High altitude wind power
Rotokite project

High altitude wind power : many groups with many different concepts

From Moritz Diehl, “Wind Power Generation via Fast Flying Kites” - January 20, 2010

Approach with kites

the Skysails project , for further information visit www.skysails.com

Approach with rigid profiles

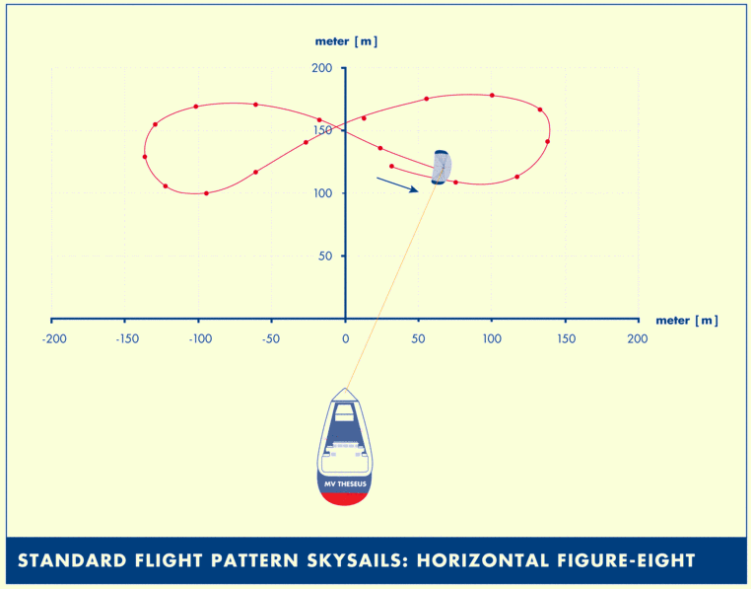
For further information visit www.skywindpower.com[ii]

Single kite parameters (for 5MW mean power production)

From Moritz Diehl, "Wind Power Generation via Fast Flying Kites" - January 20, 2010

Name	Symbol	Value
mass of the kite	m_{k}	$850\,\mathrm{kg}$
area	A	$500\,\mathrm{m}^2$
volume	V	$720\,\mathrm{m}^3$
pure drag	$c_{\mathrm{D,o}}$	0.04
induced drag	ϵ	0.04
gravit. const.	g	$9.81\,\frac{\mathrm{m}}{\mathrm{s}^2}$
air density	ρ	$1.23\,\frac{\mathrm{kg}}{\mathrm{m}^3}$
cable density	ρ_{c}	$1450\,\frac{\mathrm{kg}}{\mathrm{m}^3}$
cable friction	$c_{\mathrm{D,C}}$	1.0
internal friction	b_0	$10^5\,\frac{\mathrm{kg}}{\mathrm{sm}^2}$
elastic modulus	E	$1.5 * 10^{11}\,\mathrm{Pa}$

Some problems with a single kite



STANDARD FLIGHT PATTERN SKYSAILS: HORIZONTAL FIGURE-EIGHT

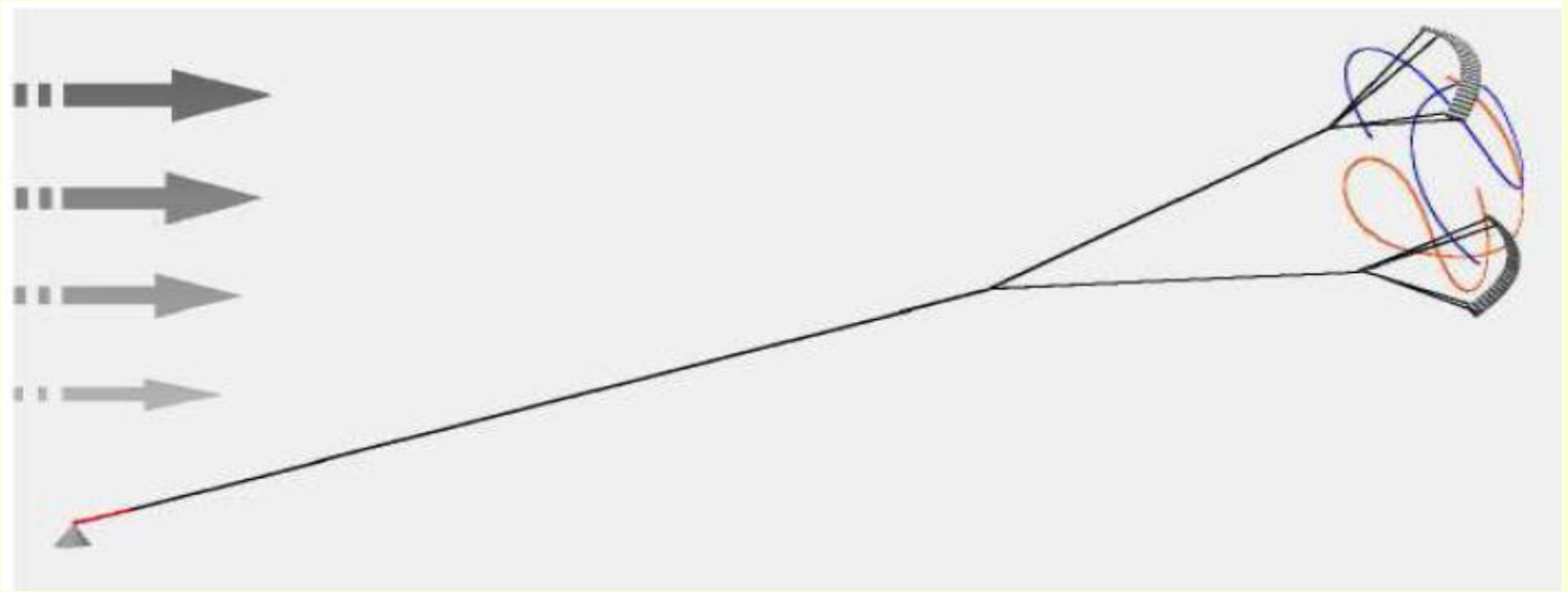
The picture to the side shows the flight cycle. This needs a complex structure for the flight control and finds a limit in the aerodynamic resistance of bonding cable subject to a relevant translation speed.

The aerodynamic resistance of the cable to translation, apart from reducing the speed of the kite, influences negatively the necessary traction power and the possibility of working at higher altitudes

Two possible solutions:

1)Two dancing kites, proposed from prof Moritz Diehl

"Wind Power Generation via Fast Flying Kites" - January 20, 2010



Why are dancing kites more efficient than a single one?

From Moritz Diehl, “Wind Power Generation via Fast Flying Kites” - January 20, 2010

Three reasons:

- absolute line drag is reduced, as only short lines move fast in cross wind direction
- centrifugal forces "become our friends", curve flying does not generate losses anymore. Kite masses can be higher.
- kites can compensate each other during retraction, without lift control

→ get 14 kW per square meter wing, 40 % better than single kites!

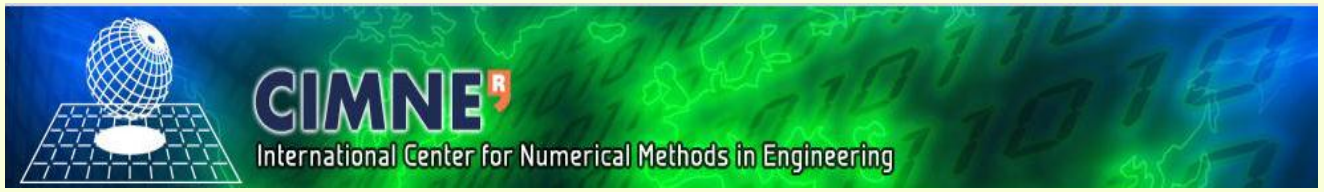
2) Our solution: Rotokite project

The Rotokite, even if based, as other projects, on the use of wing profiles similar to the kites, is greatly innovative as it uses a new form of aerodynamic profile rotating around its own axis, allowing a radical simplification of the flight control and an improvement of the performances.

The Rotokite & the partners in the European project

SEQUOIA

Expert vibration monitoring solutions



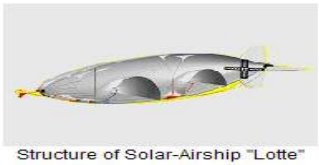
TAO-Group


TAO - High Altitude Platform

TAO Trans Atmospheric Operations GmbH
Pre-Development, Prototypes, Flight Tests
University Relation

TAO Technologies GmbH
Financing, Marketing

TAO Technologies Stuttgart
Control, Simulation, Design


Structure of Solar-Airship "Lotte"

The Rotokite & the partners in the European project

The project was submitted to the European commission, and the technical judgement we received is:

"The impact of such high altitude harvesting design is potentially high. It has the potential for opening a new path for energy conversion and could contribute to novel technological development at European level."

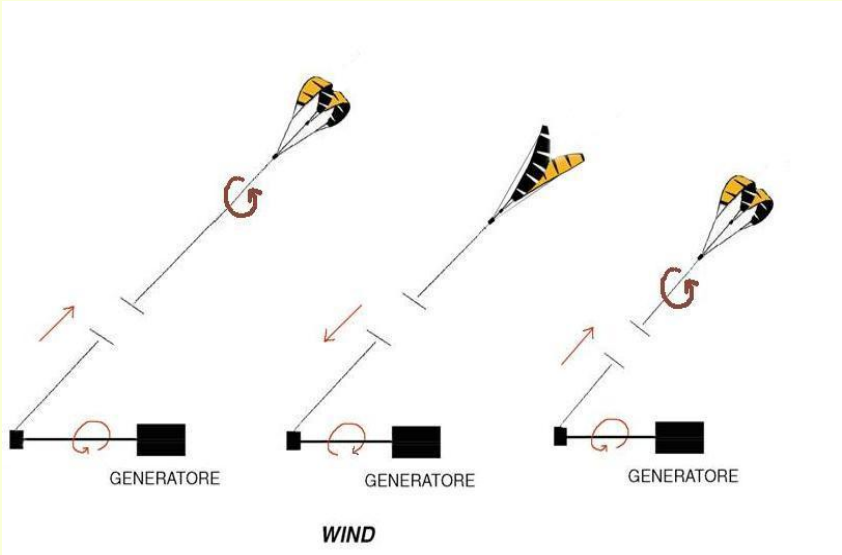
but it was not enough and the project was rejected was for bureaucratic reasons. in sp

Some information about Rotokite

From an aerodynamic point of view, the Rotokite is a stable system and does not need any automatism for the flight control.

Once reached the planned altitude, the traction phases shown in the first and third images are alternated with a quick recovery phase at the initial altitude, with warped wing profiles to offer the minimum resistance.

The pulley bonding cables are wrapped on, by rotating, transforms the rectilinear motion caused from the traction into rotating motion able to start an electric generator.



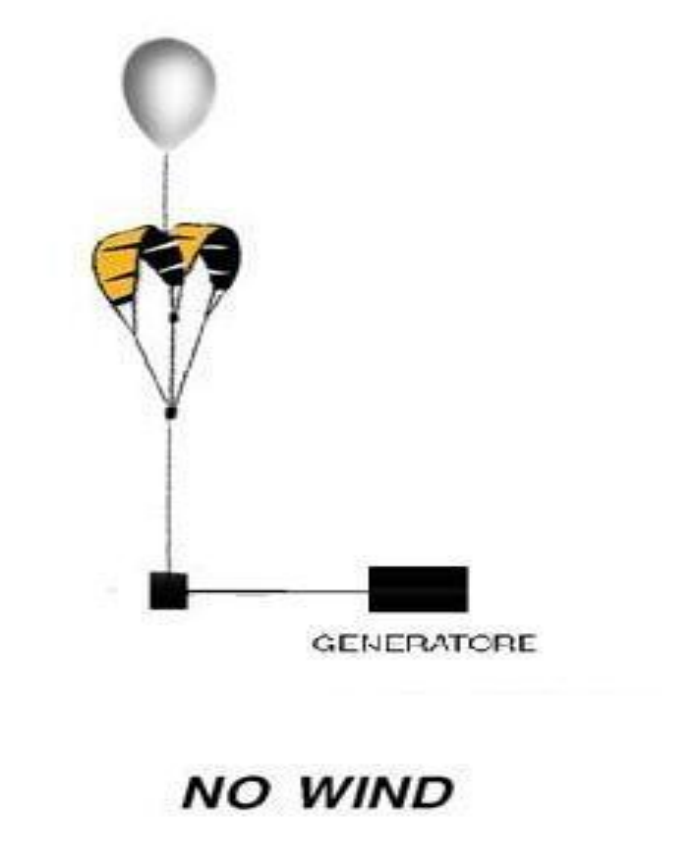
Why Rotokite is better than kiting dance

- Rotokite has the same performances of dancing kites, but it is a simpler system because it doesn’t need a complicated flight control and it is an aerodynamic stable structure.
- Since kites speed isn’t higher than 35m/s, there’s no need to increase the captation area more than that obtained by rotation itself.
- The system turns out to be lighter and more efficient, in particular for limited dimensions models.

Further information about Rotokite

For optimising the functioning of the system, there are many integrations that can be done. For example, a small aerostat that allows to bring the Rotokite at altitude and to maintain in position in case of insufficient wind.

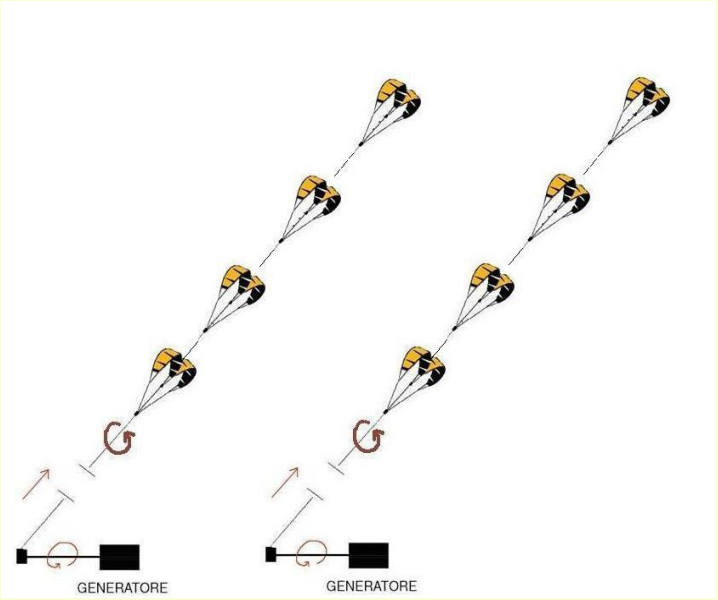
This method reduces the occupation of the ground and makes it possible to position the system even in the sea, in deep waters, where it is very difficult to install traditional wind generators.



Further information about Rotokite

Two kites with 10 m span, like those used in sporting practice, placed in rotation on their own axis, intercept a wind area of 314 m², producing from 2 to 30 Kwh depending on the speed of the wind.

Power rising can be obtained thanks to bigger dimensions but also removing the kites from their rotation centre with a consequent increase of the catching area or using different configurations as the ones shown in the picture to the side.



Main differences between Rotokite and traditional wind generator

The traditional wind generator is a sophisticated and expensive product of very high technology.

The complexity of this structure is linked to the need of positioning an electric generator that, depending on the wind direction, points to a tower that today can reach 100 meters in height.

The pressures on the structure are very strong and, for winds exceeding 20 m/s, it is necessary to stop its functioning changing the wind impact angle of the blades.

Main differences between Rotokite and traditional wind generator

A megawatt wind generator, costing 1 million Euro, is considered well positioned when, on the average, it operates six hours a day and produces two million kWh in one year. The cost of the produced energy is estimated at 0.06 Euro per kWh.

The Rotokite canvas structure, the positioning of the generator on the ground and the extreme simplicity of the control mechanisms lead to an estimate of the energy production costs that is equal to or less than 0.01 Euro per kWh.

Advantages and problems

Advantages

- ✓ Production of renewable energy without CO2 emission
- ✓ Use of simple and already known technology
- ✓ Low costs of the system and produced energy
- ✓ Exploitation of winds at high altitude, where they are more constant and stronger
- ✓ Potential positioning in the sea, even in deep waters

Problems

- ✓ Need to build wind farms on GPS maps, any aircraft is equipped with
- ✓ A single system has a discontinuous energy production

What can we do together?

We think that, to rapidly develop an innovative system for upper wind exploitation, as proposed with Rotokite, it is very important to turn to more than one research group, because the suggested solutions are very different depending on the technology used and the size of the system (for low, medium or high power).

Financing times and methods from European Community doesn't seem to fit the urgency to develop the above mentioned technology.

We are absolutely certain that the difference between current wind energy costs and what proposed will justify efforts and money put in this project.

Further information

Wikipidia: high altitude wind generator

Youtube: rotokite wind turbine

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