Hydrogen Energy in the Developing World: A Leapfrogging Opportunity

N. Lymberopoulos
Director Projects and Programmes
nlymberopoulos@unido-ichet.org

Presented by
M. R. de Valladares
IEA HIA Secretariat
mvalladares@ieahia.org

LCES 2011, 19-26 October 2011
The International Centre for Hydrogen Energy Technologies is a UNIDO project with the mission of demonstrating viable implementations of hydrogen energy technologies and facilitating their widespread use in developing countries.

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A H2&FCs Inclusive Future

Major players in H2 and FCs
- US, Canada, Japan, EU, IEA-HIA, IPHE

What about the developing world?

- Over 70% of increase in world primary energy demand between 2004-2030 comes from developing countries.
- By 2030, China and India account for 57% of world coal demand, up from 43% in 2004.
CHINA

7.4 million USD for basic research (937 Program) on:

1) Fundamentals of Large-scale Production, Storage and Transportation of Hydrogen and the Related Fuel Cells
2) Hydrogen Production using solar energy

106 million USD for demonstration, commercialization, support of Chinese car industry (863 Program):

1) Hydrogen technologies
2) High Temp fuel cells
3) Clean coal incl. H2 production
## CHINA

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<thead>
<tr>
<th>Developer</th>
<th>Tsinghua University</th>
<th>Dong Feng Motors Corp</th>
<th>Tsinghua University</th>
<th>Pan Asia Automotive Technology</th>
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<td>Mini Van</td>
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<td>Compressed/25</td>
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</table>
CHINA

2008 Olympic Games, Beijing

2010 Shanghai World EXPO
Energy and H2 vision

Preliminary phase (2020)
- Implementation of “energy saving priority”
- Coal exploitation and utilization with high efficiency and clean process.
- Maturing of core technologies for vehicle fuel cell system, and commercialization of fuel cell vehicles in several key cities.

Mid-term (2035)
- Coal dominates the energy mix, but coal-based power generation system with zero-emission gets commercialized and deployed gradually.
- Hydrogen generation from renewables is gradually deployed in scale. But coal is still the main hydrogen source.

Long-term (2050)
- The increased energy demand is mainly met by development of renewable energy and nuclear energy after 2035.
- The proportion of coal decreases gradually to less than 50% in 2050.
- The national hydrogen delivery pipeline system is primarily established, and hydrogen economy is realized.
In 2003, a National Hydrogen Energy Board has been set up under Ministry of New and Renewable Energy.

In 2007 a Hydrogen Roadmap was published:


2) Green Initiative for Power Generation (GIP): 1000 MW of H2 powered ICEs, GTs, high temp FCs.

3) Recent order for 40,000 FC-based UPS for telecom.
The emphasis on GIFT is on converting ICEs rather than using FCs. Start with H-NG mixtures and move to pure hydrogen.

In case a fuel cell is to be used it will be probably purchased from abroad – no local developments. DST tried to change this through the establishment of the Centre for Fuel Cell Technology located in Chennai, aiming to develop 1-10 kW PEM FCs.

- Work on MCFCs taking place at TERI. Monocell running on coal gas
- DMFC developed at IISc
- SOCF at IISc and the Central Glass and Ceramic Research Institute
The only Latin American country member of IPHE
- 50% share of global ethanol trade
- Brazilian Government is elaborating policy and strategies for the Hydrogen Economy – road map
  1) Hydrogen will be part of the Brazilian energy resources in 2020
  2) Ethanol is the main source of Hydrogen
  3) Hydrogen production from electrolysis using excess power from hydroelectric power plants
  4) Main applications: distributed generation, isolated systems, urban buses
Almost 15 universities, 8 research centres, 4 fuel cell companies and 7 investors are currently involved in hydrogen and fuel cell technologies in Brazil.


A 3-buses H2 fleet was established in 2006 through a GEF funded project including China and Egypt.

A H2-FC bus was recently built by COPPE solely with Brazilian parts. It is intended to put this bus in service, linking the 2 airports of Rio de Janeiro.
South Africa’s dominating position in platinum reserves (more than 75% of the world known reserves),

South Africa’s leading position in the coal gasification to liquid fuels technology.

Abundant solar energy

1) Supply 25% of catalysts demand for the global fuel cell industry by 2020

2) Develop local cost competitive hydrogen generation solutions (PGM based & others)

3) Create sustainable jobs linked to the country’s minerals wealth
A 15-year H2 and FCs R & D & Innovation strategy was launched in September 2008

HySA is a Technology Validation and Systems Integration Competence Centre on hydrogen and fuel cell technology. Annual budget of 3MR

The aim of the centre is to develop key components for hydrogen and fuel cell technologies, validate technology and systems and facilitate the export of new technology.

Focus on:

- High Temp MEAs (up to 180C)
- Membranes for reformers
Even though rich in fossil fuels, H2 and FCs are very much in focus by Iranian R&D institutions

FC Steering Committee established in 2002

More than 500 researchers working on H2 and FCs

More than 50 Universities, R&D centres and industries
Emphasis is on FCs and integrated RES - H2 systems

- 25kW grid connected FC
- 1kW direct methanol FC
- 5kW FC designed & built in Iran
- 100bar tank
- Taleghan autonomous PV-H2 plant
Thailand

Interest for H2 tuk tuks

Conventional Thai tuk tuk

H2-FC tuk tuk 5kW by Nuvera

E-vehicles commercially available
Malaysia

- H2 Roadmap in 2005
- Fuel Cell Institute, University Kebangsaan Malaysia (UKM) established in 2007

Solar H2 house

H2 scooter

Shell Eco-marathon H2 vehicle
TURKEY

TUBITAK Energy Institute

- PEM Fuel Cell (component development and system integration)
- Direct Sodium Borohydride Fuel Cell (DSBHFC) (component development and system integration)
- MCFC (500kW demonstration system and MC-WAP EU project)
- SOFCs
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UNIDO-ICHET Background

- UNIDO-ICHET is located in Istanbul, Turkey
- Formed in 2003 – trust fund agreement between UNIDO and Turkish Government (Ministry of Energy and Natural Resources)
- Started operation in 2004
- Budget $40M over 5 years
- Currently, staff of about 35 people
UNIDO-ICHET Activities

- **Design and implementation of demonstration projects**
  - H₂ 3-wheelers, New Delhi, India
  - Bozcaada Hydrogen island, Turkey
  - FC-based UPS, Turkey
  - Fuel cell fork-lift, Turkey
  - Hydrogen FC boat, Turkey

- **R&D projects / Test laboratories**
  - PEM FCs
  - FC based CHP systems
  - Analytical labs and Test stations

- **Conferences and workshops**

- **Training and education**

- **Networking**

- **Support to UNIDO Director General**
DELHY-3W Pilot Project

H₂ 3-wheelers in India
- 15 vehicles will be converted to run on H₂ in the city of N. Delhi, taking visitors from the Metro station to the Pragati Maidan Exhibition Ground
- 5 partners involved, IIT Delhi, Mahindra & Mahindra, UNIDO-India, Air Products, ICHET
- Total budget >1 M US$, ICHET support of 0.5 M US$ in the form of funds to experts and equipment
DELHY-3W Pilot Project

H2 3-wheelers in India
- Contract signed on 12 March 2009
- Expected launch August 2011
- Fleet is ready, awaiting approval of PESO for refuelling facility and vehicles
UNIDO-ICHET Activities

Bozcaada H2 island project
Bozcaada H2 island project

- Total Budget 1.5MUS$
- 100% ICHET funded
- H2 contract to Accagen
- Inauguration July 2011

Diagram:
- 20 kW PV panels
- 30 kW wind turbine
- Control Strategy
- Local grid 220V
- 50 kW Electrolyzer
- Compressor
- H2 storage cylinders @220 bar
- 20 kW Fuel Cell UPS
- 35 kW Genset UPS
- Governor’s House
- Hospital
- 2nd phase of project

Applications:
- 5 kW Fuel Cell Boat
- 5 kW Fuel Cell Golf cart
- Hospital

Images:
- Governor’s House
- Governor’s House
- Governor’s House

Notes:
- Bozcaada H2 island project
- 2nd phase of project
GEF Proposal

“Realising Hydrogen Energy Installations on Small Islands through Technology Co-operation”
Submitted to GEF Strategic Programme on Technology Transfer Framework

Project Components (in M US$)
1. Deployment of Techs on Bozcaada (1.5) and Aitutaki (3.4)
2. Transfer of Techs (0.5) US, Greece
3. Diffusion of Techs (0.3) to other communities
4. Project management (0.75)

Total Budget 6.45 M US$
GEF financing of 3 MUS$

Proposal has been approved by GEF Council
3 MUS$ earmarked for project, conditional on approval of full proposal
Technology Demo Projects

Hydrogen-Fuel Cell Uninterrupted Power Supply

Project objectives:
- to introduce environmentally friendly energy technologies in daily life through demonstrations

Project benefits:
- public awareness on applications of Hydrogen and fuel cell technologies
- to encourage local companies to take part in assembly & supply chain

Project deliverables:
- three 5 kW UPS system in different locations
- dissemination events

Project partners:
ICHET, İDO
Hydrogen-Fuel Cell Powered Forklift

Project objectives:
- to design the prototype fork lift using a 5 kW fuel cell and suitable hydrogen storage systems to fit within the existing battery compartment.

Project benefits:
- to provide consistent power while releasing no harmful emissions
- to conduct trial runs and demonstrations
- to submit healthy ambiance to the forklift operator

Project deliverables
- design and production of the fork lift and procurement of the fuel cell
- mounting the fuel cell to the forklift
- operational trials and demonstration

Project partners:
ICHET, ÇUMİTAŞ
Pilot Projects

Halic H2 refueling facility

Project objectives:
- to set-up a 65kg/day H2 production & re-fuelling facility to provide fuel to H2-ship & H2 buses at 220 and 350 bar in Golden Horn, Istanbul

Project status:
- Contract awarded to Hydrogenics, design complete, facility operational by May 2012

Project Consortium:
- Istanbul Metropolitan Municipality
- IETT
Technology Demo Projects

Hydrogen Fuel Cell Boat in Golden Horn

Project objectives:
- to construct and operate a fuel cell powered sight-seeing boat running in Golden Horn
- to involve local industry to contribute

Project benefits:
- Hydrogen technology demonstration and public education
- local technology contribution and involvement

Project deliverables:
- a fuel cell boat with 50+ passenger capacity - 48kW PEM FCs
- operational data for further implementation

Project partners:
IMM/BELBIM, ICHET, IDO, GYTE, HABAŞ, SME’s
Technology Demo Projects

Hydrogen ICE hybrid bus

Project objectives:
- to demonstrate the effectiveness of Hydrogen Internal Combustion Engine (HICE) and hybrid application on a public transportation vehicle
- to create public awareness on applications of Hydrogen on field
- to encourage local companies to invest in H₂ energy technologies

Project benefits:
- realization of the project will have high visibility

Project deliverables:
- an ICE running on H₂ fuel will be implemented on a bus
- H₂-fueled bus will be operated by the municipality
Laboratory Infrastructure

- **Fuel Cell Testing Lab**
  - Equipment purchased and installed in the basement of present facility; capable of fuel cell testing and diagnostic from single cell to 12 kW stack

- **Hydrogen Production & Storage**
  - Two 600 cc/min and one 18 lit/min electrolyzers
  - 190bar compressor, cylinder stack for storage

- **Hydrogen Analytical Testing Lab**
  - FTIR & UV-Visible Spectrometers
  - Porosimetry & Gas Adsorption Analyzers
  - Thermo-Gravimetric Analyzer
  - Scanning Calorimeter & Gas Chromatograph
  - Glove box
Education and Training

Short Courses

**Project objectives:**
- to organize short courses on H2 & fuel cell technologies
- to provide hands-on training opportunities in the lab

**Project benefits:**
- individuals from developing countries will receive practical training
- technology, safety & future energy aspects will be understood by participants

**Project deliverables:**
  - 40 international students from Italy, Iran, S.Africa, Hungary, Bulgaria, Croatia & Turkey
- Two-day short courses covering H2 & fuel cells basics
  - attendants from universities, companies
  - laboratory sessions
- Repeated quarterly with international participation
International Collaborations

ICHET is a Full Member of the EU-New European Researchers Grouping (N.ERGHY) on Fuel Cells and Hydrogen of JU

ICHET through UNIDO is a member of the ExCo of the IEA Hydrogen Implementing Agreement (HIA) and has recently been appointed to lead a new Annex on Distributed and Community Hydrogen DISCO-H2
Conclusions

- There are opportunities for Developing or Transition Economies to have a share of the emerging hydrogen energy market with products ranging from FCs to H2 3-wheelers.
- Governments have recognised this and have included H2 and FCs in R&D agendas.
- For Least Developed Countries however, the costs & complexity involved in combination with more basic needs make H2 and FCs currently an oxymoron.
- As systems become simpler and cheaper this could change and H2 could be used for electricity storage or as cooking gas.
- UNIDO through ICHET is complementing national efforts, helping the leap-frogging of Developing Economies to cleaner energy technologies.
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THANK YOU FOR YOUR ATTENTION