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  - Une clé USB bénéficiant d'un dépôt légal avec numéro ISBN spécifique sera distribuée dans plusieurs bibliothèques spécialisées. Cette clé USB est offerte à tous les délégués du Congrès.
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Technical papers accepted for the WEC Montréal 2010 will be made available through a large number of research institutes, libraries and bookstores.

- ***Electronic media***
  - *A USB key with a legal deposit and unique ISBN number will be distributed to several specialized libraries. This USB key will be provided to all Congress delegates.*
  - *The technical papers will also be published by the International Energy Technology Data Exchange (www.etde.org), the web search portal of the US Department of Energy Office of Scientific and Technical Information (OSTI).*
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  - *Technical papers will be published with a unique ISBN number by Curran Associates, which specializes in the publication of conference proceedings. The publications will be available via the website* ***www.proceedings.com****.*

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	Le droit à l'énergie est une urgence sociale, économique et environnementale	**Pierre-Jean Coulon**	France
	A race for power – Challenges of meeting the surge in power demand of the BRIC countries	**Peter Kiss**	Hongrie / *Hungary*
	New energy efficiency technologies associated with increased natural gas demand in delivery and consumption sectors of Iran	**Saeid Mansouri Alghalandis**	République islamique d'Iran / *Islamic Republic of Iran*

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	Les déterminants de la pauvreté énergétique en milieu rural au Cameroun	**Maxime Kamdem Kamdem**	Cameroun / *Cameroon*
	Understanding energy poverty – Case study: Tajikistan	**Slavica Robic**	Croatie / *Croatia*
	A new systems paradigm for the rural electrification programme, Philippines	**Fernando Roxas**	Philippines
	Renewable energy resources for distributed generation systems in South Africa	**Stefan Szewczuk**	Afrique du Sud / *South Africa*
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	Price freezes, durables and residential electricity demand – Evidence from the Greater Buenos Aires	**Ariel Casarin**	Argentine / *Argentina*
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	Vers la réalisation d'un marché régional de l'électricité en Afrique Centrale : Enjeux et défis	**Rhéaume Veilleux**	Canada

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	Energy mix in Central European countries of the V4 group: The quest for stability	**Frantisek Janicek**	Slovaquie / *Slovakia*
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	Highly efficient solutions for smart and bulk power transmission of "green energy"	**Dietmar Retzmann**	Allemagne / *Germany*
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	Use of FACTS for enhanced flexibility and efficiency in power transmission and distribution grids	**Rolf Grünbaum**	Suède / *Sweden*
	Faire de l'électricité un vecteur complet et efficace pour l'accessibilité de l'énergie – La R&D stratégique à Hydro-Québec	**Raouf Naggar**	Canada
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	The intelligent energy system for tomorrow	**Hans Hvidtfeldt Larsen**	Danemark / *Denmark*
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	Frozen heat: Global outlook on methane gas hydrates	**Anne Solgaard**	Norvège / *Norway*
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	Advanced technology development reducing CO_2 emissions	**Dongsup Kim**	République de Corée / *Republic of Korea*
	Post-Kyoto policy implications on the energy system: A TIAM-FR long-term planning exercice	**Nadia Maïzi**	France
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	Scenarios for the development of the electricity economy in Continental Europe	**Christoph Gutschi**	Autriche / *Austria*
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	Analysis of the impact of including tariff revision procedures in transmission concessions contracts	**Goret Paulo**	Brésil / *Brazil*
	An evolutionary triple helix to strengthen energy regulation: Implications for management	**Francesco Rizzi**	Italie / *Italy*
	Estimating the contribution of the private power plant on electricity market in Korea	**Yang-Hoon Sonn**	République de Corée / *Republic of Korea*

PROJET EOLICARE
EOLIENNE AEROPORTEE

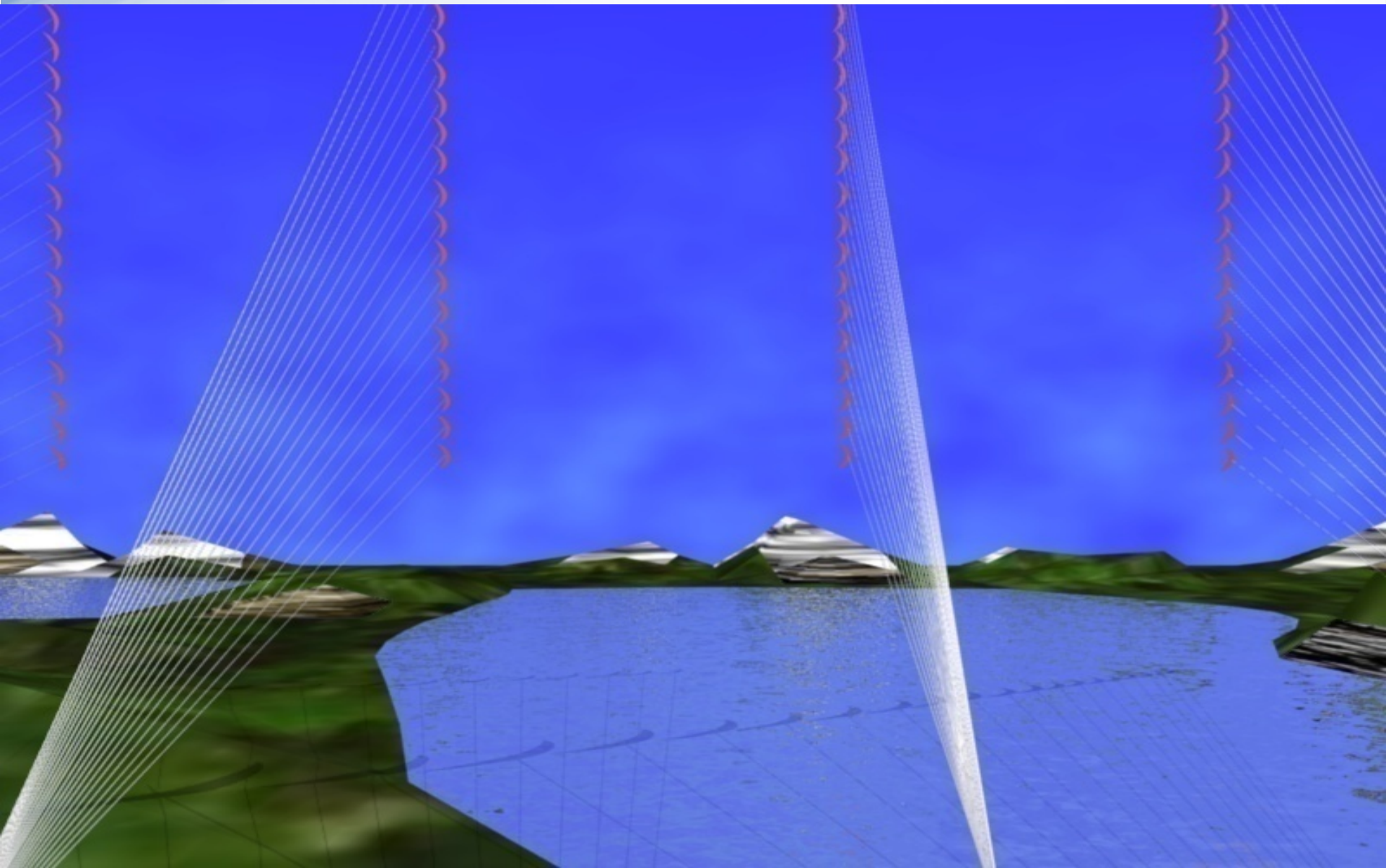
AIRBORNE WIND ENERGY CONVERSION SYSTEM (AWECS)

PIERRE BENHAIEM
France

XXI st World Energy Congress September 12 to 16 MONTREAL 2010

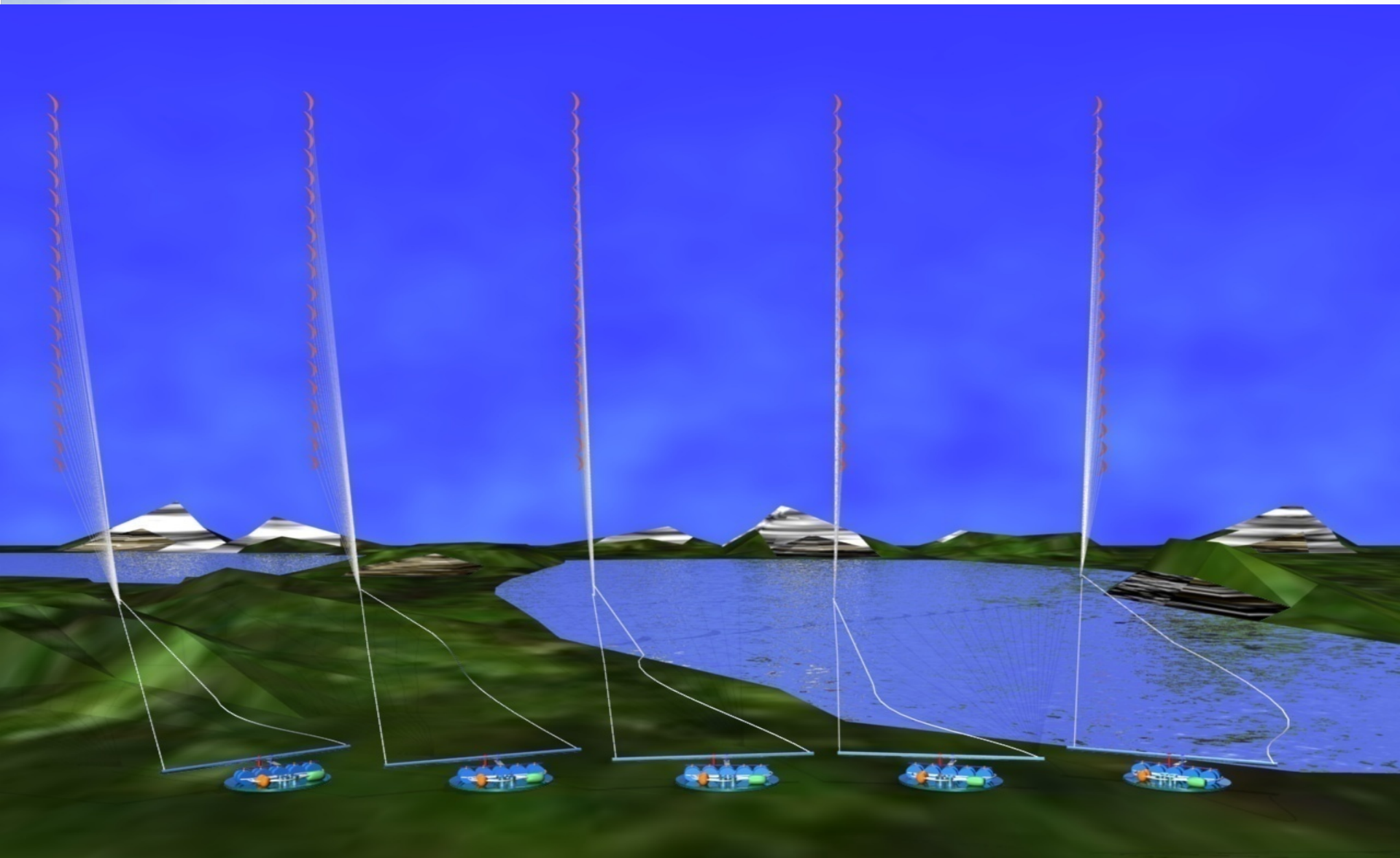
EVERY CHILD'S FAVORITE PLAYING IS ALSO...

...A FUTURE WORLD ENERGY FOR OUR CHILDREN



TWO AXIS OF SEARCH: MACROENERGY with OrthoKiteBunch

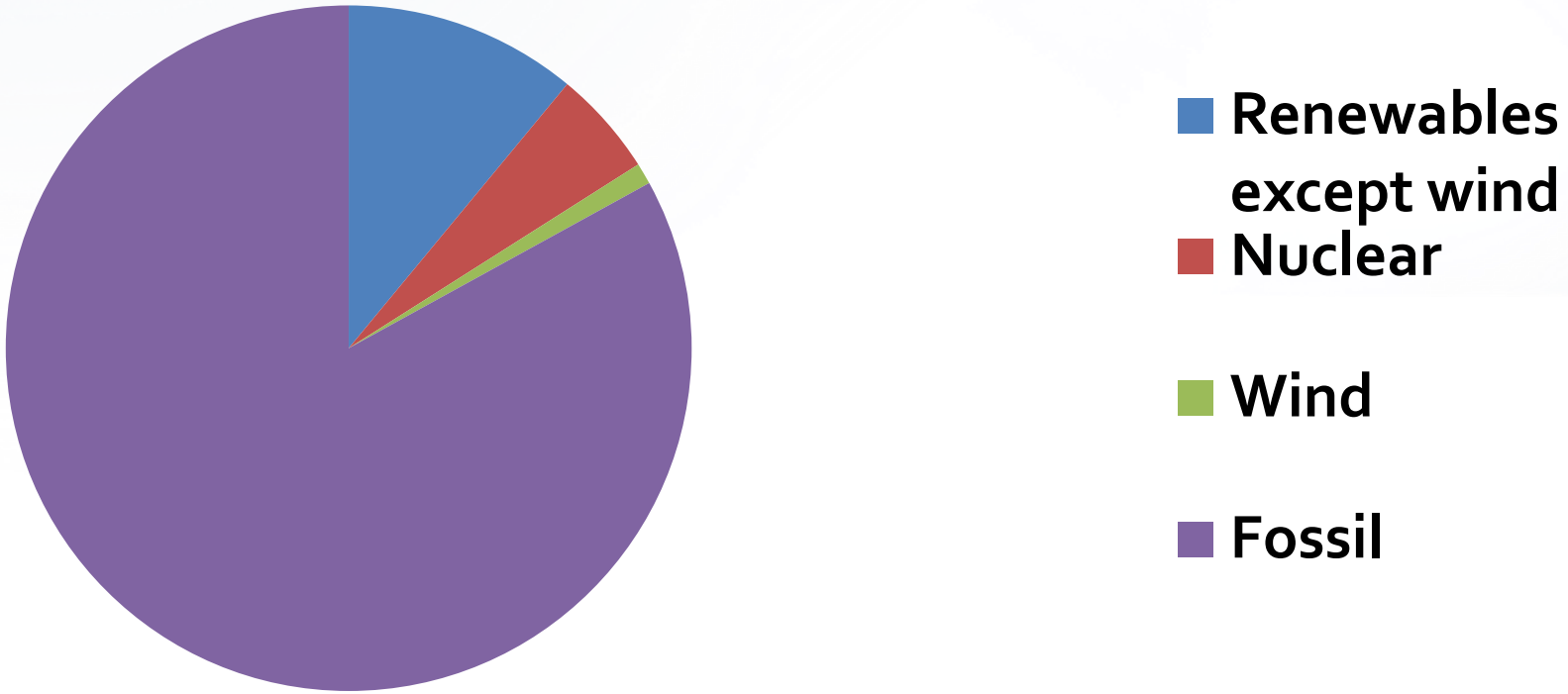
Video, click box



MICROENERGY with a manual AWECS

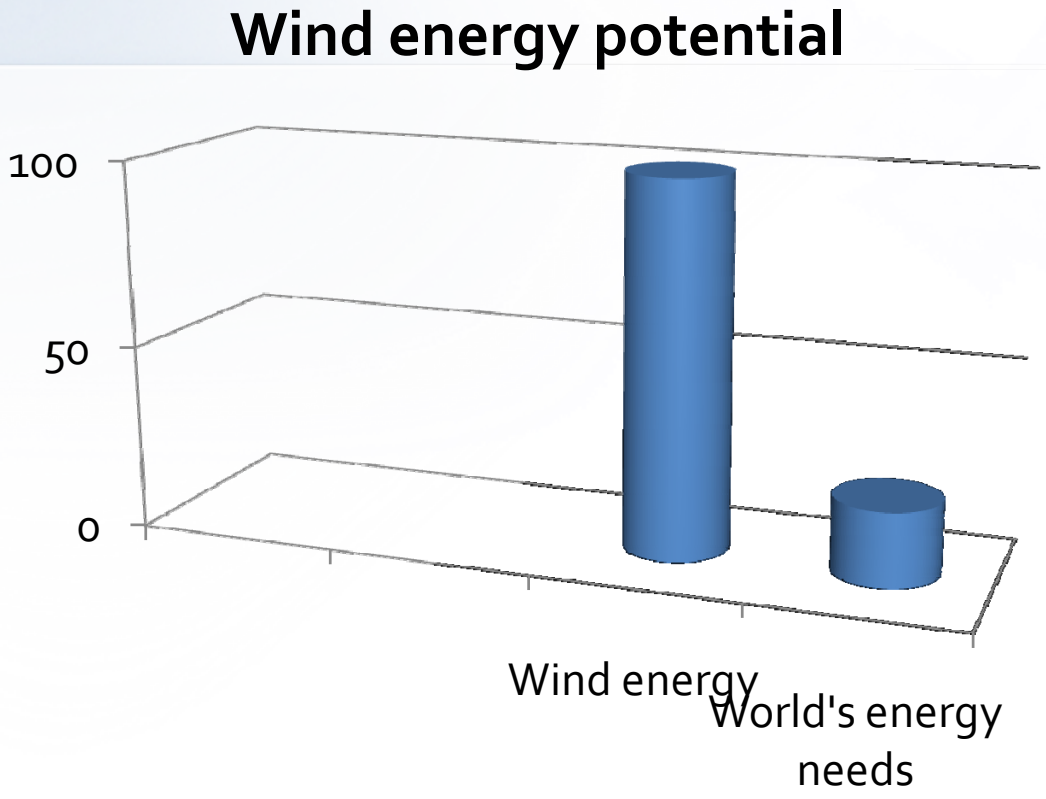
1) INTRODUCTION a) general context

Estimation of the demand for 2030 in energy parts



THE PART OF THE WIND IS VERY LOW, NETHERTHELESS...

1) INTRODUCTION a) general context



WIND ENERGY POTENTIAL IS FIVE TIMES WORLD'S ENERGY NEEDS

b) Current plants of the wind energy

LIMITS ARE:

Low density of produced energy,10 to 15 MW/km²

Low swept areas

Heavy and expensive constructions

Less powerful and regular winds

b) Both current plants of wind and fossil energies

Proportions for a same global amount of energy

Proportions with wind…

In the world average possible synergies between wind and coal are limitated.

b) Both current plants of wind and fossil energies

Photo of wind energy disappears while photo of coal plant increases a little.

…and without wind:little difference

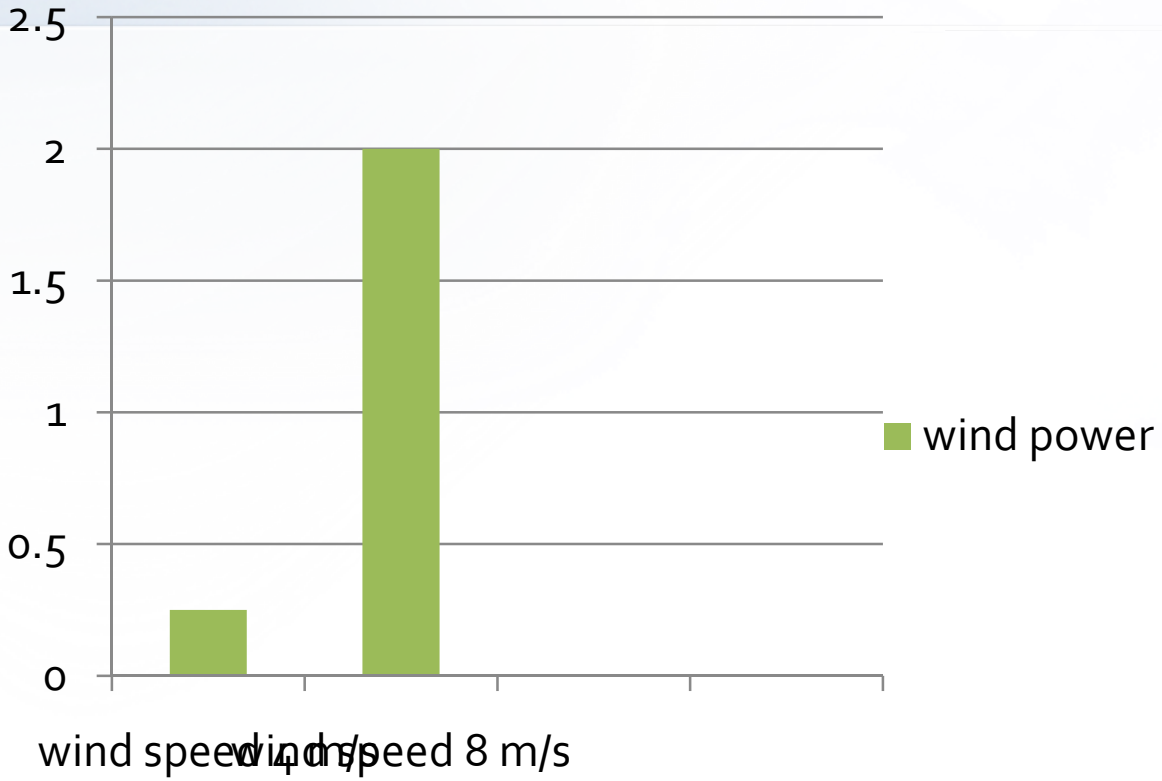
In the world average possible synergies between wind and coal are limited.

c) Towards a method of conversion of high altitude wind energy

Wind energy increases with altitude.

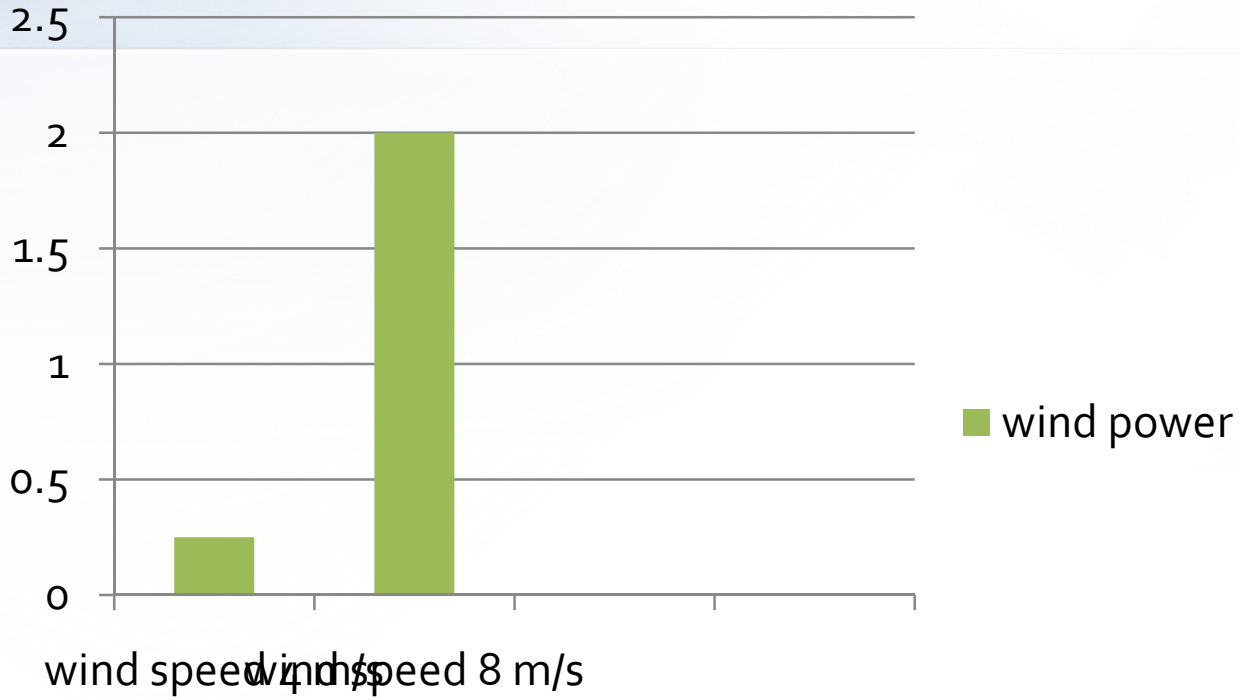
So the biggest energy reservoir is in high altitude.

c) Towards a method of conversion of high altitude wind energy



The wind power grows with the cube of its velocity.Wind velocity grows with altitude.At 80 m from the ground the average wind velocity is about 4,6 m/s,and at 1200 m it is about 9,2 m/s.

c) Towards a method of conversion of high altitude wind energy



Global power at 1200 m is more than 7 (7,2) times that at 80 m where the last generation of aeolian towers work.Morever winds by far are more regular in high altitudes.

d) Airborne Wind Energy Conversion System (AWECS) with kites

No heavy constructions,so lower pollution and costs

Best winds in high altitude

WHY KITES?

High swept areas with low land occupation

Wind energy at lower cost than fossil sources

d) Airborne Wind Energy Conversion System (AWECS) with kites

Kites fly fast in crosswind direction

Their speed allows to provide strong force

HOW DO KITES WORK?

Kites work like conventional turbines but…

With only the most fast and efficient part

d) Airborne Wind Energy Conversion System (AWECS) with kites

RULES OF THREE RATIOS

Swept area/land occupation

PARAMETERS FOR IMPLEMENTATION

Swept area/airspace surface occupation

Swept area/airspace volume occupation

d) Airborne Wind Energy Conversion System (AWECS) with kites

Robotic system for automatic piloting

Airspace volume and surface occupation

WHAT ARE THE MAIN DIFFICULTIES FOR IMPLEMENTATION OF AWECS WITH KITES?

So shared airspace with planes

Launching and recovering when wind stops or a storm arrives

d) Airborne Wind Energy Conversion System (AWECS) with kites

Base of calculation:Loyd's formula and variants

$$P = 2/27\ dA\ w^3\ CL\ (CL/CD)^2 \quad \text{for reel-out system}$$

$$P = 4/81\ dA\ w^3\ CL\ (CL/CD)^2 \quad \text{for flygen}$$

P = power
d = air density
A = kite area (not swept area)
CL = lift coefficient
CD = drag coefficient
w = wind speed

With kite speed is (2/3 w CL/CD) according to loss (1/3 w) of relative wind speed

d) Airborne Wind Energy Conversion System (AWECS) with kites

POSSIBLE METHODS

d) Airborne Wind Energy Conversion System (AWECS) with kites 1)On-board generator,called also flygen

Advantages	Disadvantages for high scales
Fast spinning, so small generators	Heavy parts on board
Simple pattern for small scales	Needed aerial electrical cable

d) Airborne Wind Energy Conversion System (AWECS) with kites 1) On-board generator,called also flygen

Flygen possible uses:

Dynamic use for small scale

Static use for jet-stream

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

The last development of "Projet EOLICARE" (filling of French patent application).

Manual AWECS

A simple low cost playful flygen

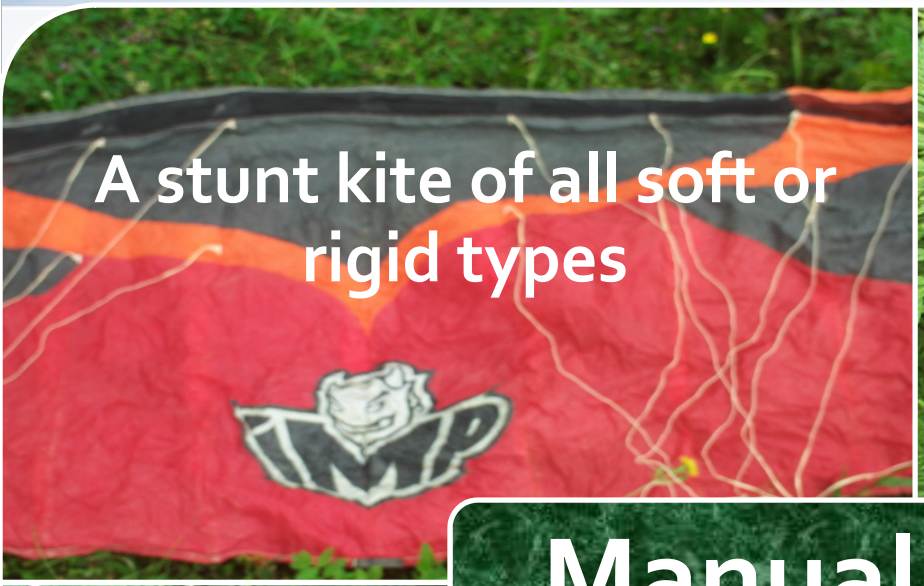
d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

High relative wind speed at the kite allows…

Manual AWECS

…high power with a small propeller.

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen



Manual AWECS

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

Manual AWECS

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

When wind speed is 5 m/s,kite speed is 20 m/s…

Manual AWECS

…so power increases by factor of 64

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

Quick loading of battery for laptop or mobile phone

Manual AWECS

Power from 20 to 400 W

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

No automatic piloting,so…

Manual AWECS

…a new concept:the user makes himself his wind energy

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

Tool of education (via laptop) for regions without grid

Manual AWECS

Sport game:1 h play for 2 h laptop

d) Airborne Wind Energy Conversion System (AWECS) with kite 1) On-board generator,called also flygen

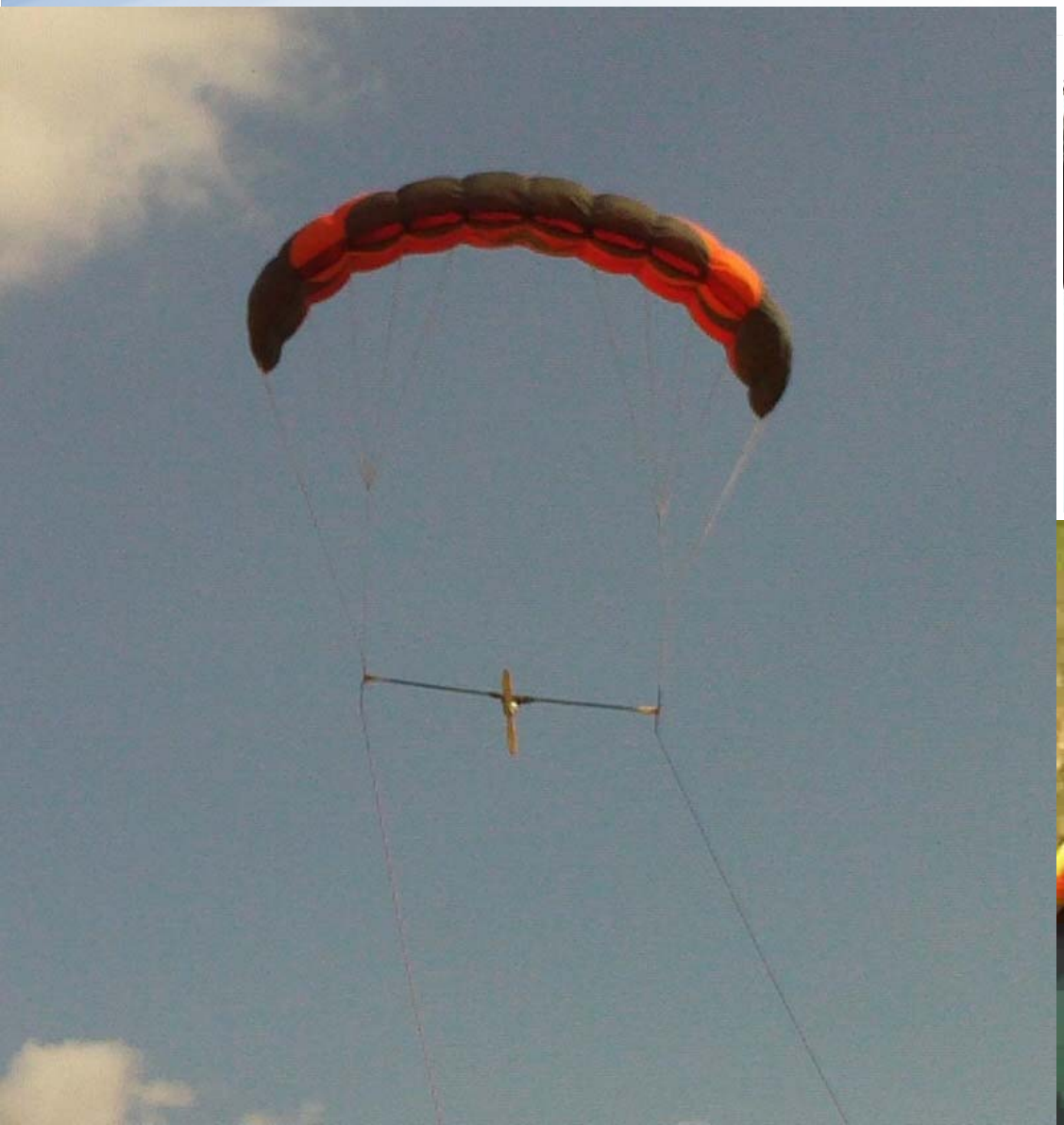
To be the first AWECS for sale to launch…

Manual AWECS

…emergent industry of airborne wind energy

NEW CONCEPT:TO DO ONESELF HIS WIND ENERGY.

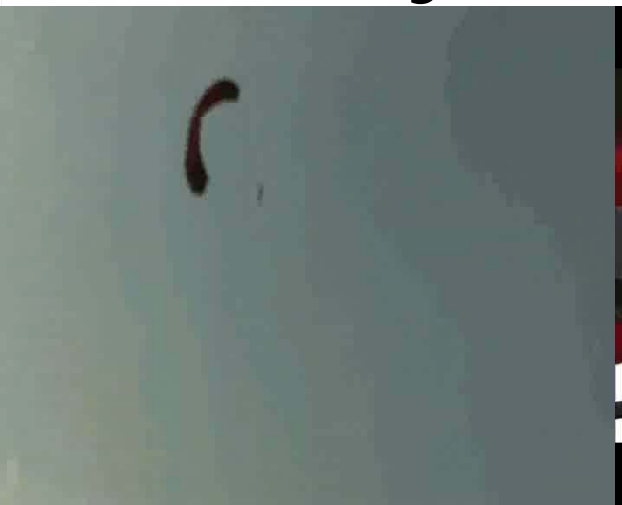
Click this to access related video set



d) Airborne Wind Energy Conversion System (AWECS) with kite 1)On-board generator,called also flygen

SCHEDULE FOR MANUAL AWECS

2010	2011	2012
WORKING PROTOTYPE	FINALI-ZATION	MARKET LAUNCH
DYNAMIC USE: WIND SPEED:5 m/s	DYNAMIC USE: KITE SPEED:20 m/s	STATIC USE:NEEDED WIND SPEED:20 m/s



d) Airborne Wind Energy Conversion System (AWECS) with kites 2)Generator at ground

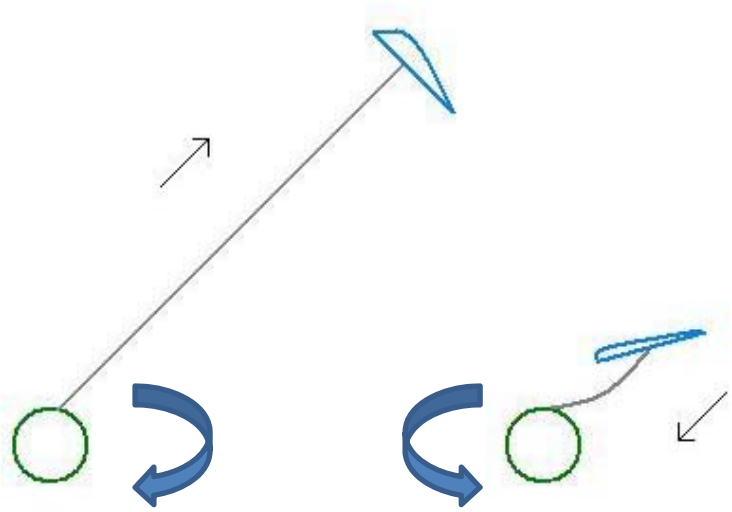
HIGH SCALES

HIGH ALTITUDE ,FROM **200** TO **2000** M

HEAVY PARTS OF CONVERSION SYSTEM AT GROUND

d) Airborne Wind Energy Conversion System (AWECS) with kites 2)Generator at ground a- Linear AWECS

Reel-out power phase



Reel-in recovering phase

Needed energy for recovering phase	The space is not enough maximized
One of the best and simpliest possibility but…	
The automatic system works…	…on two phases

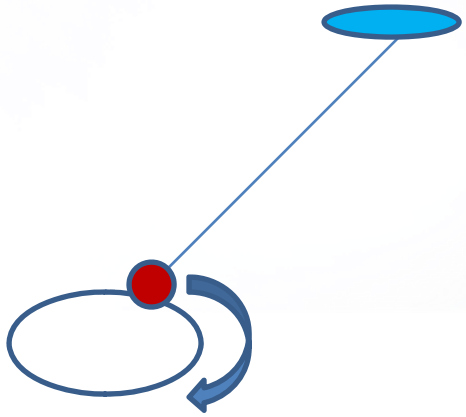
d) Airborne Wind Energy Conversion System (AWECS) with kites 2)Generator at ground
b- Cyclic AWECS,continous motion

ADVANTAGE:

no needed smoothing device.

DISADVANTAGE:

flight window is between 90° and 180°,so such a space is difficult to agree with a circular motion.



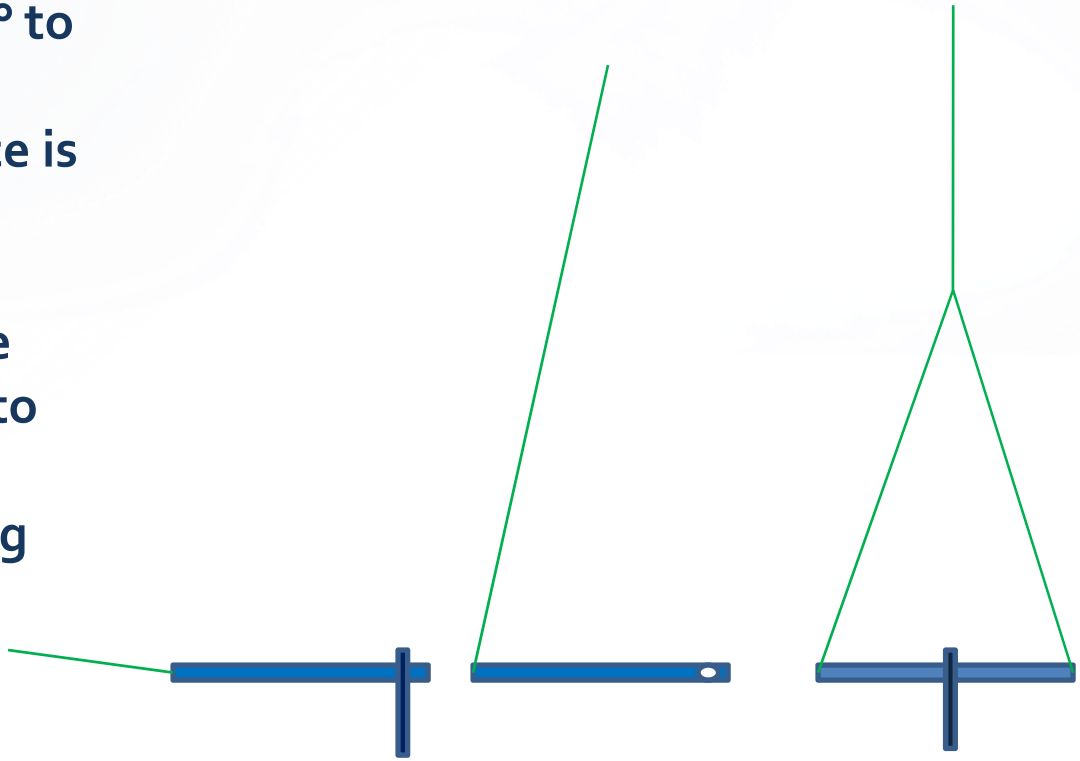
Cyclic AWECS,oscillating motion,lever systems

Prior art of lever systems:low tangential force

a) One lever,vertical or oblique axis.Angle of tether is + - 180° to let a continuous power motion,so the tangential force is very low,the parasitic radial force is high.

b) One lever,horizontal axis.Kite powered motion is limitated to lever motion,little more with oblique motion.Needed spring to recover initial position.The tangential force is low.

c) Configuration of fig.1b of US 3987987 fundamental patent.Force goes simoultaneously towards the two ends,so the tangential force is also low.



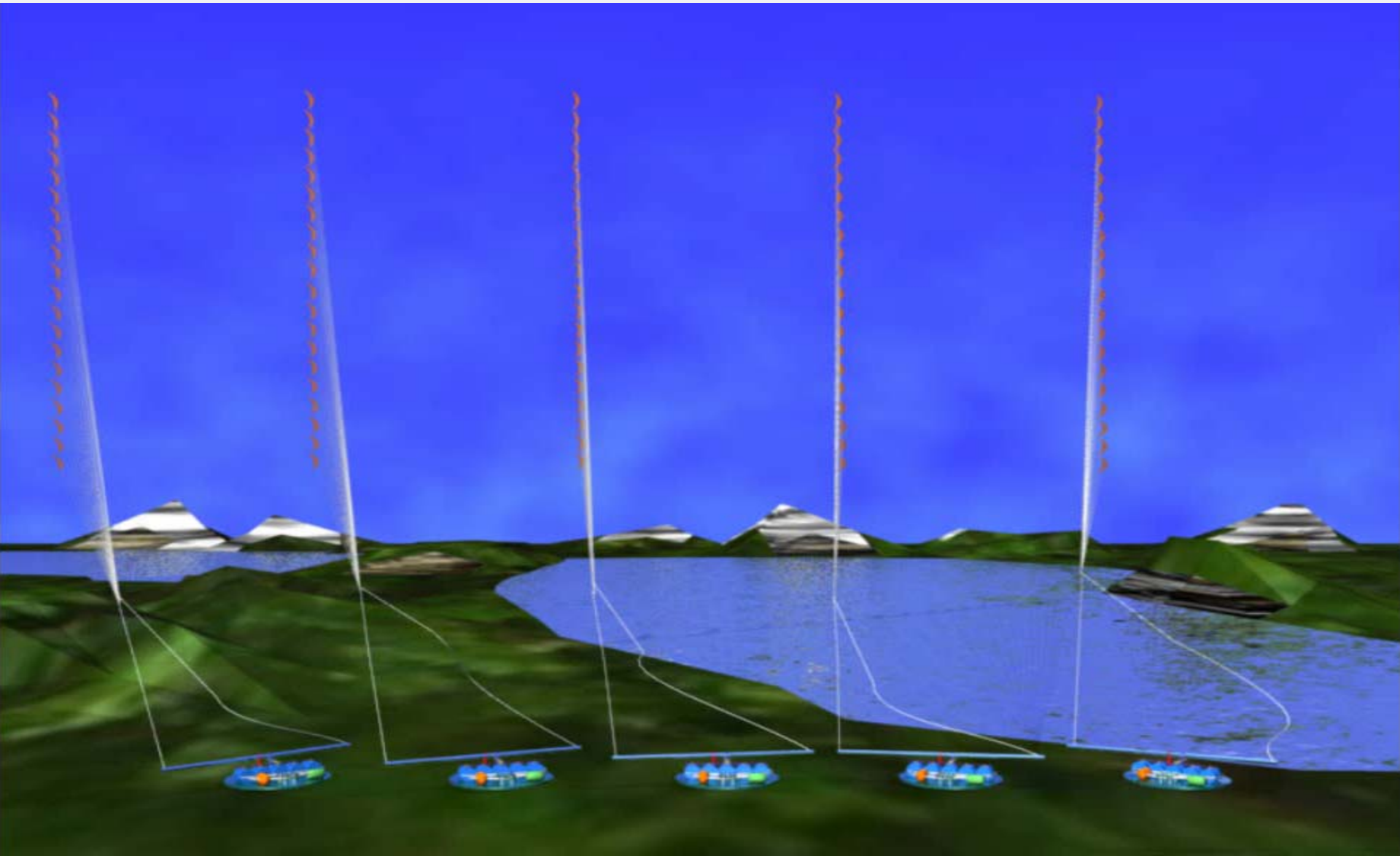
So a new lever system is needed

2) Said method OrthoKiteBunch (OKB) a) Technical features

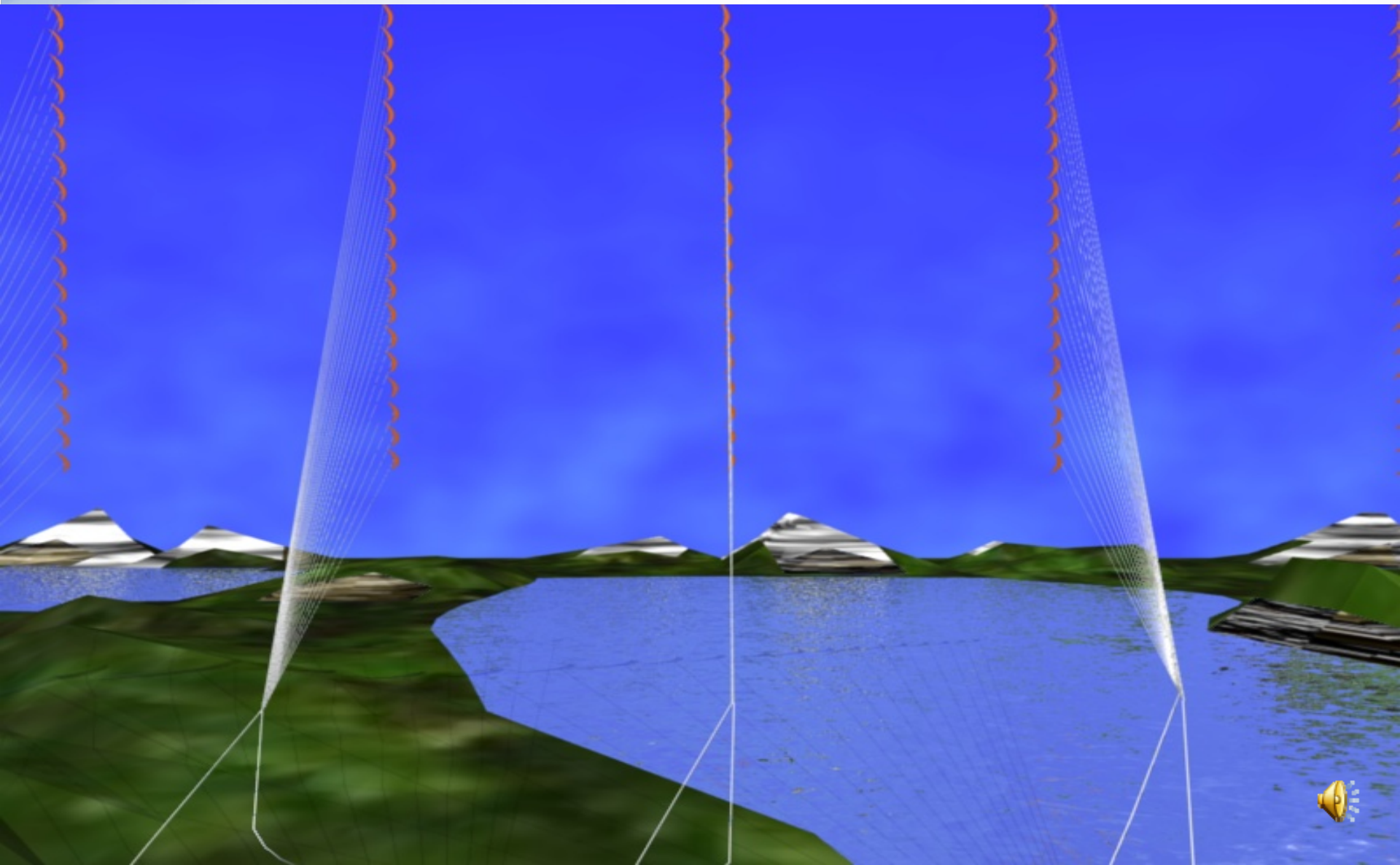
OrthoKiteBunch (OKB) links up two systems

- **OrthoKite (OK) system**
- **KiteBunch (KB) system**

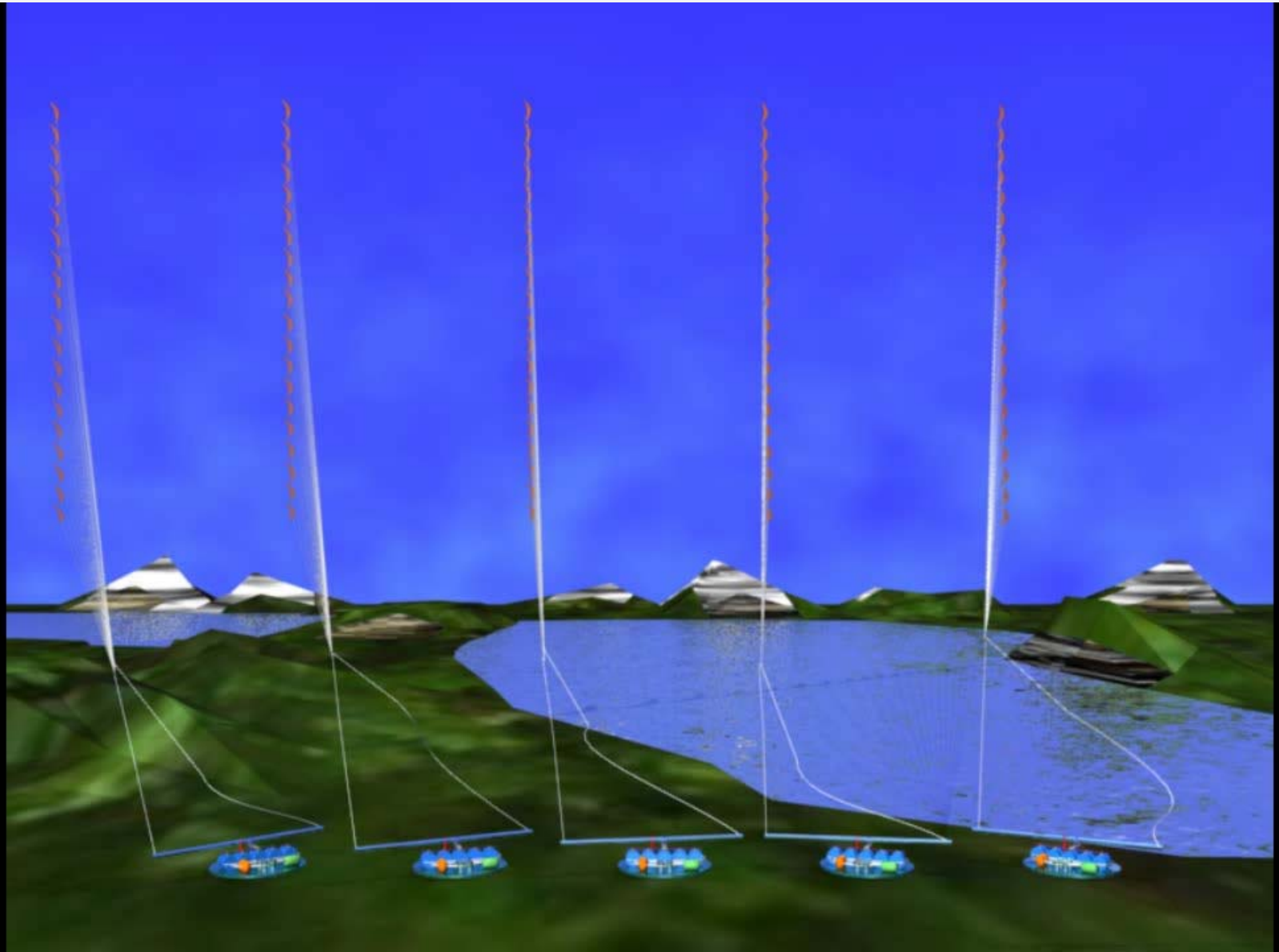
OK SYSTEM WORKS IN ATERNATION FOR AN ORTHOGONAL TRANSMISSION ON ONE LEVER THEN THE OTHER LEVER.SO THE TORQUE AND THE POWER ARE MAXIMIZED.



KB SYSTEM:INDIVIDUAL LINE OF EACH KITE CONVERGES TOWARDS THE TWO RELAY LINES THAT WORK IN ALTERNATION.



SO KB SYSTEM ALLOWS SUPERIMPOSING OF KITES,SO THE MAXIMIZATION OF THE OCCUPIED LAND AND AIRSPACE ACCORDING THE BEST THREE RATIOS.



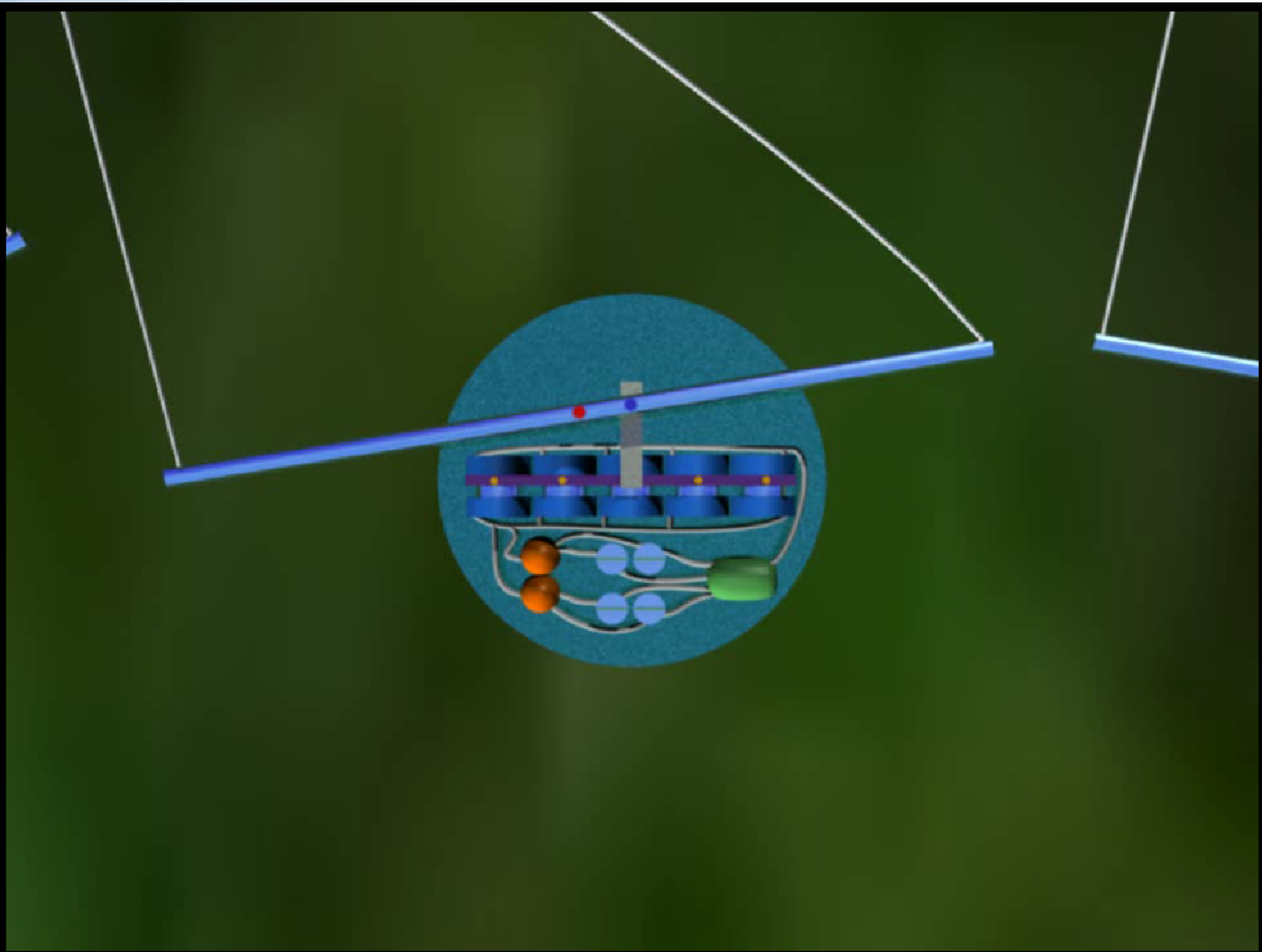
Comparaison between a conventional train of kites and the bunch of kites KiteBunch

The square and the ring represent the additional required space with a conventional train of kites

With KiteBunch area swept is nexter space occupation

WITH KB SYSTEM SWEPT AREA IS NEXTER AIRSPACE OCCUPATION

KITE POWER IS NOT REGULAR.SO A SMOOTHING DEVICE IS NEEDED:AN HYDRAULIC INSTALLATION.



2) Said method OrthoKiteBunch (OKB) a) Technical features,projection for a GW scale plant of 100 kites

Wind speed = 12 m/s

KITE AREA (m^2)	500 (x 100)
LINE LENGTH (m)	3000
LEVER RADIUS (m)	200
ANGULAR SPEED (rad/s)	0,03
NOMINAL KITE SPEED (m/s)	75
TORQUE (Nm)	333,333,333
POWER (W)	10,000,000 (x 100)
SWEPT AREA (m^2)	25,000 (x 100)
LAND OCCUPATION (km^2)	0,125 (x 5)
SURFACE OCCUPATION (km^2)	20
VOLUME OCCUPATION (km^3)	15

2) Said method OrthoKiteBunch (OKB) a) Technical features,trials of a manual OrthoKite system

Wind speed = 5 m/s

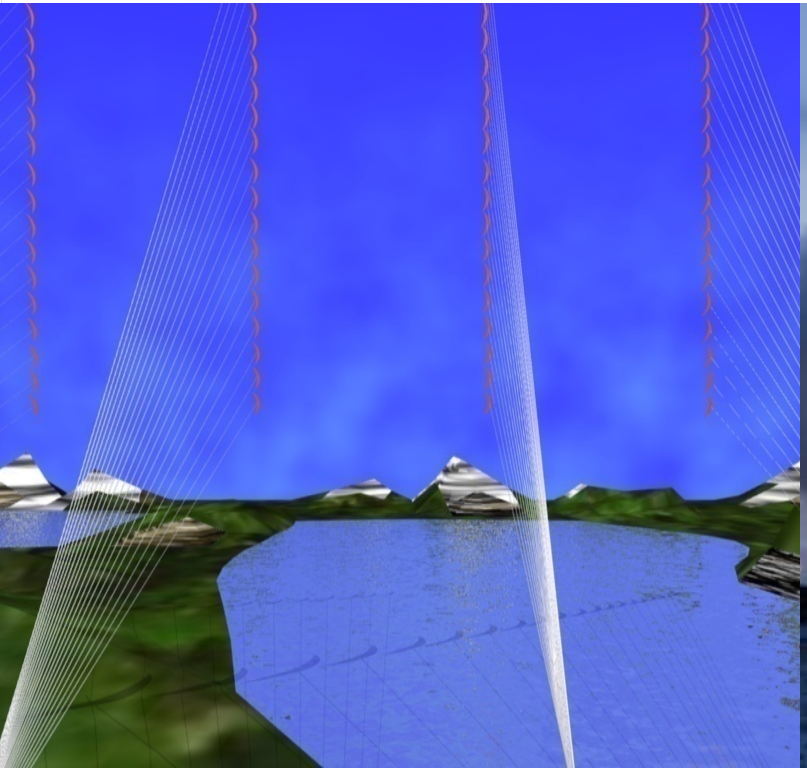
KITE AREA (m^2)	1.5
LINE LENGTH (m)	18
LEVER RADIUS (m)	1
ANGULAR SPEED (rad/s)	1.33
NOMINAL KITE SPEED (m/s)	20
TORQUE (Nm)	120
POWER (W)	160
SWEPT AREA (m^2)	50

De Prony Brake method:the user retains the lever, the dynamometer showing the strength.

3)OrthoKiteBunch in the energy mixes

Possible synergies with fossil-fuel power plant

With wind…



3)OrthoKiteBunch in the energy mixes

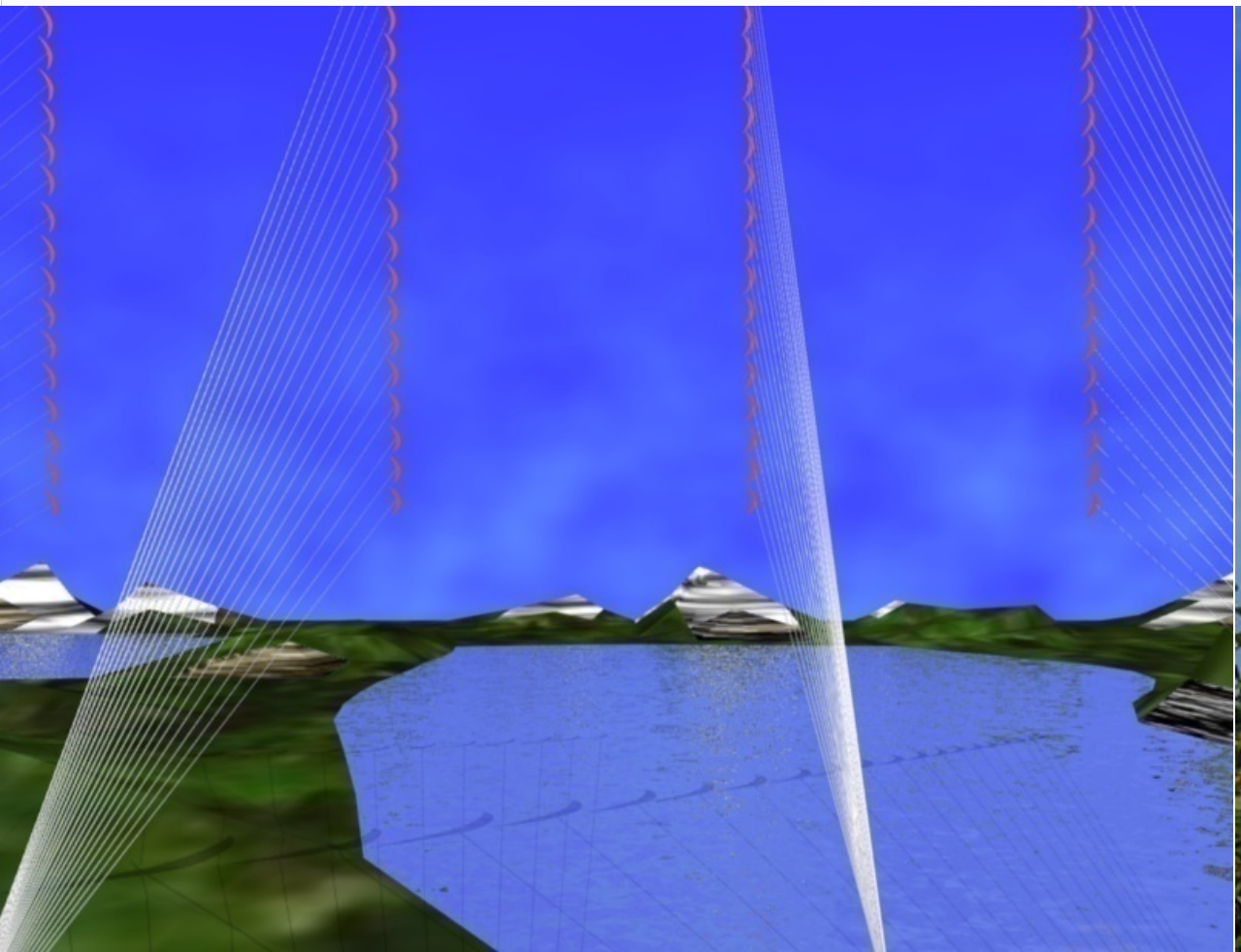
Possible synergies with fossil-fuel power plant

…Without wind (much more difference,so an important average of limitation of spent energy by the coal plant)

3)OrthoKiteBunch in the energy mixes

Possible synergies with nuclear power plant

No synergy,but the no-fly zone at nuclear plant out of order could be used.



4) CONCLUSION

Now

- Main energies: fossil,nuclear…
- Energy of supplement:wind among others

tomorrow

- Balancing between energies
- Wind energy becomes a main energy

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THANKS.

ANY QUESTIONS?

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