MAY 2016

KiteGen

The ‘magic’ energy solution





KiteGenVenture

Sommariva test plant

[Holding Company] KiteGenVenture

[Operative Company] SEQUOIA automation

[Patents holder] KiteGen

Company profile

KiteGen

Interntional awards and recognitions:

eni award

CESI

COPENHAGEN

SEVENTH FRAMEWORK PROGRAMME

Cleantech Group

REGIONE PIEMONTE

EXPO 2010 SHANGHAI CHINA

MINISTERO DELLO SVILUPPO ECONOMICO

KiteGen® is the evolution of **wind energy exploitation.**

The novelty is that the KiteGen® technology can reach an unexploited, abundant, virtually endless, suitable for baseload operations and almost universally available power source: **high altitude wind.**

Thanks to 10 years of continuous research, a strong know how, five prototypes approaching the industrial scale and more than 40 international patents, KiteGen is finally ready to drive and support the industrialization and the deployment stage, sharing the know-how with qualified partners.

Huge and growing interest

Cleantech Group

MAIN PLAYERS:

SOME INVESTORS:

MITSUBISHI HEAVY INDUSTRIES, LTD.
Google
سابك
sabic
BOEING
ALSTOM
ZEPPELIN Power Systems
CAT
Oltmann Gruppe
DSM
BRIGHT SCIENCE. BRIGHTER LIVING.
FESTO
SoftBank

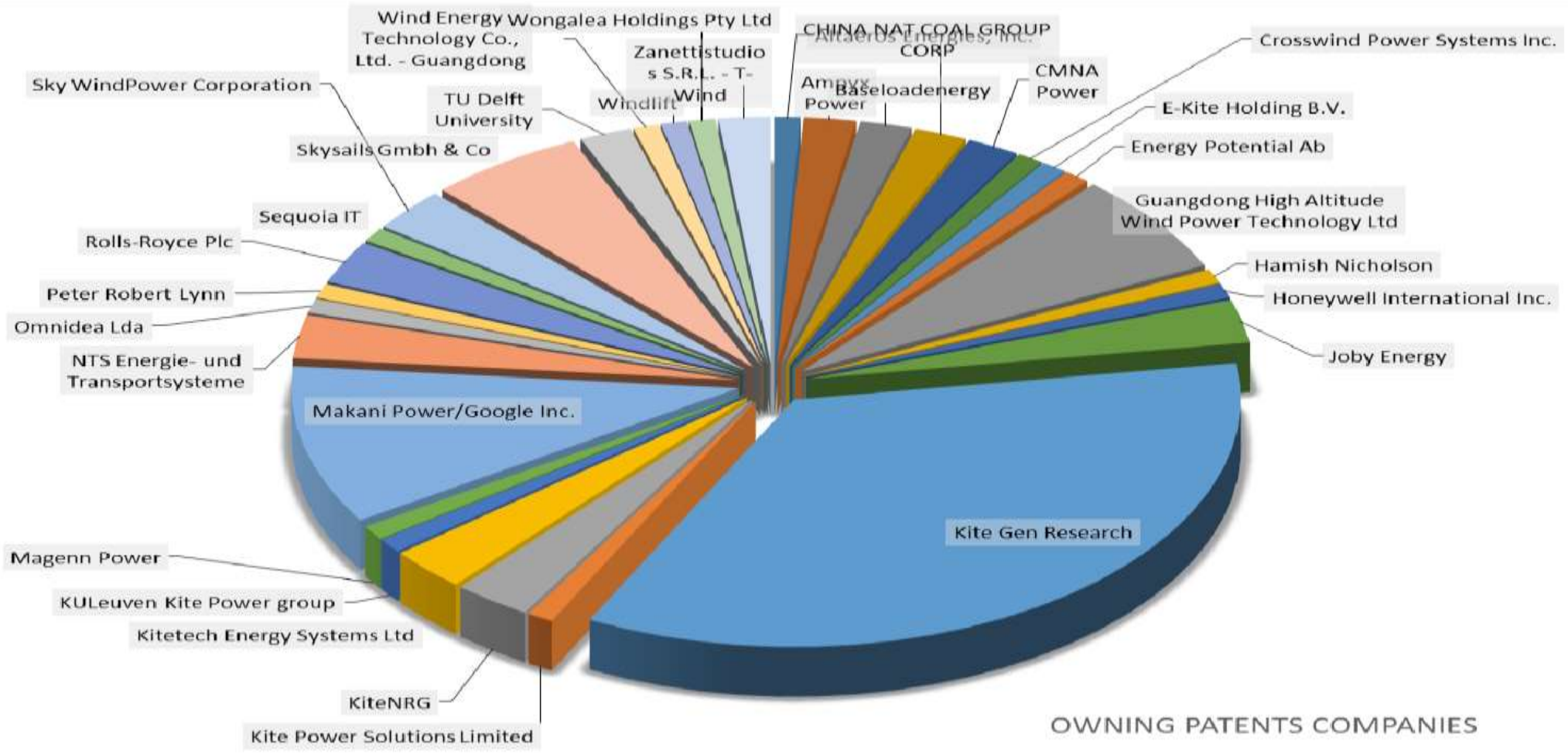
The competitive scenario

Cleantech Group

Makani Power USA	Altaeros USA	X-Wind GERMANY	Sky Wind Power GERMANY	Ampyx Power NETHERLANDS	Sky Sails GERMANY
					
FlyGen concept. Generator on board. The tether carries energy from the kite to the grid, connecting it to the ground station.	Tethered airborne platforms designed to lift a lightweight wind turbine up to 600m above ground.	Combines automatically steered kites, grounded rail systems and cable car technology on linear or circular track.	Flying electric generator with rotors that both lift the vehicle and convert the kinetic energy into electricity.	PowerPlanes flying repetitive cross-wind patterns, attached with a cable to a ground-based generator.	Ship traction using crosswind power. Traction power-kite with flying actuators.
30 kW protoype. Recently shifted from flexible to rigid airfoils.	First funcional BAT prototype launched in 2012. The company is claiming to work on the first commercial scale BAT.	A 400m linear test track is in operation since 2011. Closed loop prototype is under construction.	Small prototype tested in December 2011 flying with additional safety tethers through a limited range of the required manoeuvres.	10 kW scale prototype with rigid airfoils.	50 kW prototype already sold to pilot customers.
DRAWBACKS*: - Conducting tethering cables instead of insulating ropes as in KiteGen. - Harnessing propellers whch add drag thus limiting the aerodynamic efficiency of the system.	DRAWBACKS*: - Need of helium (non renewable source). - The trigonometric ratio between bouyancy force and wind drag vectors excludes them from the category of troporspheric wind.	DRAWBACKS*: - No relevant patent coverage, they patented a blimps rail generator. - Rail concept presumably developed in infringment with our KiteGen Carousel patent.	DRAWBACKS*: - Conducting tethering cables - Heavy structure suitable for jet streams exploitation only.	DRAWBACKS*: - No patent coverage - Lack of scalability due to the flat wing that require an heavy longeron to sustain the wind force.	DRAWBACKS*: Patent coverage for ship traction but not for energy production.

* According to KiteGen point of view. Benchmarking reports are available on request.

Intellectual Property Scenario



Milestones 1

2003. **Theoretical framework and patenting** of the KiteGen technology. Small investigation prototype realized with e-bike hub motors.

2006. Proof of concept with a prototype, the mobilegen flying a sport kite with a peak energy production of **100kW in traction**, but no solution to close the production cycle yet.

2007. Development of the **second prototype** (40 kW, over 2000 m. altitude flying test), and setup and validation of the side-sleep procedure to close the production cycle. Patenting the new findings.

2008. **7th EU Framework Project KitVes**: KiteGen considered as one of the promising solutions in the production of clean energy on board of ships. Further patent activity following deep system analysis.

2009. **CESI-Research** (now RSE): First Italian altitude wind assessment; concept comparison: KG Carousel judged by such public institution as the most promising and feasible solution for the exploitation of high altitude wind power.

2010. **ENI AWARD-** 1st prize to Doc. Lorenzo Fagiano for his master on KiteGen: Control of Tethered Airfoils for High–Altitude Wind Energy Generation. **Expo Shanghai**: KiteGen as symbol of the Italian innovators.

Milestones 2

2010-2012. **KiteGen Stem**: strategic decision focused to the development of the fourth prototype approaching the industrial scale. Design/development of many brand new parts/components and successful take-off procedures.

2011. Foundation of **KiteGen Venture** the holding company, Main objective: looking for early KiteGen wind farm customers/adopters.

2013. Cooperation and **JDA agreement** with SABIC (Saudi Arabian Basic Industries) for the setup of the necessary composite materials and chemicals, agreement for 300 KiteGen Stem installation plan in Saudi Arabia following some validation milestones.

2014. Design and manufacturing of the Big composite Power Wings in several different geometrical configurations.

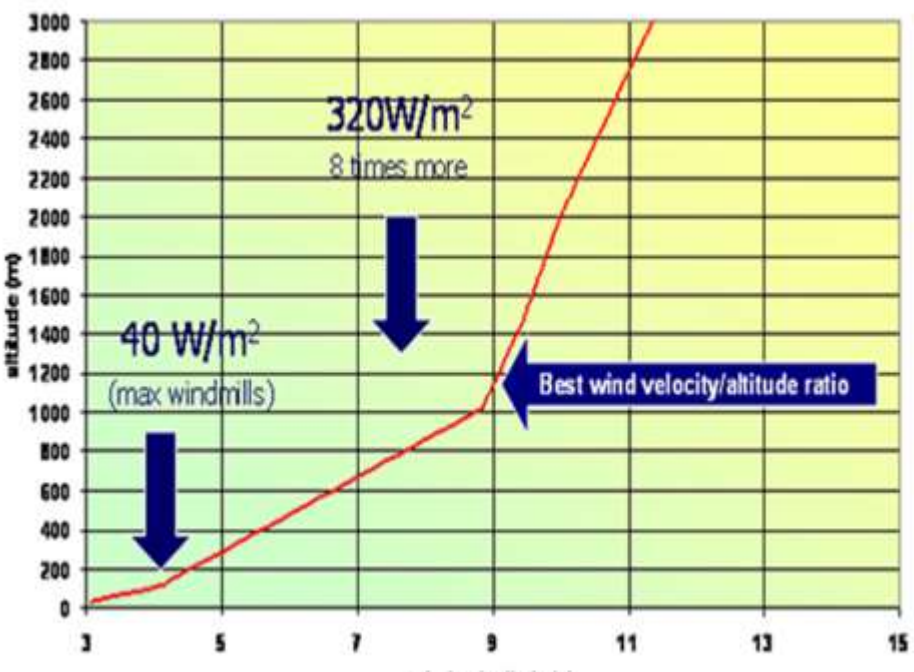
2015. Supply chain first set up; manufacturing development of subassemblies; partner scouting/evaluation; Test of the industrial machine; validation and components refining and revision loop. The Wing exposes an outstanding aerodynamic efficiency.

2016. Completion of the Full Technology Package and comprehensive specification of all components, wing and machinery. Ready to setup the system **mass production**. Efforts to enforce and engage the full supply chain for the project with commercial/production agreements. Components endurance tests, addressing safety and security issues.

High altitude winds

The first real innovation of KiteGen lies in the choice of a high-performance energy source: the **high altitude winds**, a huge, virtually endless and almost universally available energy power, but still to be explored.

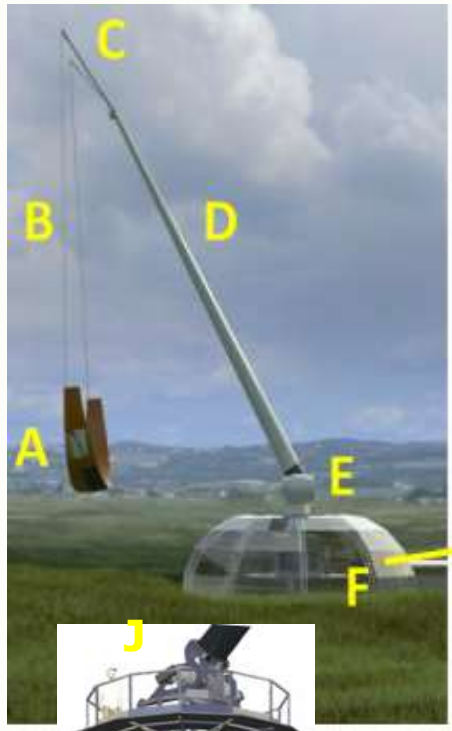
High altitude winds blow all around the globe **between 500 and 10000 meters** above the surface. Compared to normal winds at ground level, those streams are **steadier**, **stronger** and almost **equally distributed** around the earth's surface. All these characteristics make the tropospheric winds a unique reservoir with a huge unexploited potential.



	TRADITIONAL TURBINES	KiteGen®
Height	80 m	800 - ~2000 m
Wind average speed	4,6 m/s	7,2 – 16 m/s
Capacity Factor	1550 hours/year	5000 – 7000 hours/year

The KiteGen Stem machinery structure

Structure description
- **Power wing**: Composite material flexible wing structure, 150mq
- **Tethering**: designed for 60 ton max traction, 20 ton working conditions
- **Compass** (optional) + Stem: gust control within few msec, dual cable control, 24 m
- **Ground structure**: flexible for gust control, contain power generators, 13 x 6 m. Light Foundation to support ground structure and cable pull
- **Drums**: horizontal sliding to avoid cable accumulation, cooled, pulleys control tension
- **Cabinet**: inverter limiting power volatility supercapacitor used during wing recovery phase
- **Motorized joint**: gust power damping, take-off support, cable tension keeping



A. Power Wing
B. Dyneema® tethering
C. Compass (optional)
D. Stem
E. Powered joints
F. Ground structure
G. Suspended and rotating engine room
H. 2 power drums, 2 control pulleys, 8 motor-generators

I. Cabinet and 6 actuators
J. Motorized joint
K. Drums
L. Motor drivers and control

The energy problem and its solution

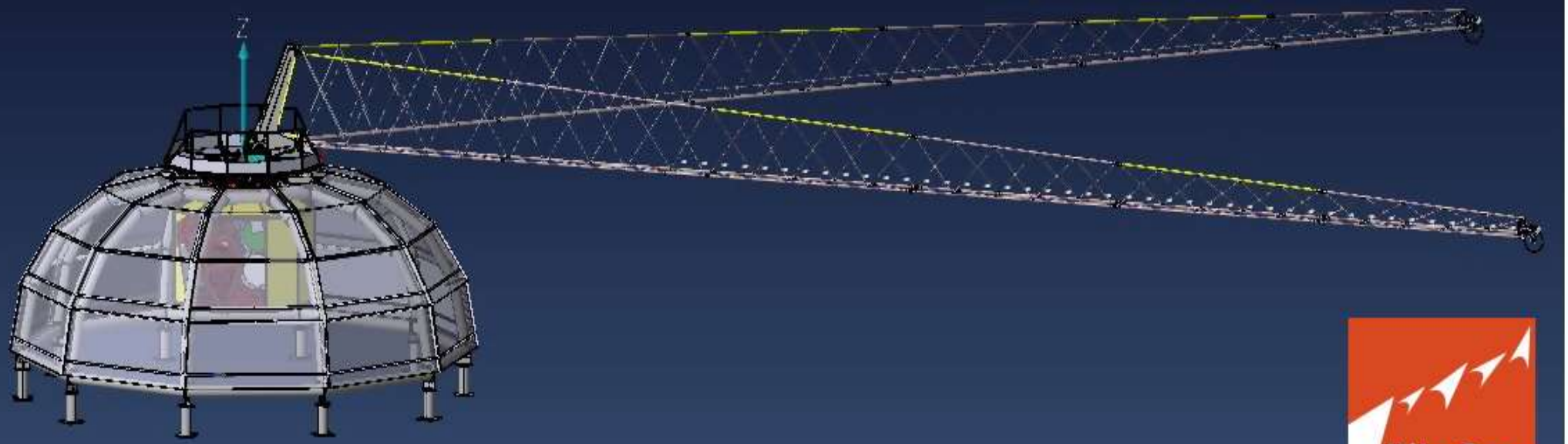
Major Problems for Power Producers	KiteGen® Solution
High human and environmental impact, risks and disasters due oil spill, nuclear, shale gas, collapse of coal mining, community costs and related financial losses	Safe for humans, plant equipment and the environment and optimal financial performances
Trouble in finding new available energy sources at competitive prices and in significant quantities, especially among the renewable ones	100% renewable with capability to achieve LCOE lower than any other energy source fossil fuels included
Inability to satisfy the rising energy demand, due to the fossil fuels peak production	3600 TW of available and renewable power resource, currently never harnessed
Regulations issued by governments on control of emissions in atmosphere and climate change	Technology with zero emissions and huge net energy balance (EROEI).
Intrinsic intermittence of solar and wind energy sources	Up to 6500 hours/year of 3MW equivalent production, independent from specific site
Uncertainty about the continuity of government incentives	Lower LCOE guarantees independence from incentives and grid parity
Inadequacy of the energy distribution systems and grids	Stable production will ease saturation problems and dispatching

KiteGen Stem: drawings snapshot

Final design

Cleantech Group

Double stem version, to handle big wings at ground

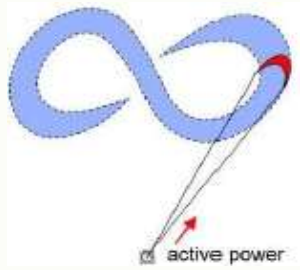


KiteGen

Operating principles

An **automatically driven wing** flies between 600 and 2000 meters to harvest the mechanical energy of powerful winds, which is then transmitted to the ground, converted into electric power and finally injected into the grid. Two **high-strength polymeric ropes** connect the wing to the base and transmit the traction of the wing thus activating the **power generators** located on the ground and producing energy. When the ropes are fully unwound and the maximum height is reached, the wing is driven to a position where it loses wind force and lift. At this point, it is wound up and brought back to the minimum height. Then the cycle restarts repeatedly.

All the heavy machinery for power generation and the management of the entire system is on the ground, consisting of an **dome-shaped base** and a 24 meters long **stem**, connected to the wing through the ropes. The base hosts the heart of the machine: the software, which controls all the operations on the bases of the data received from on-board avionic sensors. In this way the wing flight paths can be controlled and directed to maximize the energy production, in compliance with the working principles of the machine and in conditions of complete safety.



THE PRODUCTION CYCLE

1. **Production phase**: the kite gains height and unwinds the ropes, thus causing the rotation of the drums and generating electricity.

2. **Passive phase**: when ropes are entirely unwound, the wing is driven to a position where it loses its wind resistance and the cables are wound in. Then the cycle restarts. Energy consumption during the winding phase is a minor fraction of the energy generated during the unwinding phase.

Comparison: KiteGen Stem Vs conventional turbines

Overview of Relevant Factors

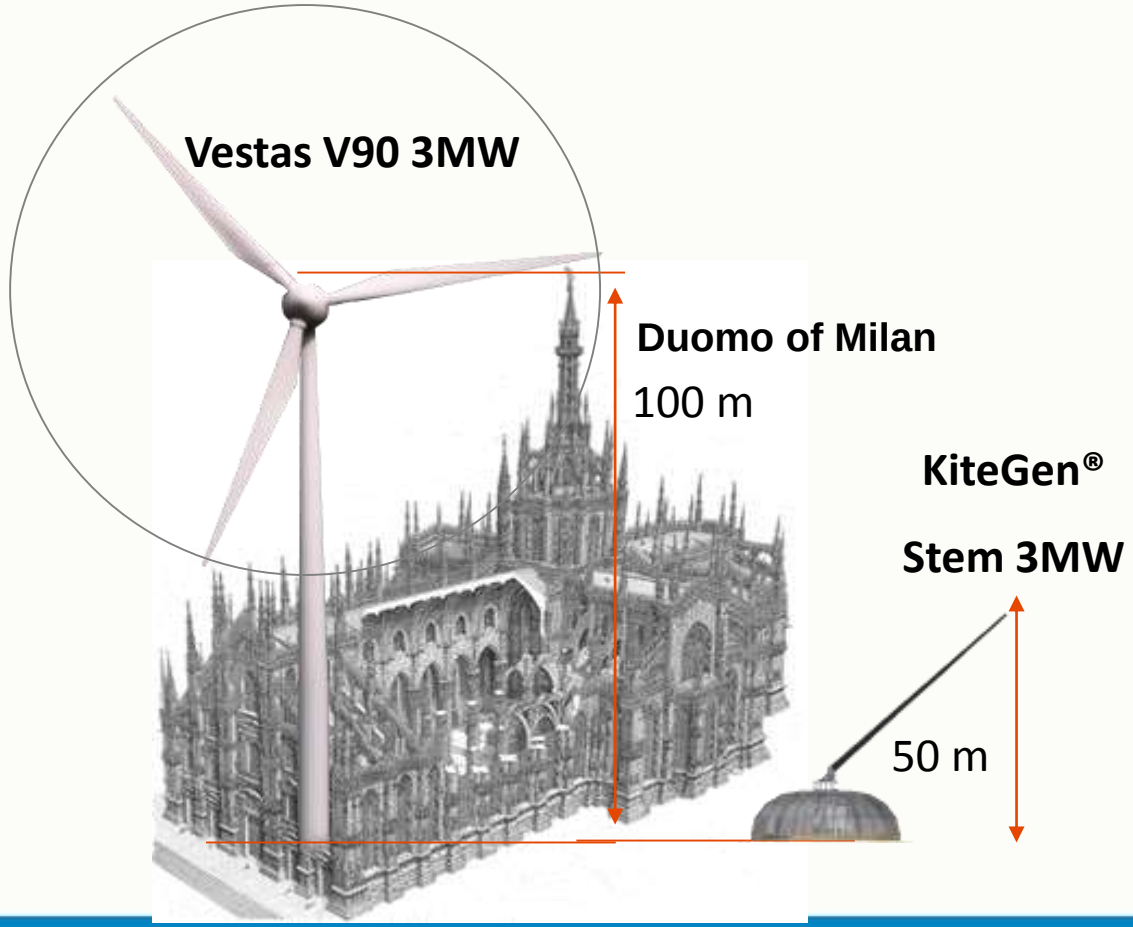
Among other factors, the relevant ones are dimensions, masses, logistics, disposal, environmental impact, capacity factor, territorial energy density, site properties, levelized costs of energy, intermittence and EROEI, as shown in the table below:

	KiteGen Stem	Wind turbines
Equivalent working hours at nominal power	6800*	1550
Weight including foundations (tons)	20	1400
Min. distance between generators (m)	100	800 (7-9 x blade diameter)
Average ground machine height (m)	30	80
Nominal power	3 MW	3 MW
Territorial energy density (MW/km^2)	363	18
Produced energy cost (€/MWh, Italy)	11**-30*	90-150

* Advanced technology learning curve

** Advanced economical learning curve

Dimensions



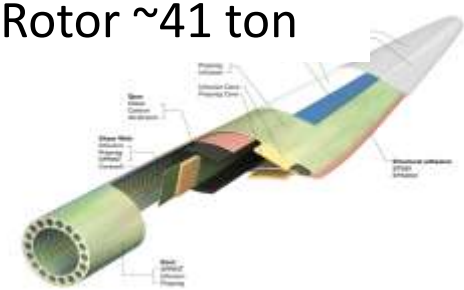
- High altitude wind remains out of the reach of current and the future's aero-generating towers, already more than 100m high. Above a certain height the structure that holds up the rotors becomes exponentially heavier, more unstable, and above all more costly
- The relatively higher wind availability at lower altitudes at open sea still does not make traditional windmills economically feasible. The high thrust and moment generated by the windmill on the platform during operations require heavy, complex (and costly) platform and mooring systems in deep water.

Masses Comparison

Conventional turbines

Nacelle ~70 ton

Rotor ~41 ton



Tower ~ 285 ton

Foundation ~1000 ton

TOT ~ 1400 ton

KiteGen Stem 3MW

The small size and reduced wieght makes the generator easy to carry and install

Igloo + Stem ~12 ton

Foundation < 10 ton

TOT ~ 22 ton

Extensive Test & Refinement Activity

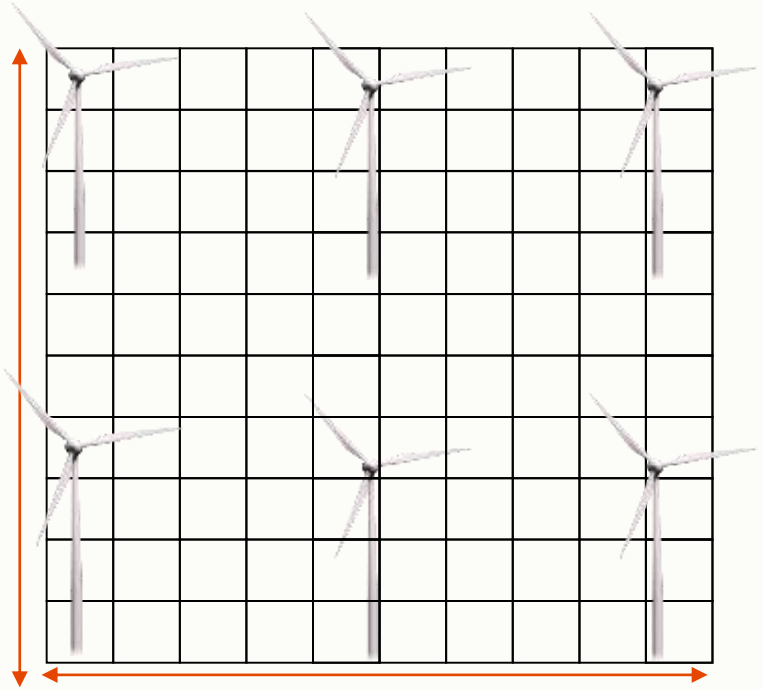
Troposphere Wind Farm Concept

Each wing fly inside a cone of pertinence and is actively controlled with an overall position error of max 10m in the airspace.
The position control accuracy is wind independent

Troposphere Wind Farm Concept

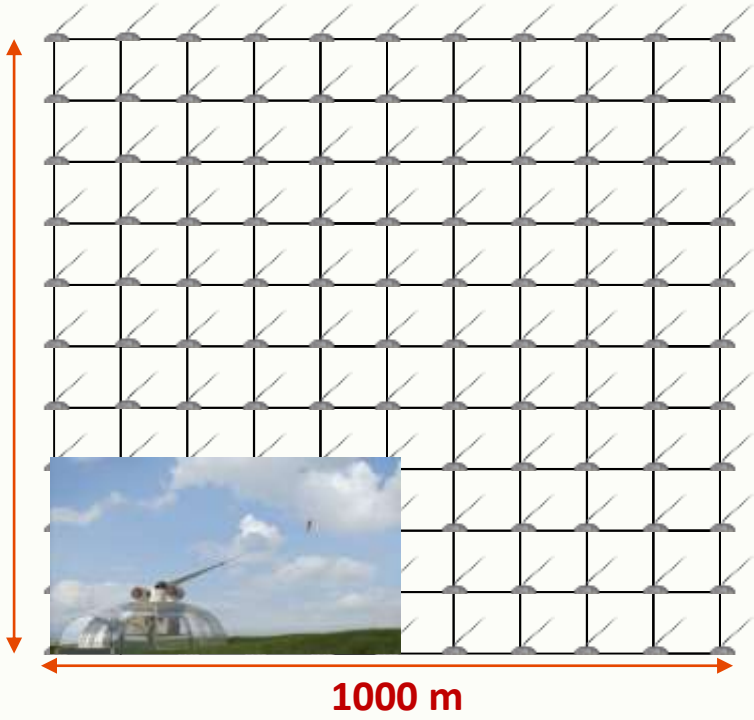
6 wind turbines x 3 MW

18 MW/Km^2

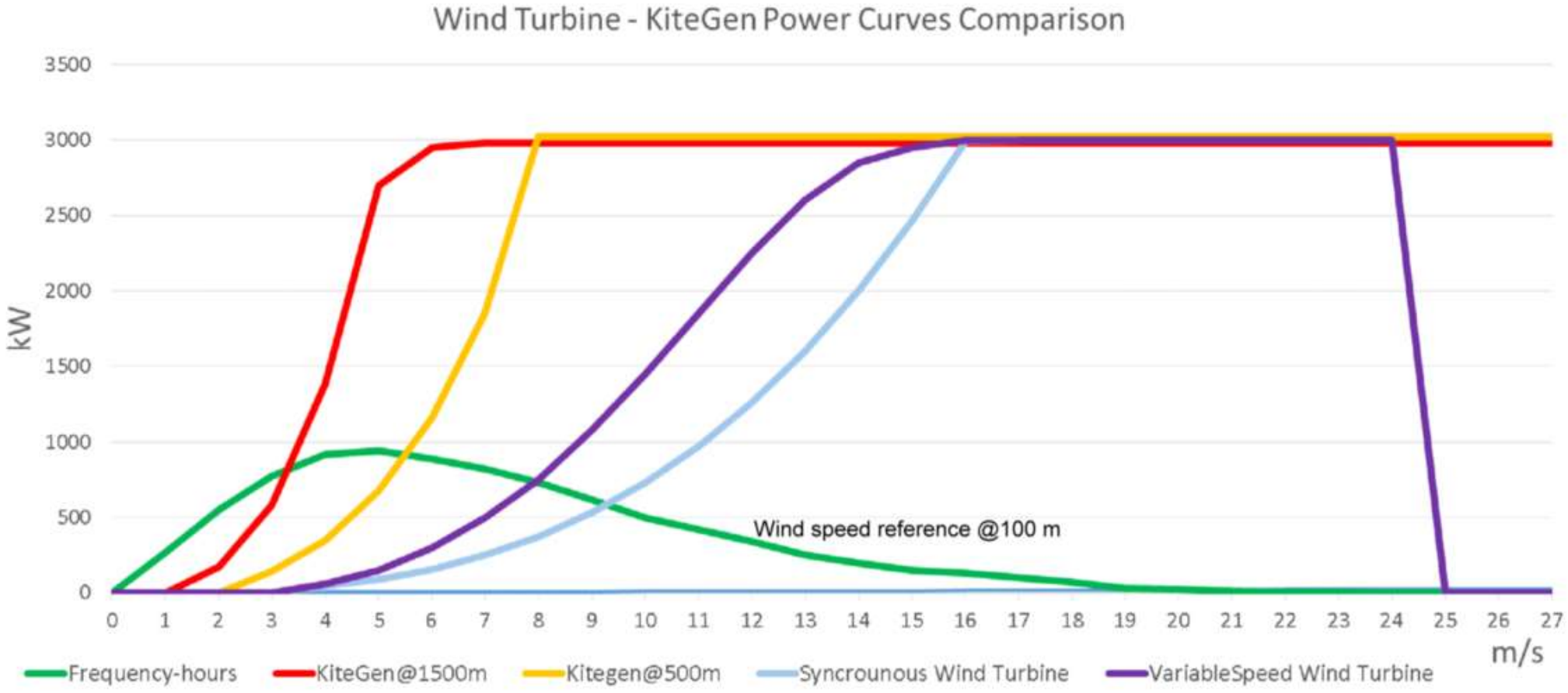


121 KiteGen STEM x 3MW

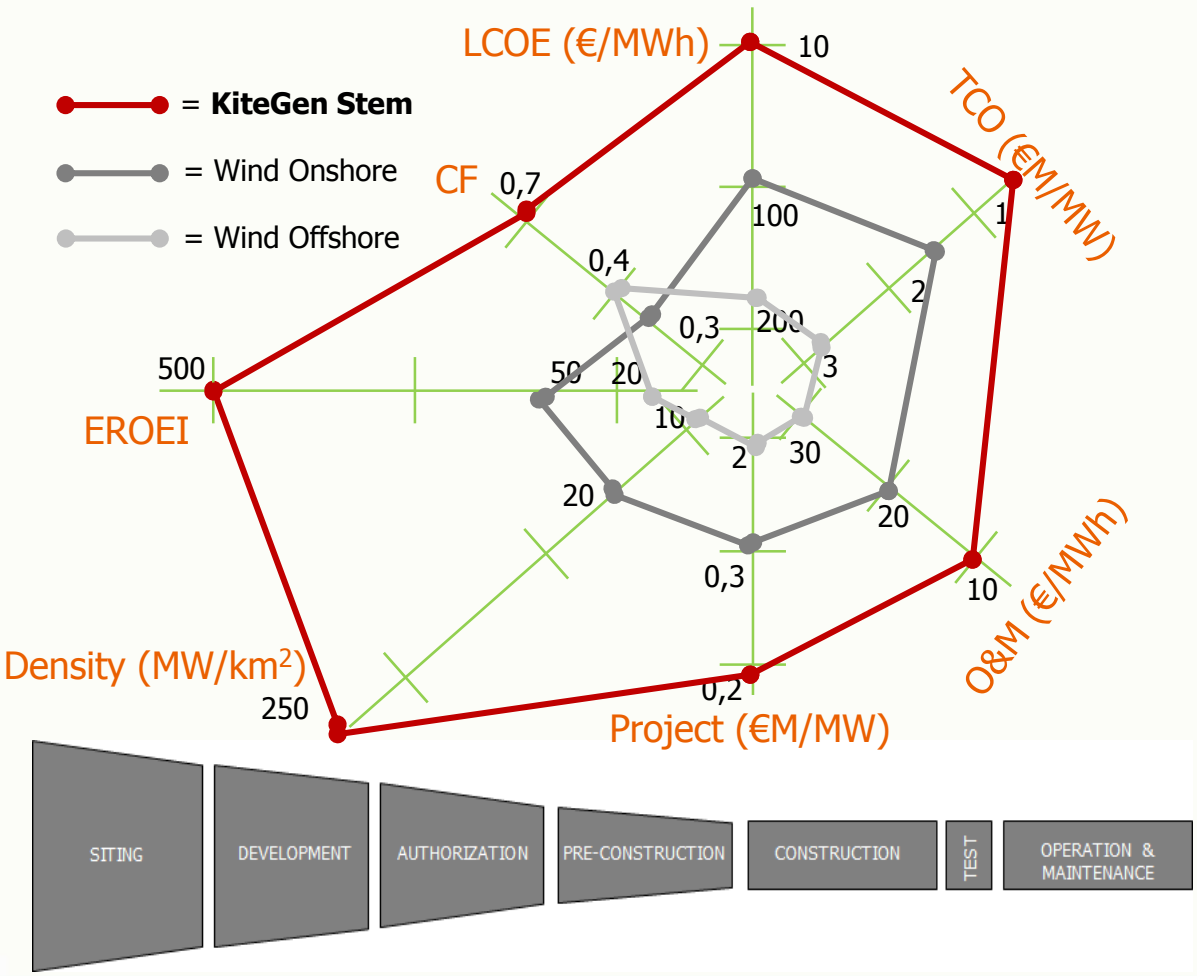
Density **250** MW/Km^2



Performance of the concept

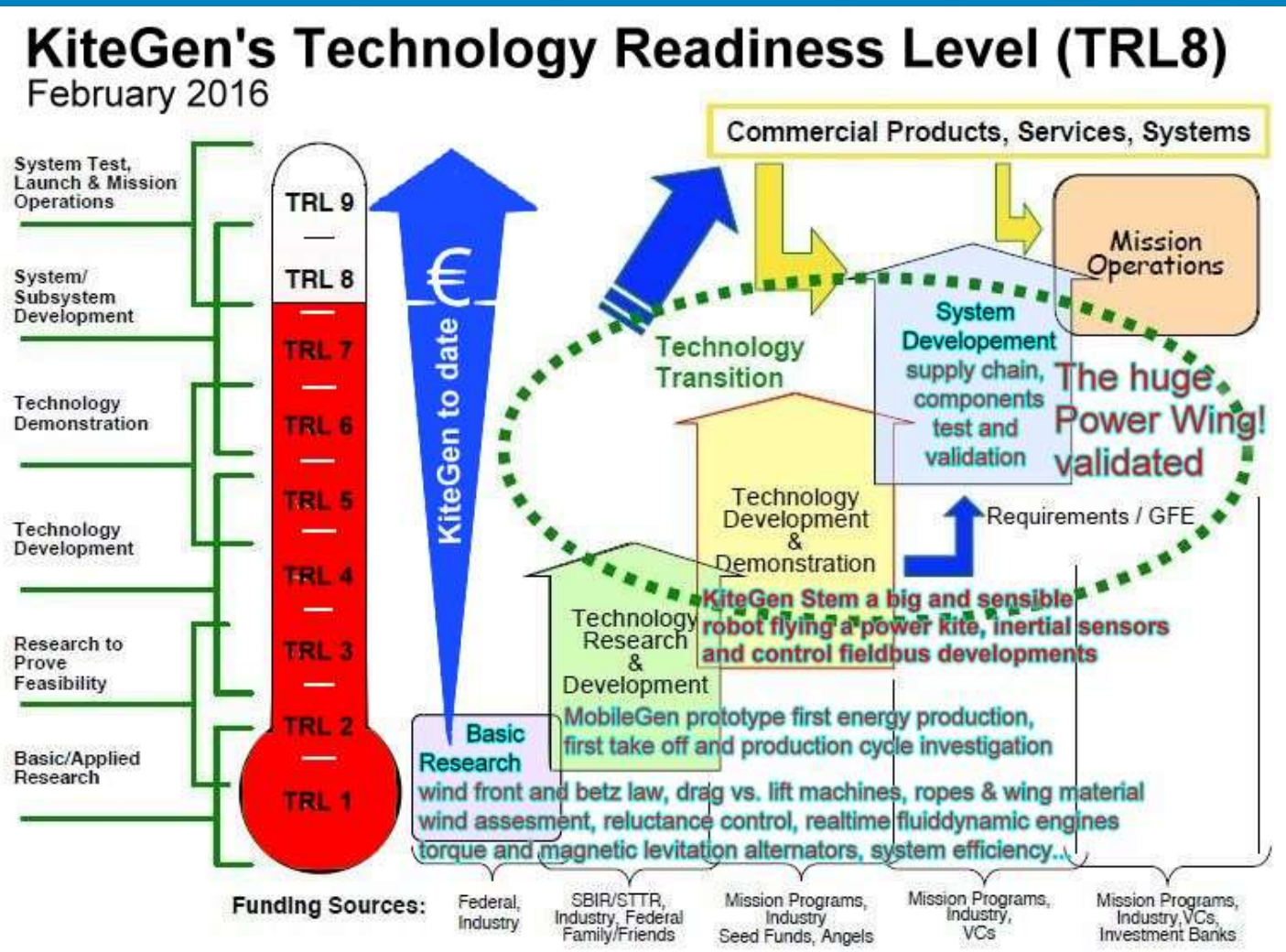


Product services and positioning



- **Sector**: renewable energy, high wind power
- **Product offered**: high wind farm shares
- **Services**: from feasibility study to farm management
- **Customers**: power producers, utilities, energy intensive industries (metal smelting, concrete production, refinery, etc)
- **Competitive positioning**: cost of energy competitive with traditional sources, equivalent initial investment respect current wind, lower operations costs, almost no limitations on siting, much easier logistics and delivery, smaller ground footprint
- **Product structure**: high wind farm composed of new KiteGen Stem generators
- **Strategic activities:** farms development, partnerships, participation portfolio, addressing R&D investments into new KiteGen® by-products or synergic technologies

TRL of KiteGen



KiteGen is a brand new concept indeed.
It was early obvious to the proponents both the challenge and the ineluctability of this paramount development.
Leading to the mission to investigate and solve all the technological problems impeding the exploitation of the biggest energy resource available to the humankind. To date the KiteGen scientists and technicians are depositary of an unprecedented knowledge and experience ready to drive the mass production and the deployment of such new energy presidium.

SWOT analysis

STRENGTHS

- Highest ERoEI source
- High performing and proprietary very feasible technology
- Strong early adopters and partners
- Broad granted patent portfolio
- Open and inclusive company approach
- Further R&D opportunities and improvements

WEAKNESS

- Hostile policies and environment against unsubsidezed RES and innovation.
- Widespread lack of awareness about the energy probem and its dimension
- Difficulty to disseminate and involve skills due concept multidisciplinatity. (all weakness are limited to the very initial deployment phase and building up the supply chain)

THREATS

- Some dependency from regulatory support for flight authorization
- Third parties patents infringement
- Governative strategic preemption
- Bottlenecs in advanced materials supply

OPPORTUNITIES

- Strong international need and growth opportunity for sustainable and cheap energy sources
- Electric and Syn Fuel markets
- Strong negative emission source
- Massive CO2 Capture and utilisation
- New world economic driver

[Holding Company] KiteGenVenture

[Operative Company] SEQUOIA automation

[Patents holder] KiteGen

A Thermodynamic Solar Power Plant vs. A KiteGen Farm: Capital Cost – Apples to Apples

Here is a simple example that illustrates a solar technology in competition with KiteGen power plants. Let's suppose that a power company is planning to install a power plant and wants to implement it with a new and **economically unproven** energy harnessing concept. Furthermore, let's assume that the plant to be built in Morocco. The options for the new plant are KiteGen and thermodynamic solar. The company wants a simple, ball-park analysis of the front-end cost to build each of these options.

The requirements:

1. Electricity demand on this facility is 4,800 MWh/day, about the demand for a community of 700,000 average households of Morocco.
2. The "up time" of both plants must be equal. That is, both must be equally reliable and produce the demand for the same fraction of time over the course of one year.

Assumptions:

1. The thermodynamic solar plant will consist of a mirrored solar collectors, molten salt, and heat accumulator. The system will harness enough during the day to produce the necessary output at night.
2. Night time demand equals day time demand.
3. The new plant will be built in Morocco, a good spot for a solar plant

Economics-Apples to Apples

Capital cost to generate energy	Termodynamic	KiteGen
Electricity Demand **(MWh/day)**	**4800**	**4800**
The net copacity to generate this load is the daily demand/ 24 hours – **Net capacity (MW)**	**200**	**200**
The capacity factor of a power plant is the ratio of its actual output over a period of time to its potential output if it were possible for it to operate at full nameplate capacity continuosly over the same preiod of time – **Capacity Factor**	**0.3**	***0.75**
The gross capacity to achieve this net capacity is the net capacity / the capacity factor of each optuoion – **Gross Capacity Required(MW)**	**700**	**250**
The upfront cost to build a power plant of this gross capacity, or capital cost, **(€million/MW)**	**7.76**	**0.6**
Total Capital Cost **(€millions)**	**5432**	**150**
Total Capital Cost Including Storage **(€million)**	***9000**	****150**

Economics-Apples to Apples

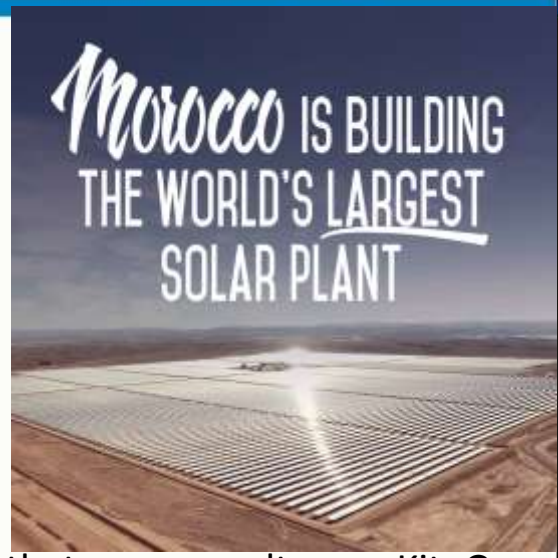
25 year operation	Termodynamic	KiteGen
A) Capex no interest rate **(€/MWh)**	**390**	**4,8**
B) Maintenance/OPEX based on 5% of the Capex/year **(€/MWh)**	**513**	**5.7**
(A+B) LCOE **(€/MWh)**	**900**	**11**
The Life Cycle Analysis could be inferred by the economics of the projects, the solar thermodynamic one is very capital intensive and almost the full investment both Capex and Opex is directly converted in the current mix of energy needed to build and maintain the plants, implying the consequent carbon emissions. An ERoEI value less than 2 means external energetic subsidy required **(Autopoietic ERoEI)**	**0.02**	**500**
Taking care of climate and the antropogenetic CO2, each human activity imply emissions in the atmosphere, KiteGen LCA expose negative emissions potential **(CO2tons/MWh)**	**70**	**-1.2**

* 1500m AGL limit, higher altitudes limits allows better CF

** energy sources with good CF, inherntly solve the storage issue with the conventional grid interconnections: http://www.kitegen.com/en/2016/03/30/spain-2015-lets-replace-turbines-with-kitegen/

Economics-Apples to Apples

***The data adopted comes from the real thermodynamic solar plant project partially (2016) built in Morocco the Ouarzazate with the support of the European Bank of Investment and the World Bank.
According to the energy analysis all those projects, as the lessons learnt about events around Abengoa, Ivanpah , Archimede, are all doomed to bankruptcy.



Conclusion

This back-of-the-envelope analysis suggests that a solar power plant that could deliver that same results as a KiteGen Farm would cost about 45 times to build and 37 times to operate. It is worth noting that the solar option cost excludes any subsidies, investment tax credits, etc., that could narrow the range, but it is obvious from this little exercise that with solar technology there is no chance that it will be sustainable, this policy misunderstanding was clearly foreseeable since the early start the KiteGen project thus our focus on it.
The involved banks are exposed to critics about the energetic (emergy) unaware investment, and in the next future will be charged by the responsibility to have supported projects that emit much more CO2 in atmosphere than the electrical conversion of fossil fuel energy itself, this could assume incurring in lawsuit due the recent introduction of specific rules with penal effects about environmental disasters.

KiteGen

Corso Lombardia, 63/c -10099 San Mauro Torinese (TO) Italy
E-mail: info@kitegen.com
www.kitegen.com
Tel. +39 011 9415745 - KiteGen Venture

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