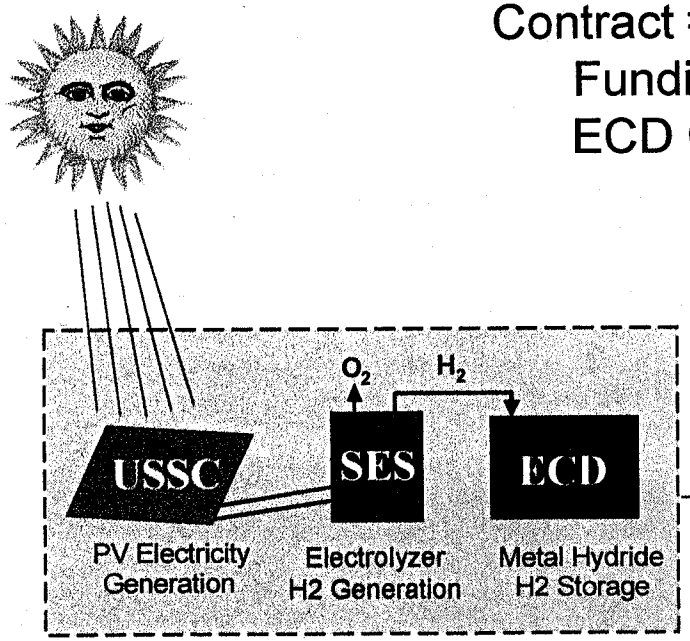
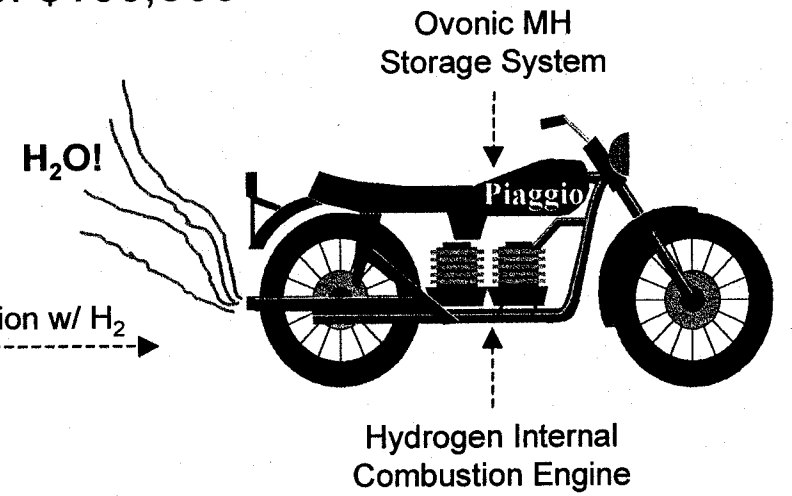
An Integrated PV-Electrolysis Metal Hydride Renewable Hydrogen Generation and Storage System

Phase I Continuation:
Hydrogen Powered Scooter Market Study

Contract #: DE-FC36-97GO10212
Funding Amount: $100,000
ECD Cost Share: $100,000



Refuel Application w/ H_2



Product: ECD's Renewable H_2 System

Application: H_2 Powered Scooter

Past Results

- ECD was awarded Phase I DOE cost-share contract to develop business plan for renewable hydrogen systems.
  - Detailed commercialization strategy and business plan, including financials, presented for several products:

Product Model #	H_2 Production (g/day)	PV (W)	Electrolyzer (W)	MH Storage (g H_2)	NiMH Battery (kWh)
model 10	10	100	100	300	-
model 50	50	500	500	450	-
model 200	200	2000	2000	600	-
model 50/500	50	1000	500	150	8

- Phase I Continuation required by DOE to assess the market potential for hydrogen powered scooters in the developing world.

Phase I Continuation

Objective:

- Evaluate the business potential of the Ovonic Renewable H_2 System in the scooter markets of the developing world.

Tasks:

- Quantify Global & Regional Scooter Markets
- Identify Driving Market Forces
- Select Near-Term Regional Markets
- Conduct Performance and Economic Comparison vs Competition
  - Gasoline & NiMH Electric
- Quantify Impacts of Displacing Gas Scooters w/ H_2 Scooters
  - Petroleum & Emission Reductions
- Evaluate Industry Interest & Obtain Industry Support

Summary of Approach & Rationale

Approach:

- Focus on H_2 ICE scooters for the near-term
- Obtain most current marketing data.
- Review existing and proposed legislation.
- Identify & meet with scooter OEM industry executives.

Rationale:

- Leverage existing ICE manufacturing base, accelerating market introduction
- Independent market studies and governmental environmental regulations will provide unbiased information that will help evaluate the business opportunity.
- Scooter OEM executives are the best source of information:
  - They have insight into strategic planning, product R&D, environmental regulations, operational finances, market economics, customer acceptance, etc.
  - Their commitment is necessary for product launch.

Current Year Results (1/3)

- Results of Market Study
  - Global Scooter Fleet is estimated at >200M units in 2000. [1]
  - Global Scooter Market is growing at ~15% AAGR through the next decade, rising from 20M units in 2000 to 80M units in 2010. [1]
    - ~85% of the market is in Asia
    - China and India represent ~50% of the total
  - Scooters powered by unregulated two-stroke engines are >40X more polluting over their lifetime than a conventional auto. [2]
  - Legislation from around the world is forcing scooter OEMs to build cleaner scooters:
    - 1999 - Taiwan mandates electric scooters
    - 1999 - Shanghai bans sales of two-stroke engines
    - 2000 - India expected to adopt strictest emission standards in the world

1. Motorcycles, Scooters & Mopeds: A Global Strategic Business Report; Global Analysts, Inc.; Nov. 1998.
2. The Motorcycle & The Environment; German Environmental Ministry; 9/2/98.

Current Year Results (2/3)

- Results of Market Study (Cont.)
  - Subsidies being offered to encourage the adoption of alternative fuels.
    - Taiwan - $185M set aside for cash rebates on 250K scooters (~$750 ea)
    - Italy - Up to $1,000 cash rebate per scooter
    - France - Up to $500 cash rebate per scooter
    - Subsidies in China, India, Japan, Malaysia and Thailand expected.
  - Impact of displacing 1M gasoline powered scooters over their useful life with Hydrogen would result in reductions of:
    - 10.8B barrels of petroleum
    - 120M metric tons of CO
    - 90M metric tons of HC
  - Letters of Commitment obtained from leading scooter OEMs in China, India, Taiwan and Italy for collaboration in Phase II.

Current Year Results (3/3)

- Performance Targets driven by Taiwan EPA study:
  - Average motorcycle speed in Taipei is 14.9 kph.
  - 95% of motorcycles run at speeds < 40 kph.
  - 62% of motorcycles require a maximum speed of < 60 kph.
  - 49% of all motorcycles are used for shopping and commuting.
  - 90% of motorcycles have an average daily travel distance of < 45 km.
- Alternative Fuel Storage Specification Comparison:

Characteristic	Gas	Pb-Acid	NiMH	Hydrogen
Fuel Storage	3.5 L	1.0 kWh	2.0 kWh	400 g
Range (km)	100	30	100	75
Weight (kg)	15	43	29	30
Volume (L)	7.5	13	12	9
Life (km)	>60,000	<15,000	>60,000	>60,000

  - Gasoline #s provided by Piaggio.
  - Pb-Acid based upon 33 Wh_{DC} /km, 30 Wh/kg, 90 Wh/L and 300 cycles.
  - NiMH based upon 20 Wh_{DC} /km, 80 Wh/kg, 190 Wh/L and 600 cycles.
  - Hydrogen based upon 5.5 g/km, 1.5 wt %, 3.5 g MH/cc and 1,200 cycles.
  - Note: Each system includes a 15% penalty on volume and weight for packaging hardware.

Technical Presentations & Public Demos

- An Integrated H_2 Generation & Production/Storage System Based On PV/Electrolysis/MH for Near-Term Applications (WHEC)
  - Argentina / June 21-26, 1998
- Preliminary Findings of Phase I Continuation reported to DOE
  - Wash DC / March 16, 1999
- 10th Annual H_2 Meeting
  - Vienna, VA / April 7-9, 1999
- Renewable Energy Expo
  - Wash DC / April 21, 1999
- Advances in R&D for the Commercialization of Small Fuel Cells for use in Portable Applications
  - Bethesda, Maryland / April 29-30, 1999
- Electrochemical Society Meeting
  - Seattle, WA / May 3-5, 1999

Plans for Future Work

- Phase II Tasks include:
  - MH Hydrogen Off-Board Storage System Optimization
  - Electrolyzer Optimization (subcontract: Stuart Energy Systems)
  - Integration of System Components
  - MH Hydrogen On-Board System Optimization
  - Develop System to Application Refueling Interface (subcontract: Piaggio)
  - Develop Detailed Cost Model
- Phase III Tasks include:
  - Build, Test & Demonstrate Prototype System
  - Convert Gas powered ICE Scooter to Hydrogen
  - Refine Cost Model and Business Plan
  - Finalize Commercialization Strategy

Status of Economic Evaluation

- In mass production, H_2 scooter can meet gasoline scooter price targets:
  - Yr 2005 - $1,250
  - Yr 2010 - $1,500
- Proposed business can be profitable at volumes of ~500K units.
  - 1% of the total market in 2005.
  - Federal subsidies may be required during initial market penetration.
- Higher up-front cost of renewable H_2 refueling system in years 1- 5 is recovered during years 6 - 10.
  - H2 Scooter Operating Expense Yr 1-5: $76.64/mo
  - H2 Scooter Operating Expense Yr 6-10: $2.25/mo
- Expected increase in gasoline powered scooter cost from modifications required to meet emission standards makes H2 system cost competitive:
  - See attached.

Major Barriers/Safety Issues

- Remaining barriers to commercialization, include:
  - Funding for Prototype Development (Phase II & III)
  - Commitment from Major OEMs to mass produce H_2 scooters
  - Market acceptance of H_2 as a viable fuel
  - Support from regional governments
- Safety Issues
  - Lack of Codes & Standards
  - On-board MH to HICE interface
  - Collaboration with Scooter OEMs from on-set will ensure certification.

Status: Technology Transfer & Partners

- ECD's MH
  - Ongoing testing of MH canisters is encouraging.
  - High volume MH production in place.
- USSC's PV
  - 5 MW production in place.
  - Expansion to 25 MW expected in near term.
- SES's Electrolyzer
  - Technical specifications & financials exchanged.
- Piaggio's Scooters
  - Technical specifications & financials exchanged.
  - Performance and economic assumptions confirmed.

Summary

- Market Analysis confirms competitiveness of ECD's Renewable H_2 System in scooter market.
- Potential for significant reduction in pollution emissions and petroleum use documented.
- Commitment from major scooter OEMs obtained for collaboration in Phase II.
- ECD and its partners committed to commercialization.
- The systems ability to generate both hydrogen and electricity make the system attractive for other applications.

Hydrogen Powered Scooter: Potential Near-term Application?