Magenn Power Inc. - Magenn Air Rotor System (MARS)

Peter Lobner, 31 October 2024

1. Introduction

Magenn Power Inc. was founded in 2004 by Frederick D. Ferguson (CTO) and Mac Brown (COO) as a private Canadian company in Kanata, a suburb of Ottawa in Ontario, Canada. The firm's CEO was Pierre Rivard. The firm's goal was to develop a scaleable airborne wind turbine design called the Magenn Air Rotor System (MARS), in which a large, non-rigid, buoyant, tethered rotor was driven by the wind and attached generators delivered power via the tether to a ground station.

MARS Alpha prototype. Source: Magenn Power (2008)

The tethered Magenn Air Rotor System was invented and patented by Fred Ferguson, who previously had invented and patented a free-flying, buoyant, rotating, spherical, hybrid airship that was being developed in the 1980s by Magnus Aerospace Corporation as the LTA 20-1. The airship's rotating gas envelope took advantage of the

Magnus Effect to generate a variable aerodynamic lift to supplement the aerostatic lift available from the helium lifting gas.
In the case of the MARS tethered, buoyant, rotating aerostat, Magnus lift supplements aerostatic lift once the air rotor lifts off and starts rotating in the ambient wind. The additional Magnus lift causes the tethered aerostat to pull up on its tether, making a MARS air rotor less susceptible than conventional aerostats to being blown downwind on its tether at steeper angles as wind speed increases.

The business case for the MARS was based in the fact that prevailing winds are stronger at higher altitudes and offer more energy for harvesting (higher energy density) than at ground level. Magenn promoted MARS as a *Wind Power Anywhere™* solution with advantages over terrestrial wind turbines and small diesel generator systems, particularly in remote applications.

MARS advantages over terrestrial wind turbines & diesel generators

Advantages of MARS over terrestrial wind turbines	**Advantages of MARS over a stand-alone diesel generators**
• Operates over a wider range of wind speeds (2 to 28 meters/second) • Can be deployed into stronger, higher altitude winds (from 400 to 1,000 feet above ground) without having to construct expensive towers • Higher capacity factor, approximately 50% (vs. 20 – 25% for terrestrial wind turbine) • Minimal site preparation needed • Rapid setup and deployment, good for supporting emergency response and disaster relief efforts • Mobile (can be relocated if needed) • Bird and bat friendly • Lower cost of electricity	• Zero carbon emissions • No fossil fuel transportation & storage costs • Lower cost of electricity • Can complement a diesel generator with a combined diesel-wind power solution that can deliver power below 20 cents per kW-h • Lower noise

Source: Magenn Power

Magenn reported that its target markets included "developing nations where infrastructure is limited or non-existent; off-grid combined wind and diesel solutions for island nations, farms, remote areas, cell towers, exploration equipment, backup power and water pumps for natural gas mines; rapid deployment diesel and wind solutions (to include airdrop) to disaster areas for power to emergency and medical equipment, water pumps; on-grid applications for farms, factories, remote communities; and wind farm deployments."

Off-grid MARS supporting a remote mine (L) and a remote military base (R).

Off-grid MARS supporting an offshore platform (L) and a small unit at a remote site (R). Source, four graphics: Chris Radisch via Magenn Power

In a combined wind and diesel solution for an isolated site, a MARS unit delivers power to a local hybrid mini-grid that includes a diesel generator and a battery backup system. The MARS unit significantly reduces the demand on the diesel as well as diesel fuel consumption and significantly reduces the cost of electricity.

Source: Magenn Power

Larger MARS units (hundreds of kW) can operate on isolated grids and also would be good candidates as grid-connected wind energy generators to supplement other grid-connected power generators.

Starting with sub-scale prototypes from 2005 to 2007, Magenn Power built its first large scale proof-of-concept MARS unit, known as the Alpha prototype, and flew it for the first time in April 2008. The firm subsequently built a larger 100 kW prototype and planned to conduct long-term operational testing before they were stopped, first by an environmental review and then by lack of funding.

Beyond the two large prototypes, Magenn Power did not get an opportunity to build and deploy MARS units for commercial customers.

The firm is out of business and the original Magenn corporate website (www.magenn.com) no longer is in service. Its contents have been archived on the Wayback Machine website here: https://web.archive.org/web/20081211041521/http://www.magenn.com/

2. Funding overview

In December 2006, the Canadian government's Sustainable Development Technology Corporation (SDTC) awarded Magenn a $691,019 grant (Round 9, 2006A). The grant was conditional on Magenn raising another $2.4 million from the private sector. Magenn was unsuccessful raising Series A funding from Canadian investors.

In October 2007, Magenn finally succeeded in raising Series A financing, with a USD $5 million investment by David Gelbaum and his California investment vehicle Quercus Trust. This investment gave Magenn enough money to finish its MARS Alpha prototype and conduct indoor and outdoor airborne tests in 2008.

Also in 2008, Magenn's Air Rotor was featured in the Discovery Channel's Project Earth documentary series (Series 1, Episode 5). Discovery Channel put up half the money to conduct a series of windspeed data collection tests in the Dominican Republic, a tether strength test and an air rotor test in a General Motors wind tunnel.

While the Ministry of Natural Resources supported operational testing of 100 – 200 kW MARS units in 2008, Magenn and the Ministry were unsuccessful in getting a project approved and securing funding from the Ontario province's Innovation Demonstration Fund.

In 2009, Magenn sought a Series B round of financing that aimed to raise $12 million to support conducting demonstration projects with larger MARS units. Series B funding was deemed necessary for the company to commercialize MARS. Magenn was not successful in raising Series B funding,

Without operating capital, the company ceased MARS development and archived its website.

3. Patents

Magenn has several patents related to the design of MARS units. All are listed at the end of this article.

The following figures 5A, 5B, 6 and 7A from Magenn Patent US8148838B2 depict a non-rigid airborne rotor similar in design to the Alpha prototype that flew in 2008 and an early design concept for a commercial 10 kW MARS. In this application, the gas envelope was inflated with helium.

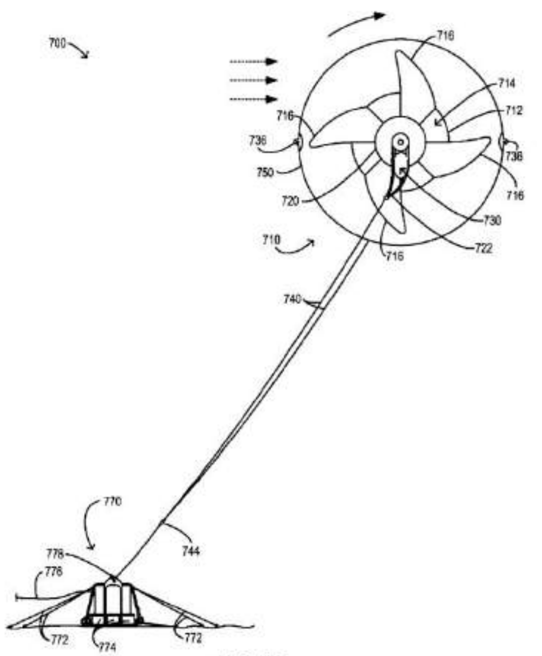


FIG. 7B

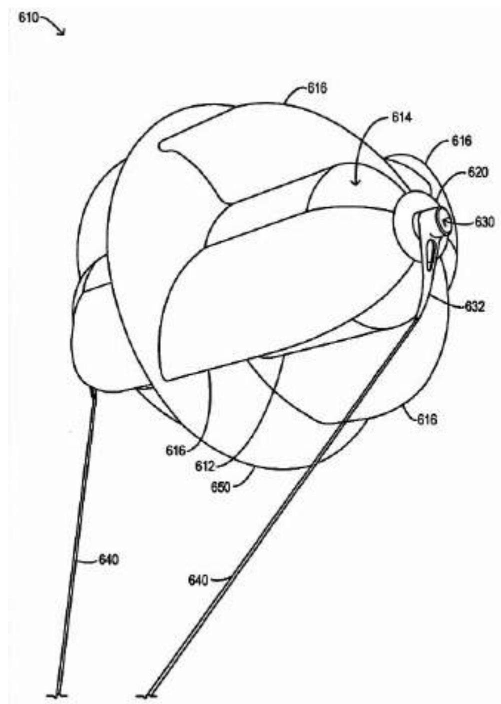


FIG. 6

Legend for Patent US8148838B2, Figures 6 & 7B

The airborne rotor (610, 710) is comprised of a non-rigid, pressure-stabilized, rotating gas envelope (614, 714), multiple vanes to catch the wind (616, 716), endplates with projecting axles (620, 720), in this case, an integral vane stabilizer (650, 750) and external securing points (736) that would be used to secure the air rotor on the ground. Stationary generators (630, 730) are driven by the projecting axles, and are connected to the power-conducting tethers (660, 740) by means of yokes (632, 722) suspended from the axles. The two tethers may be connected at a tether coupler (744). The tether terminates at a winch (778) on the ground station (770), which can be secured to the ground with anchors (772). Power conditioning equipment (774) and an electrical connection to a local micro-grid (776) may be on or near the ground station.

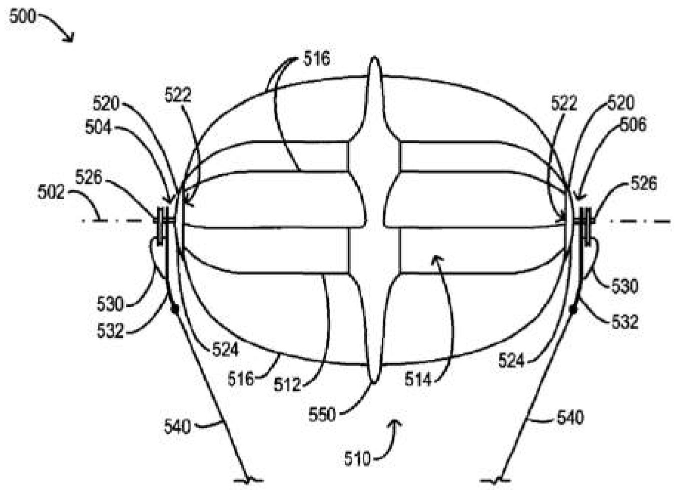


FIG. 5A

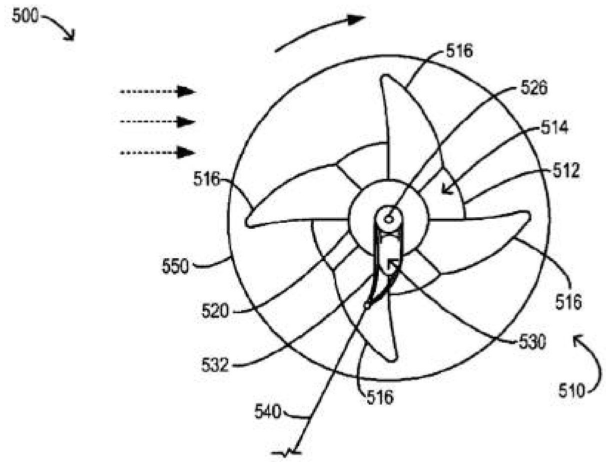


FIG. 5B

Legend for Patent US8148838B2, Figures 5A & 5B

The airborne rotor (510) is comprised of a non-rigid, pressure-stabilized, rotating gas envelope (514), multiple vanes to catch the wind (516), endplates with projecting axles (526), and in this case, an integral vane stabilizer (550). Stationary generators (530) are driven by the projecting axles, and are connected to the power-conducting tethers (540) by means of yokes (532) suspended from the axles.

Magenn notes, “Even if the envelope is filled and/or pressurized with a gas that is not lighter than air (e.g., air itself, for example), the Magnus effect associated with the rotation of the body about the axis will supply a lift force to the wind turbine. In some embodiments, this Magnus Effect lift force is substantial enough to provide all of the lift necessary to allow the wind turbine to be deployed and/or remain aloft.”

The following Figures 2A and 2B from Magenn Patent US8148838B2 depict a non-rigid cylindrical airborne rotor similar in design to large MARS design concepts (up to about 1.6 MW) developed by Magenn.

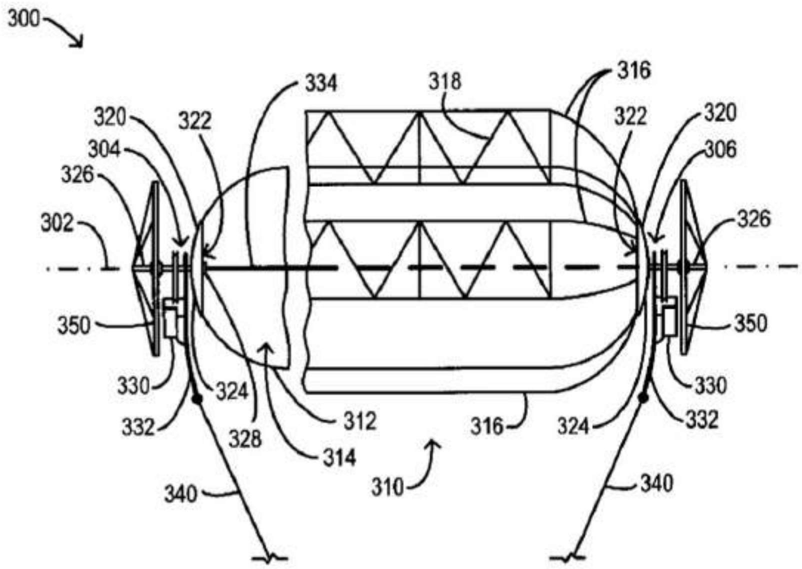


FIG. 3A

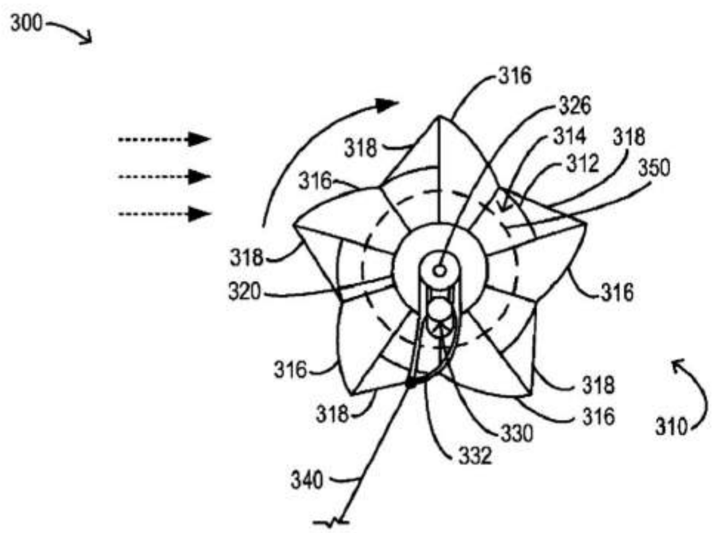


FIG. 3B

<u>Legend for Patent US8148838B2, Figures 3A & 3B</u>

The airborne rotor (310) is comprised of a non-rigid, pressure-stabilized, rotating gas envelope (314), multiple vanes to catch the wind (316) with vane supports (318), endplates with projecting axles (326), and in this case, stabilizer plates attached at the ends of the axles (350). Stationary generators (330) are driven by the projecting axles, and are connected to the power-conducting tethers (340) by means of yokes (332) suspended from the axles.

The internal view in patent Figure 13 shows the placement of an internal tension bar (1362, which may be a strap, a cable, a solid axle or a tube) secured to the two end caps (1320), and ballonets (1360 & 1364) that control gas envelope pressure and balance. The ballonets may comprise a powered blower and a pressure relief valve. Other ballonet configurations are described in the patent. Together, the tension bar and the ballonets help maintain the shape of the pressure-stabilized gas envelope of the Magenn airborne rotor.

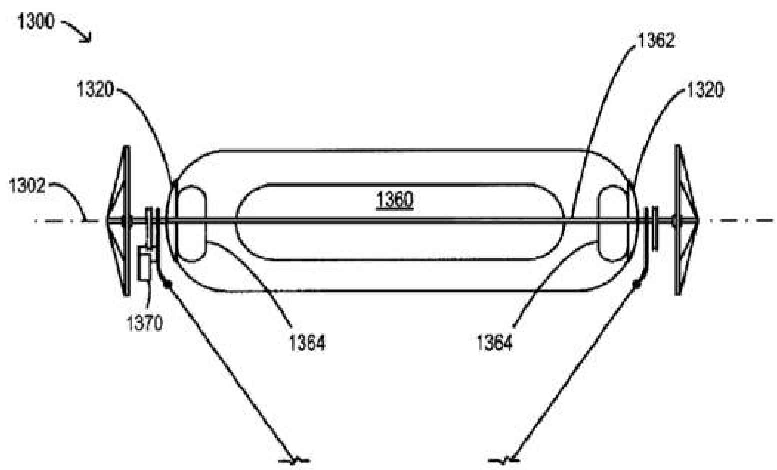


FIG. 13

The patent also describes a deployment concept for a MARS with multiple stacked airborne rotors on a common pair of tethers, as shown patent Figure 16 and the accompanying illustration.

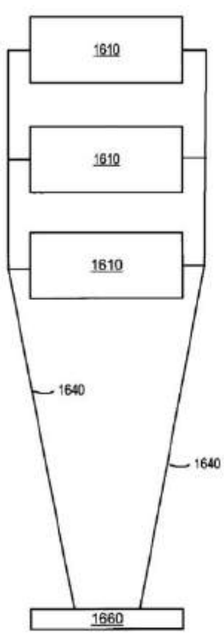


FIG. 16

Source: Chris Radisch via Magenn Power

4. Description of a MARS unit

A Magenn Air Rotor System is a lighter-than-air tethered wind turbine that rotates about a horizontal axis in response to the ambient wind, and generates electric power. This electrical energy is transferred via conductors in the tether to the ground station, which connects to on-site power conditioning equipment and then to off-grid local users or to the grid itself.

A MARS unit consists of the following elements:

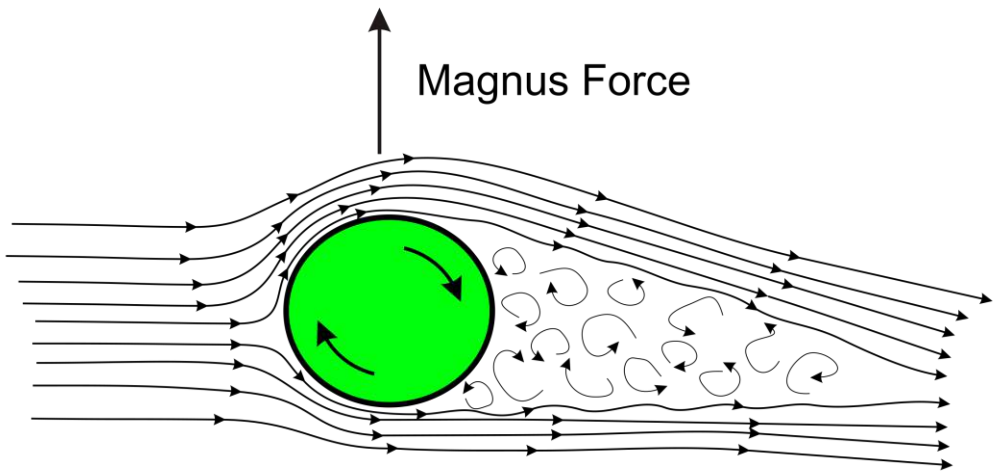
- The airborne unit:
  - Horizontally rotating aerostat (lift gas envelope)
  - Stabilizer(s)
  - Axles
  - Generators
- Tethers
- Ground station (winch, controls)

The interfaces between a MARS unit and a terrestrial power system are all located on the ground.

Horizontally rotating aerostat (gas envelope)

The MARS airborne rotor is a non-rigid aerostat using helium as the lifting gas to generate aerostatic lift equal to about twice the weight of the MARS airborne rotor and tether.

Once airborne, the rotor starts rotating in the wind and can reach 30 to 60 rpm in operation. Then the Magnus Effect comes into play, it generates substantial aerodynamic lift, so much so that the airborne rotor could remain aloft without aerostatic lift. Magnus lift increases as the wind speed increases. In prototype tests, Magenn noted that a MARS airborne rotor went straight up when deployed and, because of the additional Magnus lift, was less susceptible than conventional aerostats to being blown downwind. Magenn claimed that the maximum downwind lean of a MARS unit will never be more than 45 degrees from the vertical.



The Magnus Effect is depicted here with a back-spinning cylinder or ball (a circular airfoil) in an airstream. The vertical arrow represents the resulting Magnus lifting force, which is perpendicular to the axis of rotation. The incoming airflow has been deflected by the direction of spin, adding to the velocity of the airstream (and reducing its pressure) above the rotating object, and subtracting from the velocity of the airstream below (and increasing its pressure). The difference in airflow speeds, and the consequent pressure difference, generates the Magnus force, which is proportional to the airspeed flowing over the rotating object; the faster the airspeed, the greater the Magnus lift. The curly flow lines in the above diagram represent a turbulent wake. Source: adapted from Rdurkacz via Wikipedia

Based on experience in large airship structures, Magenn chose a multi-layer fabric envelope material with a woven high-tenacity substrate similar to Kevlar. This woven material is coated or laminated with a Tedlar outer surface, which reduces abrasion and protects against ultraviolet (UV) radiation. On the inside of the woven material is a Mylar coating acts as a gas barrier. It should be noted that the woven substrate material is the same as that used in bullet-proof vests.

Envelope gas pressure is controlled using a typical airship-style ballonet, which is an inside air bladder that inflates or deflates as needed to maintain envelope gas pressure within the desired range.

The normal helium leak rate is estimated to be 0.5% per month or 6% per year. The air rotor will need to be topped off with helium every 4 to 6 months.

As required by the FAA and Transport Canada, the MARS gas envelope has a rapid deflation device for use in emergency situations, such as the air rotor breaking free from its tether or base station. A rip cord type device opens a hole in the envelope, releasing the helium lifting gas and allowing the air rotor to safely float back to the ground.

Wind doesn't have to be strong to get a MARS airborne rotor turning; as little as 1 meter/second is enough to start rotation. MARS can operate at speeds greater than 28 meters per second, with the maximum wind speed dictated by structural integrity. Magenn recommends reeling in the gas envelope and securing it to the ground in extreme weather.

A MARS airborne rotor is 50% as efficient as the best conventional (pole-mounted) wind turbine, in terms of their wind "intercepted area". For a conventional wind turbine, this is the circular "swept area" of the propeller, and for a Magenn airborne rotor, it is the "wind facing area" of the rotor. Thus, Magenn must have an intercepted area twice as large as a conventional wind turbine to produce an equivalent power output. However, there are other considerations that help boost the capacity factor of a MARS unit, such as being able to deploy above ground mechanical turbulence, having a larger proportion of the intercepted area in the faster moving winds at higher altitudes, and being able to operate over a greater range of airspeeds.

Magenn developed the following comparison of 100 kW MARS expected capacity factors at five different sites.

Capacity factors, MARS versus conventional designs

Location	MARS 100 kW turbine at 1,000 ft, %	Conventional 2 MW turbine at 262 ft, %	Conventional 100 kW turbine at 131 ft, %
Brookhaven, N.Y.	51.0	14.4	11
Aberdeen, N.D.	50.0	24.5	19.6
Wallops Island, Va	49.1	17.2	14.8
Brownsville, Tex	48.5	21.3	19.9
La Grande, Quebec	45.8	17.8	13.5
Averages	48.9	19.0	15.8

Source: Magenn Power via Windpower (2009)

Wind vane stabilizer(s)

The wind vane stabilizer(s) help ensure that an airborne rotor will automatically point directly into the wind for optimal power generation and Magnus aerodynamic lift.

Each airborne rotor incorporates one of more vertical wind vane stabilizers. In the earlier prototypes and smaller MARS units, this was a single plate installed around the middle of the cylindrical rotor, perpendicular to its axis of rotation. In later designs for larger MARS units, two vertical wind vane stabilizer plates were installed, one at each end of the rotor.

Axles

The MARS aerostat rotates in the wind on its horizontal axis. The end plates include a rigid stub axle that is on the centerline of the gas envelope and projects beyond the endplates to support non-rotating yokes and connect via step-up gears to drive the generators. Each yoke supports a generator and mechanically connects to a tether.

The external axle does not necessarily extend all the way through the gas envelope. As described in patent US8148838B2, the two end plates are connected by an "internal tension bar," which may be a strap, a cable, a solid axle or a tube. This bar maintains a tension along the longitudinal axis and helps maintain the shape of the pressure-stabilized gas envelope.

Circular end plate with an axle extension attached to a 5 kW generator
and tether to one end of the Alpha prototype's gas envelope.
Source: Magenn Power via NewAtlas (2009)

Generators

Each MARS aerostat has two generators that are attached outside the gas envelope, at the axle ends and are supported by yokes. The generator casing includes step-up gears between the axle and the generator, which are driven at speeds of 1,200 to 1,500 rpm. As shown in the following drawings, the generator is mounted slightly below the axle and is connected to the tether via a supporting yoke that carries the mechanical load of the tether.

(L) Generator casing, yoke & tether (all green) connected to axle at one end of a 10 kW MARS airborne rotor.

(R) Generator casing & yoke (purple) connected to axle at one end of a large MARS airborne rotor with an outboard wind vane stabilizer. Tether is white.

Source, both graphics: Chris Radisch via Magenn Power

Smaller off-grid MARS units can select a generator that matches the intended local micro-grid voltage. Choices include: 120 VAC / single-phase / 60 Hz, or 240 VAC / single-phase / 50 Hz, or regulated DC 12 to 600 V.

Larger MARS units used for off-grid heavy commercial applications can deliver power at higher voltages. Grid-connected units will be configured with variable-frequency (doubly fed) AC generators, so that the generators can remain synchronous with the grid and get the most out of the energy in the wind without motoring off the grid or causing excess reactive loading.

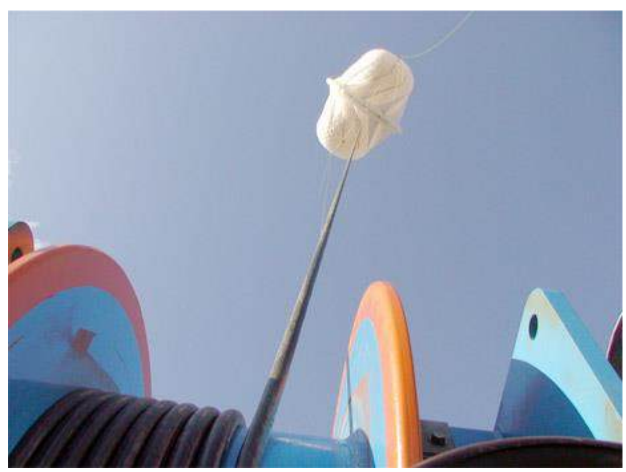
Tethers

Vectran was selected by the tether supplier, Atkins & Pearce (A&P), for use as the core material for a braided cable tether that was wrapped with copper to carry electrical current from the MARS generators to the ground station. The fiber's high strength, yet light weight and zero creep, made it well-suited for this application. The tether could support a maximum load of 9,072 kg (20,000 pounds).

Tether resin-infused aluminum end fittings were designed by Applied Fiber to connect the tether to the wind turbine and ground station. These end fittings thread directly into fittings on the yokes supporting the generators and the ground station to physically secure the aerostat and complete the electrical path to the ground station.

MARS deploys to altitudes in the 122 to 305 m (400 to 1,000 ft) range. The U.S. FAA and Transport Canada require lighting on the tether to ensure tether visibility to aviators flying nearby.

In an experiment for the Discovery Channel, an electrically energized MARS tether supported from a crane lifted six scrap cars off the ground while their headlights verified that the tether maintained electrical continuity.



10 kW MARS Alpha prototype on a 113 m (370 foot) tether. Source: Magenn Power via NewAtlas (2009)

Ground station

The ground station includes the winch system, controls for deploying and recovering the airborne rotor, and systems that constantly monitor and control gas envelope pressure (via the ballonets) and monitor rotation speed, wind speed, and generator functions. The airborne rotor self-aligns in the wind without any control action.

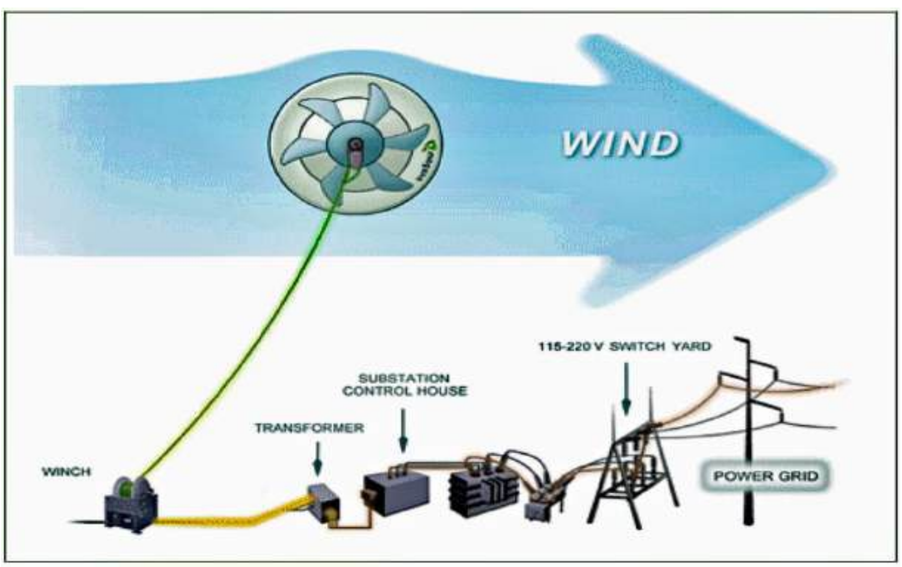
If high winds occur at the airborne rotor's operating altitude, the ground station can winch the unit down to a lower altitude that generally will have lower wind speeds. In extremely high winds, the airborne rotor should be winched all the way down and secured to the ground. These are not autonomous functions.

The ground station includes electric power output terminals that need to be connected to a site specific external power distribution system.

The ground station also can be connected to the Internet to deliver real-time operational data the unit's owner.

Isolated micro-grid and grid-connected power distribution systems

An example of an off-grid configuration to supply AC power to end users on a local micro-grid is shown in the following diagram. Standard distribution voltage to domestic users typically would be 120 VAC / single-phase / 60 Hz in North America, and 240 VAC / single-phase / 50 Hz in Western Europe and many other parts of the world.



Off-grid configuration: MARS supplying power to a local micro-grid (labeled as "power grid" in the above drawing) operating at 115 – 220 VAC. Source: Magenn Power

Larger MARS units supplying power directly to a terrestrial grid will deliver three-phase power that is synchronized in frequency and phase via a step-up transformer that raises delivered voltage to match grid voltage (i.e., 10,000 and 30,000 volts).

5. MARS prototypes

<u>Early sub-scale model tests (2005 - 2007)</u>

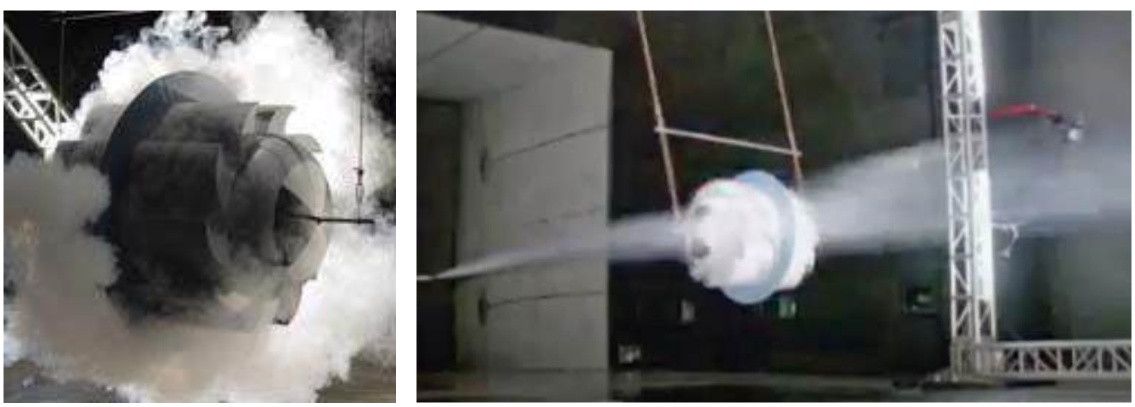
Early development work was funded by a Canadian government Sustainable Development Technology Corporation grant and successful Series A funding that together raised almost $6 million.

Early Magenn small-scale buoyant prototype with an inflated wind vane stabilizer, no generator, circa mid-2006.

A later small-scale prototype with a solid wind vane stabilizer, no generator, circa late-2006.
Source, four photos: Magenn Power via NewAtlas

In 2009, Design Engineering reported:

> “Discovery Channel put up half the money to conduct the tests that were critical to creating the prototype. First was an airspeed test in 2006 in Dominican Republic, a well-known spot for wind research because of its constant and steady Easterly Trade Winds.……’We found out that at 1000 feet above ground, the energy you can collect is eight times greater than at 300 feet,’ Ferguson says. ‘And at that altitude, the wind is stable. We also found that not much changes when you go above 1000 feet.’”
>
> “The next trial involved testing a model in a massive wind tunnel owned by General Motors. ‘Wind speed data collected during the first test was used here,’ says Ferguson. ‘The tunnel simulated the forces that would act on a real model up in the sky.’ As a result of this test, a central rudder disk was added and the blades were angled towards the center. Later, yaw stabilizers were added to each end.”

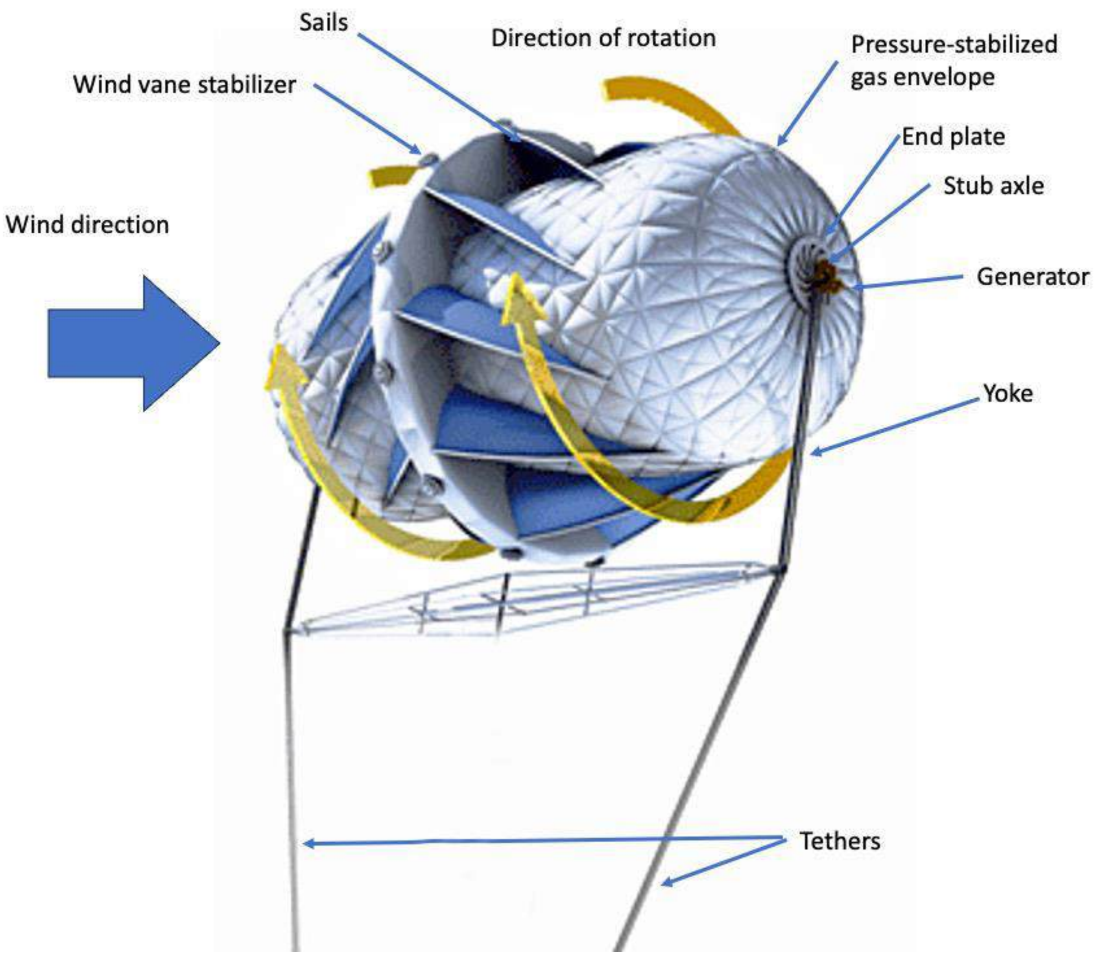


Magenn air rotor during tests in the GM wind tunnel.
Source: Screenshot, Discovery Channel, Project Earth, S1, E5

The MARS design went through several iterations following the Discovery Channel trials.

MARS Alpha prototype (2008)

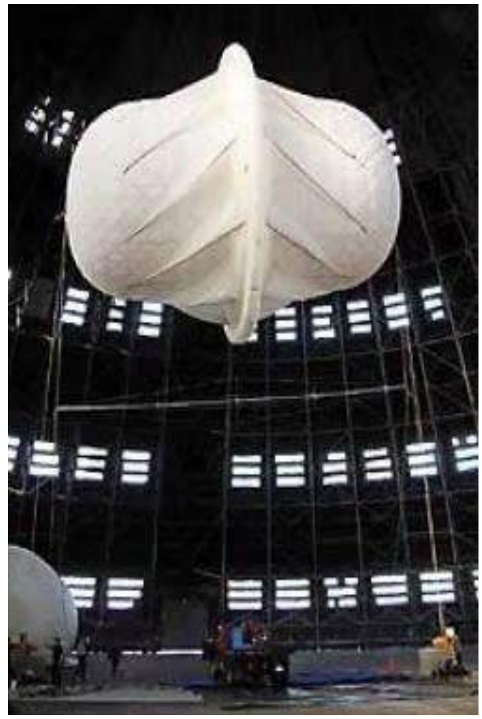
The design of the MARS Alpha prototype was based on lessons learned from the earlier sub-scale models that were flight and/or wind tunnel tested. The much larger MARS Alpha prototype measured 9.0 x 17.4 m (29.5 x 57 feet). Initially, this prototype generated 2 kW of power, and later was upgraded to generate 10 kW. The MARS Alpha prototype was built by TCOM at its facility near Elizabeth City, NC, in a large blimp hangar at the former Weeksville Naval Air Station. Float tests were conducted in the hangar before the MARS Alpha prototype made its first outdoor flight in April 2008.



General arrangement of the MARS Alpha prototype. The wind vane stabilizer is the ridge (rudder) running around the middle of the cylindrical gas envelope. Source: adapted from Bryan Christie graphic in Fortune (Oct 2008)

Alpha prototype at TCOM's hangar in N. Carolina, circa April 2008.
Source: Magenn Power via NewAtlas

Fully-inflated Alpha prototype sitting on its wind vane stabilizer.
Source: Magenn Power via screenshot from video



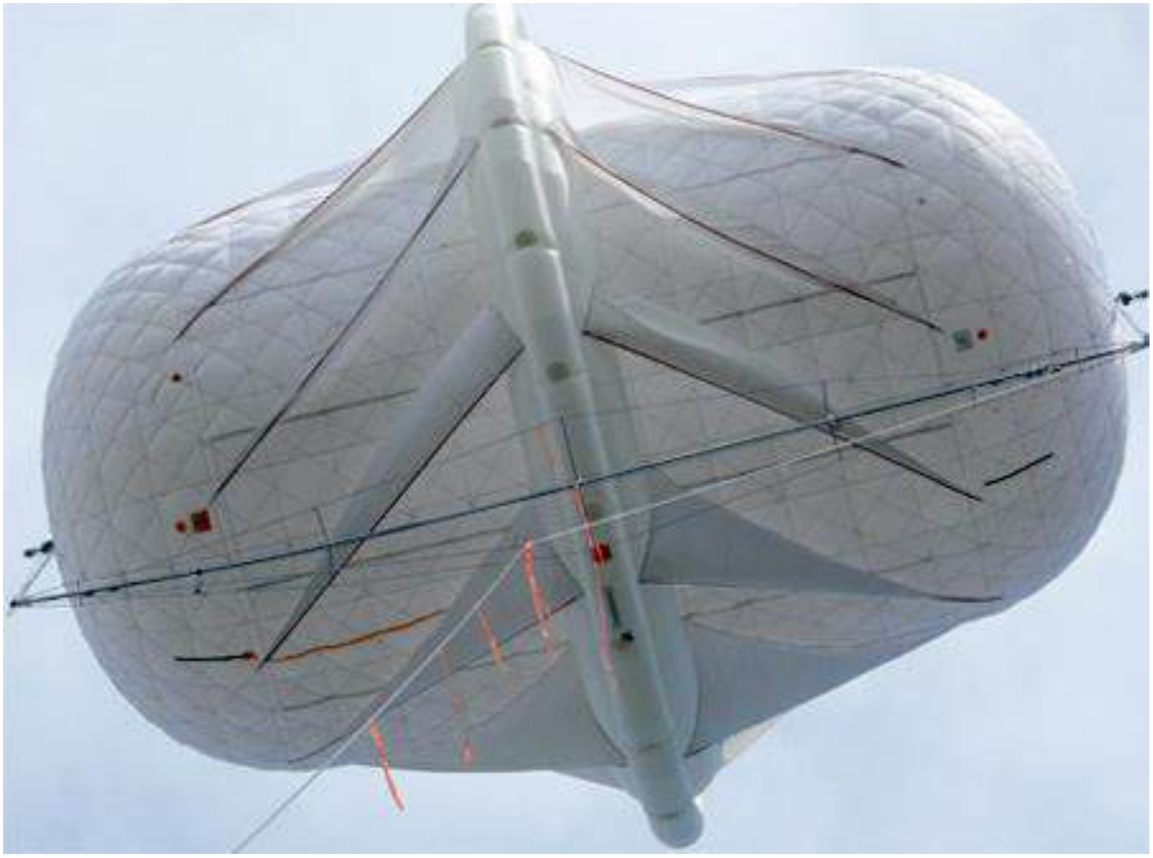
The Alpha prototype during indoor flight testing in TCOM's former blimp hangar in North Carolina, circa April 2008. Sources: (L) Magenn via CNN Money, (R) Magenn via NewAtlas

Launch site in Virginia. Source: Magenn via NewAtlas


Source: Screenshot, Discovery Channel, Project Earth, S1, E5


Alpha prototype aloft. Source: Magenn Power via NewAtlas

Alpha prototype aloft at the TCOM facility, North Carolina.
Source: Magenn Power via NewAtlas



View from directly beneath the Alpha prototype.
Source: Magenn Power via NewAtlas

30 kW MARS prototype (2009)

In 2009, Design Engineering reported: “The company is currently building an advanced 30 kW demonstration prototype in Gatineau, Quebec, which will be operational by the end of this year. ‘That size could be mass-produced as well.’ Ferguson says. ‘This one will be used for an extended period in a developing country, possibly providing power for some of a village’s needs.’”

There is no report of this 30 kW unit being completed and tested.

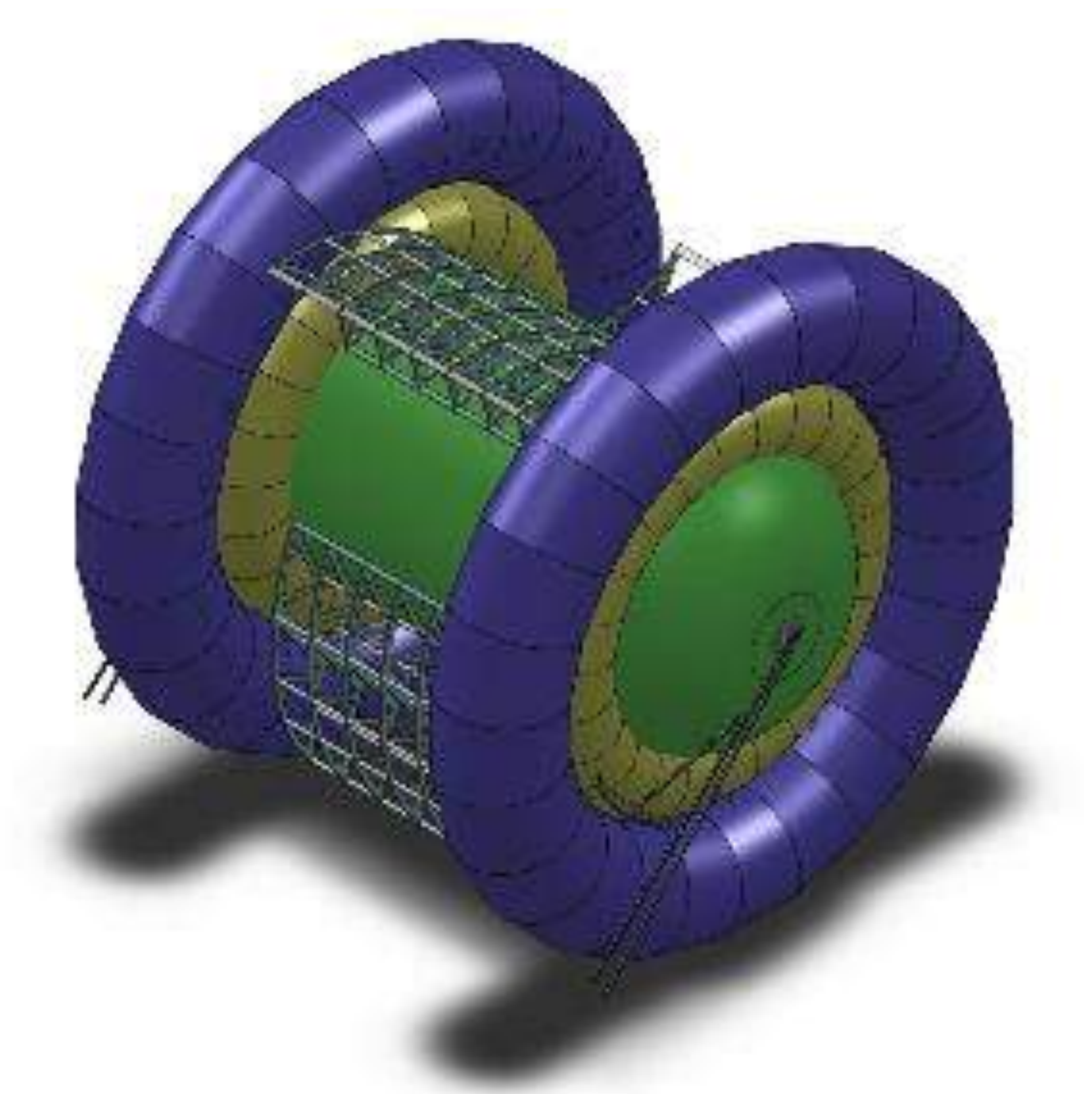
100 kW MARS prototype (2009)

In comparison to the Alpha prototype, the 100 kW MARS was a significantly different design, referred to as the “clamshell” blade design. The moveable “clamshell” style blades were operated with compression cylinders, allowing them to pivot open and then retract during each rotation cycle. This novel design is not described in any of Magenn’s patents.

100 kW MARS secured on the ground.
Source: Magenn Power via Design Engineering (2009)

In testing, Magenn noted that the 100 kW MARS “…achieved a coefficient of power that is better than 0.22, which is basically the efficiency of catching wind energy and converting it to rotational power output. ….The advantage of the large floating cylinder is the economic efficiency of building such a large unit to catch a massive amount of wind as compared to existing (terrestrial) wind turbines."

A digital 3D model of the 100 kW MARS, developed using SolidWorks CAD software, was used for design and simulation of air turbine operation. Magenn CEO Mac Brown reported, “SolidWorks lets us experiment with different turbine designs and compare electrical outputs. The software also helps us cut costs because we no longer need to outsource turbine simulations.”



100 kW MARS prototype modeled in SolidWorks.
Source: Design Engineering (2009)

The 100 kW MARS was targeted for use at small communities (up to about 15 homes) and remote industrial sites. The installed cost of a 100 kW MARS, including helium, was expected to be about $500,000.

Magenn claimed that its 100 kW MARS "…was viable in over 45 percent of the world. In many places where expensive diesel-generated power is used at $0.50 to $1 per kw-h and conventional wind and solar are not viable, MARS provides $0.08 to $0.16 per kw-h.…It could pay for itself in only 3 to 4 years."

MARS 100 kW prototype aloft.
Source: Magenn Power via Design Engineering (2009)

General design characteristics of the Magenn 100 kW MARS

Parameter	**Magenn 100 kW MARS**
Rated power	100 kW
Aerostat dimensions	Diameter = 13.7 m (45 ft), Length = 20.5 m (100 ft), plus “clamshell” blade height of 6.7 m (22 ft)
Envelope volume	5,663 m^3 (200,000 ft^3) (approx.)
Ballonet volume	Not specified
Shipping weight	Under 5,897 kg (13,000 lbs)
Tether length	• 228.6 m (750 ft) standard • Up to 457.2 m (1,500 ft) optional tether length
Start-up wind speed	2.5 m/sec (5.6 mph)
Cut-in wind speed	3.0 m/sec (6.7 mph)
Rated wind speed	12.0 m/sec (26.8 mph)
Cut-out wind speed	24.0 m/sec (53.7 mph)
Maximum wind speed	30.0 m/sec (67.1 mph)
Temperature Range	-40°C /-40°F to +45°C/+113°F
Generators	2 x 50 kW
Electric power output options (for off-grid applications)	• 480 & 600 VAC / 3-phase / 60Hz • 380 VAC / 3-phase / 50 Hz • Regulated DC
Life Cycle	10 to 15 years before a major refit

Source: Magenn via Rakesh Chaudhari, IJCSN (2015)

In 2008, Magenn planned to install and operate MARS units at Sandbanks Provincial Park, about 2.5 hours east of Toronto along Lake Ontario. CNN Money reported, “The company's 10- to 25-kilowatt airship debuts there in 2009, and a more powerful 100-kilowatt system should take flight in 2010.” While the provincial Ministry of Natural Resources supported the project, concerns were raised during a public environmental assessment, focusing on the risk that the tether or the buoyant rotor itself might fall to the ground and injure someone. Plans for an operational MARS unit at Sandbanks Provincial Park were cancelled.

The Ministry of Natural Resources proposed an alternate site at an isolated fish hatchery that required electricity and was dependent on diesel generators. The revised plan called for Magenn to install and demonstrate a 200 kW MARS unit at a fish hatchery in North Bay with funding from the province’s Innovation Demonstration Fund. However, this funding was not forthcoming and the project was cancelled.

6. Planned commercial MARS product line

Magenn Power's planned product line changed dramatically over a period of about five years. In late 2005, it included a range of smaller industrial units (10 kW, 25 kW) and larger industrial units (100 kW, 800 kW and 1.6 MW). In addition, 1 kW and 4 kW consumer-oriented MARS units were planned for early introduction in the 2006 – 2007 time frame. After signing up a U.S. distributor for the 4 kW unit in 2006, Magen Power later cancelled development plans for the consumer models.

By 2008, the firm expected that its first commercial MARS product would be in the 10 to 25 kW range and be available in 2009, with a larger 100 kW MARS product following in 2010.

On its archived website, Magenn Power reported its last product lineup: "Magenn Power will not be shipping product until the 2010/11 time frame. Test partners will start in late 2009. Our first product will be a MARS 100 kW sized unit. Please Note: the 4 kW, 10 kW and 25 kW sized MARS generators are not in our current plans."

This section provides summary information on the 1 kW and 4 kW consumer units and the 10 kW and large MARS commercial units.

Aviation-related requirements

Like other airborne wind turbines operating at over 45.7 m (150 feet), MARS units will need a permit from the FAA or Transport Canada to be installed in North America and will be subject to the following siting and design requirements:

- Units may not operate in controlled airspace or within five miles of the boundary of any airport.
- Units that are deployed on a permanent basis will require a Notice to Airmen (NOTAM) to inform pilots of new or changed hazards.
- Units must have lighting every 15 m (50 feet), and the lights must flash once per second.

- Buoyant units must have a Rapid Deflation Device installed that will automatically and rapidly deflate the balloon if it escapes from its moorings.
- The gas envelope must be equipped with a radar reflective material that will present an echo to surface radar operating in the 200 MHz to 2,700 MHz frequency range.

10 kW MARS commercial units

The early configuration of the 10 kW MARS commercial product was similar to the Alpha prototype, with a single wind vane stabilizer.

Early concept drawing of a 10 kW MARS unit (circa 2006).
Source: Chris Radisch via Magenn Power

The 10 kW MARS was primarily intended for use in off-grid applications in remote locations that may have harsh climates.

The 10 kW MARS also could be used in disaster relief to provide quick-response, temporary electric power for an isolated micro-grid (i.e., for first responders and disaster response managers). In this role, it could be used in combination with an emergency diesel generator.

On its archived website, Magenn Power provides the following details on their planned commercial MARS 10 kW unit.

General design characteristics of the Magenn 10 kW MARS

Parameter	**Magenn 10 kW MARS**
Rated power	10 kW
Aerostat dimensions	Diameter = 9.1 m (30 ft), Length = 18.3 m (60 ft)
Envelope volume	906 m^3 (32,000 ft^3) (approx.)
Ballonet volume	Not specified
Shipping weight	Under 1,361 kg (3,000 lbs), depending on tether length
Tether length	• 122 m (400 ft) standard • Up to 305 m (1,000 ft) optional tether length
Start-up wind speed	2.0 m/sec (4.5 mph)
Cut-in wind speed	3.0 m/sec (6.7 mph)
Rated wind speed	12.0 m/sec (26.8 mph)
Cut-out wind speed	24.0 m/sec (53.7 mph)
Maximum wind speed	28.0 m/sec (62.6 mph)
Temperature Range	-40°C /-40°F to +45°C/+113°F
Generators	2 x 5 kW
Electric power output options (for off-grid applications)	• 120 VAC / single phase / 60Hz • 240 VAC / single phase / 50 Hz • Regulated DC 12 to 600V
Life Cycle	10 to 15 years before a major refit

Source: Magenn Power

Magenn Power had not established a firm price for its 10 kW MARS, but planned to price their MARS units between USD $3 - $5 per watt. That would put the price of a 10 kW MARS between USD $30,000 and $50,000. For that base price, the MARS 10 kW units included:

- The gas envelope with a safety helium venting mechanisms to deflate the aerostat in case it detaches from the tether (required to meet FAA & Transport Canada regulations)
- Two x 5 kW generators, gear systems, etc.
- Tether system, 122 m (400 feet) included, [optional tether lengths will be available up to 305 m (1,000 feet) at an additional charge] with lighting required by the FAA & Transport Canada
- Onboard electronics
- 5 year warranty on parts and labor, not including helium

Not included with the base price of the MARS 10kW unit:

- Electric winch (Available from Magenn)
- Helium (Magenn planned to negotiate a world price)
- Necessary permits (Specific permits will vary from location to location. A Certified Dealers / Distributors will be responsible for obtaining permits for most customers)
- Electrical connectivity to deliver power to an isolated micro-grid or to the main distribution grid.
    - Electrical cable from MARS unit to power grid or battery system
    - Electronics to connect to power grid
    - Inverter, if required
    - Batteries, if required
- Installation and setup of the MARS unit (Available from Certified Dealers / Distributors)
- Yearly maintenance (Available from Certified Dealers / Distributors for a fixed fee per year (7 to 15%, Magenn Power will supply the parts, Certified Dealers will supply the labor)

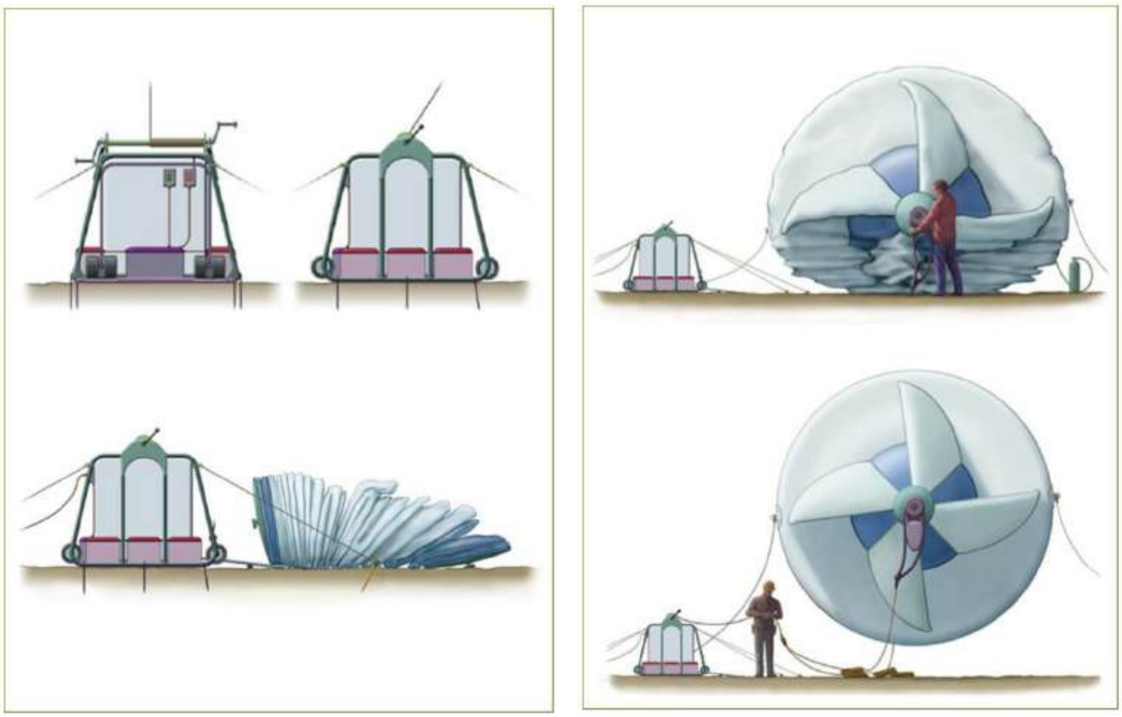
No 10 kW commercial MARS units were built.

Small consumer-oriented MARS commercial products

In 2005, Magenn Power planned to develop two small MARS units and start selling them in the Fall 2006 – 2007 time frame:

- **A home-sized 4 kW MARS unit**: Magenn Power reported the company "will start manufacturing its Air Rotors in Fall of 2006 and will start taking product orders in April of 2006 for ... 4.0 kW MARS units." These "cottage or home-sized" units were 11.9 m (39 feet) long and 4.3 m (14 feet) in diameter, were designed to operate at a height of 45.7 to 122 m (150 to 400 feet). Magenn Power planned to sell this unit for a price of around USD $10,000.
- **A camping / boating-sized 1 kW MARS unit**: This unit was 2.0 m (6.5 ft) in diameter, 5.9 m (19.5 ft) long and operate at a height of 15.2 to 45.7 m (50 to 150 feet). Magenn Power planned to sell this unit for a price of around USD $2,000 beginning in 2007.

In January 2006, Magenn and U.S. firm Krystal Planet announced a distributorship agreement under which Krystal Power would play a major role in the deployment of the first 200 4 kW MARS units. No MARS units were ever delivered under this agreement.



Deploying a small MARS unit (smaller than a 10 kW MARS).
Source: Chris Radisch via Magenn Power

Fred Ferguson also identified the potential for a portable, backpack-sized version of MARS that would be suitable for camping and emergency situations and wouldn't require helium lifting gas. Instead, the small airborne rotor would be inflated with air and deployed in the wind like a spinning kite, with rotation generating enough aerodynamic lift from the Magnus Effect to keep the unit airborne and generating electric power. The ability of a MARS unit to operate without lifting gas is noted in Magenn patent US8148838B2.

These small MARS units would not be core business for Magenn. The firm noted in 2008, "Backpack size or small units may be available in five to ten years. Magenn Power is looking to license this technology and may not manufacture it ourselves."

No small, consumer-oriented MARS products were developed.

Large MARS commercial units

In 2005, Magenn Power announced that its largest planned turbines for commercial power applications would be released in 2009, including two units rated at 800 kW and 1.6 MW. Both units supposedly would have had a diameter of 20.4 m (67 ft), a length of 61 m (200 ft), and operate at heights of 122 to 282 m (400 to 925 feet).

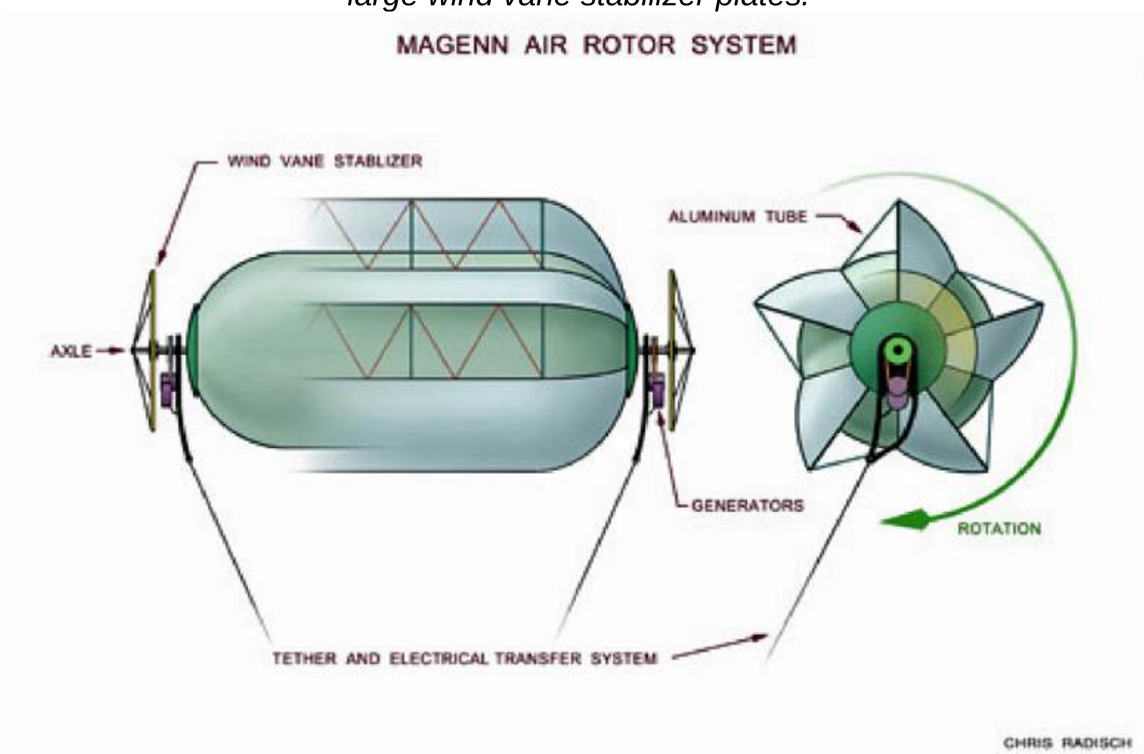
Design Engineering reported on a 2009 interview with Fred Ferguson, who offered the following observations:

> "With airships, bigger is always better from both an efficiency and economics point of view," …… "Every time you add a few percentages to the overall size, the lifting factor goes up cubically. If a MARS unit is too small, you need more buoyancy and you have a lot less flexibility with weight. In larger units, you can use cheaper, lighter materials."….."Also, because it's a three-dimensional structure, you can build a much bigger structure than you can with a 2-D wind turbine, and still achieve good structural integrity."

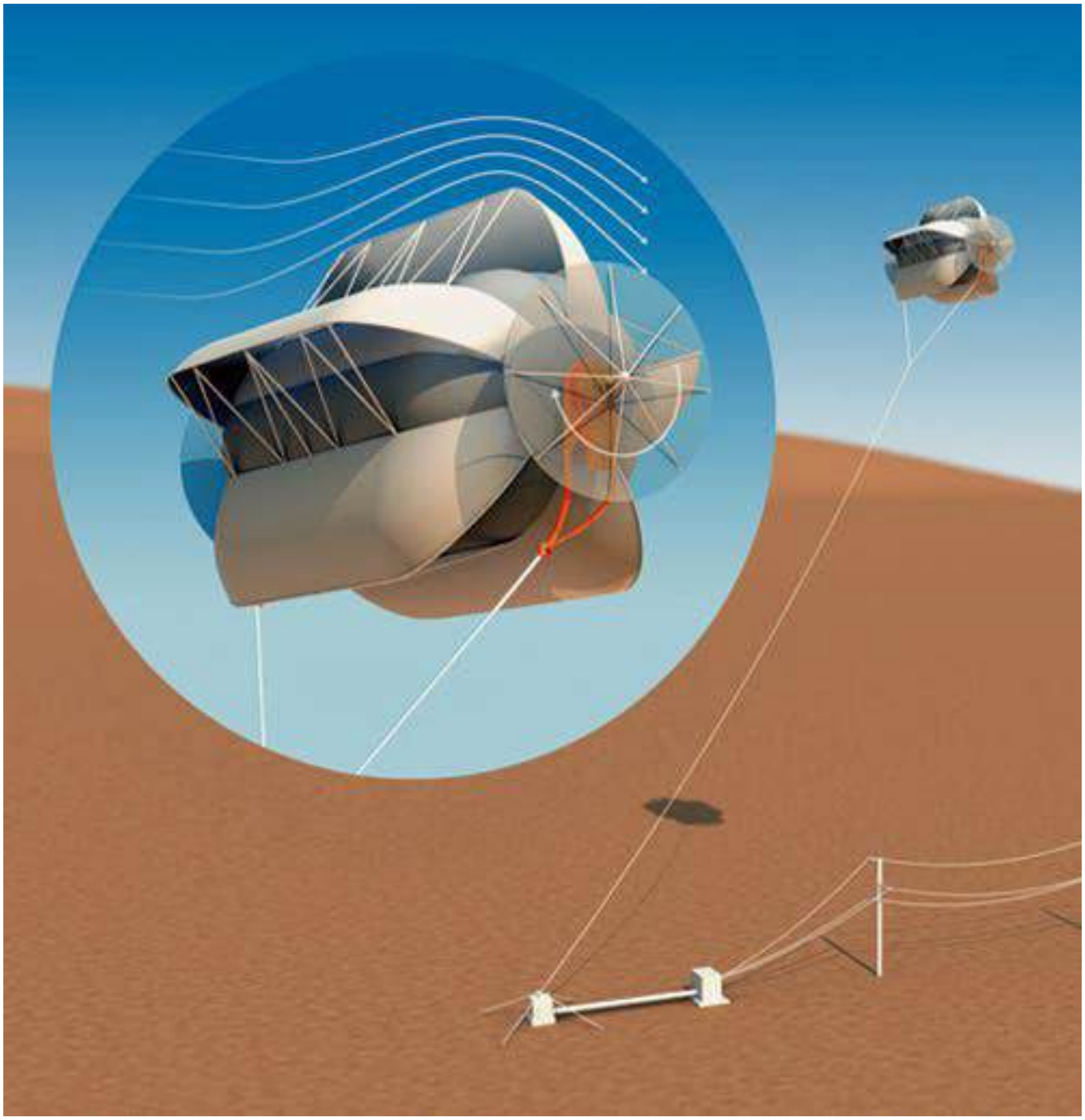
Large on-grid MARS units used for commercial power generation would need to be configured differently than the units used in off-grid applications. Magenn's plan for grid-connected MARS units was to use variable-frequency (doubly fed) AC generators, so that the generator can remain synchronous with the grid and get the most out of the energy in the wind without motoring off the grid or causing excess reactive loading. The generator controller, protection and grid interconnect equipment (including voltage-matching transformer), and a winch to regulate the elevation of the MARS above the terrain all reside on the ground.

No large commercial MARS units were ever built.

Design concept for a large (800 kW) Magenn air rotor with large wind vane stabilizer plates.



Details of a large Magenn Air Rotor with large wind vane stabilizer plates.
Source, both graphics: Chris Radisch via Magenn Power (circa 2006)



A large MARS unit connected to a local power grid.
Source: The New York Times, illustration by Bryan Christie Design (9 Dec 2007)

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