUEL GAS
- H2 COMPRESSION
- H2 STORAGE

- VC₅⁺
- CC₅⁺
- ETHYLENE
- PROPYLENE
- WASH OIL
- STEAM
- RECYCLES

Nigeria National Petroleum Corporation
<table>
<thead>
<tr>
<th>PLANT</th>
<th>CAPACITY ‘000 MTPA</th>
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<tbody>
<tr>
<td>ETHYLENE / PROPYLENE</td>
<td>STAGE I</td>
</tr>
<tr>
<td>BUTENE-1</td>
<td>22</td>
</tr>
<tr>
<td>POLYETHYLENE</td>
<td>270</td>
</tr>
<tr>
<td>POLYPROPYLENE</td>
<td>80</td>
</tr>
<tr>
<td>ETHYLENE OXIDE / ETHYLENE GLYCOL</td>
<td>STAGE II</td>
</tr>
<tr>
<td>P-XYLENE</td>
<td>45</td>
</tr>
<tr>
<td>TEREPHTHALIC ACID [TPA]</td>
<td>65</td>
</tr>
<tr>
<td>POLYETHYLENE TEREPHTHALATE [PET]</td>
<td>75</td>
</tr>
<tr>
<td>ISOPROPANOL</td>
<td>STAGE III</td>
</tr>
<tr>
<td>POLYVINYL CHLORIDE [PVC]</td>
<td>140</td>
</tr>
<tr>
<td>VINYL CHLORIDE MONOMER [VCM]</td>
<td>145</td>
</tr>
<tr>
<td>CAUSTIC SODA / CHLORINE</td>
<td>110 / 100</td>
</tr>
<tr>
<td>DOP PLASTICIZER [DI-OCTYPHTHALATE]</td>
<td>35</td>
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INVESTMENT OPPORTUNITIES

ABUNDANT NATURAL RESOURCES
- Large oil reserves
- Large gas reserves [3 x oil reserves]
- Vast fertile land [for planting cassava or sugar cane for ethanol additive project]
- Coal and other solid minerals

VIBRANT OIL AND GAS SECTOR
- 80% of Nigeria’s foreign exchange
- Cheap labour
- Large market [potentially]
- Totally reformed [by present administration]
- Generous incentives, Investor friendly.

Nigeria National Petroleum Corporation
INVESTMENT OPPORTUNITIES

GAS BUSINESS OPPORTUNITIES

- Large population with significant gas usage potential
- Both domestic and export-led gas projects show strong growth prospects
- Total Gas Reserves ~ 168 TCF
- Committed Reserves [TCF]:
  - Existing projects – 16.0
  - On-going projects – 5.4
  - New/Proposed projects – 20.0
  - Undeveloped ~ 126.6
INVESTMENT OPPORTUNITIES

CNG AUTOMOTIVE APPLICATIONS

Use of Compressed Natural Gas [CNG] as an automobile fuel is being commercialized.

Investment opportunities exist in CNG Filling Stations, Conversion Workshops [to convert vehicles from petrol/diesel to CNG operations] and Conversion Kits.
INVESTMENT OPPORTUNITIES

Nigeria plans to spend $67.1b in the petroleum sector between now and 2008

- Oil exploration and production - $34.4b
- Gas production, supply and distribution - $32.7b
- Create 10,000 new jobs

This investment strategy received wide commendation at the 18th World Petroleum Congress in South Africa last September
INVESTMENT OPPORTUNITIES

NNPC INTEREST IN ALTERNATIVE ENERGY

- A new Division has been created for renewable energy projects
- A new unit in this division has started work on Ethanol Project
- Another unit may be created for H2 Economy
- Extensive investment opportunities available

PARTNERS URGENTLY NEEDED IN ALL ASPECTS OF:

- H2 production
- Distribution and
- Storage infrastructure
THANK YOU