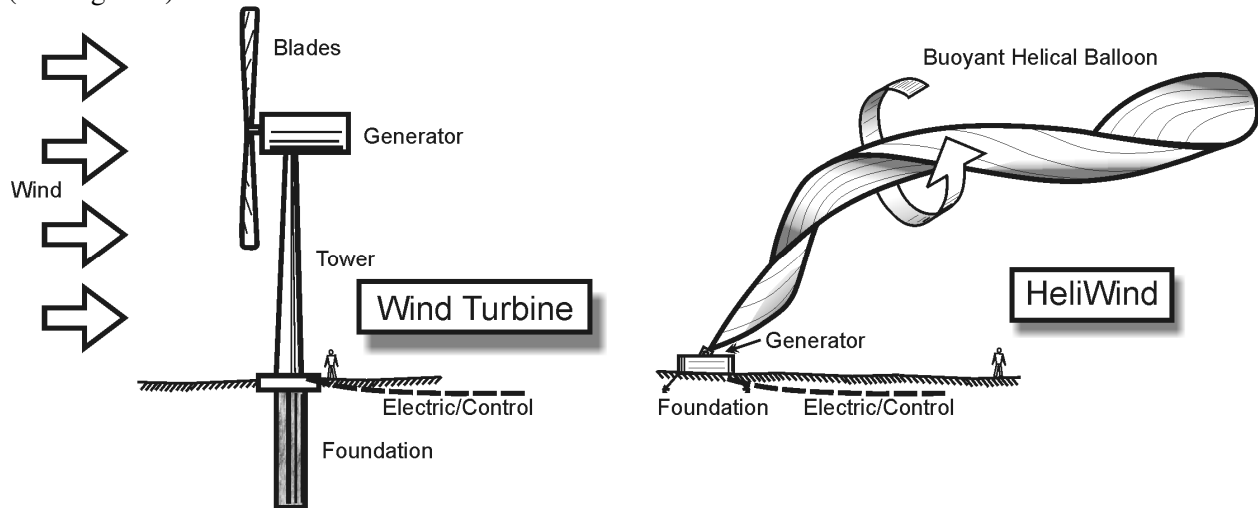


**Development Proposal**  
for the  
***HeliWind* Wind Energy Conversion System**  
by  
**Geoff Goeggel, PE**  
**May 6, 2008**

**1.0 INTRODUCTION**

*HeliWind* is a low-cost Wind Energy Conversion System that will reduce electricity generation costs from \$ 0.06 per kilowatt-hour (kW-hr) to \$0.034/kW-hr. The *HeliWind* replaces the blades and tower of a conventional wind turbine with a lighter-than-air helical balloon and lowers the generator to the ground (See Figure 1).



**Figure 1 – Standard Wind Turbine Design versus a *HeliWind***

Compared with the conventional wind turbine, the main advantage of a *HeliWind* is that a balloon is more economical than blades, a tower and caisson foundation. Another advantage is that it is easier to install, service and maintain a wind system with the generator (genset) on the ground rather than 150 feet in the air. Finally, the *HeliWind* is silent and eliminates bird and bat kills. The main disadvantages are the fragile balloon envelope, intermittent energy supply, and it is still ugly.

A closed-cycle *HeliWind Power Station* can be built. Half the power output from a *HeliWind* is diverted into generating hydrogen and oxygen by electrolysis. These gases are stored in balloons and used to power a hybrid motor-generator during peak output and low wind conditions. This has two immediate benefits:

- 1) The *HeliWind Power Station* will generate electricity 24 hours a day, 7 days a week;
- 2) The *HeliWind Power Station* can triple its energy output to meet peak electrical demands.

The downside is cost. 40% of the wind energy is lost and generation rates soar to \$ 0.127/kW-hr.

The preliminary *HeliWind* design concept is modular: a balloon, a gimbaled generator mount, a support trailer, and a flight control system. The current development schedule is to prepare a range of *HeliWind* designs during the next 24 months and then install several working prototypes for testing and research. In

2 years, design drawings will be finished and manufacturing and site licensing can begin. Operation and maintenance manuals will be prepared to guide independent manufacturing and placement of *HeliWinds* around the world.

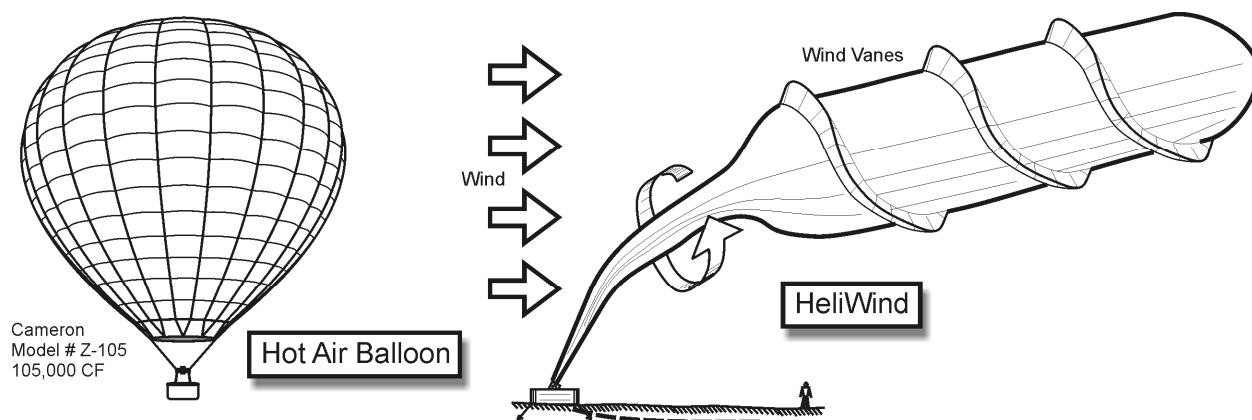
By 2012, a motivated development team can install 1,000 *HeliWinds* a month, producing 15 mega-Watts (mW) of power. By 2020, installations can exceed 1,500,000/year and installed *HeliWinds* can produce 0.01 percent of the world's energy requirements with no pollution, no carbon emissions, and at one half the cost of the current energy market. Continued research and real world experience should drop the cost of *HeliWind* power from \$ 0.03/kW-hr to \$ 0.02/ kW-hr by 2050 (in 2008 dollars).

A *HeliWind* design team of 20 people will be assembled and begin design work this year. Existing companies with relevant expertise will be solicited through a request-for-proposal (RFP) program to develop candidate *HeliWind* designs for the four components. Their best ideas will be combined and the winning companies hired to build working components for testing and evaluation. The *HeliWind* development program as presented in this report requires a budget of \$ 26 M to fund research and development (R&D) work.

The goal of the *HeliWind* project is to replace all fossil fuel based energy (oil, coal, gas) with a world based on the use of hydrogen-oxygen ( $H_2-O_2$ ) fuel. The low cost energy of *HeliWinds* can generate  $H_2$  and  $O_2$  at the same cost of an equivalent fossil fuel. This  $H_2-O_2$  supply can power plants, cars, trucks, ships, airplanes, and manufacturing. By 2050, fossil fuels will become extinct, smog and petroleum-oil-lubrication (POL) pollution eliminated, and global warming stopped.

## **2.0 HELIWIND COMPONENTS**

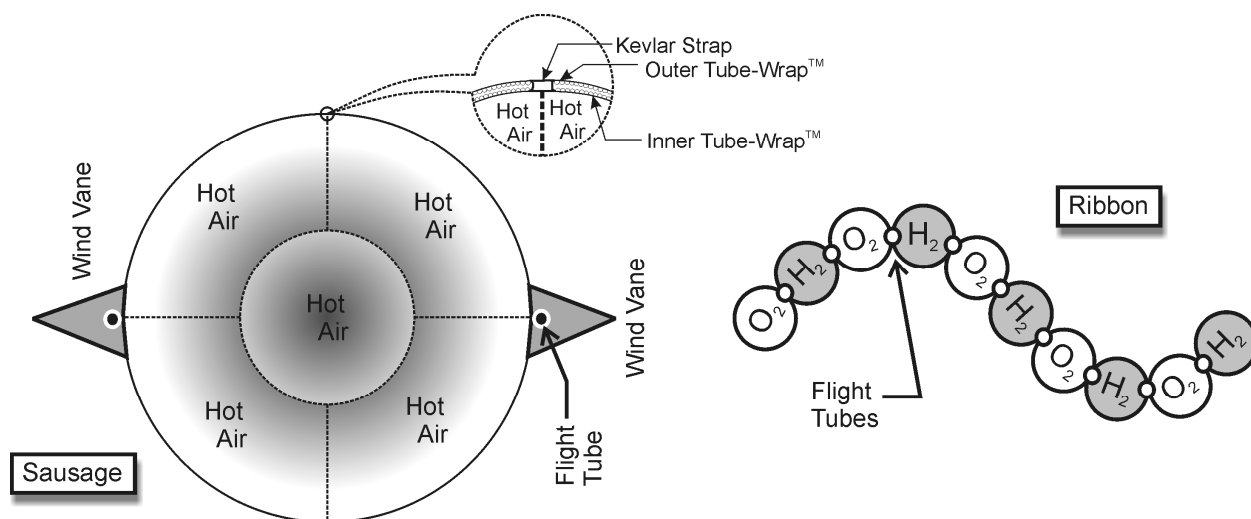
**2.1 The Balloon** The key component for a *HeliWind* is a lighter than air balloon envelope. The buoyant fluid can be hot air, helium, hydrogen, or a combination of these gases. Each has its pros and cons. Hot air is cheap and can be generated on site, but is not very buoyant. Heat inside the envelope must be maintained before any net energy production can begin. A typical 5-passenger hot air balloon holds 100,000 cubic feet (ft<sup>3</sup>) of air heated to 120°C, and lifts 7,000 pounds into 20°C air. Figure 2 illustrates converting a 65 ft diameter balloon into a 30 ft-diameter by 150 foot long *HeliWind*.



**Figure 2 – Converting a typical hot air balloon into a *HeliWind***

The envelope of a typical 100,000 ft<sup>3</sup> hot air balloon weighs about 750 pounds. A very light fabric is normally used for passenger balloons (e.g. Dacron), but becomes porous after only 500 hours of flight time and needs to be reconditioned or replaced. Because of the special needs of the *HeliWind*, its fabric needs to last at least 5 years in continuous service and also have excellent insulation to reduce heat loss from the envelope.

One candidate material is “Bubble-Wrap” packing material. It is lightweight, provides excellent insulation, and costs less than \$ 0.01 per square foot (ft<sup>2</sup>) in large quantities. It is easily fabricated on-site with small portable machines. After it wears out, it can be economically recycled into a new balloon. Required improvements of this conventional packing material include better stress endurance and resistance to sunlight. Since it is translucent, it will reduce *HeliWind* visibility on the landscape. Two layers are assumed as shown in the balloon cross-sections shown in Figure 3. The sausage (Figure 2) will be easier to build, but the ribbon (Figure 1) easier to fly.



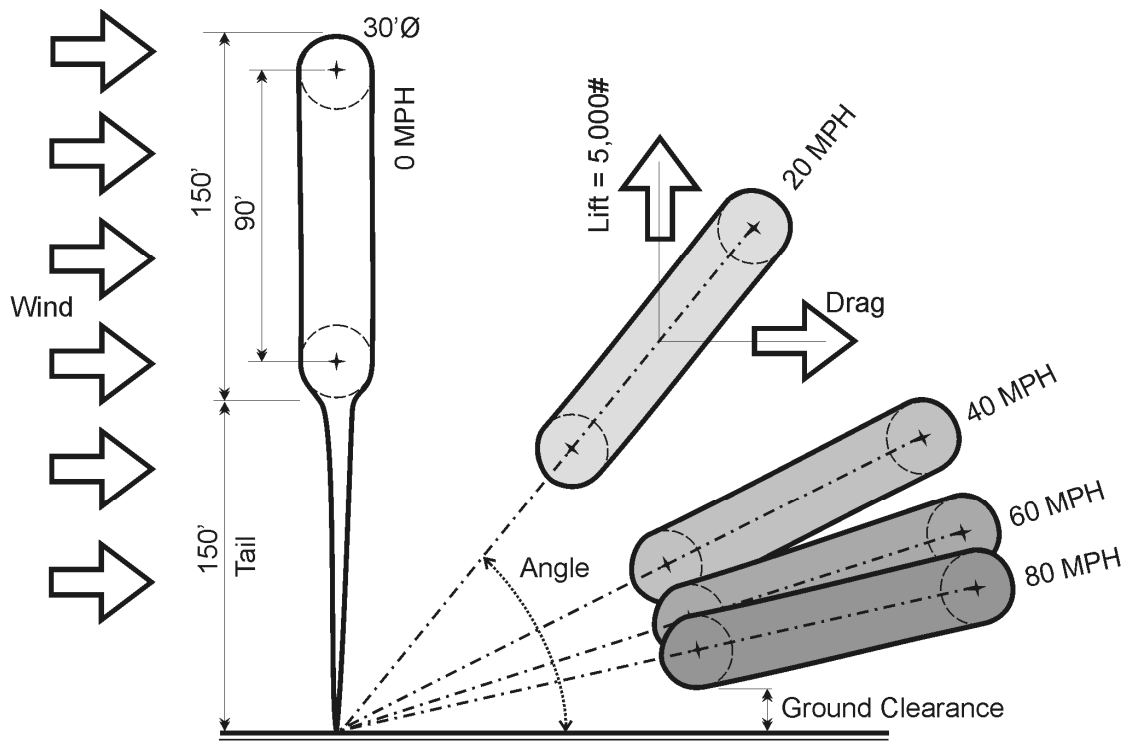
**Figure 3 – Possible *HeliWind* balloon cross-sections**

A second candidate fabric is Mylar, a metalized nylon film (e.g. Birthday balloon). Highly reflective, it may aid in heat retention, but is very expensive (\$ 0.10/SF), and may attract lightning strikes. Mathematical modeling, prototyping, and discussion with fabric manufacturers and balloon fabricators will set the initial designs. Gradual improvements, insights, and new technology will only improve the design over the next 40 years.

For preliminary analysis, a 30 foot diameter by 150 foot long hot air balloon, weighing 2,000 pounds, is assumed, resulting in a net lift of 5,000 pounds. An estimated 10 percent of the energy production will be returned to the balloon as heat to maintain lift. The waste heat from the generator will also be cycled into the balloon. With 5 ft wind vanes in a 20-mph wind, the swept wind area is 3,600 ft<sup>2</sup> and will generate 32 kW. Drag forces are about 1,500 pounds and uplift at the *HeliWind* foundation is estimated at 5,000 pounds. At 80 mph, drag increases to 9,800 pounds and available power is 850 KW. Most wind farms operate in the 15-45 mph range. Table 1 provides a force analysis for a range of wind conditions.

As wind speed picks up, the *HeliWind* will lean over farther and farther, and at 80 MPH would tilt to 9 degrees with only 20 ft of ground clearance (See Figure 4). While potential power output is 850 kW at 80 mph, drag forces increase by a factor of 5, requiring a much stronger balloon, tail, spindle, trailer, and

foundation anchors. It is unlikely that the system can produce enough power at winds above 50 mph to justify the increased strength and larger genset required.



**Figure 4 – HeliWind tilt with increasing wind speed**

**Table 1 – HeliWind energy analysis**

Speed (mph)	Pressure (lb/ft <sup>2</sup> )	Tilt (degrees)	Area (ft <sup>2</sup> )	Drag (lb)	Clearance (ft)	Energy Kw	
0	0.0	90	4,300	-	150	-	
20	1.0	54	3,600	1,500	110	31.8	
40	4.1	27	2,300	3,800	60	162	
60	9.2	17	1,800	6,600	30	429	
80	16.4	12	1,500	9,800	20	847	
Wind Pressure = $0.00256 * V^2$				Tilt = $\tan^{-1}(\text{Lift}/\text{Drag})$ ... Lift = 5,000#			
Exposed Area = $\pi * (15') * 15 + 90' * \cos(\text{Tilt}) * 30$				Ground Clearance = $\tan(\text{Angle}) * 165' - 15'$			
Drag = $C_d * \text{Exposed Area} * \text{Pressure}$ ... where $C_d = 0.4$							
Energy Output = $30\% * \text{Exposed Area} * V^3 / 272,000$							

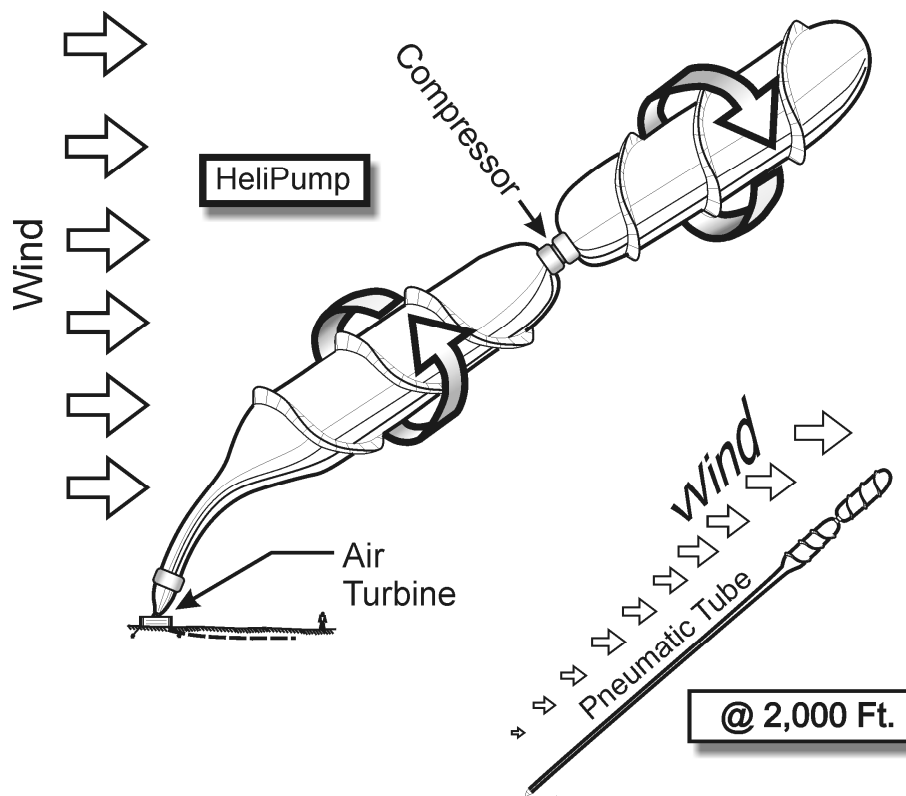
Helium is very buoyant and 10 times lighter than hot air, allowing for a smaller envelope. But helium has a small atomic diameter and will leak through any fabric membrane. If used, lost helium would need to be regularly replenished. And it is very expensive. In contrast to helium, hydrogen is cheap and abundant, can be made on site, but it is flammable. The required volume of a helium/hydrogen balloon is

estimated at 20 percent of an equivalent hot air balloon, but the wind vanes need to maintain the same net swept area for power production.

The tail of the balloon will attach to the spindle and transmits balloon torque to the genset. Woven Kevlar is probably a good tail material. Webbing straps will connect the tail into the gores of the balloon. Longer tails will allow the balloon to fly at higher altitudes where winds are stronger, and will also allow vertical spacing between nearby *HeliWinds*.

Because balloons are fragile, the balloon will be divided into separate air chambers to reduce deflation risks from such hazards as severe weather, the wayward bullet or angry woodpecker. The ideal sizes, shapes, configurations, fill gases, longevity, and flight characteristics of the balloon will be determined during the next 24 months.

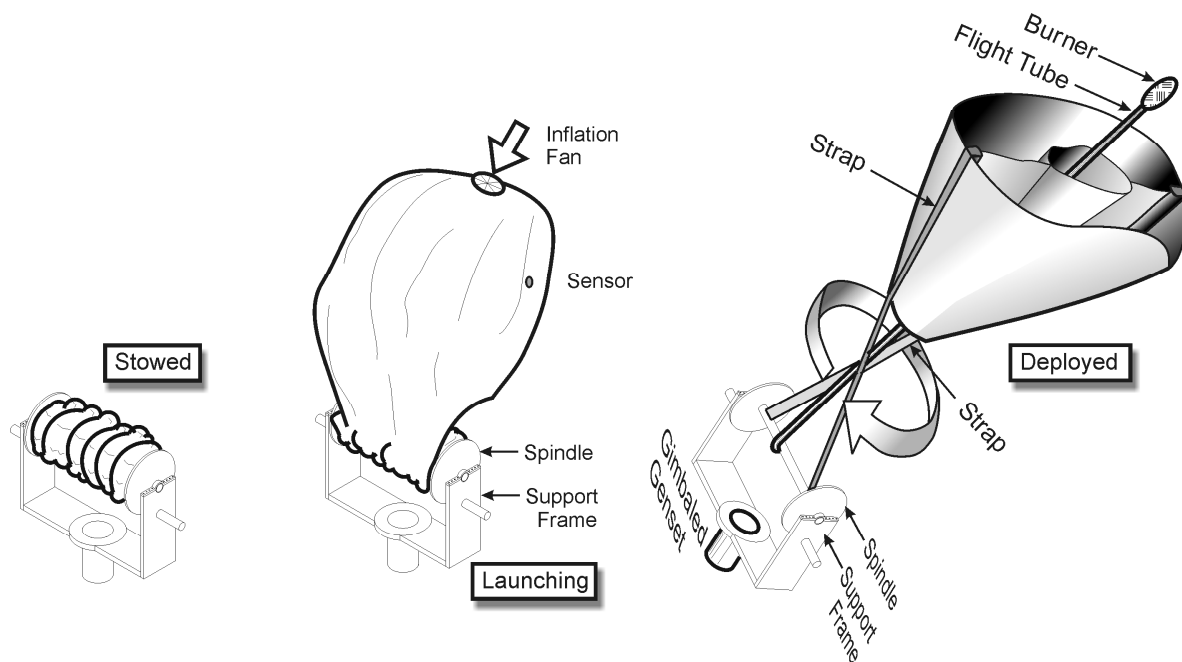
The *HeliWind* will be flown as high as economically practical since higher altitude means stronger and more consistent winds, and therefore more energy output. However, having a long Kevlar tail piece transmitting required torque to the genset may limit the effective flying altitude. One candidate design that overcomes this torque limitation is the *HeliPump* shown in Figure 5. Two counter-rotating *HeliWinds* are connected to a compressor, driving pressurized air down the central chamber of the lower balloon. An air turbine on the ground will convert this pneumatic energy into usable power. Flying at 2,000 feet elevation, a 10 foot diameter pneumatic tail tube would require 60,000 Sq. Ft. of light weight plastic fabric. It would not carry any torque and would rotate freely at the support frame. The two major disadvantages of the *HeliPump* are a 50 percent energy loss in the compressor, air tube, and turbine; and it will be harder to roll up this system onto the spindle.



**Figure 5 – a *HeliPump***

Some conflict problems with aircraft are expected, and a cooperative mitigation program with the Federal Aviation Administration (FAA) is mandatory to reduce risks to airplanes, helicopters and the occasional hot-air balloon passing by.

**2.2 The Gimbal Mount** A gimbaled support frame (Figure 6) will allow the balloon to rotate 360 degrees into a downwind position and tilt into a stable position that aligns with the balloon's lift and drag. The spindle will allow the balloon to be easily launched and recovered. It will also allow free rotation of the balloon to deliver torque to drive a power unit (in most cases an electrical generator). With a low rotation rate of the balloon, transmission gears will be required to increase revolutions per minute (RPM's) to drive the generator.



**Figure 6 – Launching a HeliWind**

A retractable cage will surround the spindle to capture and collapse the balloon as it is reeled in. The air pockets in the Bubble-Wrap will deflate as the balloon is spooled onto the spindle to reduce storage volume. Conventional air blisters cannot work, and some form of air tubes will be developed (e.g. *TubeWrap*). The inflation fan at the top of the balloon will re-inflate the *TubeWrap* during launch. High pressure  $H_2-O_2$  from the flight tube will drive the inflation fan, and when ignited, generate the required heat for lift.

**2.3 The Support Trailer** The support trailer will hold the gimbal mount and allow the spindle to rotate freely so that the balloon can be easily launched and recovered. The support trailer will house the flight controls and instrumentation, and will be attached to the ground with four helical soil anchors screwed into the ground. Each trailer must have an  $H_2-O_2$  supply for re-inflating the balloon with hot air after it has been spooled up for maintenance or bad weather. Properly sited, this should happen only once or twice a year.

Each *HeliWind* will be modular and easily portable to and from a Central Maintenance Facility (CMF) for repairs. The balloon spindle will allow quick removal and replacement of the balloon at the *HeliWind* site. For problems with other components, the trailer will be returned to the CMF for simple repairs, or returned to the factory for major repairs. A spare *HeliWind* will take its place in less than an hour.

#### **2.4 Flight Control**

Sensors on the balloon will provide the computer flight control system with local wind speed, humidity, air temperature, rainfall, and flight parameters of the *HeliWind*. The flight characteristic of the *HeliWind* will be controlled by altering the internal pressure and buoyancy inside the balloon chambers, opening and closing exhaust vents, and moving flight control surfaces. Regional flight factors will be monitored for advanced flight planning, particularly when incoming bad weather makes deflation prudent.

#### **2.5 Energy Storage**

Wind energy is intermittent, even in the best wind locations. Energy demand is not. The major problem with wind energy is the lack of continuous power. The current solutions to this problem include pumped hydroelectric storage, compressed gas, or batteries. Each has its problems, most importantly high cost.

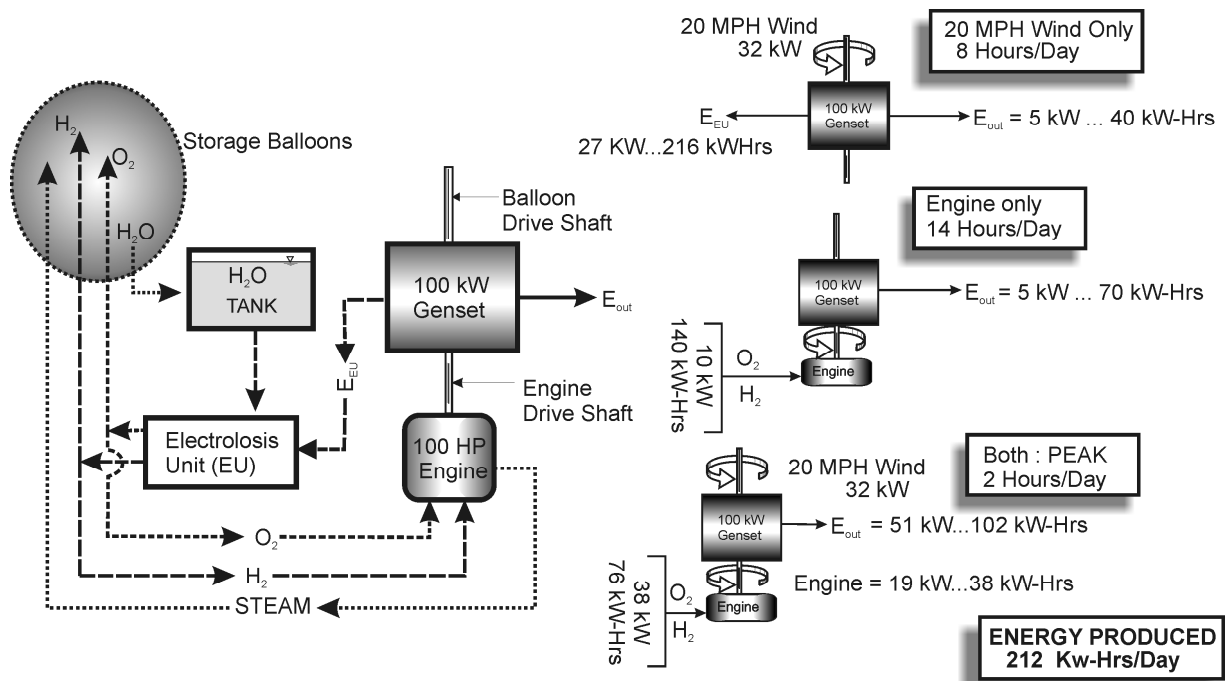
The primary output of a *HeliWind* farm should be  $H_2-O_2$ . It should become the only fuel for vehicles (cars, trucks, farm equipment, ships and aircraft) and power plants worldwide. Liquefying hydrogen to  $-259^\circ C$  and oxygen to  $-218^\circ C$  is still very expensive. However, burning only  $H_2$  in an IC engine generates  $NO_x$  pollution. Fuel cells are more efficient, pollution free, but are not as yet cost effective, and would not work for helicopters and airplanes. Burning  $H_2-O_2$  is 100% pollution free. Aircraft would need cryogenic storage tanks, but can easily burn the  $H_2-O_2$  as a fuel source with engine modifications. This is future technology and does not exist today. The encouragement of an  $H_2-O_2$  world is the Number 1 goal of this project.

A closed cycle, pollution free *HeliWind* power station is presented in Figure 7. An electrolysis unit generates  $H_2-O_2$  for storage in the main *HeliWind* balloon and adjacent storage balloons. An internal combustion (or turbine) engine drives the genset during periods of low wind. For peak electrical demand, both the engine and the balloon drive the genset (e.g. hybrid). A 10% energy loss during electrolysis and a 40% loss by the engine are assumed. (Most IC engines lose 70%). 216 kW-hrs of power is converted into  $H_2-O_2$  and stored, but 50% of this energy is lost during the engine cycle. Exhaust from the engine is 100% steam and is used to heat the fill gases inside the *HeliWind*, allowing for some energy recovery. Genset heat also is fed back into balloon. Power produced by the system is estimated at 212 kW-hrs per day. Use of a fuel cell might seem appropriate, but current fuel cells are 10 times more expensive than an engine, are troublesome to maintain, and still lose 50% of the energy potential of the hydrogen.

Storing  $H_2-O_2$  can be very dangerous. Massive explosions could be caused by lightning, static electricity or vandalism ("Remember the Hindenberg!"). 100,000 ft<sup>3</sup> of  $H_2-O_2$  is equivalent to a ton of dynamite. A *HeliWind* explosion could detonate the adjacent *HeliWinds*, and the entire *HeliWind* Farm is gone in seconds. A farm safety perimeter (e.g. an ESQD arc) might be prudent, or separating the  $H_2$  from the  $O_2$  in separate balloons. In adjacent balloon chambers, the  $H_2$  will leak into the adjacent  $O_2$  storage chamber. Regularly recycling these cross-contaminated chambers could reduce explosion risks.

Severe weather could shut down the *HeliWind* Farm for a week, or more. Inflating a *HeliWind* requires 200 pounds of  $H_2-O_2$ . Deflating a hot air *HeliWind* loses this energy but given enough time, a single *HeliWind* could re-inflate the entire energy farm. In an emergency, the gases in a hot-air, helium and/or hydrogen balloon must be thrown away, and the balloon stowed. A deflated *HeliWind* farm generates no power until it can be re-inflated. Just as there are some places where the wind regime (e.g. Weibel

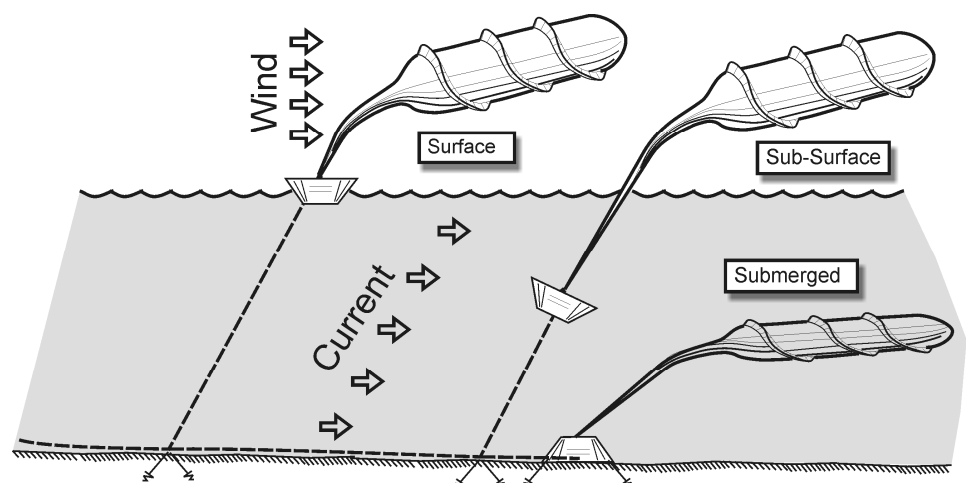
Distribution) makes WECS impractical, there will be some locations, Tornado Alley for example, where the frequency of deflation makes it un-economical to put in *HeliWinds*.



**Figure 7 – Power Schematic for a *HeliWind* Power Station**

## 2.6 Ocean Installation

Most of the *HeliWinds* will be installed near the ocean along the coastlines, where winds are stronger, more consistent, and away from populated areas. Three potential configurations are shown in Figure 8.



### **Figure 8 – *HeliWind* Ocean Installations**



Floating platforms will be more expensive to install and maintain than land-based systems, pose a hazard to ship navigation, and it will be expensive to transmit power ashore. The improved wind regime in the oceans will offset some of these issues. A submerged platform would be even more expensive, but would eliminate the hazard to ship navigation. Ships may still impact (and destroy) the balloon but will not suffer damages themselves. The totally submerged *HeliWind*, filled with fresh water for buoyancy and driven by ocean currents, may become the best energy production alternative. It is invisible, and except for submarines and fishing trawlers, will not affect ship traffic. Available energy from ocean currents exceeds wind power by several orders of magnitude. The near shore wave climate must be avoided, but even in deeper water, 100'+ waves may occur and would be capable of destroying a shallow installation. The environmental impacts of ocean siting must be fully addressed before installations could begin.

H<sub>2</sub>-O<sub>2</sub> could be produced in-situ and piped to shore, probably much less expensively than electricity. Or it might be possible to drive a reverse-osmosis pump, sending fresh water to shore instead of electrical power or H<sub>2</sub>-O<sub>2</sub>. Ocean siting is the ultimate goal of the *HeliWind* development effort, but must await the completion of the land based installations. Within 24 months, ocean installations will become the primary goal of the development team and preliminary designs developed.

### **3.0 HELIWIND COSTS**

The key to *HeliWinds* working economically is to produce and operate the systems at half the cost of an equivalent wind turbine system. The ground system of the mounting, trailer, genset and power distribution is conventional and easily designed. The balloon presents the most challenges and must be the primary focus of the R&D effort. An extensive computer modeling effort will relate design characteristics with power output and economics. This 3-dimensional program will provide dynamic analysis of the flight characteristics and stresses within the *HeliWind* and its trailer/foundation system, and help develop the SCADA flight control system.

Suitable balloon fabrics must be determined from available materials. A range of materials will be needed for a variety of environments, from deserts to arctic conditions. As the ambient air temperature rises, a hot-air *HeliWind* loses its lift. In these locations, either much hotter air must be used or supplemental helium or hydrogen gas pockets installed.

Once mass-manufactured in automated factories, the estimated manufacturing cost for a 32 kW *HeliWind* is only \$ 7,500 (See Table 2). An equivalent wind turbine costs \$ 50,000. Although it can be installed as a single isolated unit, the most cost effective siting will be wind farms with 200 or more *HeliWind* units. A Central Maintenance Facility would service, repair and operate the farm. Spare *HeliWind* units would be kept on site for recycling *HeliWinds* for maintenance and/or repair. The estimated cost for produced power is \$ 0.034/kW-hr. With a market price \$ 0.06/KW-hr, annual profits for a *HeliWind Farm* are estimated at \$ 700,000. This should attract siting companies. The additional subsidies available from government agencies will only improve motivation for site operators (again ... this R&D effort will not manufacture or install any *Heliwinds* or *HeliTubes*).

The *HeliWind Power Station* will produce power at \$ 0.127/kW-hr, well above market costs (See Table 3). Government subsidies, usually 3 or 4 cents/kW-hr, could make it a competitive alternative to coal or oil fired plants. Compared to wind turbines, this plant generates power 24/7. Meets peak electrical demands. And except for manufacturing and freight (hopefully in H<sub>2</sub>-O<sub>2</sub> vehicles) produces absolutely no pollution. No bird kills. No Noise. But it is still ugly.

**Table 2 – HeliWind Estimated Cost Analysis**

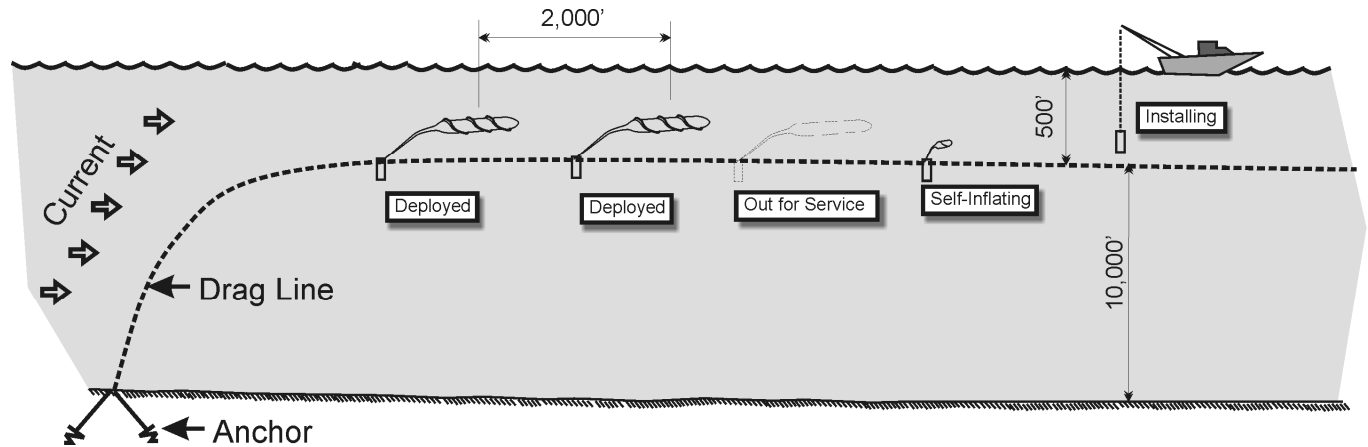
Description	Quantity	Units	Cost per Unit (\$)	COST	Comments
<b><u>HeliWind</u></b>					
Balloon Envelope	20,000	ft <sup>2</sup>	\$ 0.10	\$ 2,000	bubble-wrap
Tail Section	2,500	ft <sup>2</sup>	\$ 0.50	\$ 1,250	kevlar - high torque
Flight Tube	300	ft	\$ 5.00	\$ 1,500	SCADA, gas in/out
Spindle	1	ea		\$ 100	plastic, powered
Gimbal	1	ea		\$ 200	
GenSet	1	ea		\$ 1,000	100 KW
Trailer, Fdn Anchors	1	ea		\$ 1,000	9' x 12'; Atlas Helical piers
SCADA	1	ea		\$ 200	Flight Control Computer
Instrumentation				\$ 200	wind, temp, telemetry
		<b>HeliWind Subtotal =</b>		<b>\$ 7,450</b>	
Licensing Fee				\$ 1,000	mnfg. Royalty + siting
Haul to Site				\$ 250	2 tons, 9' x 20' trailer
Site Prep	5	yd <sup>3</sup>	\$ 50.00	\$ 250	5 CY Gravel
Assembly and Launch				\$ 900	3 man crew, 4 hours
Service Road	2,500	ft <sup>2</sup>	\$ 1.00	\$ 2,500	10', gravel on geotextile
Connect to Power Grid	250	LF	\$ 20.00	\$ 5,000	direct bury - 400 KVA cable
		<b>Installed HeliWind Subtotal =</b>		<b>\$ 17,350</b>	
		<b>Site TOTAL =</b>		<b>\$ 3,470,000</b>	200 units per farm
<b><u>Maintenance Center</u></b>					
Design, Permitting				\$ 50,000	10 sites/month
Bldg, Yard	1,000	ft <sup>2</sup>	\$ 100.00	\$ 100,000	Prefab FG, 1,000 SF, 1 Acre
Water/Sewer System				\$ 50,000	
Access Road	24,000	ft <sup>2</sup>	\$ 10.00	\$ 240,000	24' Ac
Perimeter Fence	15,000	ft	\$ 5.00	\$ 75,000	200 Ac., Barbed Wire, Signs
Spare HeliWinds	5	ea	7,450	\$ 37,250	
HeliWind Service Truck	1	ea	50,000	\$ 50,000	factory built, equipped
Connect to Grid Power	5,000	ft	\$ 50.00	\$ 250,000	depends on siting
		<b>Maintenance Center Subtotal =</b>		<b>\$ 852,250</b>	
		<b>SITE CONSTRUCTION =</b>		<b>\$ 4,322,250</b>	Maint. Center + HeliWinds
		<b>Annual Site Cost =</b>		<b>\$ 440,231</b>	I = 8%, 20 year
<b><u>Annual Operation</u></b>					
		HeliWind operators		\$ 200,000	3- man team
		Trucks, supplies		\$ 10,000	
		Repair HeliWinds		\$ 89,400	4/month, assume 75% salvage
		Land rent		\$ 50,000	200 Acre farm? Federal?
		Head Office Support		\$ 40,000	multi-farm operator
		<b>Annual Operations Subtotal =</b>		<b>\$ 389,400</b>	
		<b>TOTAL ANNUAL COST =</b>		<b>\$ 829,631</b>	Annual Site plus Operation
<b><u>Power Produced</u></b>					
200 units*32 KW*24 hours*365 days*45% recovery =				25,228,800	kwhrs
HeliWind Royalty @ \$ 0.001/KwHr =				\$ 25,000	
				<b>\$ 0.034</b>	<b>per kwhr</b>

**Table 3 – HeliWind Power Station Estimated Cost Analysis**

<u>Description</u>	<u>Quantity</u>	<u>Units</u>	<u>Cost per Unit (\$)</u>	<u>COST</u>	<u>Comments</u>
<b>HeliWind Power Station</b>					
Balloon Envelope	20,000	sq. ft.	\$0.10	\$2,000	bubble-wrap
Tail Section	2,500	sq. ft.	\$0.50	\$1,250	kevlar - high torque
Flight Tube	300	sq. ft.	\$5.00	\$1,500	SCADA, gas in/out
Spindle	1	ea		\$100	plastic, powered
Gimble	1	ea		\$200	
GenSet	1	ea		\$1,000	100 KW
100 HP Engine				\$500	
Electrolysis Unit	1			\$1,000	
Piping, Tubing				\$500	
Storage Balloon	2	ea	\$3,250	\$6,500	100,000 CF
Storage Trailer		ea		\$750	1/2 size, w/spindel
Flight Control Computer	1	ea		\$400	
Instrumentation				\$200	wind, temp, telemetry
<b>HeliWind Power Station Subtotal =</b>				<b>\$15,900</b>	
Licensing Fee				\$1,000	mnfg. Royalty + siting
Haul to Site				\$250	2 tons, 9' x 20' trailer
Site Prep	10	CY	\$50.00	\$500	5 CY Gravel
Assembly and Launch				\$900	3 man crew, 4 hours
Service Road	250	sq. ft.	\$1.00	\$250	10', gravel on geotextile
Connect to Power Grid	250	LF	\$20.00	\$5,000	direct bury - 400 KVA cable
<b>Installed HeliWind Subtotal =</b>				<b>\$23,800</b>	
<b>Site TOTAL =</b>				<b>\$4,760,000</b>	<b>200 units per farm</b>
<b>Maintenance Center</b>					
Design, Permitting				\$100,000	10 sites/month
Bldg, Yard	1,000	sq. ft.	\$125.00	\$125,000	Prefab FG, 1,000 SF, 1 Acre
Water/Sewer System				\$50,000	
Access Road	24,000	sq. ft.	\$10.00	\$240,000	24' Ac
Perimeter Fence	15,000	ft	\$5.00	\$75,000	200 Ac., Barbed Wire, Signs
Spare HeliWinds P S	5	ea	\$15,900	\$79,500	
Spare Balloons	10	ea	\$3,000	\$30,000	
HeliWind Service Truck	1	ea	\$75,000	\$75,000	factory built, equipped
Connect to Grid Power	5,000	ft	\$50.00	\$250,000	depends on siting
<b>Maintenance Center Subtotal =</b>				<b>\$1,024,500</b>	
<b>SITE CONSTRUCTION =</b>				<b>\$5,784,500</b>	<b>Maint. Center + HeliWinds</b>
<b>Annual Site Cost =</b>				<b>\$ 589,164</b>	<b>I = 8%, 20 year</b>
<b>Annual Operation</b>					
			HeliWind operators	\$500,000	6 - man team
			Trucks, supplies	\$20,000	
			Repair HeliWinds	\$238,500	5/month, assume 75% salvage
			Repair engines, E Unit	\$216,000	5/month, assume 75% salvage
			Land rent	\$100,000	400 Acre farm? Federal?
			Head Office Support	\$75,000	multi-farm operator
<b>Annual Operations Subtotal =</b>				<b>\$1,149,500</b>	
<b>TOTAL ANNUAL COST =</b>				<b>\$ 1,738,664</b>	<b>Annual Site plus Operation</b>
<b>Power Produced</b>					
200 units*212 KWHRS/Day*365 days*90% operations =				13,928,400	kwhrs
HeliWind Royalty @ \$ 0.001/KwHr =				\$14,000	
				<b>\$0.127</b>	<b>per kwhr</b>

#### 4.0 **HELITUBE**

It is not possible to install enough *HeliWinds* to replace fossil fuels. But the same concept, a rotating buoyant balloon labeled the *HeliTube*, could be 1,000 times more effective when installed in strong ocean currents such as the Gulf Stream or Oyashio Current. As shown in Figure 9, the *HeliTubes* would be completely out of sight. The income stream from *HeliWind* installations will support the *HeliTube* R&D.



**Figure 9 – Schematic *HeliTube* Installation**

*HeliTubes* could be anchored in ocean depths of 10,000 feet on drag lines 20 miles long. With drag lines spaced a ½ mile apart and *HeliTubes* attached at 2,000 feet on center, each drag line could hold 50 *HeliTubes*. Along the eastern seaboard, the Gulf Stream is 30 miles wide and 1,000 miles long: 150,000 *HeliTubes* could be located there alone. Once hooked onto the drag line, the *HeliTubes* would inflate themselves with fresh water using reverse osmosis. The bio-stimulation of these units could help repair the damage to the oceans from commercial over fishing. As fish stocks rebuild, the jobs of installing and maintaining these units could provide the commercial fishing fleet with much needed employment.

#### 5.0 **SCHEDULE**

The proposed *HeliWind* schedule is outlined in Table 4.

**Table 4 – *HeliWind* Development Schedule**

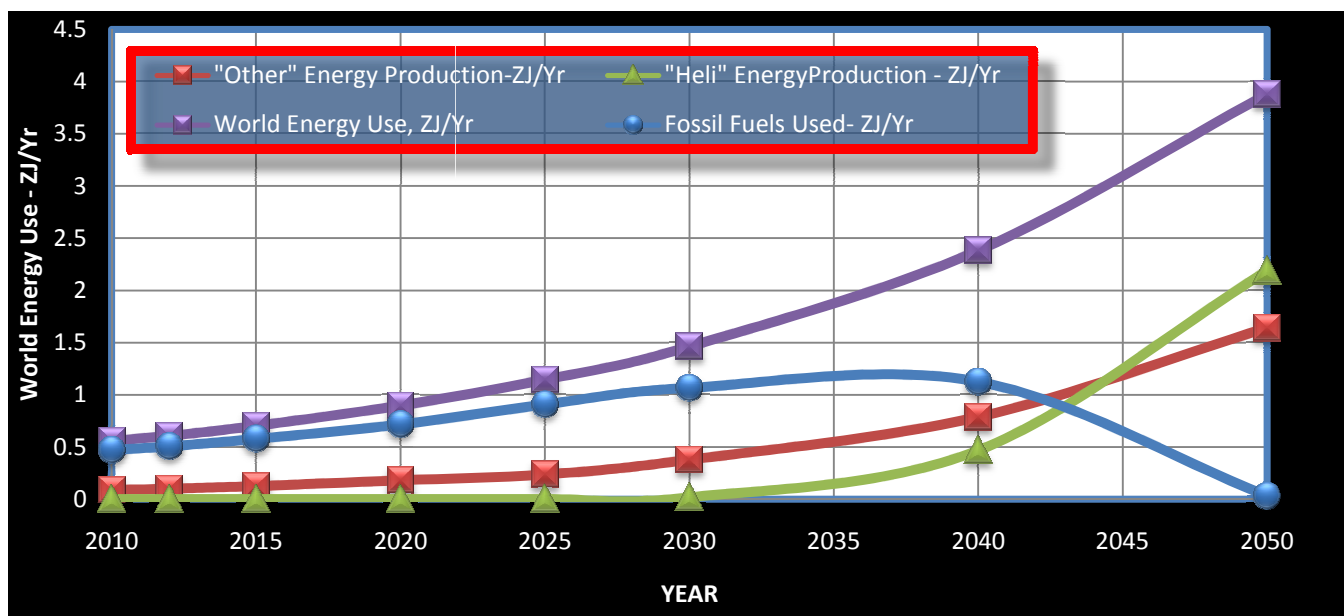
MILESTONE	Finish Date	Comments
<b><i>HELI</i> Patent Application</b>	May 1, 2008	Submitted to USPTO
<b>Funding Established</b>	September 2008	Need incorporation
<b>Team Assembled</b>	December 2008	Need office & laboratory
<b>Mathematical Model</b>	March 2009	3D, animated
<b>Prototypes Designed</b>	June 2009	5', 20', 100', 300'
<b>Prototypes Installed</b>	October 2009	Need large test site – 15 acres
<b>Final <i>HeliWind</i> Design</b>	March 2010	15KW through 300 KW
<b>First <i>HeliWind</i> Installation</b>	December 2011	10,000 per Month - Hawaii???
<b>Start <i>HeliTube</i> Design</b>	January 2011	20'Ø x 75'
<b>First <i>HeliTube</i> Installed</b>	January 2015	10,000 per Month
<b>Last <i>HELI</i> Units Installed</b>	December 2050	Nigeria??? The World powered by H <sub>2</sub> O <sub>2</sub>

World energy usage in 2010 is estimated at 17.6 tera-Watts ( $= 17.6 \times 10^{12}$  tW - a measure of Power) or 0.56 Zetta-Joules ( $= 0.56 \times 10^{21}$  J - a measure of Energy). Available wind energy world-wide is estimated at 370 tW. Currently, 85 percent of the energy used on the planet is generated by fossil fuels, and this use is growing at 2 percent per year. The remaining 15 percent of energy generation is from renewables (wind, solar, hydro) and nuclear, and this percentage is increasing at 2½ percent per year (See Table 5).

The first *HeliWind* will be brought on-line in late 2011 with an initial target of installing 1,000 *HeliWinds* a month. These will be small 34 kW units, roughly 30 foot in diameter by 150 feet long and will produce  $4.2 \times 10^8$  Joules a year ( $34 \text{ kW} \times 10 \text{ Hours/day} \times 365 \text{ Days/Year} \times 3,600 \text{ Joules/kW-hr}$ ). As the technology improves, larger units will be designed and installed: 1,200 kW units in 2020 and 50 mW units by 2050 (See Figure 10).

**Table 5 – World Energy Projections**

<u>Year</u>	<u>2010</u>	<u>2012</u>	<u>2015</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>	<u>2040</u>	<u>2050</u>
<b>World Energy, zJ/Yr</b>	0.56	0.61	0.70	0.90	1.15	1.46	2.38	3.88
<b>Fossil Fuels %</b>	84%	83%	82%	80%	79%	73%	47%	1%
<b>Fossil Fuels - zJ/Yr</b>	0.5	0.5	0.6	0.7	0.9	1.1	1.1	0.0
<b>"Other" (solar, , ...) %</b>	15.8%	16.6%	17.8%	20.2%	20.7%	25.8%	33.1%	42.3%
<b>"Other" -zJ/Yr</b>	0.09	0.10	0.13	0.18	0.24	0.38	0.79	1.64
<b>H-Winds Installed M/Year</b>	0.012	0.048	0.38	1.54	1.54	1.54	1.54	1.54
<b>Total H-Winds Installed-M</b>	-	0.08	0.76	7.7	15.3	23.0	30.7	30.7
<b>H-Wind Output - kW/Unit</b>	-	100	500	1,200	2,500	3,500	5,000	50,000
<b>HeliWind Output - zJ/Yr</b>	-	<0.00001	<0.00001	<0.0001	<0.0005	<0.001	0.002	0.02
<b>H-Tubes Installed M/Year</b>	-	-	0.0005	0.02	1.54	2.048	2.048	2.048
<b>H-Tubes Installed - M</b>	-	-	0.0005	0.032	1.0	10.2	30.7	51.2
<b>H-Tube Output - kW/Unit</b>	-	-	34	500	5,000	50,000	500,000	1,400,000
<b>HeliTube Output - zJ/Yr</b>	-	-	<0.0001	<0.001	0.001	0.02	0.46	2.17
<b>"Heli" Energy - zJ/Yr</b>	-	-	0.00005	0.0001	0.001	0.02	0.47	2.19



**Figure 10 – World Energy Use : 2010 thru 2050**

By doubling production each year, *HeliWind* installations will increase to 128,000/month by 2020, when 7.7 Million *HeliWinds* will be in place, but producing only 0.01% of the world's energy demands.

Design work on the *HeliTube* will start in 2011 after final designs for the *HeliWind* are completed. The knowledge and experience gained by *HeliWind* R&D will be applied to the *HeliTube* R&D. Unlike the wind, the major world currents are 90% consistent. Each 500 KW *HeliTube* will produce 14 Giga-Joules ( $500 \text{ KW} * 22 \text{ hours/day} * 365 \text{ Days/Year} * 3,600 \text{ Joules/KW-HR} = 14 \times 10^9 \text{ GJ}$ ). By 2050, God willing, 51 Million - 1.4 gW *HeliTubes* will be producing 56% of the world's energy needs. By 2050, *Helical Energy Systems* will employ 16 million people for the manufacturing, installation and maintenance of *HeliWinds* and *HeliTubes* (See Table 6). *Helical Energy System's* royalty and licensing income in 2050 is estimated at \$ 600 Trillion a year.

**Table 6 – Helical Energy System Employment**

<u>Year</u>	<u>2010</u>	<u>2012</u>	<u>2015</u>	<u>2020</u>	<u>2025</u>	<u>2030</u>	<u>2040</u>	<u>2050</u>
World Population, Billions	6.8	7.0	7.2	7.5	7.8	8.1	8.6	9.0
Fossil Fuel Jobs, Millions	10	11	12	15	19	23	24	1
"Other" Employment, M	1.00	1.91	2.05	2.32	2.63	2.97	3.81	4.87
H-Winds Installed M/Year	0.012	0.048	0.38	1.54	1.54	1.54	-	-
Total H-Winds Installed-M	0.012	0.08	0.76	7.67	15.3	23.0	30.7	30.7
H-W Mnfg Jobs - Thousands	4.8	21.4	177	1,013	1,520	2,027	2,027	2,027
H-Winds Install Jobs - T	0.30	1.20	9.6	38	38	38	-	-
HW Maint. Jobs - T	0.17	1.20	10.8	110	219	329	439	439
H-Tubes Installed M/Year	-	-	0.0005	0.02	1.54	2.048	2.048	2.048
Total H-Tubes Installed - M	-	-	0.0005	0.032	1.0	10.2	30.7	51.2
HT Mnfg Jobs - T	-	-	0.60	22.3	1,741	4,096	8,192	12,288
HT Installation Jobs - T	-	-	0.03	0.80	77	102	102	102
HT Maintenance Jobs - T	-	-	0.014	0.90	29.2	293	878	1,463
<b>TOTAL HELI-Jobs - M</b>	<b>5.22</b>	<b>23.8</b>	<b>198</b>	<b>1,185</b>	<b>3,624</b>	<b>6,885</b>	<b>11,637</b>	<b>16,319</b>
<b>HELI-INCOME - \$ Billions</b>	<b>\$ 0.001</b>	<b>\$ 0.031</b>	<b>\$ 1.38</b>	<b>\$ 34</b>	<b>\$ 183</b>	<b>\$ 4,592</b>	<b>\$ 29,506</b>	<b>\$ 607,352</b>

### **Employment Assumptions**

<b>World Population</b>	Growing at 1½%/yr
<b>HeliWind Manufacturing Jobs</b>	\$ 7,500/unit .... 1 employee make 3.3 units a year + 20% replacements/yr
<b>HeliWind Installation Jobs - T/Yr</b>	3 man crew, 2 days/unit, 250 days/year = 40 units/man/yr
<b>HeliWind Maintenance Jobs - T/Yr</b>	3 man crew maintains 200 units = 70 units/man/yr
<b>HeliTube Mnfg Jobs - T/Yr</b>	\$ 30,000/unit .... 1 employee makes 1 unit a year+ 20% replacements/yr
<b>HeliTube Installation Jobs - T/Yr</b>	6 man crew, 2 days/unit ( incl. Drag Line) = 20 units/man/yr
<b>HeliTube Maintenance Jobs - T/Yr</b>	6 man crew maintains 200 units = 35 units/man/yr
<b>HELI INCOME</b>	\$ 0.001/kW-hr + \$ 1,000/unit

## **6.0 FUNDING**

For the first 24 months, an operating budget of \$ 26 M is needed to bring the *HeliWind* to market as shown in Table 7.

**Table 7 – HeliWind R&D Budget**

<b><u>ITEM</u></b>	<b><u>Budget</u></b>	<b><u>Comments</u></b>
Personnel	\$ 8,000,000	20 @ \$ 200K/yr ave (CEO, CFO, staff, engineers)
Office/Lab Rent	\$ 600,000	5,000 Sq. Ft. + 2 acre site
Travel	\$ 1,200,000	20 trips/month @ \$ 2,500 ea
Computers	\$ 200,000	20 @ \$ 10K ea.
Office	\$ 2,000,000	furniture, supplies, utilities : \$ 10K/mo
Lab equipment	\$ 1,000,000	wind tunnels, supplies
Legal, Insurance	\$ 1,000,000	Contracts, patents
Fabric RFP	\$ 1,000,000	Solicit 3 designs, chose the best..FINAL DESIGN
SCADA RFP	\$ 1,500,000	Solicit 3 designs, chose the best..FINAL DESIGN
Balloon RFP	\$ 4,000,000	Solicit 3 designs, chose the best..FINAL DESIGN
Trailer RFP	\$ 2,000,000	Solicit 3 designs, chose the best..FINAL DESIGN
Siting RFP	\$ 2,000,000	Solicit 3 designs, chose the best..FINAL DESIGN
5' prototype	\$ 25,000	test in wind tunnel
20' prototype	\$ 50,000	test in wind tunnel
100' prototype	\$ 250,000	test on airfield site
300' prototype	\$ 750,000	test on airfield site
<b><u>TOTAL =</u></b>	<b>\$ 25,575,000</b>	

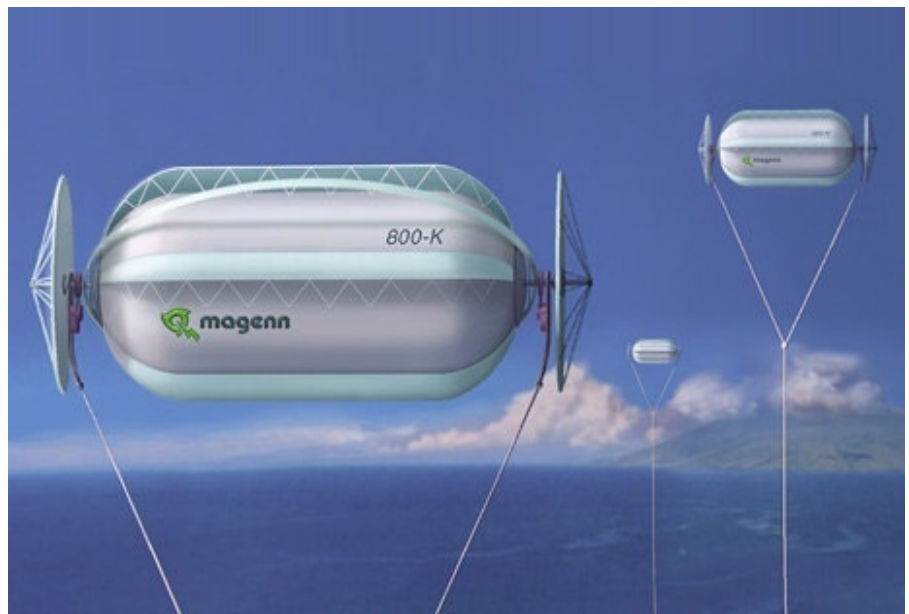
Funding sources include venture capital, government grants, and donations from private Non-Government-Organizations (NGO's). Over the next several months, these sources will be solicited (using this report) and brought aboard. By 2009, sufficient interest will be generated to obtain preliminary licensing and royalty fees from wind farm clients and manufacturers, and establish a positive cash flow.

## **7.0 OTHER WIND BALLOON PROJECTS**

In 1981, Austrian researchers (Reigler, et al) investigated high altitude balloon wind power for NASA:

“Design considerations for a high altitude power plant (HAPP) are discussed. A HAPP has a generator platform supported by a balloon, a tethering and conduction cable, and a ground station for control and energy distribution. Each streamlined balloon would carry six symmetrically arranged wind turbines and could be raised or lowered by a ground winch in response to 4 hr meteorological forecasts. A double bladed, variable pitch, horizontal axis rotor was chosen for HAPP application in the jet stream at 8,000-10,000 m height. Humidity and icing are calculated to be within tolerable limits; higher winter and lower summer heights are indicated. Optimization studies for 2, 5, and 7 MW turbines are presented, and rotor diameters are found to be limited to 40 m for weight considerations.”

No additional development work from this paper could be found. In 1978, Magnus Airship began investigations into building airships employing the lifting power of rotating spheres: the “Magnus Effect”. In 2006, the Magenn Energy Division was formed for production of a high altitude energy balloon called the MARS, pictured at right. Its goal is to extract wind energy from the jet-stream 5 miles up and moving at 200+ mph. Energy production costs of 3¢/kW-hr (similar to *HeliWind*) are predicted. This design also appears on the Mars Exploration website.



**Figure 11 – Magenn Energy Blimp**



**Figure 12 – Helix-Wind**

Makani Power Inc. is another high altitude wind energy developer. No details could be found on their expected approach (kites were mentioned on some blogs?) but they did receive a \$ 10M grant from Google’s **RE<C Program**.

A similarly named product, the HELIX-WIND is a small 1to 2 kW rigid (i.e.non-balloon) savonius rotor (shown at left).



The *HeliWind* patent search was completed March 19, 2008, and a Patent Application for the *HeliWind* was submitted to the USPTO on May 1, 2008. A patent award, or rejection, for the *HeliWind* is expected in mid-2009.

The patent search for inventions similar to the *HeliWind* found eighteen “Primary” and seventeen “Secondary” relevant patents. None of the secondary inventions were in conflict with the *HeliWind*. The Primary Inventions were of three types:

- 7 lighter than air systems with the genset in the air (see Figure 13) ;
- 7 kite systems (see Figure 14);
- 4 lighter than air (LTA) WECS’s similar to the HeliWind with a rotating lighter-than-air balloon attached to the ground-based genset (see Figure 15).

U.S. Patent

May 22, 1984

4,450,364

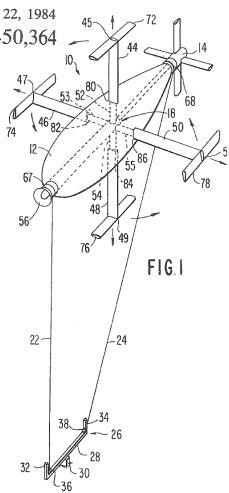


FIG. 1

FIG. 2

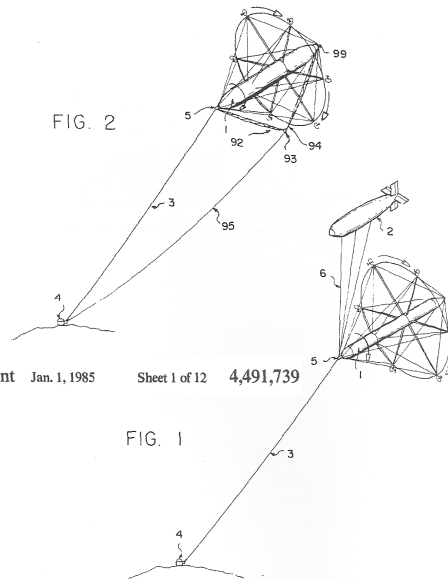
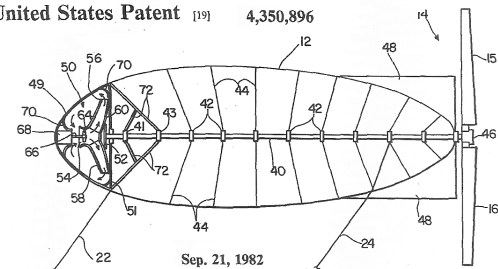


FIG. 1

United States Patent [19]

4,350,896



Sep. 21, 1982

**Figure 13 – Lighter Than Air WECS w/Genset on Blimp**

FIG. 1

U.S. Patent

5,435,259

July 25, 1995

Sheet 1 of 9

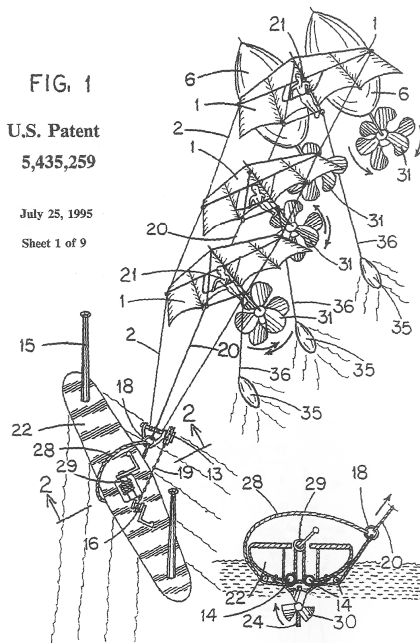


FIG. 2

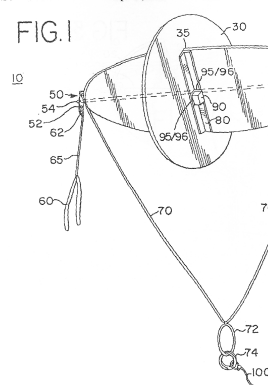
U.S. Patent

Sep. 21, 1999

Sheet 1 of 5

5,954,297

FIG. 1



**Figure 14 – Aerial Kite Systems**

U.S. Patent

Sep. 9, 2003

Sheet 48 of 51

US 6,616,402 B2

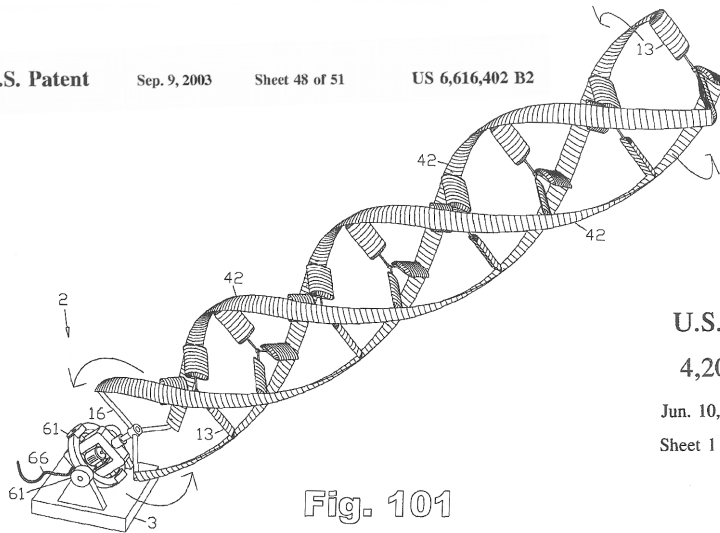


Fig. 101

U.S. Patent

4,207,026

Jun. 10, 1980

Sheet 1 of 4

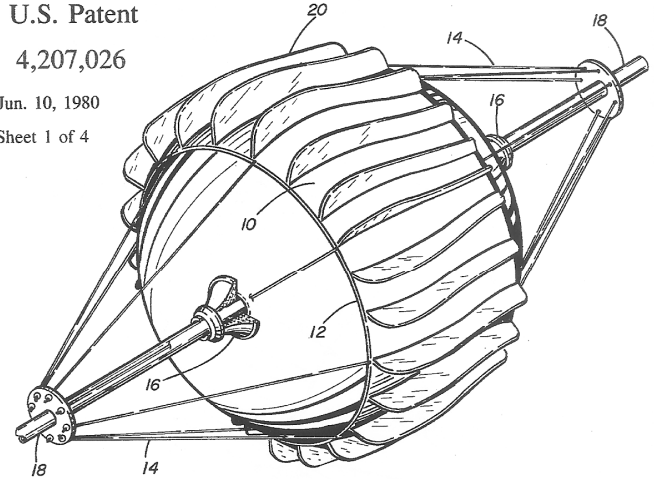
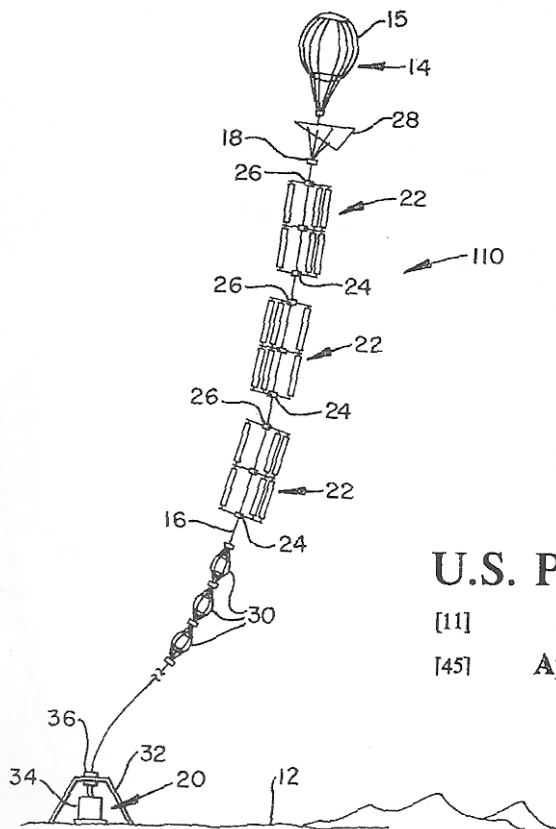


Fig. 1



U.S. Patent

[11]

4,084,102

[45]

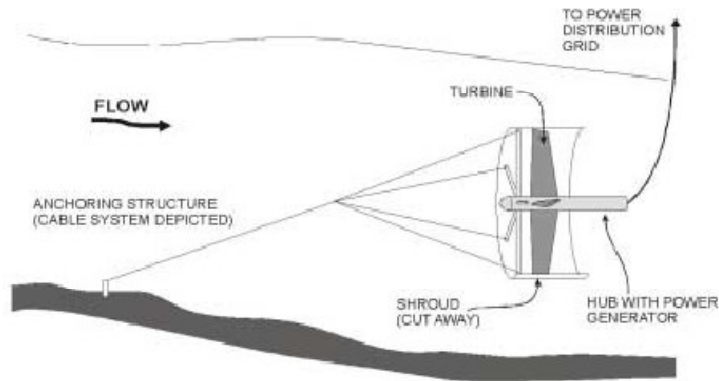
Apr. 11, 1978

### Figure 15 – “Lighter Than Air” WECS Systems

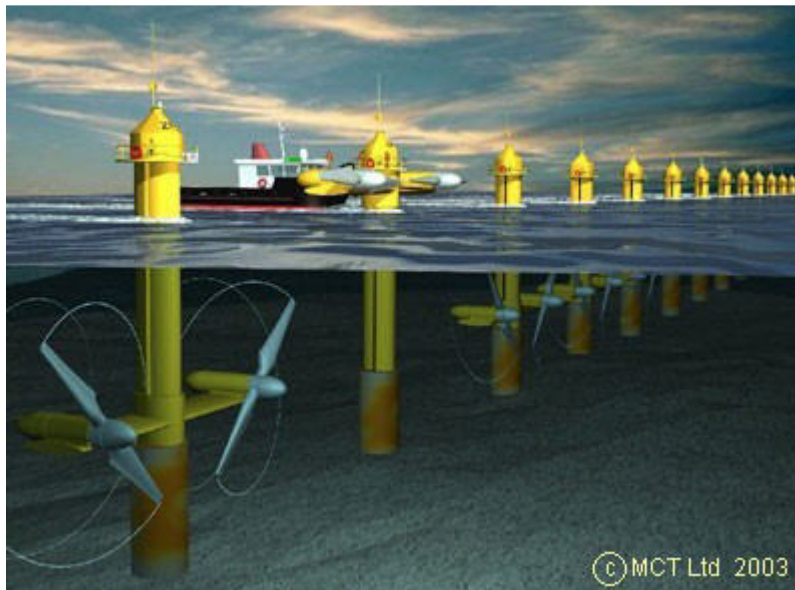
None of these Light-Than-Air systems had any of these six key *HeliWind* features:

- Easily launched and recovered;
- Simple and inexpensive to build;
- Economical to operate;
- Generates power 24/7;
- Silent;
- No bird or bat kills.

There were no patent search results for an invention similar to the proposed *HeliTube*. The closest internet match was the Shrouded Turbine shown in Figure 16, usually powered by river currents. There were also several tidal power plants found, including the Rance River Project in France (barraged flow) and several underwater turbine proposals in Britain (See Figure 17).



**Figure 16 – Shrouded Turbine**



**Figure 17 – Current Turbines**

## **8.0 R&D TEAM**

The function of the R&D Team is to prepare successful *HeliWind* designs that can be economically manufactured, easily installed, effectively generate low-cost power, and be simply maintained. All the essential parts for a *HeliWind* are already in production. It is only necessary to assemble the right design team and design companies to transform existing materials and components into a workable *HeliWind*.

By September 2008, the *HeliWind* team will be assembled from qualified energy experts around the world. A CEO with a strong background in wind energy will be selected and a CFO hired to take over funding, budgeting and financing. The CFO will administer manufacturing royalties and site licensing fees. A public relations firm will keep the energy community abreast of *HeliWind* developments and generate sales interest. Every major company and government agency considering installing wind turbines will be contacted and urged to consider switching to less expensive and more reliable *HeliWinds*.

A team of 7 engineers must be assembled. A Chief Engineer will supervise six specialists:

**Balloon Design**... Aeronautical engineer with balloon and LTA airship experience;  
**Trailer/Genset**... mechanical/electrical engineer with power generation experience;  
**Flight Computer** ... computer programmer: modeling, simulation and SCADA control systems;  
**Siting Engineer**... electrical engineer with WECS experience;  
**Operations and Maintenance** ... design, CM, building maintenance experience;  
**Energy Storage**... emphasis on H<sub>2</sub>-O<sub>2</sub> production, storage and power generation.

These engineers will supervise and coordinate the design work of outside companies hired for their expertise. Request-for-Proposals (RFPs) will be prepared and sent to companies in a relevant business. The companies will manufacture the necessary prototypes for preliminary testing and evaluation.

The same team will supervise the selected *HeliWind* manufacturers to develop an efficient range of *HeliWind* designs and then supervise manufacturing to ensure design compliance. The team will assist site operators in preparing efficient wind farm layouts using *HeliWinds* and support their design, permitting, installation, and operations.

## **9.0 SUMMARY**

*HeliWinds* will produce electricity at a cost of \$ 0.034/kW-hr without government support. By 2020, it is hoped 7.7 million *HeliWinds* will generate 1.4 Peta-Watt-hrs of energy. With the results from the *HeliWind* program, development of the *HeliTubes* will become the primary focus of the design team. The ultimate goal, admittedly ambitious, is that by the year 2050, fifty million *HeliTubes* will replace the use of almost all fossil fuels on the planet. The burning of fossil fuels will be reduced to less than 1 percent of current levels and replaced with low cost hydrogen and oxygen powered cars, airplanes, power plants, etc. Coal will be abandoned, and oil only used for lubrication and plant feed stock.

*HeliWinds* can solve the most critical environmental issues facing the planet: pollution and global warming. To help ensure this outcome, 75 percent of *HeliWind* income and equity will be dedicated exclusively to solving global warming. The remaining 25 percent will go to *HeliWind* employees and investors. Securing \$ 26 M in R&D funding and setting up the *HeliWind* design team are the first tasks in achieving this goal.