

TOWARDS HYDROGEN ENERGY ECONOMY IN INDIA

by

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Alternatives in the Transport Sector:
Issues for Developing Countries
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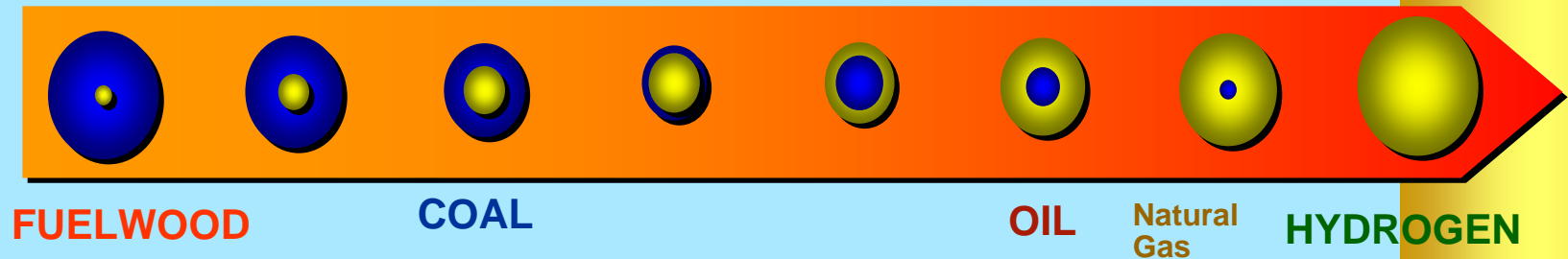
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CHALLENGE OF DECARBONISATION: GLOBAL

- **Primary energy used globally: 9741.1 mtoe;**
- **Of this 88% is fossil fuels - 37% oil, 26% coal, 24% natural gas**
- **Global trend is to move from fossil fuels to carbon free fuels, including renewables. Decarbonisation driven by protection of environment.**
- **For India and other oil importing developing countries, *energy security* is the main driver for decarbonisation.**

Transition to Hydrogen Energy



▣ Present Scene :

Petrol /Diesel /CNG based Automobiles & Power Generation

▣ Intermediate Stage :

Electric & Hybrid Vehicles; Bio-Fuel / Synthetic Fuel based Vehicles & Power Generation

▣ Ultimate Objective :

Environment Friendly and Carbon Free Hydrogen Based Vehicles & Power Generation

A world map with a blue background. The continent of India is highlighted in a bright yellow-green color. The rest of the world's landmasses are shown in a lighter, semi-transparent yellow-green. The map is centered on the Indian subcontinent.

***||
ENERGY SITUATION IN INDIA***

ENERGY SCENARIO IN INDIA

- **India ranks fifth in the world in terms of energy consumption.**
- **Commercial energy consumption in India 3.5% of the world consumption in 2002.**
- **Average annual growth rate of energy consumption about 6% during 1981 - 2002.**

Challenge of Energy Security: India

- **Commercial energy demand will grow at 4.5% per annum till 2020, as economy grows at 7 to 8% annually over this period.**
- **Growing gap between demand and supply of commercial energy with increasing dependence on imported oil.**
- **Oil imports expected to rise from present 70 percent to 100 percent in next fifteen years.**
- **Substitution of imported oil main driver for energy security.**

Primary Commercial Energy Mix – (%)

Resource	World	India
Oil	37.4	30.1
Natural Gas	24.3	7.8
Coal	25.5	55.5
Nuclear	6.5	1.4
Hydel	6.3	5.2

ENERGY DEMAND - SUPPLY GAP

- **Growing Gap between energy demand and supply requires an integrated framework for tackling this multi-dimensional problem.**

Energy demand-supply gap: 2006-07

Fuel	Demand	Imports	Dependence
Oil (MT)	144.58	94	73%
Coal (MT)	190.00	54	12%
Natural gas	42.70	81	45%

Major Concerns in the Energy Sector in India

- **Growing gap between demand and supply of commercial energy: electricity, oil and gas.**
- **Oil intensification of Indian economy due to declining self-sufficiency in oil and increasing oil demand.**
- **Growing dependence on non-commercial energy sources like fire-wood, cow-dung and agricultural wastes in rural areas.**
- **Inadequate development of eco-friendly energy sources including hydro and renewable energy.**
- **Urgency for containing environmental pollution caused by burning of fossil fuels and biomass energy.**
- **Need for sustainable energy pathway for India which will ensure energy security.**

Sustainable Energy Pathway for India: Components

- **Clean coal technologies**
- **Centralized production of electricity based on increasing share of hydro, nuclear and renewables.**
- **Decentralized power through renewable energy - sun, wind, biomass and small hydro.**
- **Alternative fuels for surface transportation – biofuels electric vehicles, hydrogen and fuel cells vehicles.**
- **Sustainable energy pathway to progressively increase share of renewable energy.**

RENEWABLE ENERGY : INDIA AND THE WORLD

WORLD
Outline Map

- India has set up among the largest programmes of renewable energy in the world.
- Wind Energy - Fifth in the world
- Solar photovoltaic - Second in the world production and utilisation
- Biogas - Second in the world

Map not to Scale

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MAINSTREAMING RENEWABLE ENERGY : GOALS

- **Substitution of fossil fuels by alternative renewable energy options: biofuels, synfuels, electric/hybrid vehicles, hydrogen, fuel cells.**

2012 : 5%

2020 : 10%

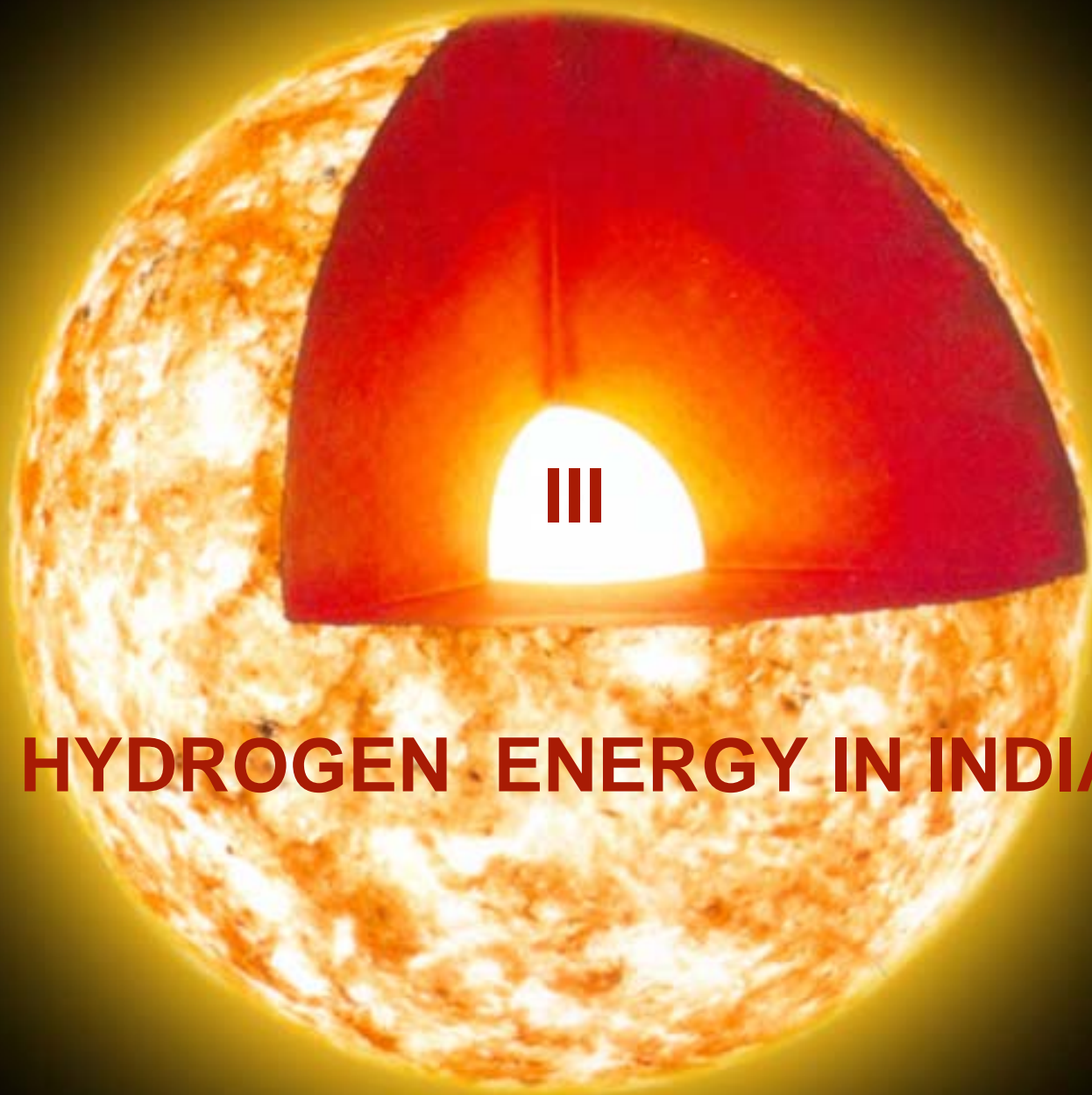
SUSTAINABLE PRIMARY ENERGY SOURCES

➤ **Sustainable primary energy sources including renewable energy; to replace fossil fuels have the following shortcomings:**

- ❖ **Diffused and dispersed**
- ❖ **Intermittent**
- ❖ **Not storable**
- ❖ **Not fuel for transportation available.**
- ❖ **Away from consumers centres.**
- ❖ **Not transportable**

Hydrogen Energy

- **Need for intermediary link between renewable energy sources with consumers.**
- **Intermediary energy system must be transportable, storable, fuel for transportation, economical to produce, renewable, pollution free and independent of primary energy sources.**
- **Among all options hydrogen best fulfils these requirements - lightness, highest energy density, versatility, clean and inexhaustible.**

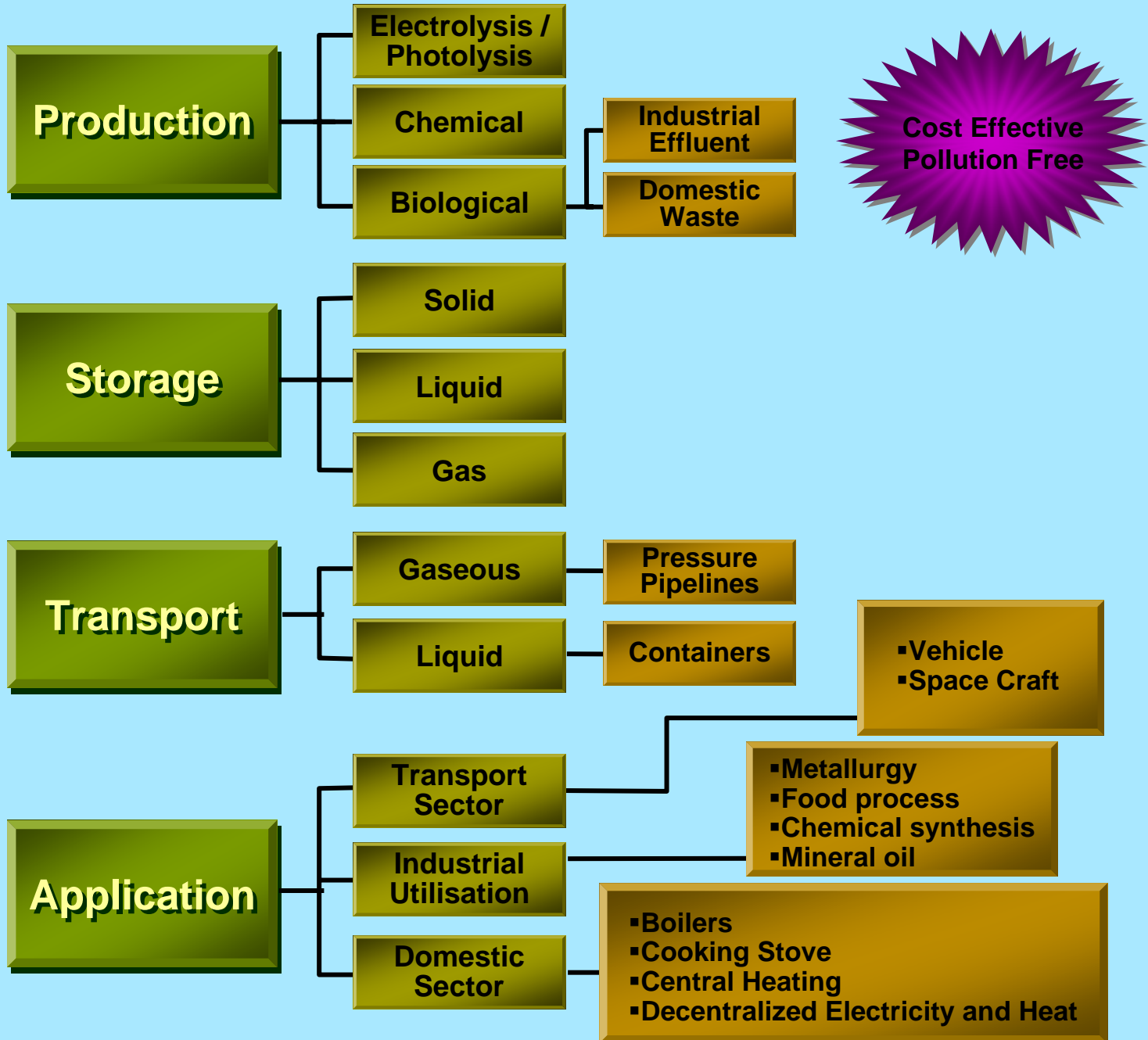


HYDROGEN ENERGY IN INDIA

Importance of Hydrogen in India

- **Hydrogen has significant potential as a clean energy source for broad range of applications including power production and transportation.**
- **Large areas in the country do not have access to electricity which can be provided decentralized power based on hydrogen energy.**
- **Hydrogen and fuel cells vehicles can progressively replace petroleum based vehicles specifically two & three wheelers.**
- **Hydrogen energy: carbon-free fuel with major promise for ensuring sustainable energy security in India.**

HYDROGEN System



International Scenario

HYDROGEN PROGRAMMES IN MAJOR COUNTRIES

Japan

Set up hydrogen fueling stations
Plans to spend \$20 billion by 2020

Germany

Largest number of demonstration of
hydrogen based applications;
Hydrogen fueling stations

Iceland

Plans to be world's first hydrogen economy

USA

Annual spending around \$ 30M Hydrogen
Freedom Fuel Initiative announced in
January, 2003 with budget of US \$ 2.2
billion. IPHE set up in November 2003

International Partnership on Hydrogen Economy

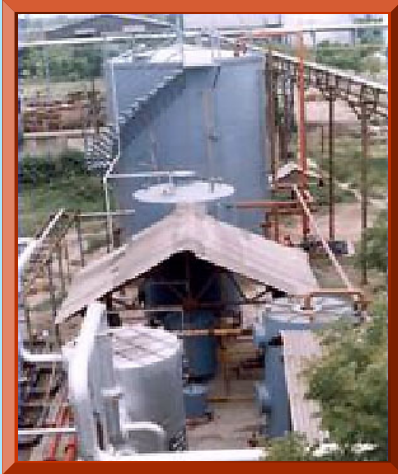
- **International Partnership on Hydrogen Economy set up in Washington D.C. in November,2003.**
- **India is one of the 16 founder member countries of IPHE. China, India and Brazil are the three developing countries along with 13 advanced countries, including USA, Japan, European Union, U.K., Iceland etc.**
- **Fourth Steering Committee Meeting of IPHE held in Kyoto in September, 2005 in which India presented its achievements in Hydrogen Energy and Road Map.**

Hydrogen Energy - Indian Achievements

- **Efficient production methods developed in laboratory conditions.**
- **Successfully demonstrated utilization in :**
 - ❖ **Motorcycles and three wheeler.**
 - ❖ **Power generating units.**
 - ❖ **Catalytic combustor.**
 - ❖ **Air conditioning.**
- **Biological production of hydrogen :**
 - ❖ **from organic wastes; demonstrated at pilot plant scale.**
 - ❖ **from bagasse; demonstrated at lab scale production.**

Bio Hydrogen Plant

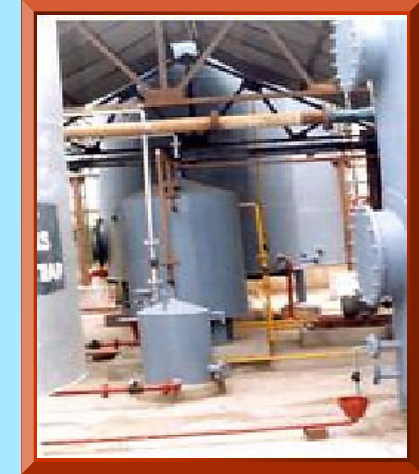
TOP VIEW



SIDE VIEW



FRONT VIEW



REACTORS



Hydrogen Motorcycle



Hydrogen Motorcycle



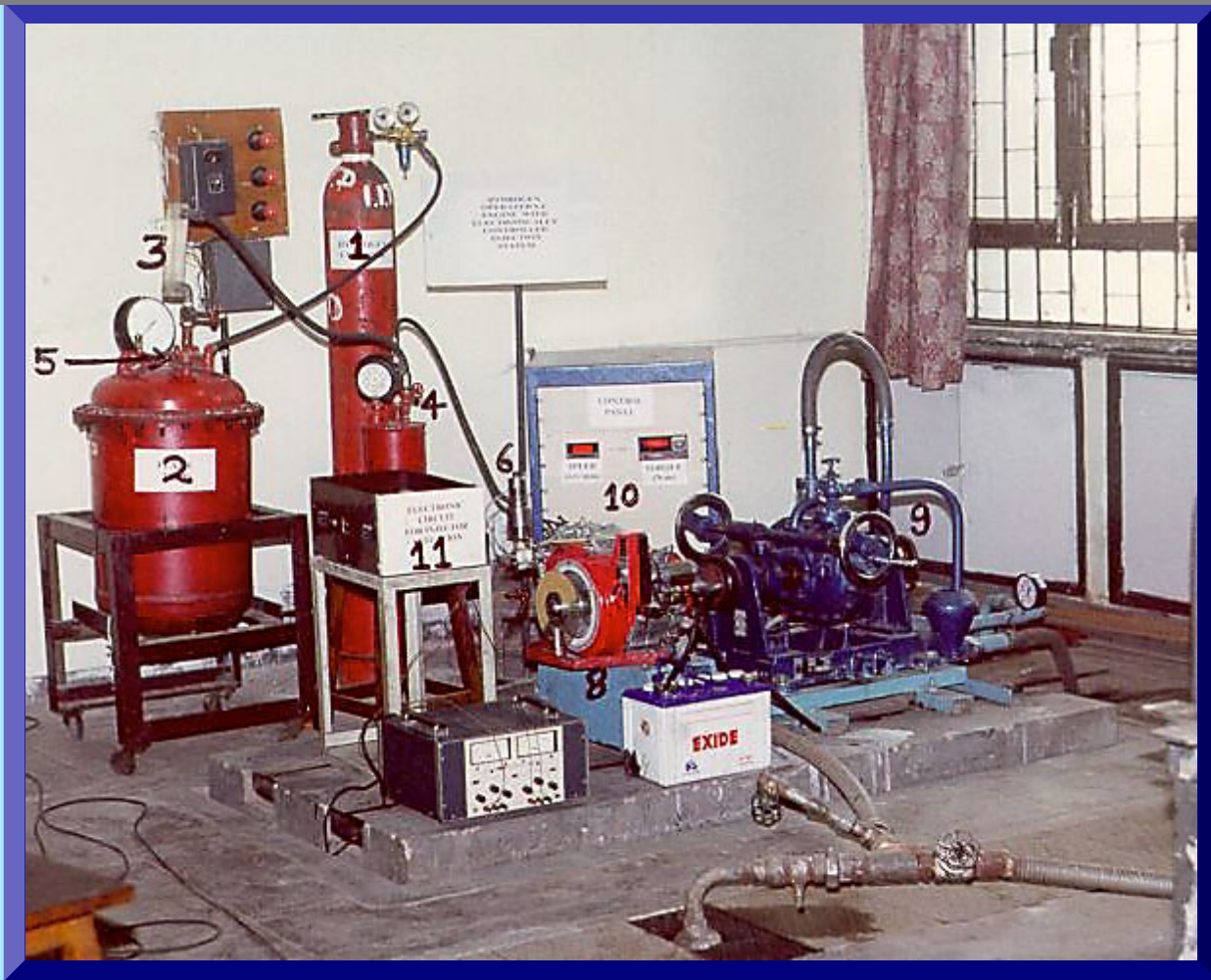
Hydrogen Three Wheeler



Hydrogen Fuelled Home Cooker

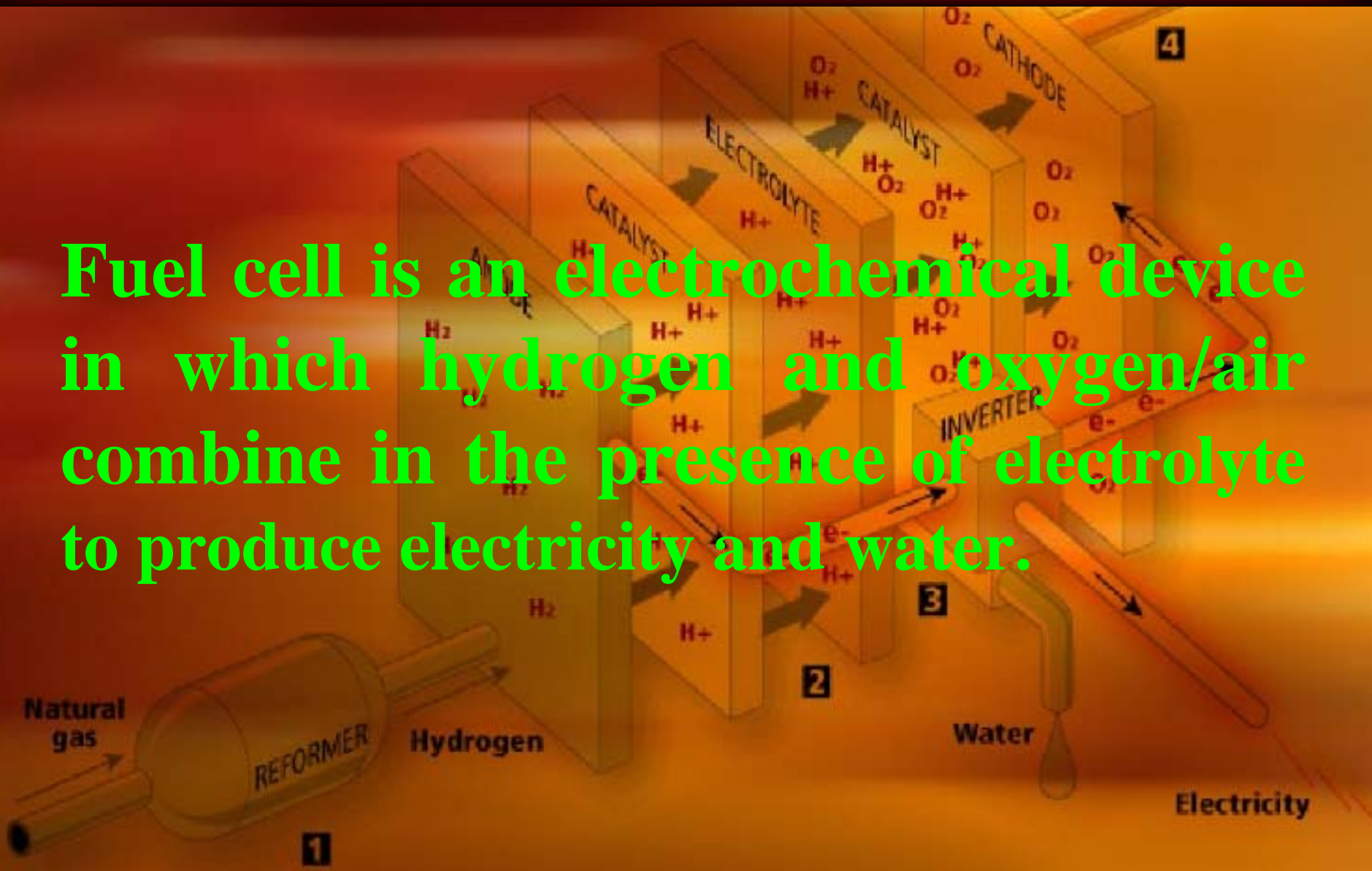


Hydrogen Power Generating System (10 KW)



FUEL CELLS

Fuel cell is an electrochemical device in which hydrogen and oxygen/air combine in the presence of electrolyte to produce electricity and water.



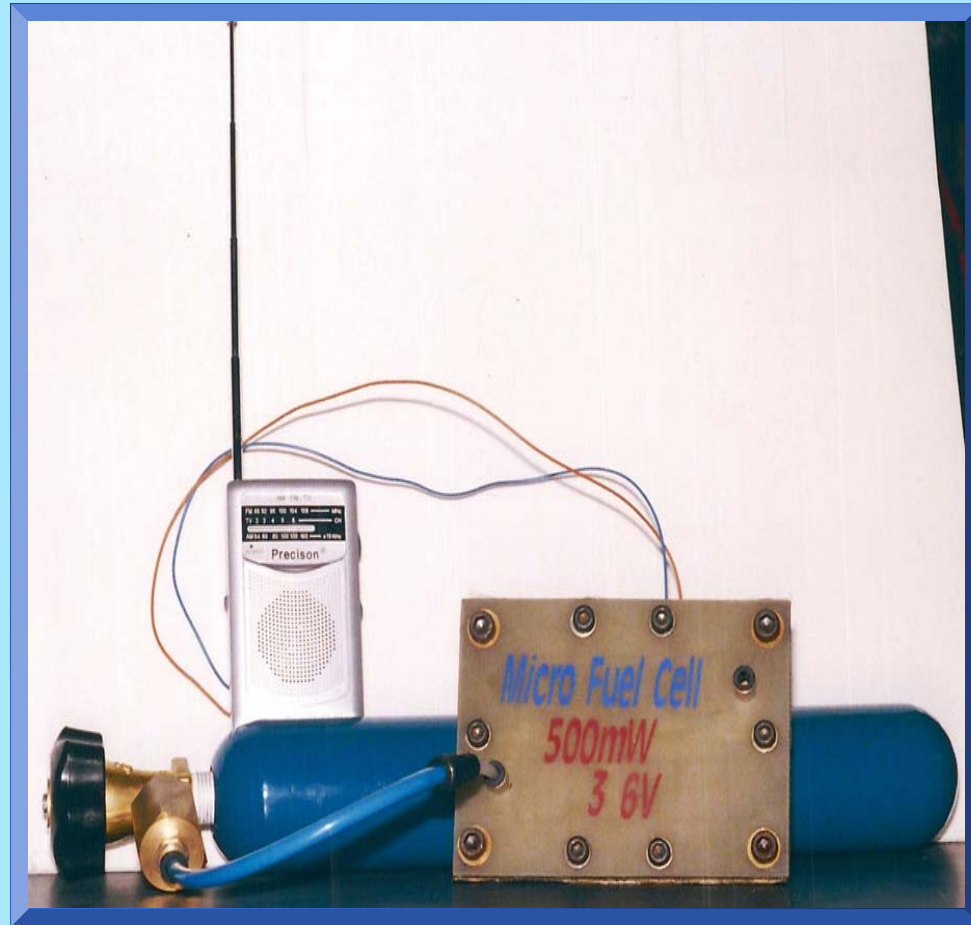
Indian Achievements

- **Developed and demonstrated:**
 - ❖ **50 KW PAFC power plant .**
 - ❖ **5 KW PEMFC power plants.**
 - ❖ **3 KW UPS systems.**
 - ❖ **Reformers.**
- **Prototype Fuel Cell Vehicle.**
- **Fuel cell power packs for distributed power production.**

Fuel Cell based 3 kW UPS



Micro Fuel Cell



Fuel Cell-Battery Hybrid Electric Vehicle





It is **H**y Time



COMMERCIALIZATION LEADS THE WAY



MOBILE



PORTABLE



STATIONARY

National Hydrogen Energy Board

- **Constituted in October,2003 with Hon'ble Minister, Non-Conventional Energy Sources as Chairman**
- **High level representation from Government, Industry, Research and Academia, Public Figures and other stakeholders.**
- **Direct, coordinate and guide preparation and implementation of the National Hydrogen Energy Road Map and Programme.**

National Hydrogen Energy Board

- ❑ **Guiding preparation and implementation of National Hydrogen Energy Roadmap**
- ❑ **Creation of policy framework cutting across different sectors**
- ❑ **Guiding research & development programme in Hydrogen and Fuel cells**
- ❑ **Demonstration and pilot programmes**
- ❑ **Business development initiatives**
- ❑ **Nationwide education and training programme**
- ❑ **International cooperation**

National Hydrogen Energy Road Map

- **Provides long term solution to meet growing energy needs of India while ensuring energy security**
- **Identifies paths for gradual introduction of hydrogen energy in the country**
- **Accelerate commercialization efforts**
- **Facilitate creation of hydrogen energy infrastructure**
- **Total systems approach for developing hydrogen energy technologies**

National Hydrogen Energy Road Map

- **Based on Public-Private Partnership**
- **Roadmap is an Industry driven Planning Process**
- **Guided by Government, with support from Research Organizations, Academia, NGOs and other stakeholders**
- **Development of sustainable and cost effective hydrogen energy technologies & infrastructure**
- **Issues relating to Production, Storage, Delivery / Transport, Applications, Safety and Awareness, capacity building addressed**

National Hydrogen Energy Road Map

Two major initiatives with goals and targets upto 2020

- Green Initiative for Future Transport (GIFT)**
- Green Initiative for Power Generation (GIP)**

National Hydrogen Energy Road Map Strategies

- **R&D through Public – Private - Partnership**
- **Demonstration through Public Private Partnership**
- **Safety, Standards and Codes**
- **Awareness and Capacity Building**

National Hydrogen Energy Roadmap

Technology Development : 3 Tier set -up



**Demonstration
of integrated
hydrogen system
(production, storage,
delivery and application) in
a village/township/city**

**Development and demonstration of
products for hydrogen utilization for
power generation and use in transport
sector e.g. fuel cells/IC engines/ turbines**

**Broad based Research and Development on different aspects
of hydrogen (production, storage, transportation, delivery,
application, safety etc.) including development of materials,
processes, components, codes, standards etc.**

Status of Major Technologies and Gaps

Technology	International Status	National Status
Coal Gasification (IGCC)	Commercially available	Efforts underway to set up pilot plant
Biological route for Hydrogen Production	In Pre-Commercial stage	Demonstration Plant set up
Metal Hydrides for Hydrogen storage	Hydrides with 1.5 - 2.0wt% storage capacity for ambient conditions developed	Hydrides with 2.42wt% storage capacity for ambient conditions developed

Status of Major Technologies

Technology	International Status	National Status
Carbon Nano-structures for Hydrogen Storage	In R&D Stage	In R&D Stage, Further R&D efforts underway
IC Engine for Hydrogen	Not commercially available	Dedicated engine to be developed
PEM Fuel Cells for Stationary applications and automobiles	Commercially available	Prototype Demonstrated, PEMFC of international specifications and suitable for automobiles to be developed
Solid Oxide Fuel Cells	In R & D Demonstration Stage	In early stages of R&D

Challenges

- **Lower cost of hydrogen by a factor of 3-4 & improve production rates from different methods**
- **Development of compact, inexpensive storage capacity up to 9 wt%, cycle life > 1,500, conveniently transportable and easy to refuel storage devices**
- **Capacity of hydrogen storage system to be high enough to give a range of 150-500 km per charge, depending upon type of vehicle**

Challenges

- **Development of high pressure cylinders (~700 bars).**
- **Establishment of hydrogen gas pipeline network in high demand areas.**
- **Development of hydrogen fuelled IC engine having operating life > 30,000 hours and costs comparable to existing petroleum based IC engines.**
- **Efficiency improvement for different types of Fuel Cell Systems in 40 – 80 % range.**
- **Development of fuel cell stacks having operating life > 5,000 hours and cost comparable to existing vehicles for transport applications.**

IV CONCLUSION

The
Economist

Don't blame China

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The Democrats' economic ideas

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Iran's last chance

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A SURVEY OF CORPORATE LEADERSHIP

AFTER PAGE 50

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www.economist.com

The end of the Oil Age



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SUPREME

CONCLUSION:

TOWARD A
HYDROGEN
ECONOMY

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TOWARDS HYDROGEN ENERGY ECONOMY IN INDIA

- **National Hydrogen Energy Road Map for India upto 2020.**
- **National Hydrogen Energy Programme.**
- **National Mission involving Government, Industry, Research, Users and other stakeholders.**
- **National Hydrogen Energy Web.**

India Vision : National Hydrogen Energy Web

Empowering Indians to use and produce their own ecologically sound and limitless energy which provides sustainable energy security for all.

