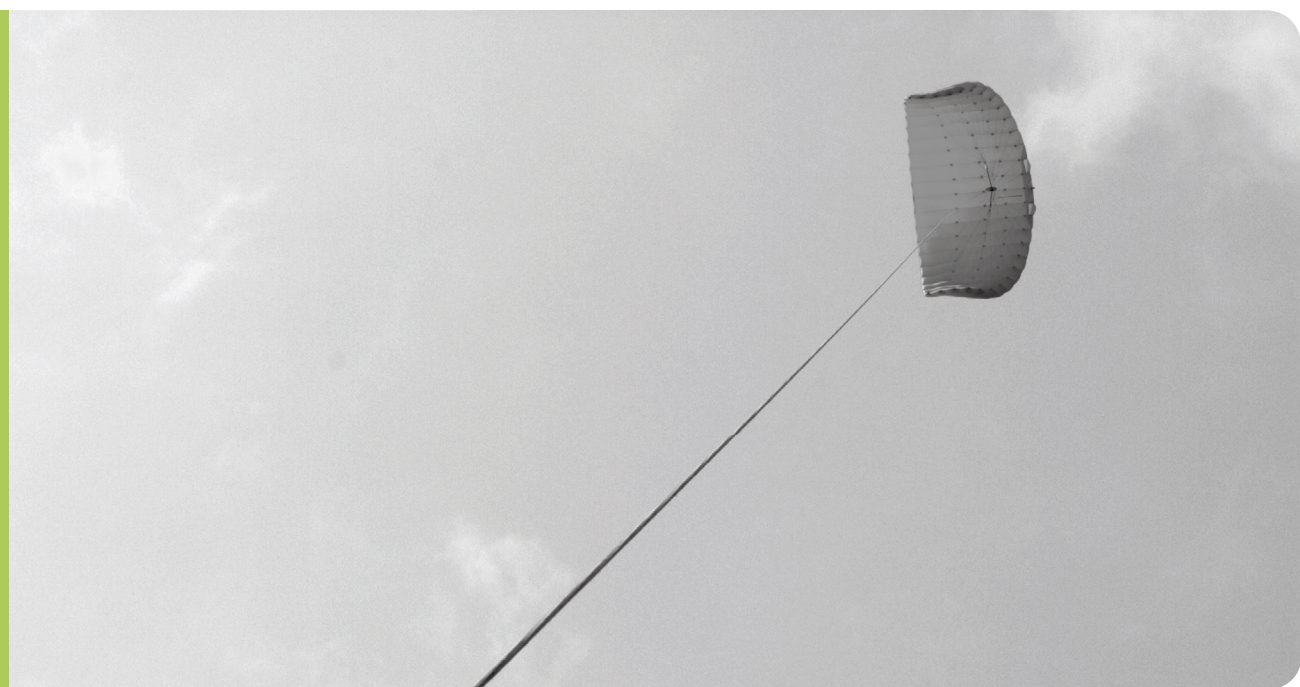


Renewable energy consultants

**GL** Garrad Hassan



## MARKET STATUS REPORT HIGH ALTITUDE WIND ENERGY

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## MARKET STATUS OF HIGH ALTITUDE WIND ENERGY

*This copy of the High Altitude Market Status Report,  
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## 1 EXECUTIVE SUMMARY

### ***BASICS - WHAT IS HIGH ALTITUDE WIND ENERGY?***

This GL Garrad Hassan (GLGH) Market Status Report reviews and discusses the emerging Airborne Wind Energy (or “High Altitude Wind Energy”) industry and market. High Altitude Wind Energy systems are electro-mechanical systems that extract power from the kinetic energy of the winds high in the sky. At altitudes above 200 m the wind speeds are higher and more consistent than below in the near surface layers. Thus the higher altitudes will provide new opportunities for wind energy projects with increased power density and wind consistency.

### ***BACKGROUND – THE (RENEWABLE) ENERGY MARKET AND TRENDS***

Based on various different sources, this report highlights the increasing energy demand worldwide and the benefits of renewable energy as a future energy source in various regions of the world. Furthermore, wind energy status, as the most mature of the current renewable energy technology, is discussed in more detail. As an interim conclusion, it can be seen that onshore wind energy is now a mature and feasible technology, indeed becoming “mainstream” in many markets. Also it is clear that onshore wind energy needs space on land preferably close to the energy consumption areas. This space is one of the limiting factors for onshore wind and one of the answers to this challenge found today is to look into the new offshore wind technologies.

Offshore wind energy offers greater energy potential as wind speeds are higher as well as new areas for wind energy development. On the other hand, offshore wind energy is more complex in terms of the technology and this leads to higher cost of energy (compared to both conventional and onshore wind energy). Thus new technological developments and higher wind potential would help to overcome this hurdle. This is the reason why this study investigates the new technologies of High Altitude Wind Energy and also looks into the question of future offshore potential for these new systems.

### ***METEOROLOGY - WIND ENERGY AT HIGH ALTITUDES***

Based on public available research publication and on our own assessment, GLGH discusses the wind potential behaviour in high altitudes. Regarding the term “high altitude wind energy”, this generally refers to heights of 200m to 20km, with the main focus being altitudes significantly above 2km. With respect to the wind resources, this clearly is beyond the focus of “conventional wind energy” research efforts. Thus, data sources and relevant references are very limited. Hence, when examining the wind resource, the extent of the applicability of known conditions (e.g. wind profiles) as well as the judgement regarding the relevance of known functions (such as for the extrapolation of wind profiles) needs to be explored with great care. Thus, within this report an approach of using available measurement data wherever possible is followed, when discussing the high altitude wind energy potential and the estimation of higher wind resources.

This analysis reveals that currently the research in this area is increasing also due to the new High Altitude Wind Energy market to further clarify the “basis” for this young technology. Further the data available is limited with respect to wind potential above 300m, but also the data and projections for the wind potential in heights above 300m are very promising, and even more promising is the potential of the associated energy figures.

### ***TECHNOLOGY – SYSTEMS AND COMPANIES ACTIVE IN THIS INDUSTRY***

The analysis of the supply side for currently active High Altitude Wind Energy systems being developed reveals that there is already a very active industry with the first small scale prototypes and further real scale prototypes announced for the future. A total of 22 active companies have been found and the systems are looked at in detail to discuss advantages and disadvantages of the technology as well as the current status of the companies.

For capturing the power within such high altitude winds, various different mechanisms have been developed and these are discussed. These include but are not limited to: kites, kytoons, aerostats, gliders (also with turbines attached) and sailplanes (also with turbines or airfoils attached). A detailed assessment of the current issues to overcome and the possibility of this to happen is highlighted and discussed.

Whether a final cost of energy needs to be lower than for conventional wind turbines or solar energy systems is unclear. The airborne systems in floating offshore deployment would access resource areas unavailable to all except floating wind turbine systems which similarly are currently present only at the prototype stage.

Current systems and the status of the regulative boundary conditions lead to the conclusion that the offshore application might be a good way of solving some of the issues and having a superior application of the concept compared with onshore.

### ***MARKET – MARKET POTENTIAL AND BOUNDARY CONDITIONS***

A market potential of the new technology is given, focusing on the offshore application of this new technology; this is because the previous findings lead to the conclusion that onshore application might be difficult with respect to regulation and acceptance. The energy potential clearly shows the areas where this new technology could be applied. Further regarding the different markets, the advantages and disadvantages of the individual markets and regions are discussed and compared. With regard to individual markets, these are summarised with respect to attractiveness.

There is significant development expected over the next years both within Europe and globally. Regarding currently identified projects, the UK looks set to dominate the European market, while China is expected to take the global number one spot.

Looking beyond identified project sites, it is clear that significant high altitude wind resource exists. Some promising regions include east of Japan, the Pacific west of Oregon and British Columbia, the Atlantic east of North America and west of the UK and Ireland. Most of these areas have deep waters, much greater than that capable of being developed using fixed offshore foundations, and so might present suitable regions for economical floating solutions.

## 2 INTRODUCTION

### 2.1 Motivation and Background

This report reviews and discusses the young *Airborne Wind Energy* industry and market. Airborne Wind Energy is also referred to as *High Altitude Wind Energy*. This new industry focuses on a technology that proposes some new concepts that aim to use high winds as an energy source and to generate power using it. This idea could enlarge power generation from wind into a new dimension in terms of contribution to the energy market.

Experts from GL Garrad Hassan have combined their know-how and skills to assess the current technologies found, the energy potential, the local market chances and regulative frameworks. The findings should serve to be a good start for developers and investors to get some orientation in the new market segment of high altitude wind energy. Due to the nature of the technological systems the report will focus on the offshore application of the different systems.

This study was undertaken to provide an overview on the currently rising young industry of high altitude wind energy (also referred to as “airborne wind energy”). There are various reasons for our motivation to look into the high altitude wind energy market at this point in time. The main reasons and questions for us have been:

- Is there a potential with respect to the energy source (high winds) and where can it be found?
- Is there a potential from the energy demand side for this new industry to become mature and really contribute to the energy market?
- What are the main technologies within this new sector?
- Which systems are currently developed and what are the companies behind it?
- Is there a potential from a technological point of view? Are the proposed systems feasible and will they have the chance to become a mature industry?
- What are the legal and regulative boundary conditions for these systems?
- Finally what are the main challenges of the new industry as a whole?

Thus this market status report provides an overview on the young industry and gives the current status of it. At this point in time the detailed market analysis of different systems is not possible and also the differentiated discussion and weighting of the available concepts against each other is only possible on a high level, because currently the market is very young and most of the systems are not available in a very advanced development stage.

The key deliverables of this report are:

- Summary on Energy Demand in general
- Summary on the energy potential and location
- Overview on the market of the systems
- Overview on the technological development
- The main technological challenges
- Outlook on the regulative and legal environment

GL Garrad Hassan has completed policy and market reviews for many clients, from technology start-ups and site developers to government agencies, in all of the key wind energy markets. The particular strength of this report is that markets can be compared, based on GLGH’s activity in all of them, using first hand information.

## 2.2 What is high altitude wind energy?

High Altitude wind energy systems are electro-mechanical systems that extract power from the kinetic energy of the winds high in the sky. At altitudes above 200m, the wind speeds are higher and more consistent than below in the surface layers. Thus the higher altitudes will provide even more chances for increased power density and wind consistency.

Due to the high altitudes no conventional towers are used for the high altitude wind power systems. The airborne flight systems are tethered to the ground and here also various different systems are suggested in the industry to bring power as well as the forces down to the earth.

For capturing the power out of the high altitude winds different mechanisms are developed and discussed. They include but are not limited to: kites, kytoons, aerostats, gliders (also with turbines attached) and sailplanes (also with turbines or airfoils attached).

Many different companies are currently starting to develop and engineer advanced concepts to take advantage of this high wind energy potential. Nevertheless several significant technical, regulatory, and perception barriers are still outstanding to slow down their progress.

## 7 CONCLUSION AND OUTLOOK

When looking at the demand side this study revealed that there will be a rising energy demand worldwide. The main areas of this energy demand will be in Europe and America (as the current areas) but strongly growing also in Asia and Africa. This energy will need additional power production capacity and these capacities will need to be more and more environmental friendly, thus CO<sub>2</sub> neutral. Wind energy (onshore) is one of the most advanced technologies nowadays for renewable energy sources.

In the areas where energy production capacity is needed the onshore wind energy spaces are limited. This already leads to a strong focus on offshore technology for the future investments. Offshore wind energy technology still needs to overcome various technological barriers and also significant cost savings need to be achieved in order to be competitive with conventional power production as well as wind onshore in the present market conditions. Thus the offshore wind energy market offers opportunities for new market players that can offer good (reliable and cheap) technologies to the market.

High altitude wind energy is one of the options that could be used especially in offshore wind market when the technology becomes more mature and viable for the commercial application. One of the objectives of this Market Status Report is to further create a more detailed picture of the technological systems as well as the different technological concepts underlying to help establish a foundation for this new industry.

Our investigation revealed that:

- The wind resource in high altitudes is very promising when compared to the conventional wind energy height and wind speed, as in high altitudes there is significantly higher wind speeds and more consistent wind resources;
- The currently predicted costs of energy estimates raise some attention when compared to the cost of energy for other renewable energy sources as well as offshore wind in particular;
- The detailed principles of the technology are currently proven in first scaled prototypes and further full scale prototypes are announced already;
- The solutions for the technological subjects are currently followed by the different companies as well as research organisations supported by strong industry organisations. Thus first results and solutions on urgent questions can be expected in the future;
- The regulative situation for this new technology needs to be clarified, but governments of the involved countries are committed to renewable energy targets and thus have a strong interest to help this new technology on its way;

With respect to the current status of this young industry the main areas for further research and development as well as regulation improvement can be pointed out as follows:

- Environmental Conditions: Thunder and lightning pose very serious risk of system destruction with the most realistic defence strategy being avoidance retracting the systems in threatening weather conditions.
- Feasibility of tether cable power transmission regarding cable weight and drag down forces;
- Control, although certainly for kites there is now much experience with systems such as SkySails have developed;
- Energy losses in the conducting cable from an airborne generating system as there is always a design demand to minimise the size of the cable;
- Challenges in realising automated systems for deployment and recovery;

- Regulatory Issues: Permissions from air traffic authorities. Considering the experience of commercial wind developments in respect of flight path issues and radar interference, the authorities are likely to be very conservative and restrictive in their responses to flight path issues;
- Safety. Kites, airborne systems and power cables becoming detached or damaged in storm conditions or through unexpected faults and falling may present a hazard;
- Public acceptance. This will largely be an issue only if there is deployment over land in which case safety for falling hardware and electrical safety of suspended power cables may be of significant concern.
- Design standards and a certification scheme are needed for large scale commercialisation. Investors and insurance companies will require this to be in place.

On the market side the findings can be summarised to the currently obvious barriers for the technology to be deployed:

- airspace access,
- operational safety,
- environmental impact,
- concept of operation viability,
- economic viability, and
- energy production scaling potential.

Also there are advantages in some of the high altitude wind technology concepts that could help to overcome some of the main technology issues in conventional offshore wind energy technology. Most high altitude wind energy technologies have lower structural forces (e.g. tower bottom bending moments) when compared to conventional wind turbines, leading to lower material expenses for the systems. Also the applicability on floating structures will be easier from a structural point as moment resistance required by a floating platform for an airborne system. This advantage would help for market regions where the site conditions (dominantly water depth) are too difficult or expensive for normal fixed structure systems.

Looking into the market side the high altitude wind energy systems could participate in the boosting offshore wind energy industry and market in which several of the challenges and barriers - especially regulatory, safety and acceptance issues - are much easier to solve. Looking beyond identified project sites, it is clear that significant high altitude wind resource exists. Most of these areas have deep waters, much greater than that capable of being developed using fixed offshore foundations and so might present suitable regions for economical floating solutions. This benefit could at the near future be realised in parts of the market where the normal fixed structure systems are not applicable. Some of the prospect regions include:

- North America especially the Pacific West of Oregon and British Columbia and the Atlantic east;
- Northern Europe especially west of the UK and Ireland and the deep water areas of the German Coast;
- east of Japan coastal areas.

Currently the first research projects appear on the horizon and also the airborne industry as a whole becomes more visible in the policy and industry public. Thus maybe in the near future more government research investment as well as commercial research and development investment will be made into this emerging technology.

The development and success of the renewable energy industry including wind energy will benefit from new technologies being introduced and getting more mature. From what is visible now of the young airborne technology and industry the concepts seem to have a promising potential to play a vital role in the renewable energy sector and should be seen as one of the available technical solutions.

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