



*INVESTING IN HYDROGEN TECHNOLOGIES*  
*A VENTURE CAPITALIST'S PERSPECTIVE*

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GLOBE 2002  
Vancouver, B.C.  
March 15, 2002

# INVESTMENT CRITERIA

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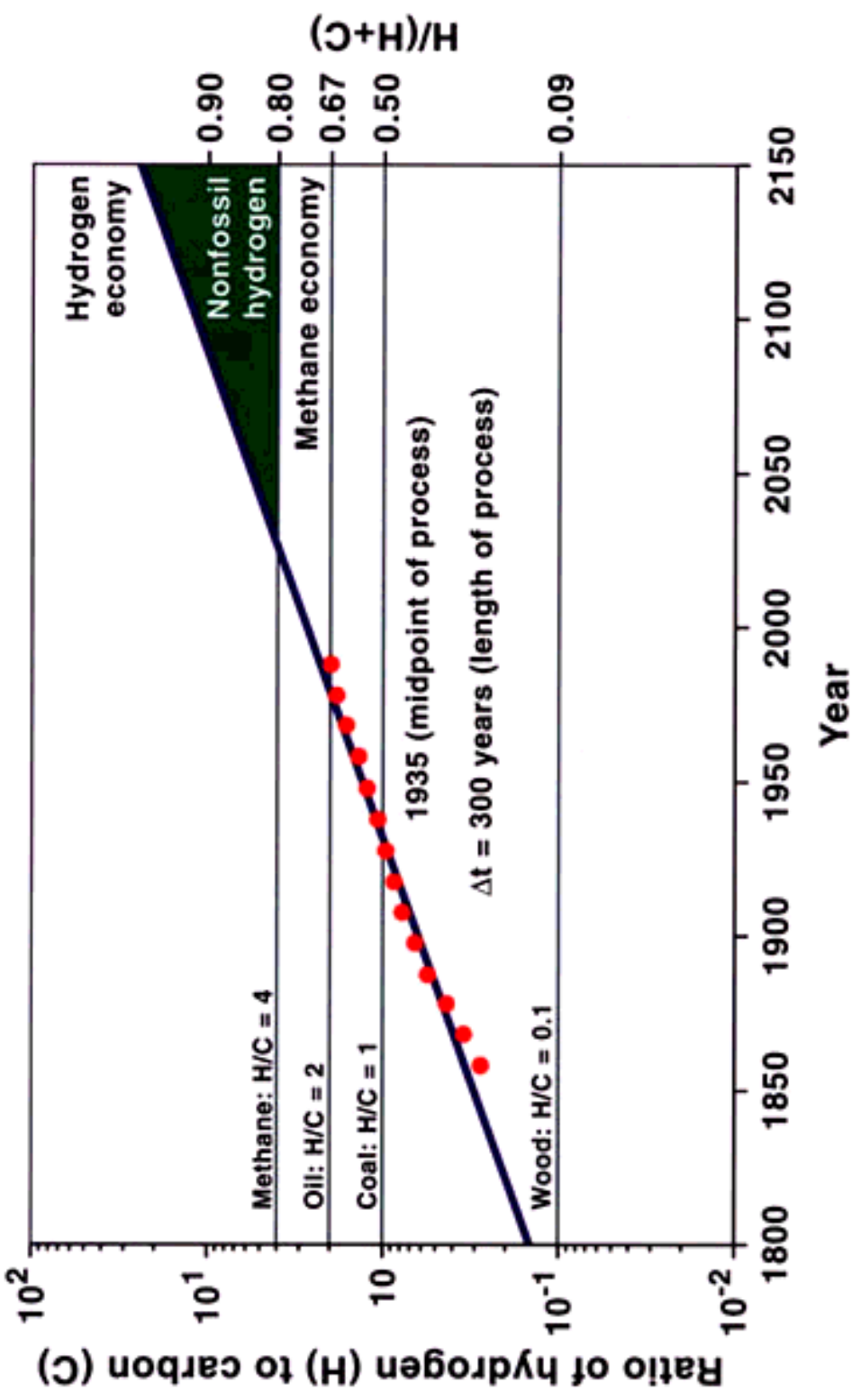
- Successful venture capital investments always have three key characteristics
  - » A huge market opportunity
  - » A protectable and sustainable technology advantage
  - » Superb management talent
- Hydrogen investments will be no exception

# THE MARKET OPPORTUNITY IS ENORMOUS

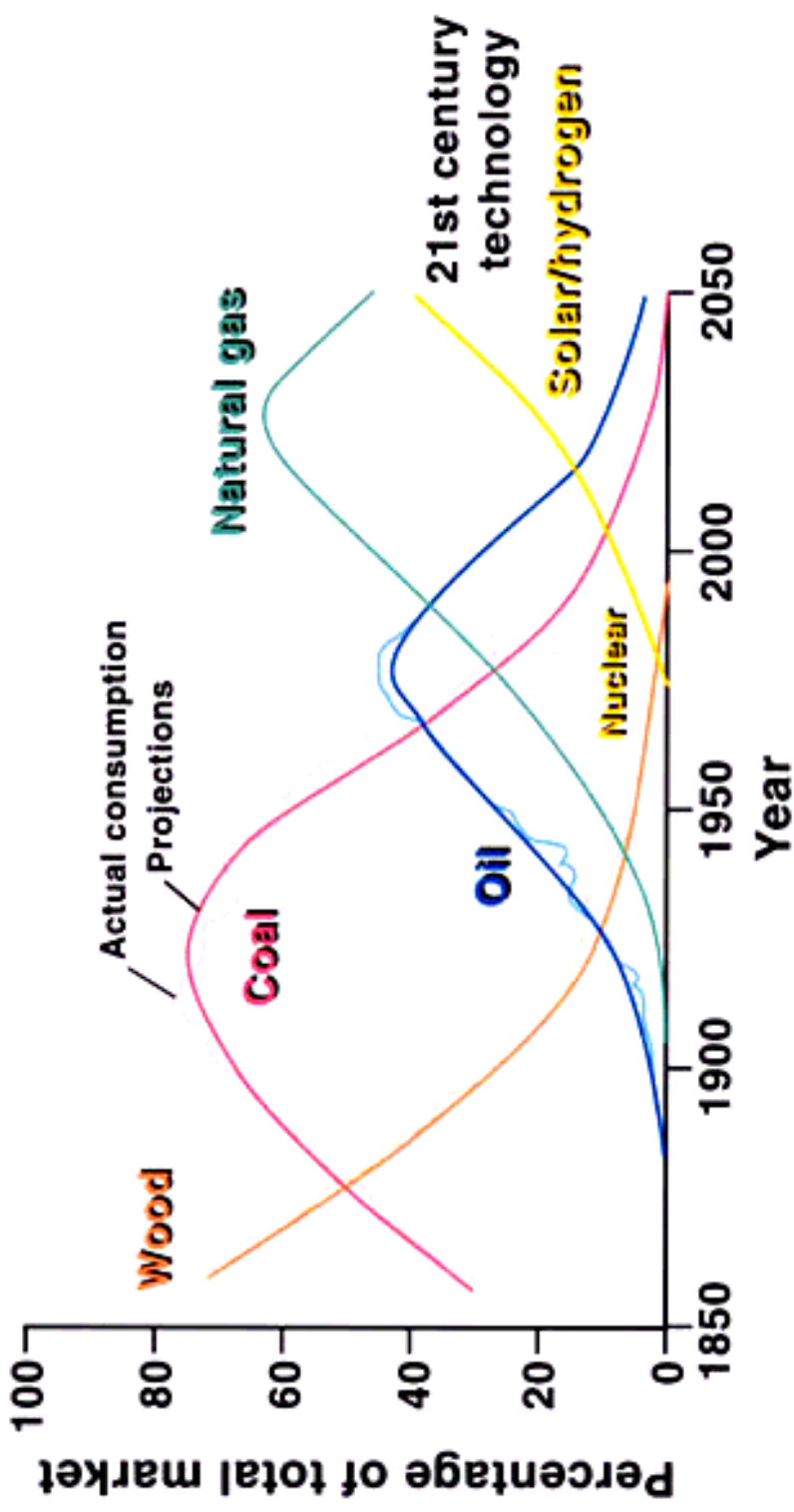
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- The energy economy is shifting to gaseous fuels -- with hydrogen the long term winner
- But there are major uncertainties concerning
  - » Timing of the transition
  - » Which technologies will win
  - » Infrastructure build out
- And these create substantial investment risk

# THE ENERGY ECONOMY IS SHIFTING TO GASEOUS FUELS



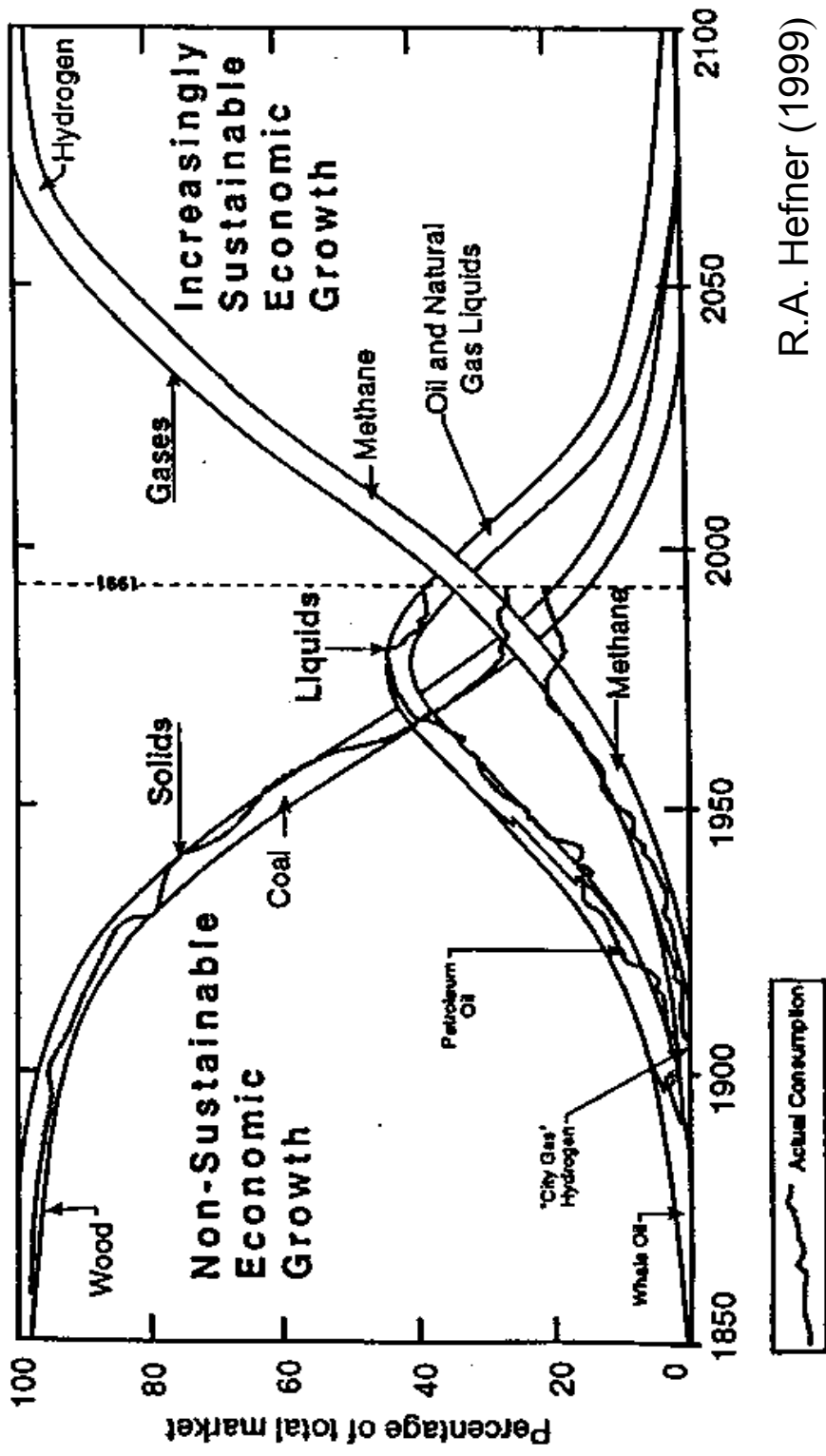
# THE ENERGY ECONOMY IS SHIFTING TO GASEOUS FUELS...



Marchetti and Nakicenovic (1994)

QAC605c

# THE ENERGY ECONOMY IS SHIFTING TO GASEOUS FUELS...



R.A. Hefner (1999)

# MANAGING INVESTMENT RISK

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- Financing Risk
- Technology Risk
- Infrastructure Risk

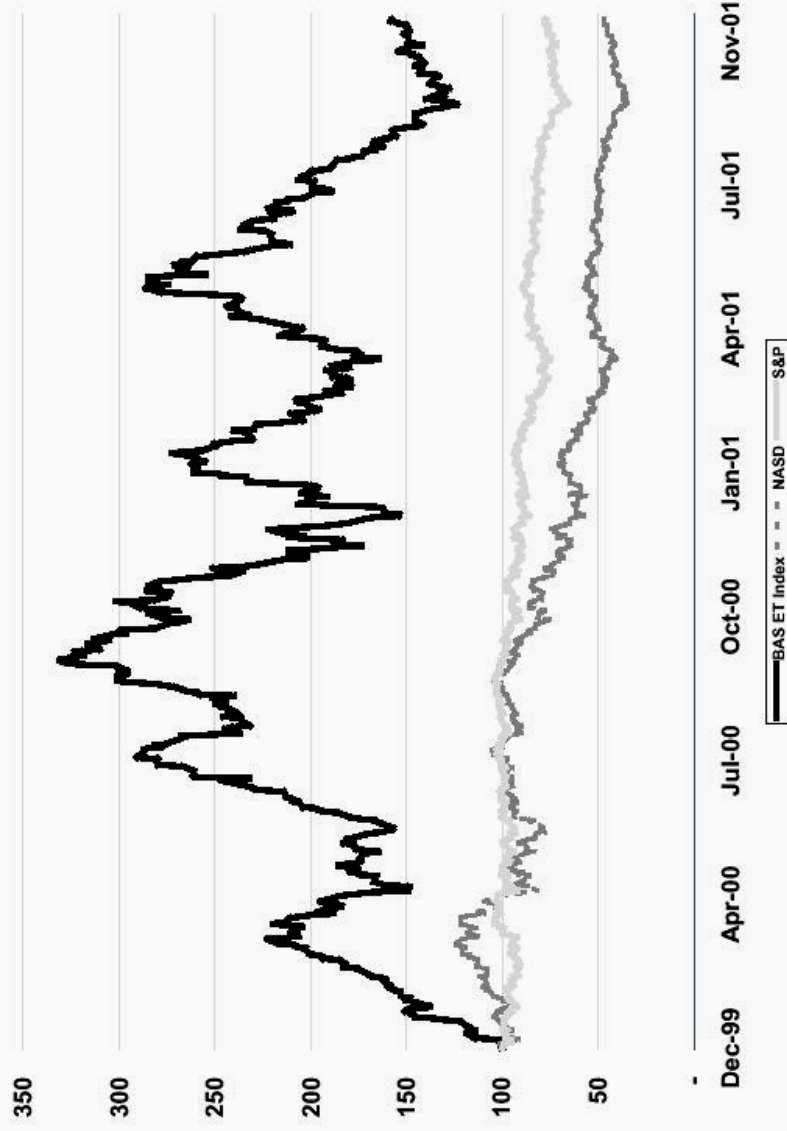
# FINANCING RISK

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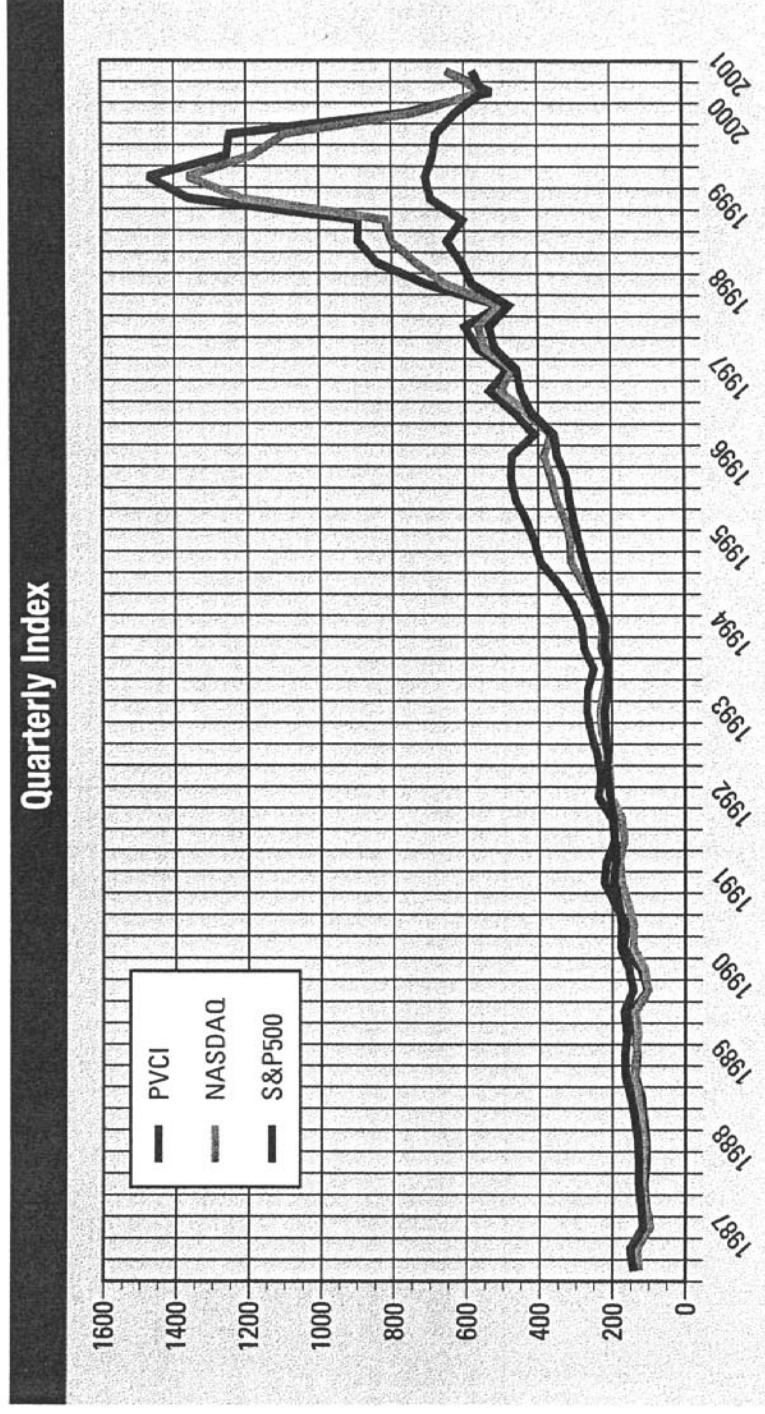
- Energy technology companies -- including hydrogen technologies -- always take longer, and cost more, to get to the goal line than anyone expects
  - » Patience is essential: 5 - 10 year development cycles
  - » So are deep pockets: \$50 - 100M to reach revenue generation
- When markets were frothy, it was possible to achieve substantial return on the large capital investment required -- but that may not be so easy in the current market

# FINANCING RISK ...

**BAS Energy Technology Index Versus Nasdaq Composite and S&P 500**  
Each indexed to 100 at 1/1/00; index is tiered by market cap.



# FINANCING RISK ...



Source: *Venture Economics*

PVCI = Post Venture Capital Index

# FINANCING RISK ...

	Valuation (\$M)		
	Pre-Money	Investment	Post-Money
Seed Stage	3	2	5
First Stage (Series A)	10	5	15
Second Stage (Series B)	20	10	30
Third Stage (Series C)	40	15	55
Mezzanine (Series D)	65	25	90
IPO in 2000	250	100	350
vs.			
IPO Today	<b>**75**</b>	25	100

## FINANCING RISK ...

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- There are three potential strategies to mitigate financing risk in a down market
  - » Consider only deals requiring limited capital
  - » Accept lower return
  - » Do not invest
- Or hope for a return of “irrational exuberance” in the market

# TECHNOLOGY RISK

- Hydrogen deals are not the only ones investors are considering

## FOSSIL FUEL MICRO-GENERATION

- TURBINES
- I.C. ENGINES
- FUEL CELLS
- STIRLING ENGINES
- ALTERNATE CYCLES
- THERMAL PV

## MICRO-STORAGE / POWER QUALITY

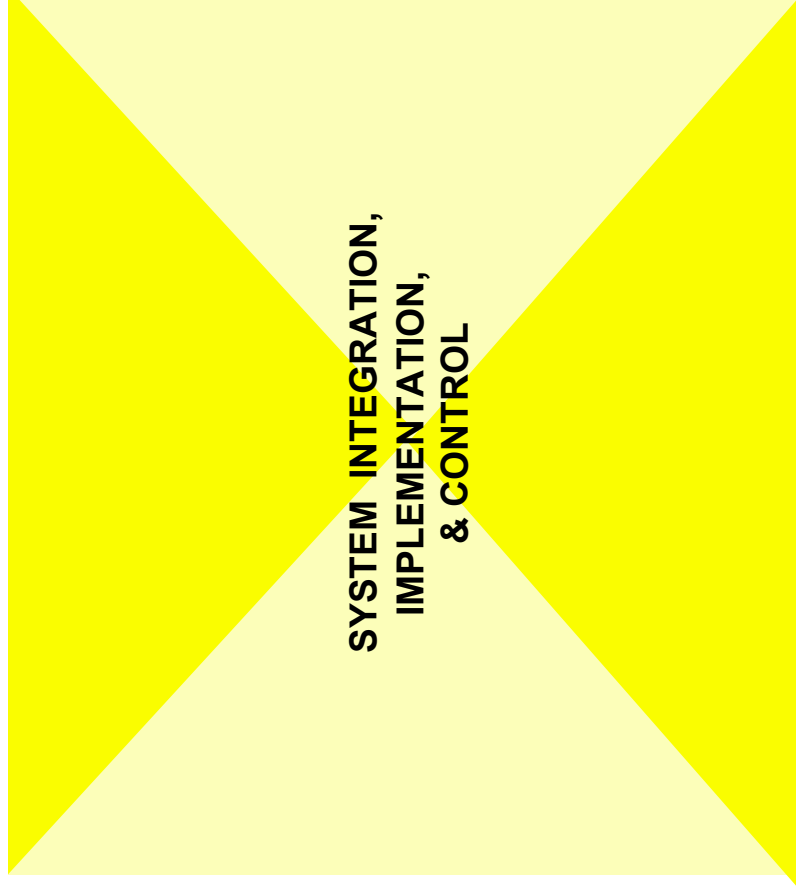
- MICRO - SMES
- FLYWHEELS
- BATTERIES
- ULTRA-CAPACITORS

## HYDROGEN SYSTEM TECHNOLOGY

- FUEL CELLS
- ELECTROLYZERS
- STORAGE
- REFORMERS

## RENEWABLES / MICRO-GENERATION

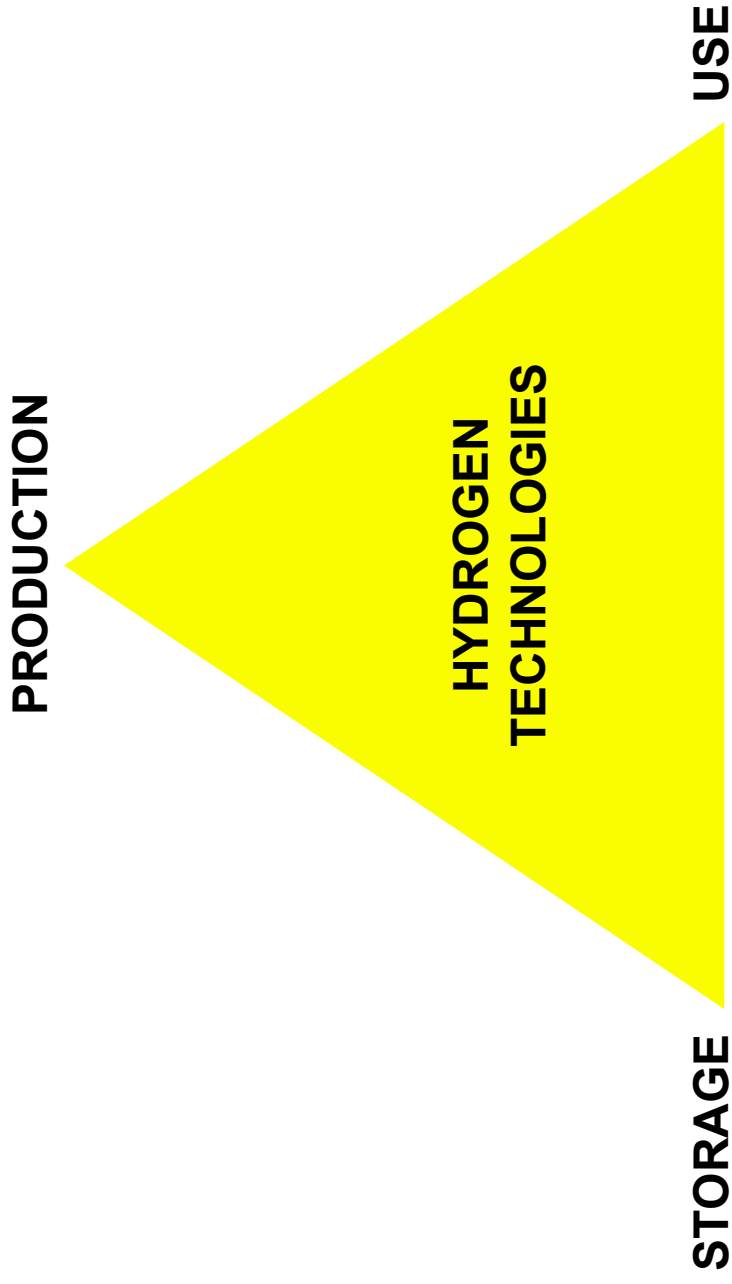
- WIND
- PHOTOVOLTAICS
- BIO - GENERATION
- EMERGING TECHNOLOGY



# TECHNOLOGY RISK ...

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- Even in the hydrogen technology (HY-TECH) space, there are numerous choices



# TECHNOLOGY RISK ...

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- There are several ways to manage technology risk
  - » Know the HY-TECH space very well
  - » Consider only deals with broad-based intellectual property protection
  - » Build a diverse portfolio
  - » Invest over time to capture the benefits of technology evolution

# INFRASTRUCTURE RISK

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- Hydrogen -- ultimately produced by electrolysis of water using sunlight -- is clearly the energy carrier of choice for a sustainable future
- The technology to achieve this future is largely understood even today
  - » Refinements and breakthroughs will doubtless be made
  - » But the immediate challenges are cost reduction and manufacturability -- not fundamental invention

# INFRASTRUCTURE RISK ...

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- What is missing is a hydrogen production and delivery INFRASTRUCTURE, for both
  - » Stationary Applications, and
  - » Mobile Applications
- Imagine the difficulty of creating the petroleum infrastructure from scratch starting today
- The most frequently cited concerns are
  - » Timing of technology readiness
  - » Cost of the infrastructure
  - » Build-out strategy: Who goes first?

# INFRASTRUCTURE RISK ...

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- All the pieces of the hydrogen infrastructure will clearly not become commercially available simultaneously
- Investing in a company whose success depends entirely on some other high-risk event occurring is unwise
- The timing risk is mitigated if the company can address immediately available markets
  - » Fuel cell test stations: Hydrogenics
  - » Industrial gas: Proton Energy Systems; H2Gen Innovations

# INFRASTRUCTURE RISK ...

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- The INFRASTRUCTURE COST is definitely high -- but not forbidding
  - » Full U.S. build-out of the mobile infrastructure:
    - ~100,000 fueling stations
    - \$50 - 100 Billion
  - » Points of comparison
    - Venture capital invested in Year 2000: ~\$100B
    - Asset value of Enron: ~\$65B
    - Proposed Alaskan gas pipeline: ~\$30B

# INFRASTRUCTURE RISK ...

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- It is easy to imagine the hydrogen infrastructure fully in place
  - » SMR's or electrolyzers at every corner fueling station
  - » Possibly an electrolyzer in your garage to fuel the vehicle overnight using off-peak power
  - » Vehicles powered by high efficiency fuel cells -- with the only effluent being pure water
- The question is how to get started?
  - » The fueling system will not be built if there are no vehicles to use the fuel
  - » Nobody will buy a vehicle that can only be used within a short range of a limited number of fueling stations -- fleet vehicles and busses may be exceptions

# INFRASTRUCTURE RISK ...

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- The popularity of hybrid vehicles suggests a potential way to launch the infrastructure
  - » The small I.C.E. in a hybrid can be configured to run on both gasoline and hydrogen interchangeably -- with a flip of a switch on the dash
  - » Vehicle performance would be unaffected -- acceleration comes from the battery
  - » Compressed gas storage for the hydrogen would occupy some -- but not all -- of the trunk
  - » When hydrogen refueling is available -- say in city center -- the hybrid vehicle would run on hydrogen; outside the city center it would run on gasoline

## INFRASTRUCTURE RISK ...

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- Initially only a few cities (e.g. Los Angeles, Denver, Phoenix) might self-select for introduction of hydrogen fueling and the specially equipped hybrids sold only there
- Over time, additional cities, and expansion of the hydrogen fueling network in each city, would permit incremental roll-out
- When running on hydrogen, the dual-fuel hybrids could display an external green light -- a “feel good” signal initially, and a possible enforcement tool eventually

# INFRASTRUCTURE RISK ...

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- Advantages of this approach are many
  - » No need to wait for fuel cell vehicles -- when they are ready they flow smoothly into the system
  - » The dual-fuel hybrid does not force consumers into buying a limited use vehicle to act on a “green” sentiment
  - » The initial commitment of capital would be relatively modest compared to full build-out
  - » Only a few players would need to act in order to get started
  - » The system build-out would be organic -- and driven by economics
  - » First-to-market companies could establish a commanding competitive position

# INFRASTRUCTURE RISK ...

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- The “build-out risk” is daunting indeed
- The dual-fuel hybrid approach may be one way to mitigate it -- not necessarily the only way
- No one company can take on this risk alone
  - » It will take a committed partnership of at least
    - One auto maker
    - A hydrogen supplier, and
    - An enlightened city
  - » And a substantial dose of political will

# INFRASTRUCTURE RISK ...

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- Investments in **HY-TECH** that can facilitate and participate in infrastructure creation may be exceptionally attractive

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For a copy of this presentation, visit

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