PowerAvenue Corp.

Presentation to

H S H HEREDITARY PRINCE ALOIS

Prince of Liechtenstein

February 26, 2008

By

Prof. Dr. Firouz Shahrokhi, President

Primary Goal

Delivery of secure, safe, reliable, environmentally friendly technology at competitive cost through high-volume manufacturing

"… the most significant initiative in distributed secure and clean power generation of the 21st century…"

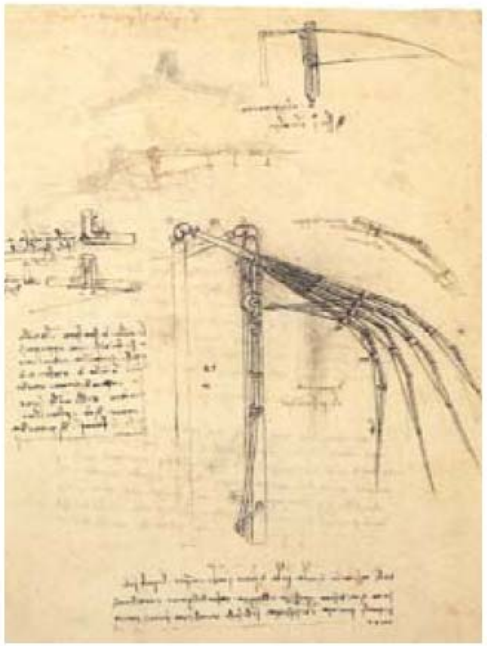
Rocco Guarnaccia, CEO

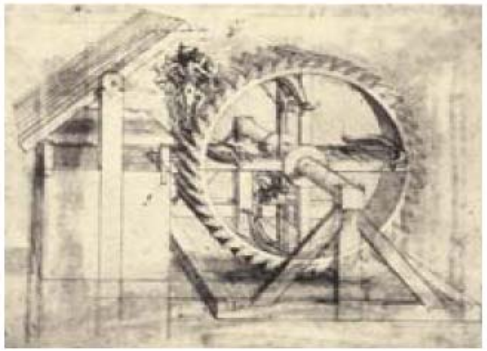
On the Leading Edge of Technology

Some of *PowerAvenue's* More Than 40 Innovations and Patents

(Patent numbers in parentheses)

- Method for producing silicon (WO 03/059814)
- Method for production of silicon nitride (WO 02/090254)
- Method for generation of energy (WO 02/090257)
- Method for producing hydrogen (WO 2004/052774)
- Fuel cell and fuel cell arrangement (DE 298 03 325.9)
- Device for energy transformation having at least one fuel cell and/or one hydrolyzer (DE 199 16 243.3)
- Differential pressure security valve (DE 100 53 609.3)
- Elongated fuel cell having cross channels for gas supply (DE 102 01 149.4)
- Fuel cell with an internal chamber, in which a gas storage device is placed (DE 102 00 222.3)
- Air-heating device with fuel cell (EP 03 000 250.5)
- Device for providing hydrogen using silicon and/or aluminum and water (DE 10 2006 002394)
- Method of operating a fuel cell, and device having a fuel cell (DE 10 59 410.7)
- Fuel cell with an internal chamber, in which a gas storage device is placed (EP 02 029 001.1)





Leonardo DaVinci's

... in the tradition of the greatest innovators and visionaries throughout history ...

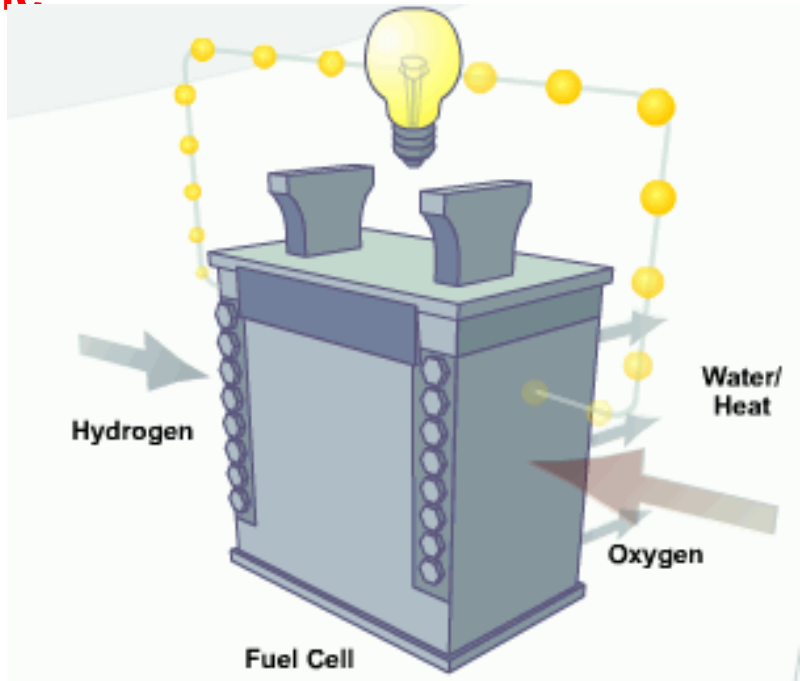
The Company

PowerAvenue was formed in 2002 to become mass manufacturer of secure and clean power

PowerAvenue's focus is on Proton Membrane Exchange (PEM) fuel cells due to their;

- **operation at low pressure and temperatures,**
- **high power-to-weight ratio, and**
- **reliability and efficiency**

Decentralized Modular
Point-of-Use Power
Delivery Systems



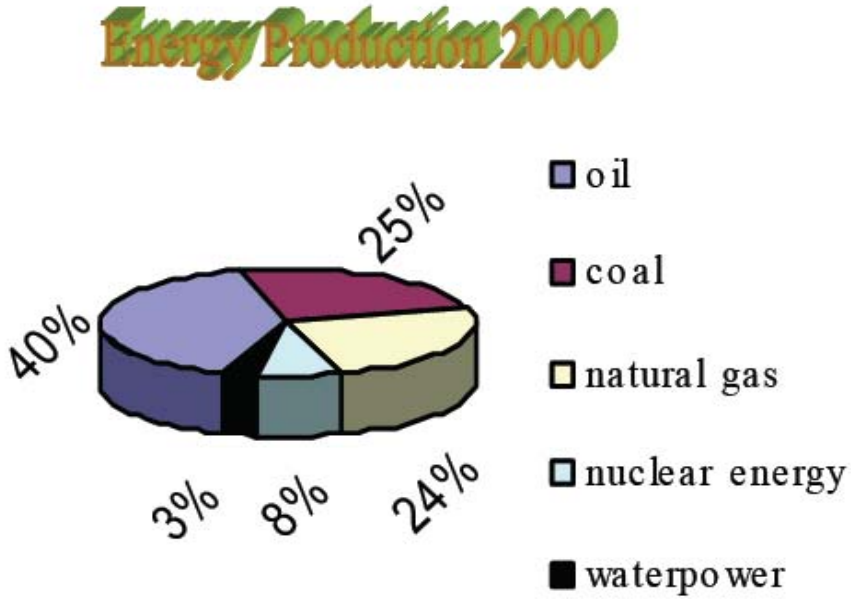
‘Hydrogen is the fuel of the future’ *President Bush, Earth day, 22 April 2006*

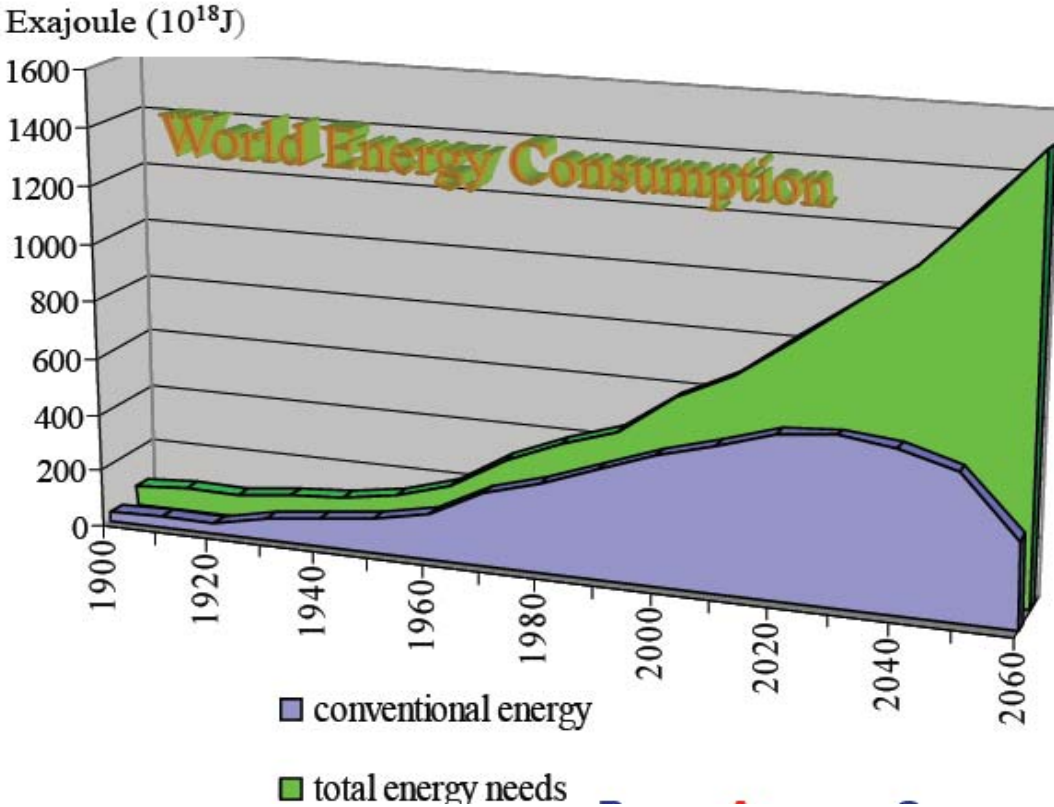
- *Hydrogen* is the most abundant element in the universe and third most abundant on earth
- *Hydrogen* IS NOT toxic, corrosive, radioactive, polluting, or carcinogen
- *Hydrogen* has the highest energy density (per mass) compared to other traditional fuels
- *Hydrogen* is NOT burned in a fuel cell
- *Hydrogen* can be produced from variety of feedstock using proven technologies

The Problem …

G. Schröder, R. Prodi, E. Stoiber; HYFORUM 2000:

The most urgent challenges facing the just beginning new century are focussing on the fields of health, food and ***energy***





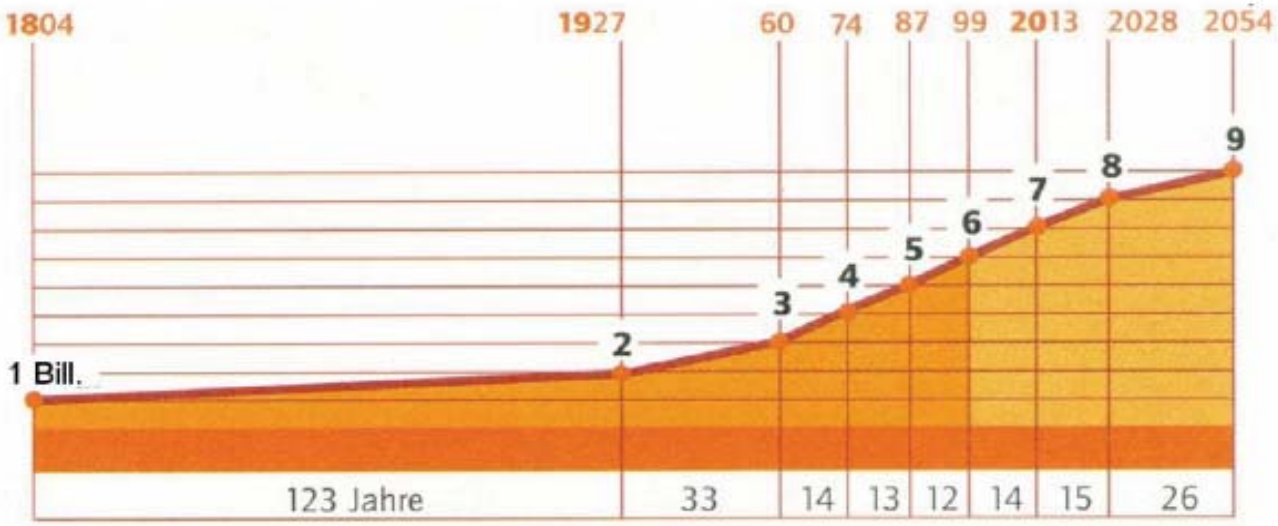
… in Numbers and Statements

- Within one day, mankind burns more carbon, oil and natural gas than being formed within a thousand years in history of earth.
  In forty years the need of energy will be twice as much (Greenpeace)

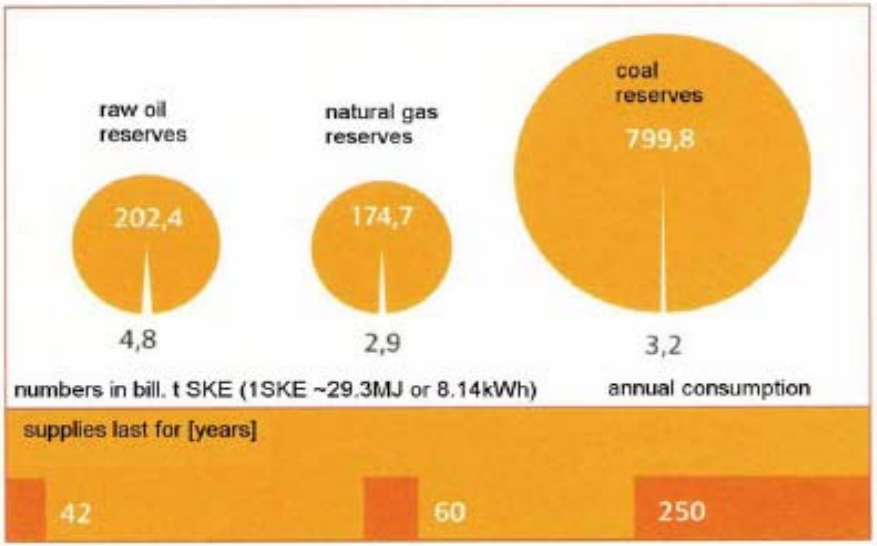
- Step by step the earth runs out of oil
  (Fritz Varenholt, Shell AG)

- The problem with the green house gas (CO_2)
  (HYFORUM 2000)

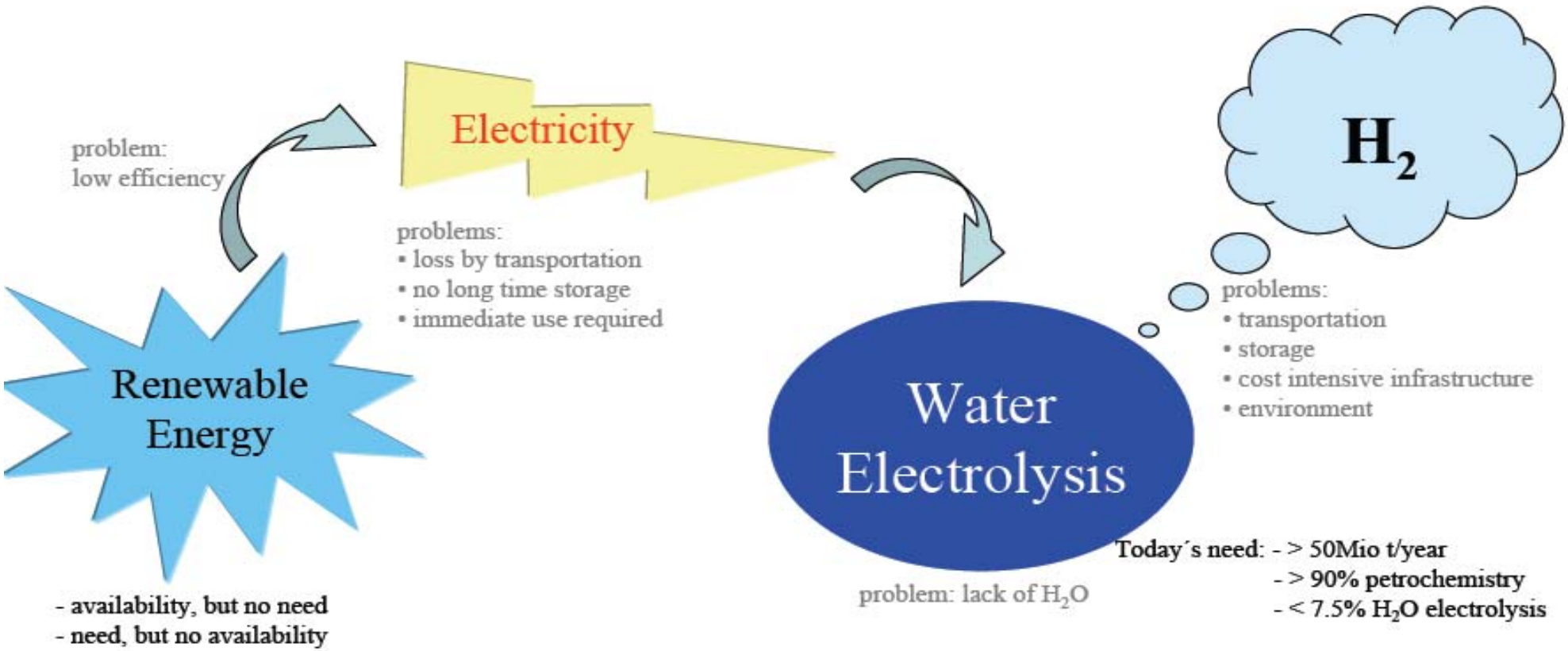
World population in billions [prognosis]



Resources in carbon based energy



The FUTURE is …



… full of problems

Statement of the Energy Departement, Washington DC, *July 2002*:
… we are looking for „revolutionary" new energy production schemes, being convinced that „incremental" progress and all of the conventional approaches to fuel cells, photovoltaics, fossil fuels etc., aren´t going to be sufficient for the future. Simply, our need is a secondary energy carrier, which is transportable without hazards.

Excess of

Renewable Energy

transportation by a carrier

Need of Energy

The ENERGY PROBLEM is a problem of

=> ENERGY STORAGE and of
=> ENERGY TRANSPORTATION
and thus requires an efficient
=> ENERGY CARRIER

HYFORUM 2000: The energy carrier of the new century is *hydrogen*

(Patronage: G.Schröder, R. Prodi, E. Stoiber)

FERRO-SILICON

- Steel
- Foundry

- Automotive
- Buildings
- Industriel equipment
- Farming

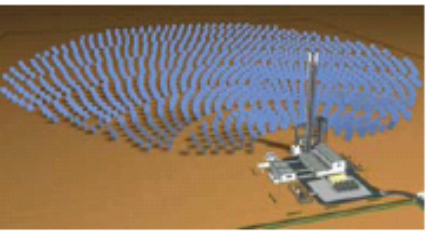
SOME SILICON AND FERROSILICON USAGES

SILICON METAL

- Aluminum
- Chemical
- Electronic

- Automotive
- Aeroplanes
- Silicones
- Computers
- Solar Cells

The FUTURE is …



Silicon* → transportation and storage → H_2O

Electricity

problems:
- loss by transportation
- no long time storage
- Immediate use required

Water Electrolysis

problem: lack of H_2O

H_2

problems:
- transportation
- storage
- cost intensive infrastructure
- environment

SiO_2

… full of silicon based options

	C	Si*
Energy content [kJ/g]**	32,8	32,6
Energy density [kJ/mL]**	74,2	75,9

** obtained from heat of formation of the oxides

Alternative Fuels

OIL : Limited supply, Pollution issues

COAL : More abundant, but more polluting
some problems solved using *clean coal tech*

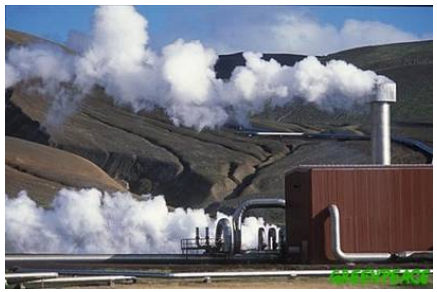
Natural Gas : Limited supply, clean, transport problems

Bio-diesel : “Replacing food for fuel, energy intensive to produce, low altitude ozone issues

Alternative Energy

Solar: Location dependent,
Land use intensive,
Low energy density

Wind: Location dependent,
Land use intensive,
Low energy density



Geothermal: Limited supply
Pollution issues
Location sensitive

Nuclear: Clean Energy
Political and security issues
Major Waste Disposal problems

Hydrogen Economy cannot be developed by itself

Evolution of energy vectors from 1850 up to date

Experience on hydrogen as an "alternative" energy source in 70s was negative

Why hydrogen comes out again?

Barriers to the market

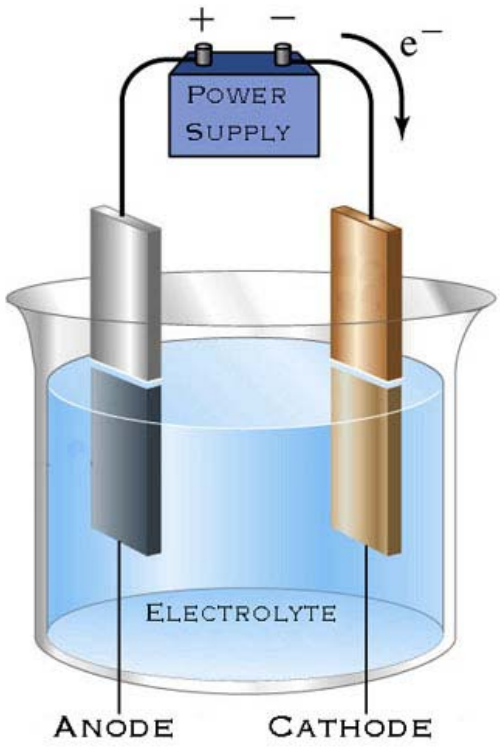
Therefore, the transition process towards the hydrogen-economy should be adopted

How We Produce Hydrogen NOW

Electrolysis

Simple Concept BUT
Not practical

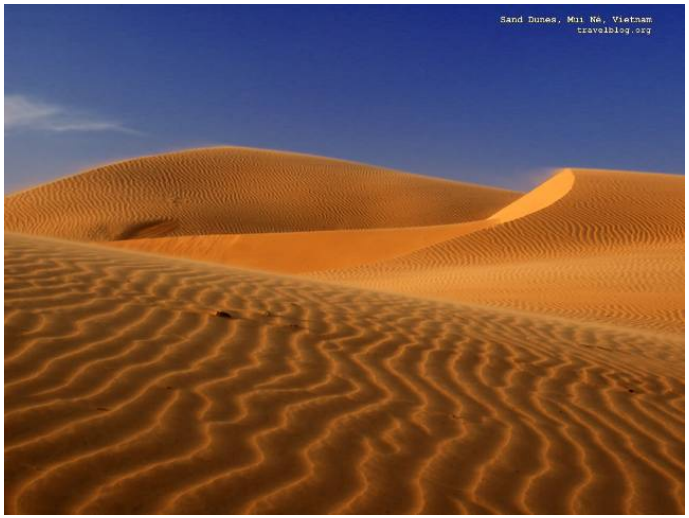
The process is very energy Intensive. It requires more energy to produce hydrogen than other competing processes

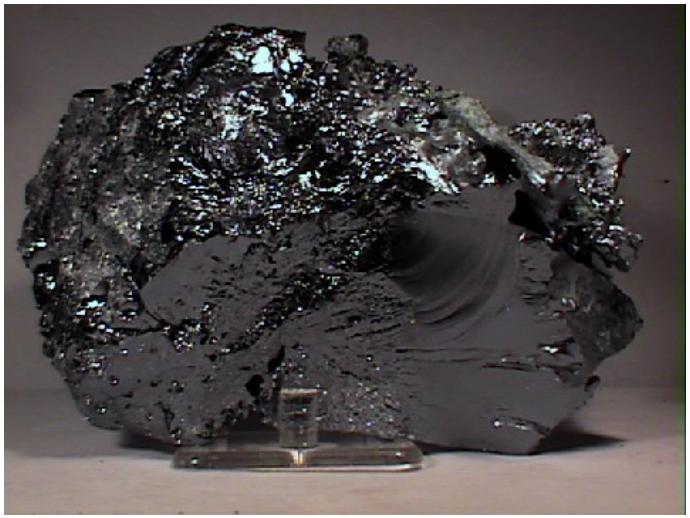


A Better Approach : Hydrogen from Sand

- Silicon (via sand) - second most abundant element on Earth's crust
- Sun is used to purify Si to 98%
- Water is used to produce H_2 from Si

The resulting products are SiO_2 and pure water





New Way of Using Hydrogen

Non-burning of H2 –

Hydrogen in not burnt in a fuel Cell as with fossil fuels, but instead its electron is separated to generate electricity

Sample reactions

Burning

Non-Burning

Typical Combustion Reactions Where Fuel "Burning" Takes Place		
natural gas + oxygen	→	CO_2 + water + 891 kJ/mole heat
or		
gasoline + oxygen	→	CO_2 + water + 5471 kJ/mole heat
Noncombustion Alternative Energy Schemes (NASA's Sodium Sulfide battery)		
sodium + sulfur	→	sodium sulfide + 183 kJ/mole heat
***PowerAvenue's* Use of Silicon to Generate Hydrogen**		
silicon + water	→	sand + hydrogen + 340 kJ/mole heat

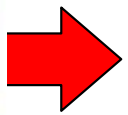
Does Hydrogen Measure up?

- Fuel cells powered by pure hydrogen emit no harmful pollutants.

Fuel efficiency comparison	
1 gal of gasoline	25 mi
1 gal of hydrogen (1 kg)	60 mi

Pound for pound hydrogen holds more energy	
Hydrogen	52,000 BTU/lb (120 kJ/g)
Gasoline	19,000 BTU/lb (43.5 kJ/g)

Energy yield of hydrogen	
1 kg of H_2	115,000 BTU
1 kg of H_2	33.3 kWh
1 kg of H_2	120 MJ



Comparison to other fuels	
Fuel (kg)	Output (kWh)
gasoline	13.0
methanol	5.6
propane	12.9
ethanol	7.5
butane	12.7
natural gas	13.9
HYDROGEN	33.3

Additional Technical Information …

Production of 1 MW of Electricity*		
Reactants	**Consumption rate kg/h**	**Consumption rate metric tons/yr**
Sand	900	8000
Silicon	400	3700
H2	60	535
Water	556 (liters/h)	5,000,000 liters per year

1 kg of pure silicon (Si) can be extracted from 2 kg of SiO_2 ("clean sand")
1 kg of hydrogen is obtained from 7 kg of silicon, or
1 kg of hydrogen is obtained from 14 kg of sand, or

1 kg of sand yields 2.4 kWh of energy

Operational Hydrogen Requirements (Fuel cell efficiency – 50%)		
Power output (kW)	Mass rate (g/min)	Volume rate (Liters/min)
1	1	11
5	5	56
10	10	112
15	15	167
50	50	556
100	100	1,120

Fuel	Energy [kJ/g]	Energy [kJ/l]
Coal	29.3	
Brown coal	8.1	
Wood	14.6	
Gasoline	43.5	30,590
Diesel	42.7	29,890
Methanol	19.6	15,630
Natural gas	50.0	31.7
Hydrogen	119.9	10

Power Conversion and Applications		
Power rating	applications	hp
15 – 100 W	small electronics, toys, etc.	
1.5 kW – 2.5 kW	bicycles, scooters, golf carts, fork lifts	2 – 3.3
5 kW	stationary units, houses, campers, … at 110 V, provides 45 Amps (typical homes use about 40 amps at a given time); several modules can provide typical power	6.7
100 kW	high power, compact size applications typical ½ ton truck uses two 100-kW (total of 268 hp) units	134

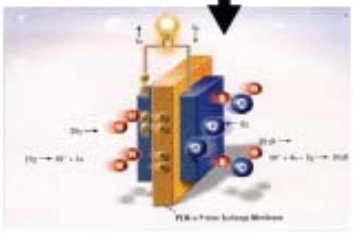
Hydrogen Conversions and Facts	
1 mole of H_2	2 g
1 mole of H_2	22.4 L
Heat of combustion	242 kJ/mol (LHV)
1 standard ft^3 of H_2	2.53g

Rough Cost Calculation

1 ton FeSi (98.5%)

140 kg H_2

~ 4L



$\eta \sim 40 - 50\%$

$\eta \sim 20 - 25\%$

chemicals + materials competitive

Solar power

2.1 tons of Sand

PowerAvenue Corp

15 kg of Sand yields 1 kg of Hydrogen !

Hydrogen Fuel Cells

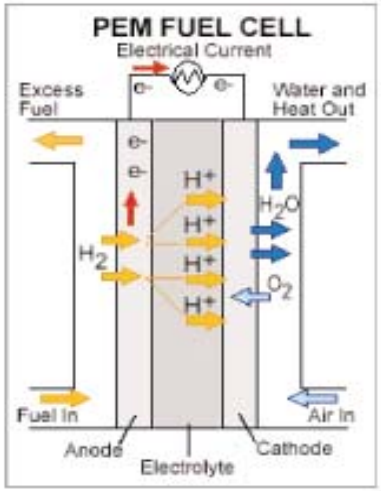
Advantages:

- Direct energy conversion
- No emission
- High Efficiency
- No moving parts
- Quiet operation
- High reliability
- Rapid response to load fluctuations

Types:

- Alkaline
- Proton Exchange Membrane (PEM)
- Direct Methanol
- Phosphoric Acid
- Molten carbonate
- Solid oxide

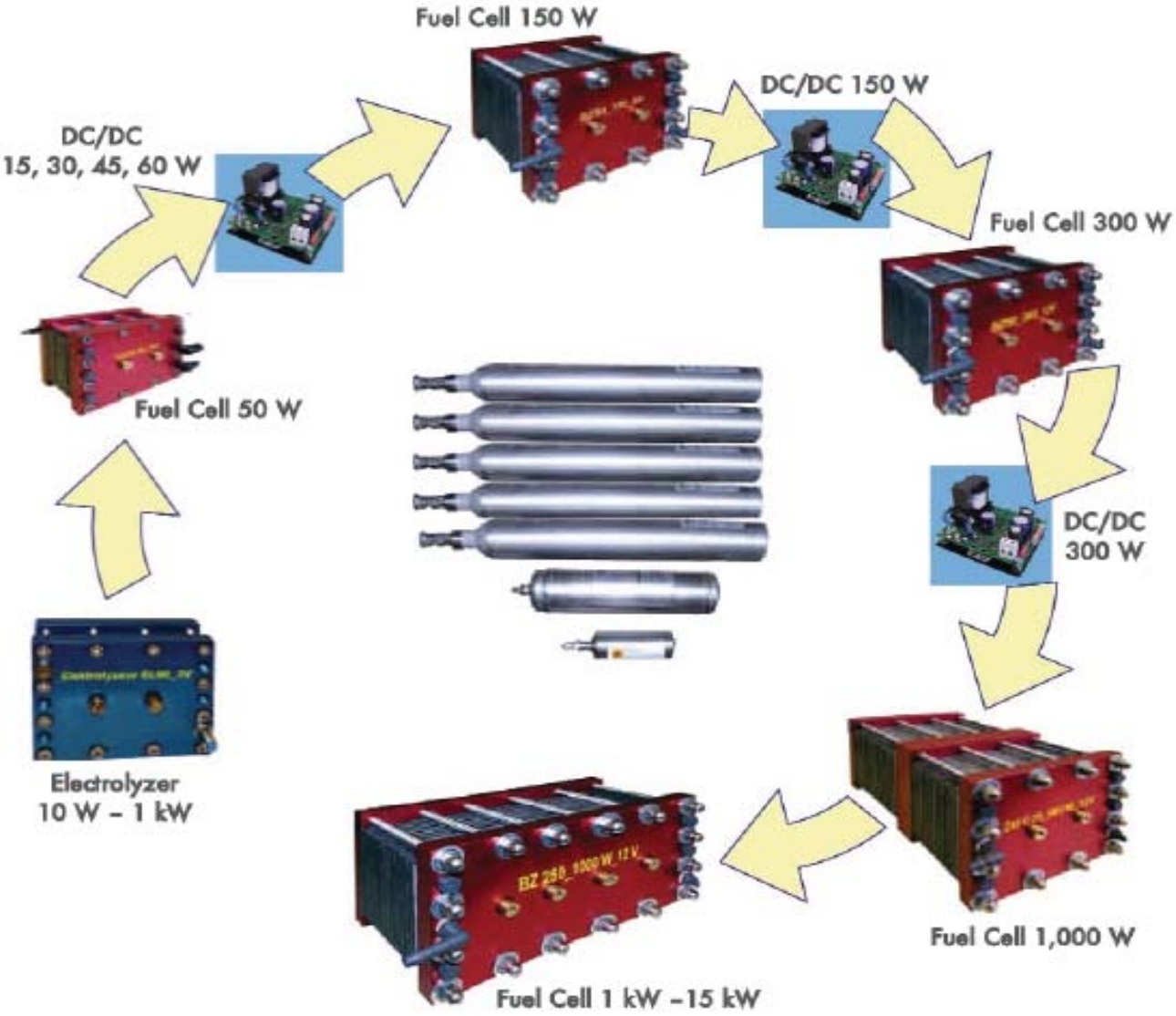
The Fuel Cell Technology



PowerAvenue Corp

Fuel Cell Types	A-FC	PEM-FC	DM-FC	PA-FC	MC-FC	SO-FC
	Alkaline	Proton Exchange Membrane	Direct Methanol	Phosphoric Acid	Molten Carbonate	Solid Oxide
Applications	Transportation Space Military Energy Storage Systems Portable Power Systems Decentralized Stationary Systems			Combined heat and power for: Decentralized Stationary Systems Transportation		
Operating Temperature (in ° Celsius)	< 100	60 - 120		160 - 220	600 - 800	500 - 1000

PowerAvenue Fuel Cells



MANY ADVANTAGES OF FUEL CELLS

- Direct energy conversion, no combustion
- No emissions
- High efficiency
- No moving parts
- Quiet operation
- High reliability
- Rapid response to load fluctuations
- Siting ability, limited infrastructure needed

500 W TECHNICAL SPECIFICATIONS

Design:	FFC Foil-Fuel Cell
Air Supply:	Fan only
Cooling:	Water cooling
Nominal Power:	500 Watt
Nominal Voltage:	23-12V DC without DC/DC
Active Area:	119 cm^2
Dimensions:	260 x 130 x 106 mm^3
Weight:	3 kg

Products and Solutions

Portable Products	Stationary Products
• Portable Generator	• Bungalow Primary Power
• CPS, Video Equipment	• Residential Primary Power
• Bicycle	• Neighborhood Generator
• Recreational Vehicles	• Small Power Plant
• Forklift	• Medium Power Plant
• Gardening	• Hospital, Clinic
• Solar Back-Up	• IT, Telecom Premium Power
• Toys	• Mobile Trailer Back-Up Power
• Wheel Chair	
• Golf Cart	
• Scooters	
• Shipyard vehicles	**Special Applications**
• Pure Oxygen Production	
• Mining Lights	• Utensils
• Wind Back-Up	• Biomedical Equipment
• Shopping Cart	• Clean Cars (SUV)

Applications of Fuel Cells

Education

Households / Hospitals..

Fuel Cell Modules

Mobile

Golf Cart

Stationary

Telecom / IT

Generator

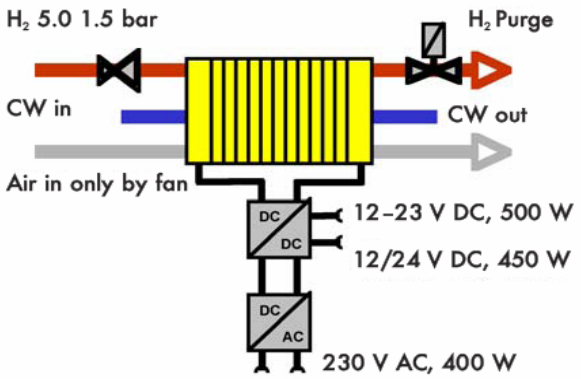
Portable

Battery Charger

Zero-Emission Scooter

PowerAvenue Corp is currently collaborating with an industry leader in zero-emission scooter products. These scooters utilize a 1,500 W brushless wheel motor that may be supplied by three 500 W *PowerAvenue* hydrogen fuel cells or a dedicated 1.5 kW cell. Using hydrogen fuel cells will eliminate the disadvantage of battery-operated scooters in terms of range and charging time.

- Environmentally friendly
- Easy handling
- Max speed of 60 km/h
- Hydraulic disc brakes
- 10 in. wheel rims
- Weight of approximately 100 kg



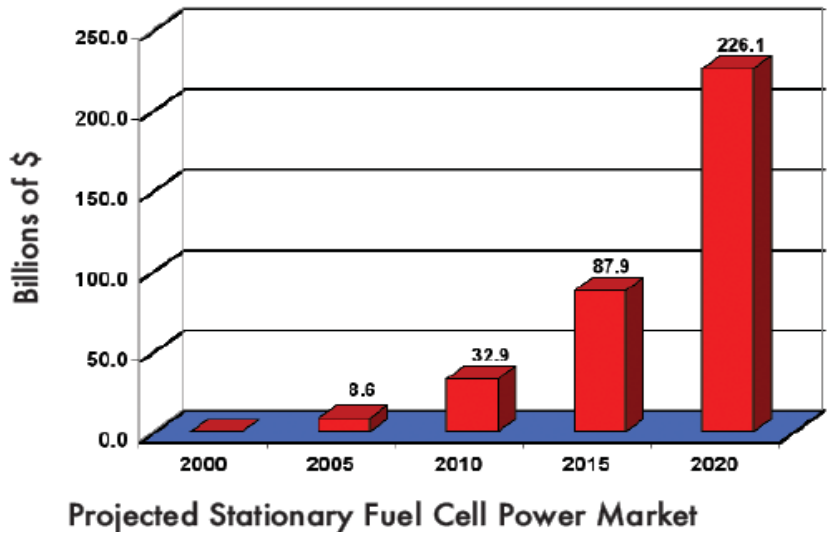
Stationary Power Systems

PowerAvenue: 1 kW to 25 kW

Applications:

Homes, Business, Hospital

Hotel, School, Emergency Power



Projected Stationary Fuel Cell Power Market

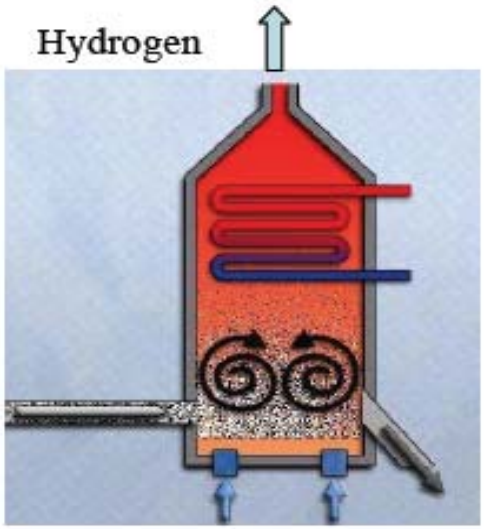

Residential Units


PC/Networks/Telecom-Servers

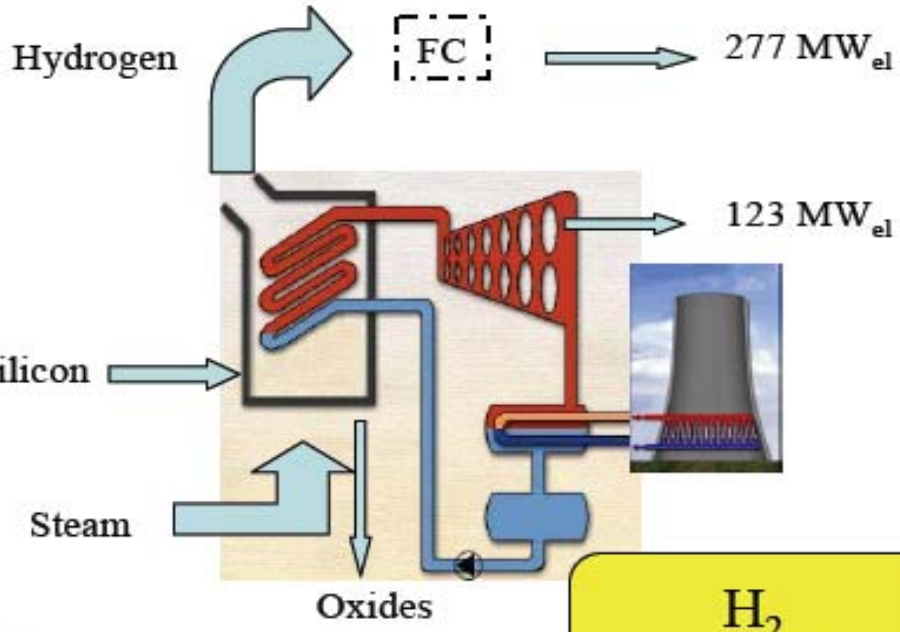

Data Centers

Stationary Power Plants

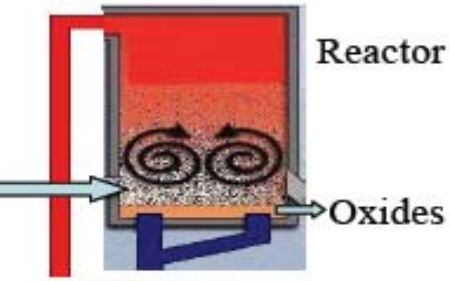
H_2 generation



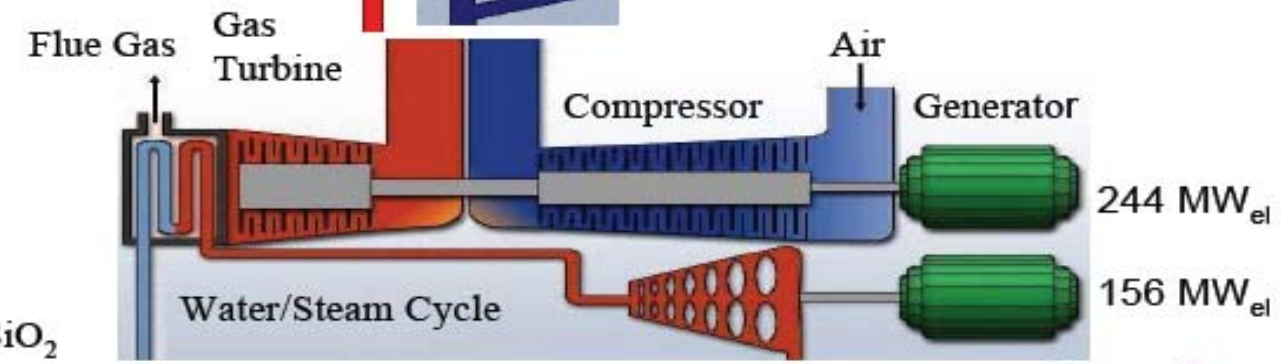
$3\ FeSi_6 + 40\ H_2O \rightarrow Fe_3O_4 + 18\ SiO_2 + 40\ H_2$



H_2 generation



Electricity generation



$3\ FeSi_6 + 20\ O_2 \rightarrow Fe_3O_4 + 18\ SiO_2$

Silicon/Hydrogen fuel Power Plant

The following data are for conversion of Silicon to Hydrogen and the use of Hydrogen in a H2 burning gas turbine to generate electricity. Since many of the process and component efficiencies are not well known, a 50% overall efficiency has been assumed for the entire process. This number maybe on the optimistic side since most fossil-fuel power plants operate at below 40% cycle efficiency.

Silicon Consumption	1MW	10MW	50MW	100 MW
Si consumption per hour	220 kg	2.22 tons	11.1 tons	22.2 tons
Si consumption per day	5400 kg	54 tons	270 tons	540 tons
Si consumption per year	1940 tons	19,400 tons	97,000 tons	194,000 tons

Hydrogen Hub Silicon Fuel based

Power generation
560 MW

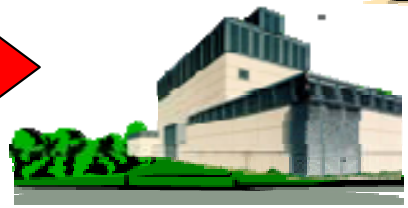
Hydrogen vehicles
2500 buses
25000 cars

Silicon

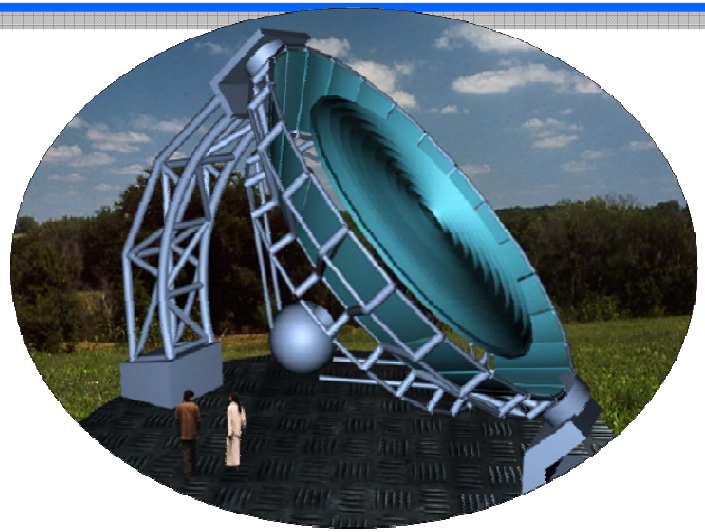
H_2

Hydrogen production plant

Distributed
generation
240 MW



Solar Energy based



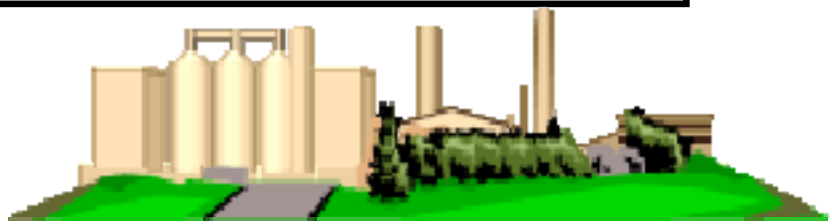
Solar production plant

Hydrogen vehicles
1350 buses
13500 cars

H_2

Distributed
generation
50 MW

Solar thermal HT
Photolysis LT



Avoided CO_2 for each hydrogen hub

Hydrogen Hub
Silicon
Fuel based

Installation Forecast electric power 800 MW

Vehicles ~ 2,500 buses

~ 25,000 cars

2.3 – 2.7 million ton CO_2/year

Hydrogen Hub
Solar
Fuel based

Installation Forecast electric power 50 MW

Vehicles ~ 1,300 buses

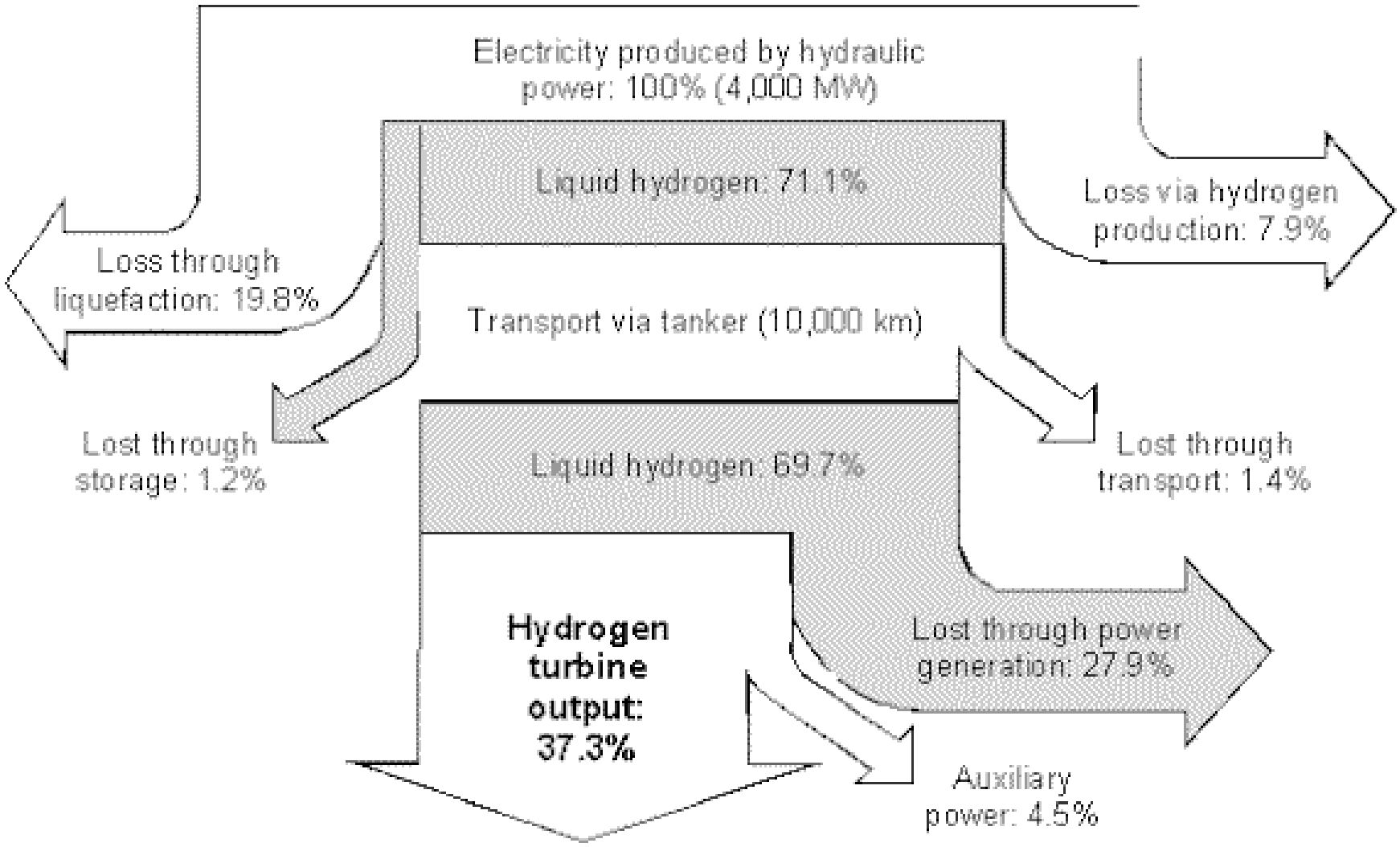
~ 13,000 cars

0.3 million ton CO_2/year

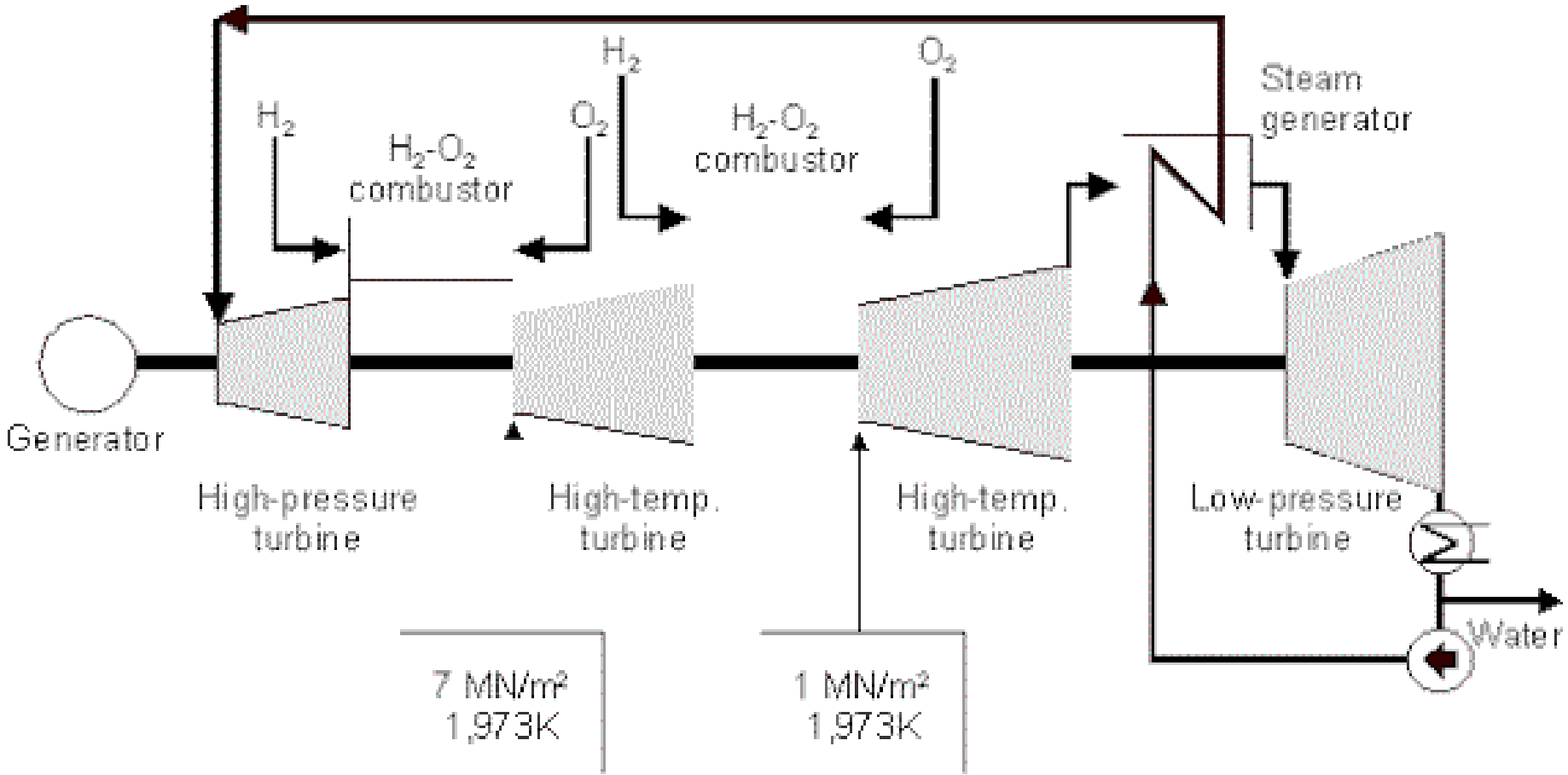
Hydrogen Combustion Turbine

In the 21st century, nations must optimize use of low-quality fossil fuels and sustainable-source energy while giving equal consideration to resource depletion, environment protection, and the varying economic considerations affecting all nations. Because these three factors -- energy, environment, and economy -- are interdependent, advances in one must be compatible with the others.

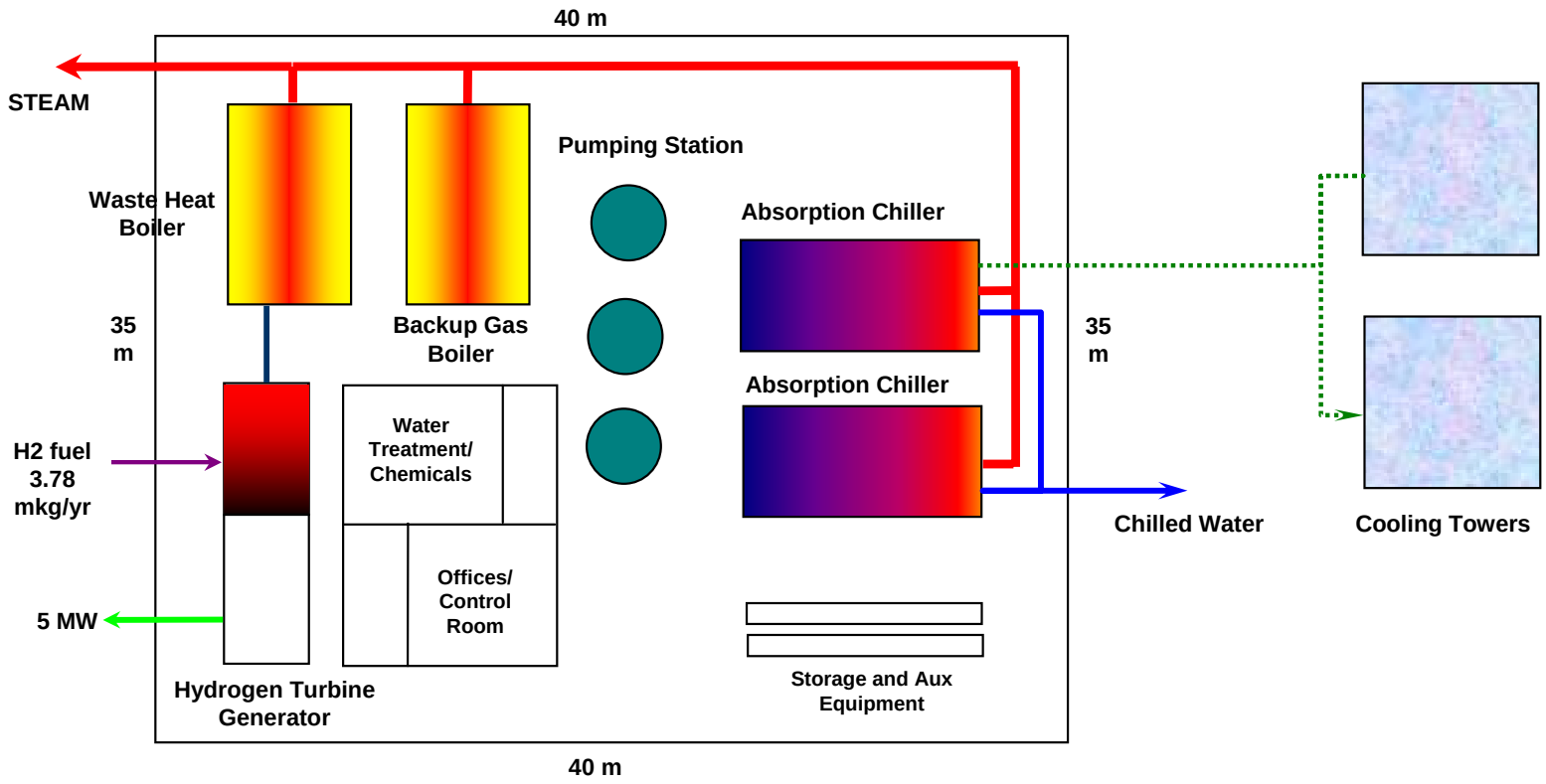
Energy Balance for a Hydrogen-Fueled Turbine



Hydrogen Combustion Turbine



5 MW Hydrogen Burning Plant



1 MW Power Plant

To be developed by

PowerAvenue Corporation

(poweravenuecorp.com)

in cooperation with

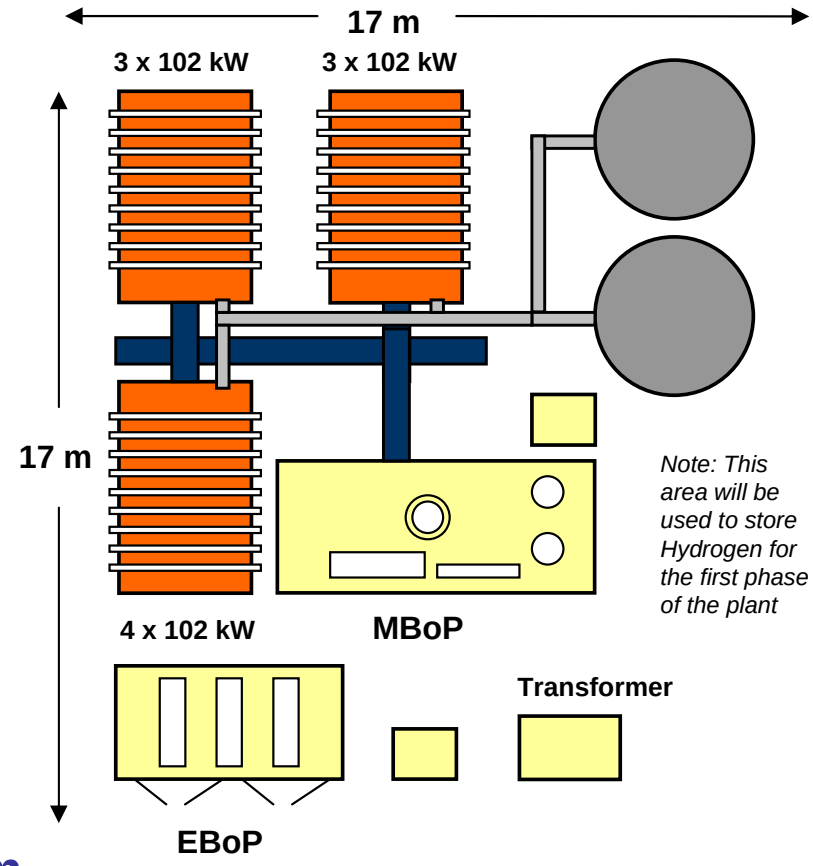
CO-VER Holding Industries

(www.cover.it)

1 MW Power System,

30 parallel 34 kW Modules.

Ten Systems of 102 kW each



Dimension (each 34 kW system)

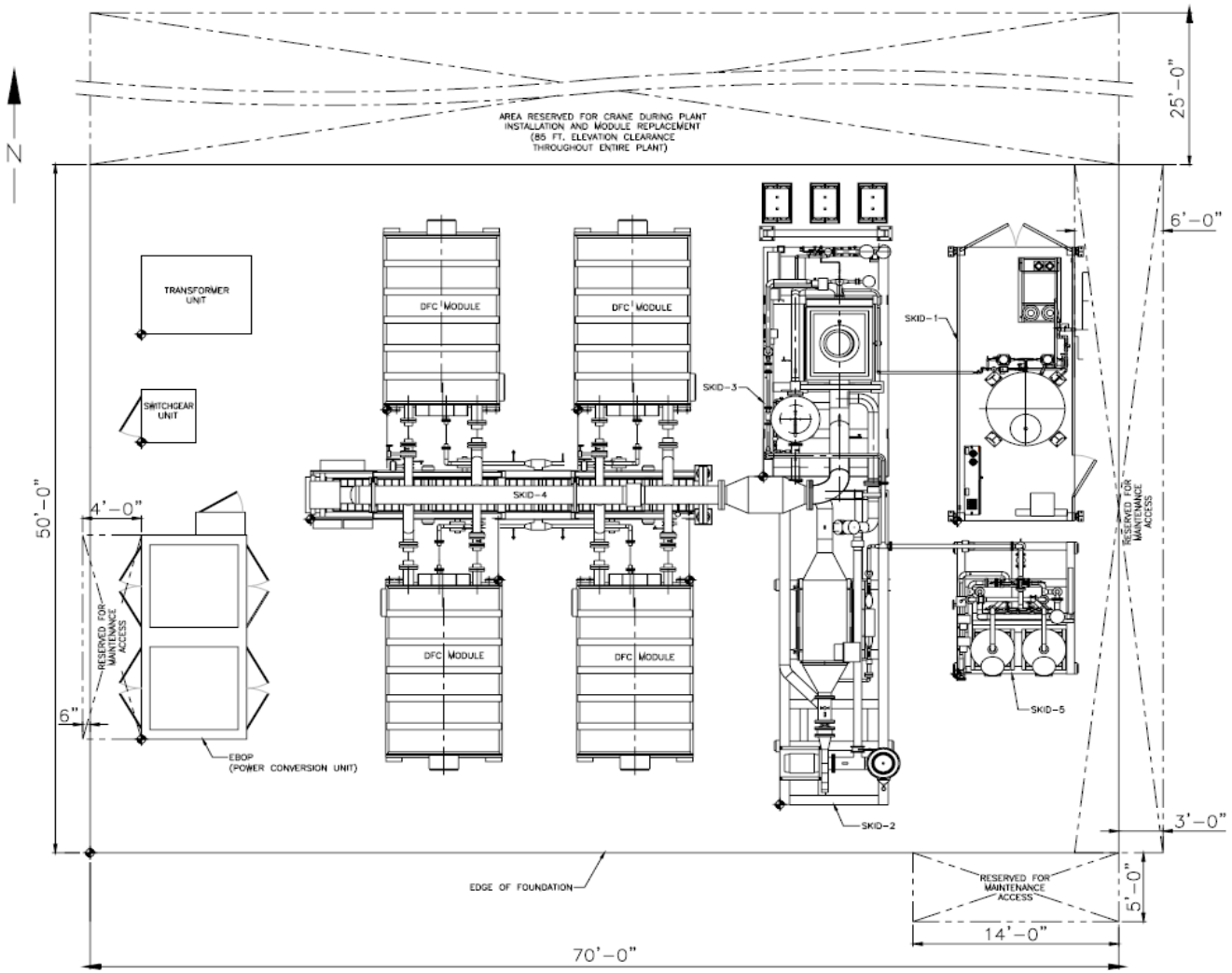
1 m x 0.6 m x 0.5 m/ system

Start up time: 10 sec, full power

In 2 minutes

Overall Layout

OVERALL LAYOUT AND ACCESS SPACE



Hydrogen utilization
Critical steps

2004-2011

Hydrogen Turbine	Commercial Units
Stationary Fuel Cells	Distributed Generation
Automotive Fuel Cells	City Buses and Dedicated Cars
	Logistics

Renewable Energy Based On Silicon

Today‘s Energy:

based on
Carbon technology

Tomorrow‘s Energy:

based on
Hydrogen technology

Conclusion

- How can you provide *ENERGY* without damaging the planet?

- PowerAvenue Corp. provides solution, security and reliability with *HYDROGEN* without damaging capacity to power delivery systems.

- In addition, addressing efficiency to optimize the use of capital to meet return on assets (ROA) and return on investment (ROI)

Liechtenstein:

Europe's First Clean Energy Nation