



INVESTING IN HYDROGEN TECHNOLOGIES
A VENTURE CAPITALIST'S PERSPECTIVE

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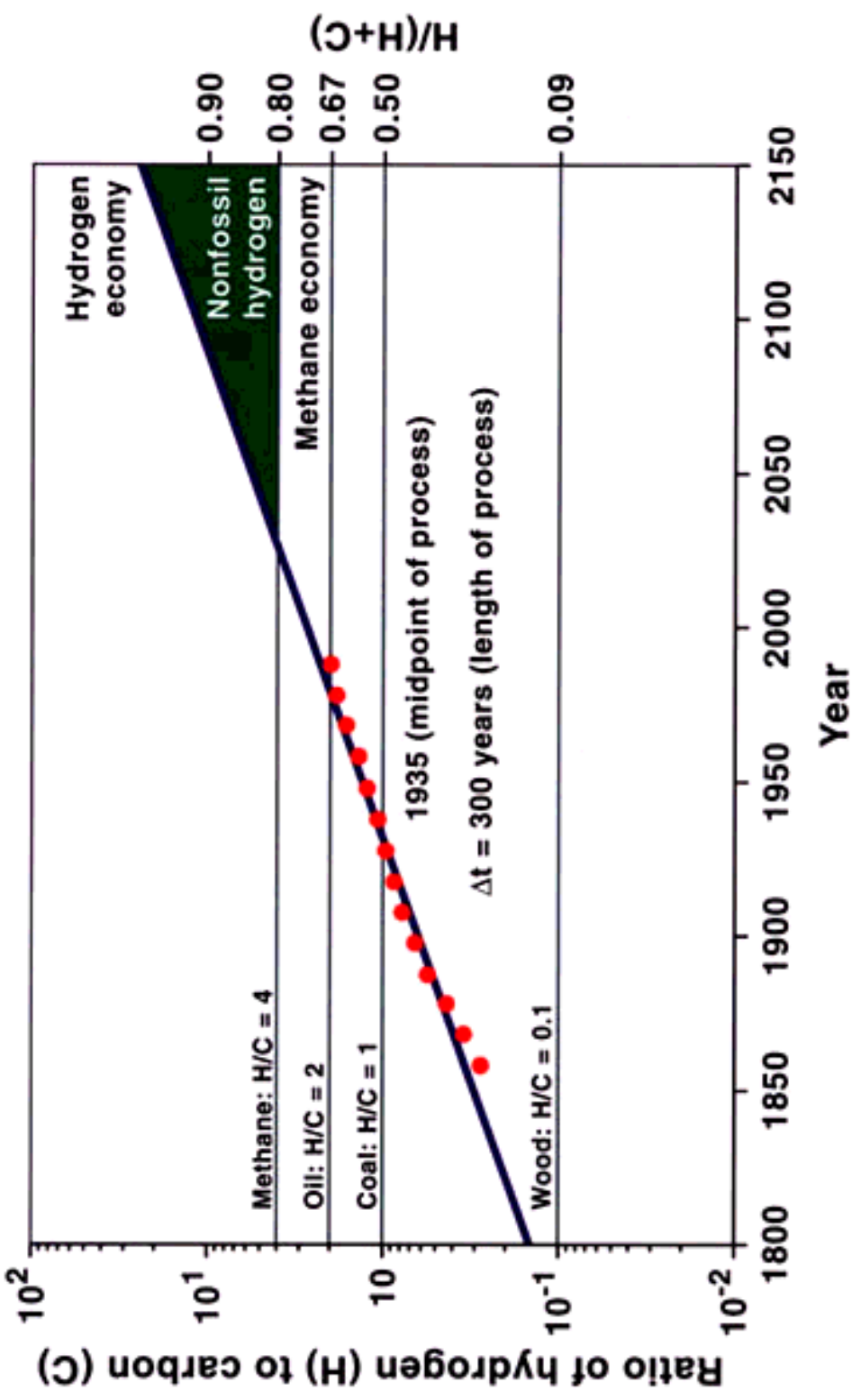
INVESTMENT CRITERIA

- 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

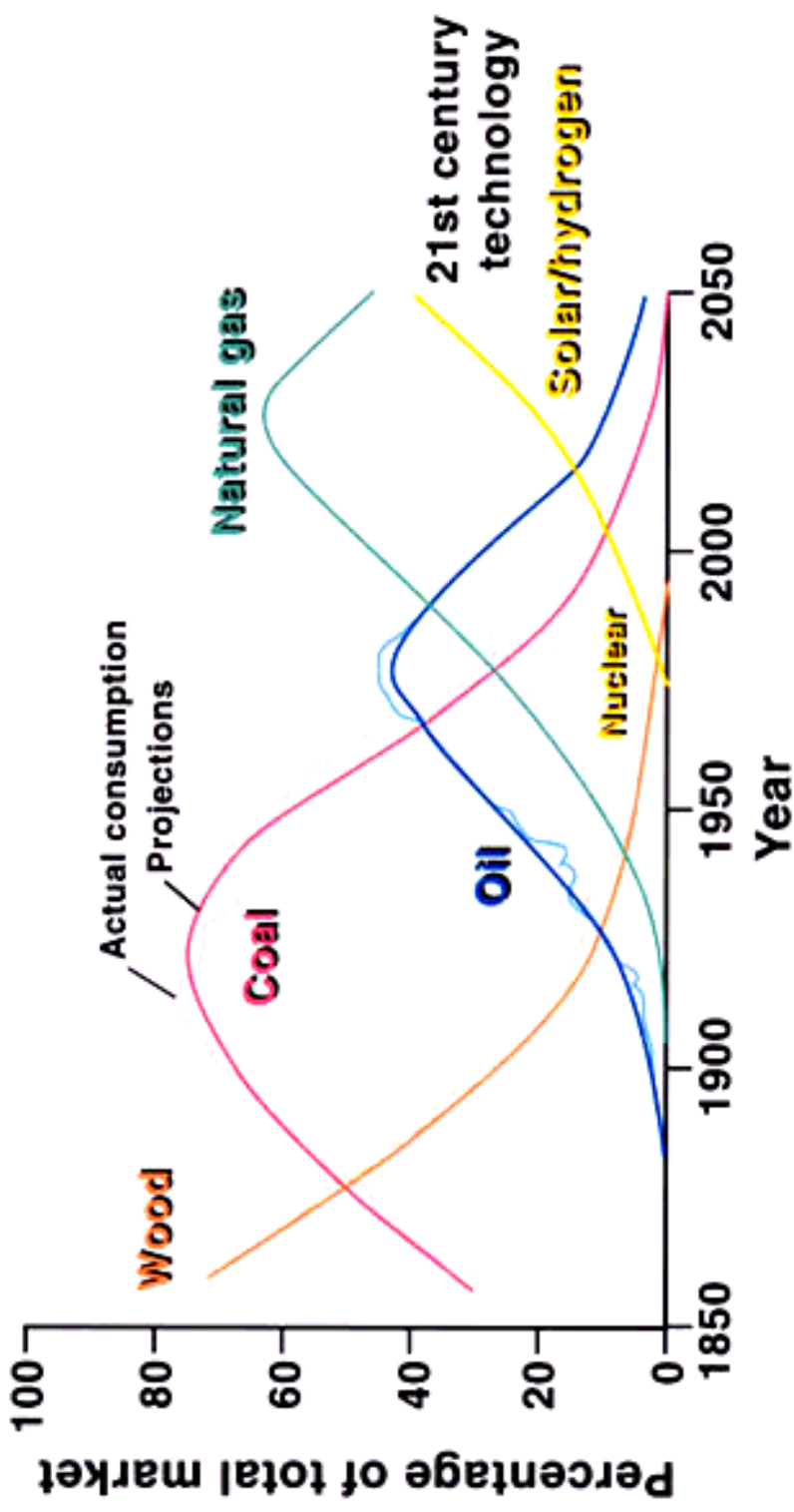
THE MARKET OPPORTUNITY IS ENORMOUS

- 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



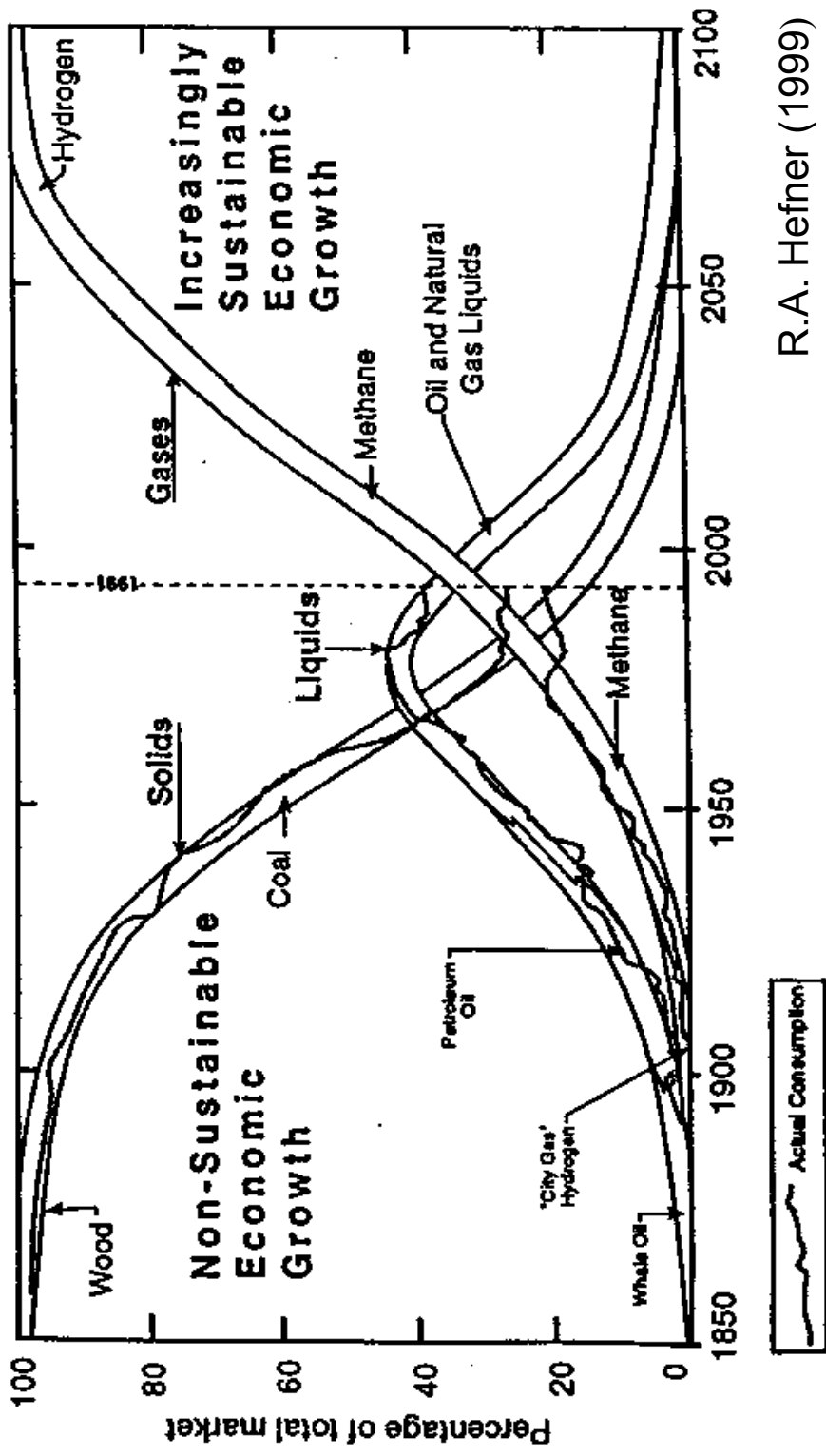
THE ENERGY ECONOMY IS SHIFTING TO GASEOUS FUELS...



Marchetti and Nakicenovic (1994)

QAC605c

THE ENERGY ECONOMY IS SHIFTING TO GASEOUS FUELS...



R.A. Hefner (1999)

MANAGING INVESTMENT RISK

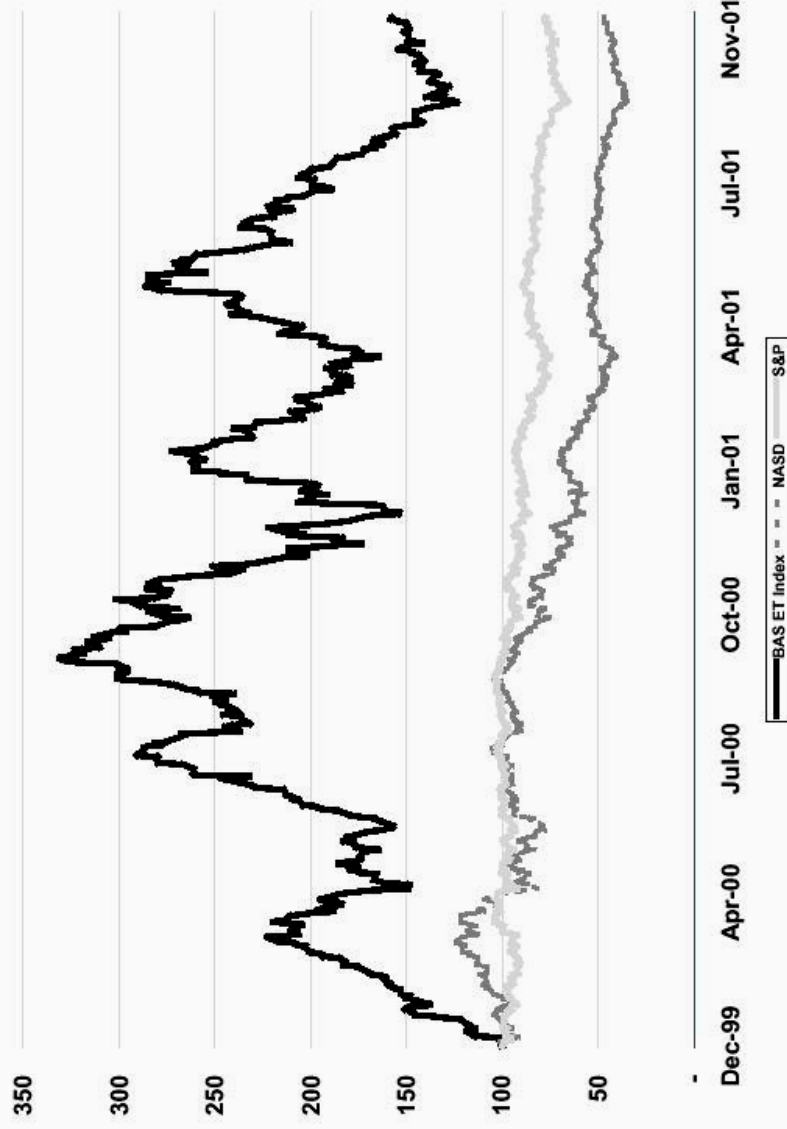
- Financing Risk
- Technology Risk
- Infrastructure Risk

FINANCING RISK

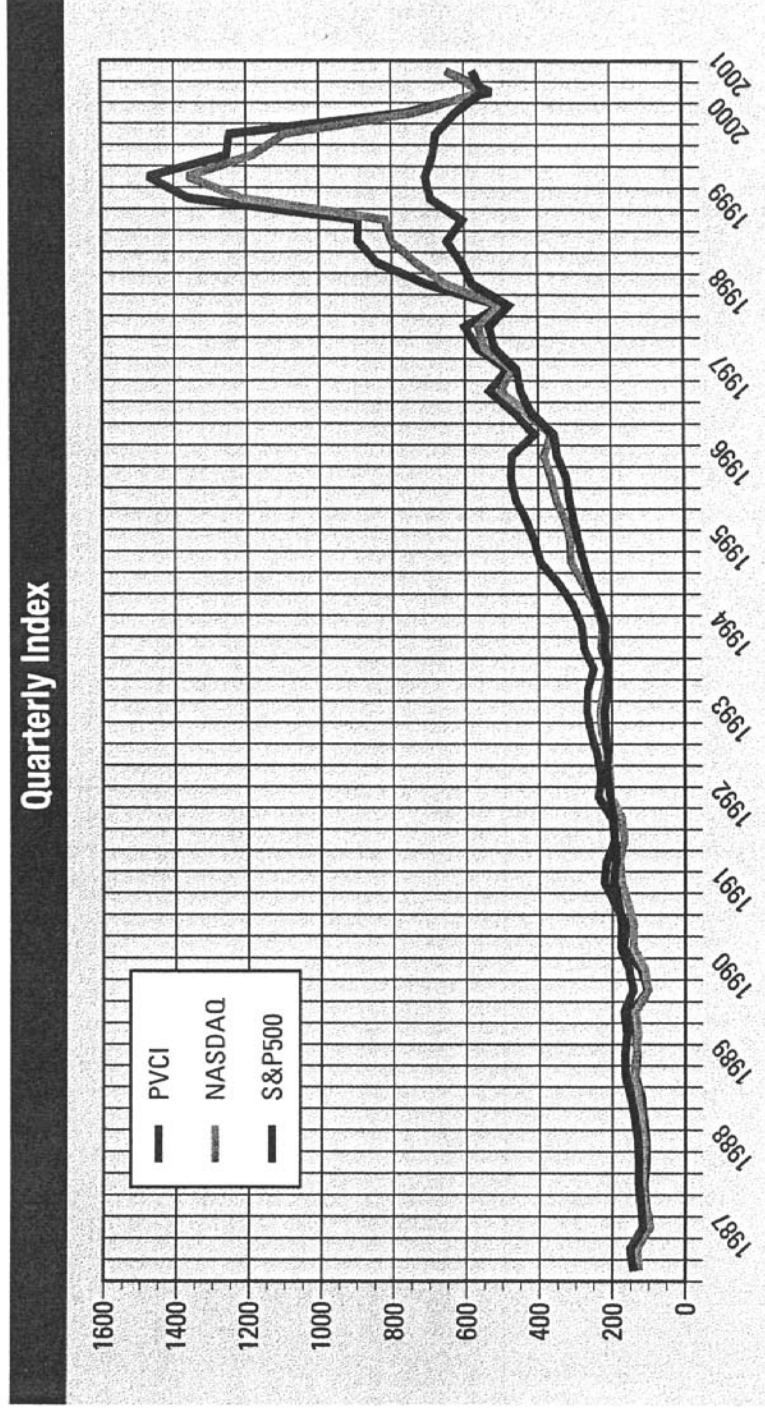
- Energy technology companies -- including hydrogen technologies -- always take longer, and cost more, to get to the goal line than anyone expects
 - » Patience is essential: 5 - 10 year development cycles
 - » So are deep pockets: \$50 - 100M to reach revenue generation
- When markets were frothy, it 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 ...



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	**75**	25	100

FINANCING RISK ...

- 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

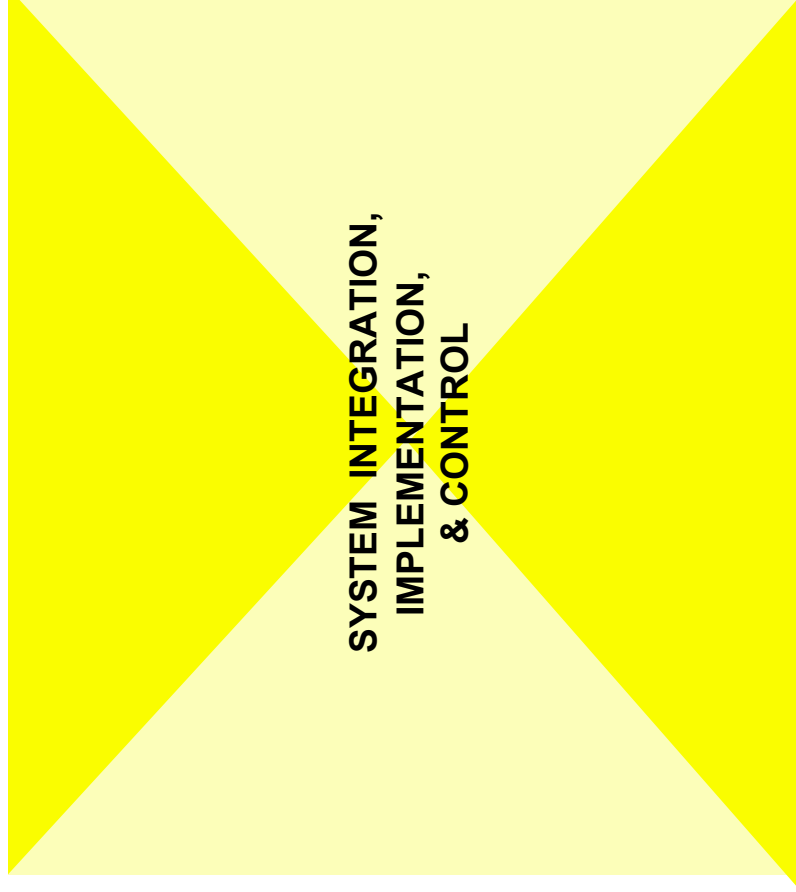
- MICRO - SMES
- FLYWHEELS
- BATTERIES
- ULTRA-CAPACITORS

HYDROGEN SYSTEM TECHNOLOGY

- FUEL CELLS
- ELECTROLYZERS
- STORAGE
- REFORMERS

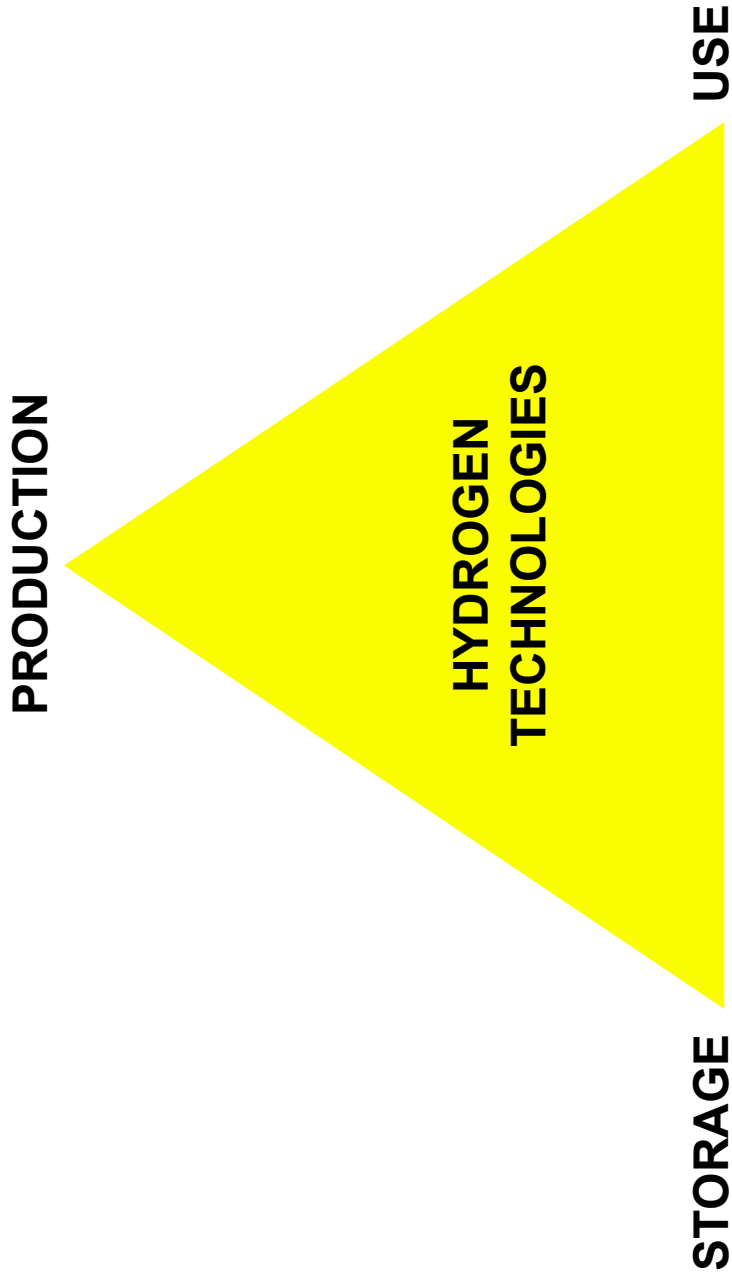
RENEWABLES / MICRO-GENERATION

- WIND
- PHOTOVOLTAICS
- BIO - GENERATION
- EMERGING TECHNOLOGY



TECHNOLOGY RISK ...

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



TECHNOLOGY RISK ...

- 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

- 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 ...

- 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 ...

- 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 ...

- 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 ...

- 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 ...

- 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 ...

- 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 ...

- 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 ...

- 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 ...

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

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