# PRIORITY 6.1
# "Sustainable Energy Systems"
# Call FP6-2003 -TREN-2

## SPECIFIC TARGETED RESEARCH PROJECTS (STREP)

# Project Acronym: "KiWiGen"
# Project full title: "Kite Wind Generator, smart control of power kites for renewable energy production"

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# Contents

## Proposal summary

Proposal: full title: "Kite Wind Generator, smart control of power kites for renewable energy production"
Proposal: acronym: "KiWiGen"
Research areas addressed: 6.1.3.1.1.2. Large-scale integration of renewable energy sources into energy supplies

## Proposal abstract

The "Kite Wind Generator" –KiWiGen- is a project based on the awareness that the energy available in wind, at high altitudes, is virtually endless. Currently, the possibilities for its exploitation have barely been touched. The KiWiGen project intends to build and run a small version of a troposphere wind generator. The prototype demonstrator will be capable of freely-driving a series of power kites, in order to convert the wind energy into RES electricity.

The main objective of the demonstrator development is to prove the feasibility and the effectiveness of renewable energy production, both at **a very large scale and low cost**. This is made possible by **the smart control of power kites.** The project aims to show the feasibility of a device that autonomously extracts energy from the wind, using tethered kites in tandem assemblies.

The output of this project will be the design, feasibility study and the simulation of a Megawatt class and Gigawatt class RES power plant, capable of supplying continuous and modulated energy for the integration into the EHV grid. This will be done through the assessment of the demonstrator's comprehensive features, both in terms of feasibility and investment/management costs.

In the current scenario, where the effective large-scale integration of RES into energy supplies is impeded by a low territorial energetic density, KiWiGen can provide an original method for concentrating important amounts of dispersed energy into a single generation plant.

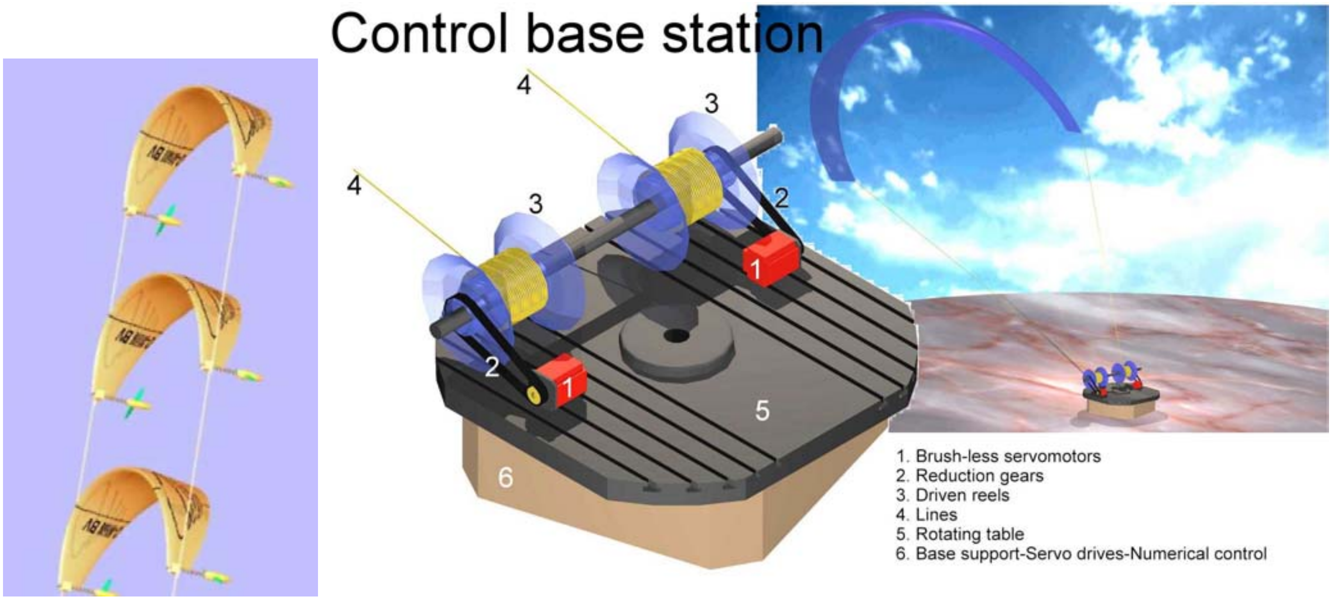
Energy has become an urgent, strategic issue at the global scale. For this reason it is of primary importance for the society to explore and support new technologies, such as the ones proposed in the present project, as they may provide the ultimate solution to the severe energy shortage of the planet.

# B1 Scientific and technological objectives of the project and state of the art

## Project S&T Objectives

The project is focused on the development of a troposphere wind generator, hereafter called kite wind generator KiWiGen. The main project's S&T objectives can be summarised as follows:

- To realise a prototype, in substance: a demonstrator, capable of driving a kite freely and to set-up a procedure capable of converting around 10 kW of wind energy.
- To set-up an optimised method for providing for the automatic control, including the ability to drive the process and correctly react to unforeseen events and to natural wind variations.
- To develop and prove the effectiveness of soft computing theory and technologies envisaged for controlling the kite generator prototype.
- To argument the sustainability of the proposed embodiment in terms of security, safety and environmental impact.
- To prove the scalability of the proposed system, establish the basis for the implementation of Mega or Gigawatt plants, probably in offshore installations, and demonstrate the economical and technical feasibility of the scaled application in the short term/medium, by offering an effective solution to the strategic problem of energy shortage.
- To create public awareness as to the enormous opportunities offered by the proposed technology and to overcome, through demonstration of the running prototype, disbelief or underrating that can be raised by social actors and stakeholders.




### The Demonstrator Prototype

The first step demonstrator that will be developed during the project is a device capable of extracting energy from the wind, by employing single tethered kite or tandem assemblies. The wing or kite is connected by lines to the base station, which acts as the controller and energy generator. The main challenge in the implementation of the generator is expected to be the development of the intelligent control base system.
The generation process, that will be put in place in this particular embodiment, is an intermittent procedure that can be divided into two phases:

- Firstly, the wind causes an upward lift force to the kite, which exerts traction on the cable. This force is transmitted to the alternator-motor pulley and is converted into electrical energy.

- Secondly, the controller manoeuvres the kite through the lines in order to reach the quasi stall or an attitude with a low lifting force situation and reel-in the lines with a small energy consumption.

During both of these phases, an active control of the kite attitude, in combination with the control of the ground pulley, enhances the energy production during the release of the tethers, by increasing the apparent wind. It reduces the energy needed to retract the tethers through an optimisation of the aerodynamic forces on the kites.

The process of **knowledge formation** required to achieve this objective can be divided into three phases:

### The first phase – human control

This stage takes place after having built and completed the system hardware. It consists of sessions where a **trained human** (for instance a kite-surf trainer or a model aircraft pilot) will practice driving the kite by means of a **(joy)stick** interfaced to the control machine. The manoeuvring result can be directly **seen by the pilot**. This phase will be useful to build the base functionality that must be performed by the automatic control and to set-up the responsiveness of the system. It will be possible to harness the **first precious wind energy** and make the first real evaluations and assessment of the proposed solution.

### The second phase – instrumental flight

The trainer will drive the kite in **remote** by employing only the instrumental information. The base station will provide all the useful information, such as forces, energy, tilt, bending angles, wind speed and direction, winding speed etc. The data will be presented to the trainer in a form that makes piloting as easy as possible.
The data stream coming from the machine and the commands issued by the trainer are routed to build a **history database**, which could be available, even in real time, in network. The history database will become the off-line training instrument available to all the involved partners for setting-up the control software.

### The third phase – automatic flight

The software for automatically control the system will be set up. This is a **recursive** phase, during which the progress made in software development will be tested and validated. The still active database collection will allow the programmers to analyse the software behaviour even in remote, in order to rapidly test and fix the revisions.

Therefore the KiWiGen will deal with two interdisciplinary aspects, i.e. the wind and airfoils aerodynamics plus sophisticated control mechatronics.
For the wind and airfoils aerodynamics part, the project assumes that the market already offers special sport kites, for surfing, karting and snow surf activities. They are categorised as power kites with an important background of included research and characteristics which are fully suitable for the first project implementation. One of the partners has already established a working relation with the world's largest surf-kite designers (Naish).

Consequently, the project is mainly focused on the executive design and implementation of the control apparatus, which can be conceptually divided in sensor systems, actuation hardware on the ground and at the kite, plus controlling software.
A special set of wind self-powered sensors, such as an inertial platform, anemometer and electronic compass and attitude steering servos are the kite's onboard equipment in wireless connection with the control base.
From the hardware point of view, part of the technology is borrowed from the machine tool and robotics field, by deeply exploiting servo motors-drives and numerical controls. Most of the partners involved in this project are specialised in smart sensors, machine tools, robotics,

automation, aerodynamics, simulation, flight control and stability of objects in flight. They offer the highly specific skills and experience to face this task.

The kite generator base station that we are outlining has a functional diagram very similar to the one of an industrial machine. It can use more or less the same standard components of a 3 or 5 axis milling machine: servomotors, servo-drives, encoders, numerical control, rotating table etc. A servo drive with full energy regeneration capability has already been analysed and the brush-less motors act as well as generators, with optimum efficiency. Further a kite based servo control will allow the kite attitude to be changed according to the needs for optimal power generation
The great accuracy and precision of these components is not required by the proposed application, but it is not harmful. Instead, the robustness and high power management capabilities fit exactly with the requirements, in terms of kites and line manoeuvring, set by the new application.

### The Software – analytical Vs. cybernetic approach

The control software is the core of the project development and must be built with perception-based decision making, motion and force modelling of the kite in the airspace. An analytical approach is foreseen to set-up the special algorithms required for reducing the developing time. However, it is also an ideal cybernetic application, to be based on neural/fuzzy logic techniques.
Remote interfacing of the numerical control is the main feature on which the method for setting-up the knowledge and the ability for automatic kiting is based.
This knowledge is comprehensive of a correct reaction to unforeseen events and to natural wind variations.
In parallel, a comprehensive simulator will be developed, in order to describe the actual kinetic behaviour. This simulator will be used to study optimal strategies for energy production, as well as for the analysis of the motion obtained during the tests. The combination of the tests and simulator will provide an insight into the stability and control parameters related to this concept of kite control which can lead to further refinements.
The kite generator controller should acquire the skill and copy the behaviour of a **trained person** driving acrobatic kites and model airplanes. This result will be achieved by pursuing both analytical and fuzzy solutions for the development of software modules:

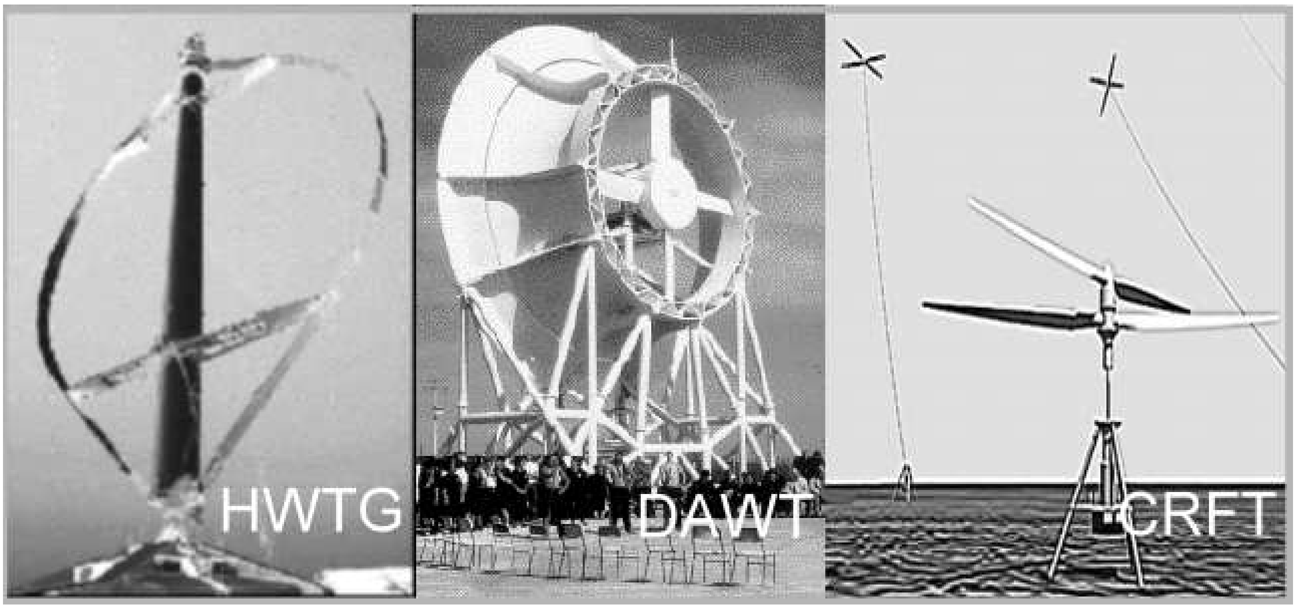
- The **analytical** approach means that the system will be described and controlled by a set of specially designed **algorithms**, providing feedback on the lines through the winch/reels, on the basis of the data collected by the **sensors,** (in combination with the kite's on board attitude control.) This software can be **scaled** at different levels of **coding difficulty** and efficiency in exploiting the wind. On one side, an **easier coding** can behave in conservative mode, by improving the operational determinism. On the other side, the software complexity can be forced towards acrobatic performance, thereby improving the energy collection attitude. In any case, the computing power available in current microprocessors can support every level of **real time software** complexity and resource demands; certainly enough to outperform humans in providing fast and calibrated retro-actions.
- Lofti A. Zadeh, the **fuzzy logic** inventor, is expecting to see many new apparatus with high "**MIQ**" (Machine Intelligence Quotient) appearing in the near future. In this project, the soft automation solutions based on neural/fuzzy can find a good field of application for developing **high MIQ**. An optimisation advantage in the amount of energy conversion of the fuzzy vs. the analytical approach can be expected.

# State of the art and limitations of the current wind generation systems

### (WTG) Wind turbine generators or windmills

The project intends to build a system that can integrate or even replace traditional wind turbines. WTG are currently considered the most promising sources of renewable energy. But they are still built with a "**low MIQ**", on the basis of hard automation concepts. In order to produce electric energy, they require huge towers and blades, which make a significant impact on the environment, require massive investments and long-term amortisation periods. They incur high maintenance costs as well, estimated at 3% of the original investment. Heavy problems arise when building the foundations of the structure, especially for offshore installations, as complex engineering works are required. WTG have a wide problem of social acceptance and even the economical assessment declares a cost for kilowatt hours (kWh) several times higher than the one incurred with the traditional systems for energy production.
Research is currently focused mainly on improving the performances of the current systems. Little has been done to study and develop new concepts. Debates on the number of blades, aerodynamics concepts, multi-rotor turbines and research for lighter materials and structures are in progress. However, a windmill installation project often results as being unsustainable, due to the limited installed power (0.5-2MW) that makes the connection to the grid unpractical. For this reason, there are big efforts to improve the power of a single turbine, but no more than twice as much power is expected.

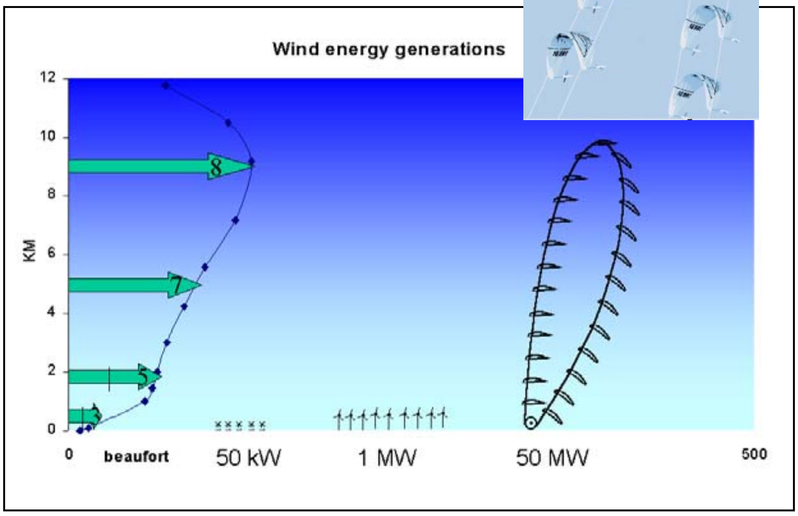
## State of the Research




Some attempts to propose different designs of wind turbines are known, such as the diffuser augmented wind turbine (DAWT) and the horizontal turbine (HWTG) that have already been tested as prototypes. Another idea is the concept of counter rotating flying rotors (CRFT) but it has never been implemented.
However none of these projects attain the property of exploiting arbitrary large sections of wind front as is foreseen by the KiWiGen.
The process for the conversion of the high altitude wind energy, has been patented in different forms and variations, at least 20 times since 1966. **However, no one has ever tried to actually produce a working demonstrator**. Almost all the patent authors have presented the idea without entering deeply into the challenges and the problems raised by the control systems.

### The Laddermill project

One of the most recent European patents is the LADDERMILL. It has also led to the publication of an expression of interest for integrated projects under the title "EXPLOITATION OF WIND ENERGY AT HIGH ALTITUDE". Similar to our premises, the Laddermill is a huge and very interesting project.




It aims at capturing the enormous energy available in the troposphere wind via a system composed of a series of wings or kites connected to one or more cables. This system forms a wide loop which is self-supported by the wind. The kites can reach altitudes up to 10000 meters. The ascending kites would drive an energy generator on the ground, while the descending kites would either follow a closed loop cable or could fly down independently, like a glider plane.

It is argued that by connecting the ground wheel to a generator, an important amount of electricity could be produced, around 50MW of installed power.

The author of this concept, Prof. Ockels, from the University of Delft, who is now a member of the KiWiGen consortium, has reasonably classified this specific approach as a long-term project. Laddermill has been underway for some years as a national project.

In the case of the KiWiGen project, it is focused on a short-term result. However there is a clear synergy between the KiWiGen project and the Laddermill project. The knowledge developed in the Laddermill project is made available to KiWiGen and vice versa. In particular the aerodynamics, the kinetic simulation, the attitude stability and control expertise of the Laddermill project will support the KiWiGen project. The knowledge obtained regarding advanced software control of the kites will enhance the progress of the Laddermill's development.

The Laddermill's published patent shows a solution that addresses mechanical and physical aspects of the problem. The control developed in the KiWiGen project provides sophisticated and retroactive control and management capabilities. The kite wind generator project that we are envisaging can be considered a never explored approach. But it can be seen as a meaningful and value adding phase to the Laddermill as well.

### KiWiGen Breakthrough, Step forward, Enhancement

Rather than pursuing an incremental approach towards innovation, as made by DAWT and HWTG, the KiWiGen, as the LADDERMILL proposes an actual breakthrough.

From the research point of view Kite Wind Generator candidates itself as a totally renewable energy generator capable of:

- Running in territory considered as not having enough wind to install conventional windmills.
- Potentially achieving powers of hundreds of Megawatt supplied by a single plant, by harnessing large sections of dispersed wind energy.
- Running without fix installation and overcoming the foundation issues raised by windmills thanks its low centre of gravity (the small version can work even mounted on a truck).
- Automatically interacting with weather, wind, environment in order to optimise energy production at various altitudes, to envisage and properly react to security and safety issues
- Demonstrate effective soft computing in high power applications, by implementing motion and attitude control based on analog sensing and behaviour modelling.

# B2 Relevance to the objectives of this Priority Thematic Area

### SUSTDEV 6.1 Workprogramme compliance

The KiWiGen project is an innovative technical approach to RES electricity production, storage and integration. It intends to verify, in a very short period of time, with a clear methodology, the feasibility of integrating this form of energy generation into the existing grids at an exceedingly large scale. Thus it fully addresses the priority thematic area 6.1: "Sustainable energy systems," whose main goal, according to the Workprogramme is to alleviate and reverse the adverse trends, to achieve a truly sustainable energy system, while preserving the equilibrium of ecosystems and encouraging economic development.
The strategic and policy objectives of this Workprogramme, of research into sustainable energy include(...) increasing the security of energy supplies, (...) and increasing the use of renewable energy.

### KiWiGen STREP, topic compliance with the section 6.1.3.1.1.2

Our proposal is focused towards those "Research activities having an impact in the short to medium term". In particular it refers to Section 6.1.3.1.1.2 "*Large-scale integration of renewable energy sources into energy supplies*," as it addresses "*innovative technical approaches to the* ***production****, storage, integration and use of:* ***RES electricity****, such as* ***wind****, biomass and wastes*". In this Section, according to the Call Text, all topics are addressable in the case of STREP projects. According to the Workprogramme section, "*The research component of such projects may include the development and analysis of innovative technologies*," which is the case of KiWiGen.

This project overcomes the limitation of proposing only an incremental innovation on WTG or components and design tools (as delineated in cost effective supply of RES 6.1.3.1.1.1) as it may lead to a breakthrough that raises the production of energy by several orders of magnitude. It addresses the feasibility of concentrating unforeseen amounts of wind energy into **Gigawatt power plants** along with their large scale integration into the EHV grid, an effort which fits better into 6.1.3.1.1.2.

### Overall strategic relevance

It is redundant to highlight the urgency of creating sustainable and renewable energy sources for Europe, as an endless list of official and advisory documents may be quoted relative to this need, such as the "Issue Advisory Group/Energy" (February 28, 2002) report regarding Sustainable Energy. According to this document some of the main targets for creating an enabling sustainable energy framework are:

- To ensure that renewables are adequately considered as part of international energy policy.
- To help formulate and implement domestic sustainable energy policies taking in account both the role of renewables, (solar, wind, bio-mass, geothermal, hydro and fossil fuels.)
- To strengthen advanced research and innovation for renewables, and also manage fossil fuels more effectively and efficiently by financing energy institutions and organisations, and encourage the participation and contribution of businesses at all levels.

All of these targets coincide with those of the KiWiGen project.

### Short-to-Medium term KiWiGen compliance

The project is aimed at achieving an impact within the short to medium term. According to the workprogramme *"In the short to medium term, the sustainable energy priority states the goal of paving the way for the introduction of innovative, cost competitive, renewable and energy efficiency technologies into the market, as quickly as possible, through demonstration and other research activities directly aimed at the market"*.
The KiWiGen project has already gone through preliminary activities involving conceptual design

and revision of its theoretical framework and now has to move forward in a well-focused straight line. Moreover the knowledge acquired in the Laddermill project will be available.
The development path starts from the demonstrator realisation, moves through the performance assessment and leads toward gaining enough specifications and information, credibility and authority, to propose to the stakeholders the first large scale pilot implementation of a power plant based on the KiWiGen project.
Therefore, the aim of this project is to prove the functionality and the feasibility of the KiWiGen concept by achieving meaningful results at a small scale, with a relatively small investment when compared with the huge potential impact.
The follow-up will be public understanding and approval leading to a large initiative aimed at the design and physical realisation of the first large scale kite generator.
The following considerations show how the proposal complies with **the four guidelines** defining **short-term research**.

***1.*** ***"****Deliver results, which will accelerate the market penetration of innovative energy technologies with a particular emphasis on the 2010 energy policy objectives".*
It is expected that evidence of the high competitiveness of the KiWiGen system will be accertained, even compared to the conventional energy sources. Therefore the strong acceleration of the **RES integration** process will be almost **unavoidable**, by triggering an avalanche effect that can make KiWiGen RES energy the primary global source in few years.

***2.*** ***"****Consist mainly of integrated demonstration actions with a typical research component of up to about 20% and including, where appropriate, pre-normative research, energy technology integration, dissemination and technology transfer activities. The risks to be addressed are mainly technological and might include market related and financial issues".*
Principal support is required to **assemble** and set-up the demonstrator, to present the principles and analyse the data, to carry out **dissemination and outreach** activities aimed at building the new concept of KiWiGen into people's mind; to get political and social support and recognition and to create a favourable framework for the exploitation of the new opportunities offered by the proposed technology.

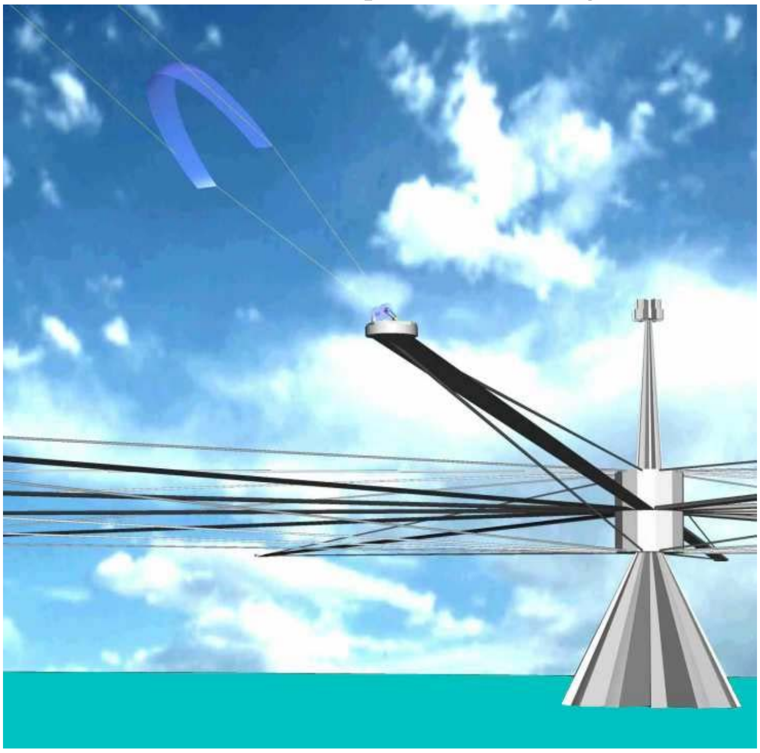
***3.*** "*Demonstrate reductions in the costs associated with implementation of new technologies and/or demonstrate how innovative technological solutions can be integrated under full-scale operating conditions".*
First evaluation figures show a **reduction of about 100 time** the required capital investment and the plant exploitation **costs**. Moreover the system is scalable, from very small to huge dimensions with minor conceptual adaptations. This project aims to provide evidence and consolidate these presumptions.

***4.*** ***"****Provide inputs for the future development of energy policy and legislation. Indeed, an effective process of policy design has to take into account the net environmental effects and the cost of different renewable energy sources".*
It is urgent to increase public awareness so as to seize this new opportunity and suggest energy policies and legislation in **research orientation**. The hope is that this project will be in time to halt the planned construction of new thermo-fossil/nuclear power plants, as it is addresses the energy shortage emergency, by providing a real alternative.

## Large scale integration: the two-fold outcome of the project

1. The KiWiGen **control base station** can become a stand alone machine, to be produced and sold as a distributed generator capable of providing energy at the local level, with very easy and fast installation. It can be considered the first **high power portable wind generator**. It is foreseen that the first demonstrator can be mounted on a truck, and moved from site to site for verification.

2. Setting-up the KiWiGen control base station can lead to the **conception** and design of Megawatt or GigaWatt plants, built on the same basic concept and maintaining or more likely outperforming its advantages in terms of investment per installed Watt. In this case, the KiWiGen becomes one of many identical modules that build up a large scale RES electricity generator. The control base station acts as kite pilot renouncing the direct conversion of energy, rather its precious ability to drive a kite is used to thrust and modulate forces on a wider frame. The latter makes use of a circular tensor-structure, that rotates around a vertical axis, whose pivotal centre is geared with a **conventional alternator**. This embodiment is called the KiWiGen CAROUSEL.
   One of the worst problems in the generation of RES electricity is the low territorial energetic density. The connection to the existing grid is an additional cost that weighs on the economical balance of the RES system. The KiWiGen research project will provide an answer to the important question regarding the feasibility of concentrating large amounts of renewable wind energy into a single plant, allowing for an effective connection to the EHV grid.



The project, by developing a system capable of directly generating electricity by means of the wind, without the need for massive investments and structures, provides a direct contribution to the EU's commitment to "*increase the percentage of renewable energy sources in its supply mix*." The adoption of a radical new approach would exceed the expectations set in the WTG research objectives: presently limited to the design or study of new solutions for foundations, propellers and support structures.

## The centre of gravity of the proposal

The priority thematic area 6.1 is clearly the "centre of gravity" of the proposal. But several activities in the project are also relevant to the research topic "FP6-2003-IST-2 2.3.2.4 Cognitive Systems". This is an evidence of its high degree of multi-disciplinarity. The focus of IST 2.3.2.4 is on "Methodologies and construction of robust and adaptive cognitive systems integrating perception, reasoning, representation and learning, which are capable of interpretation, physical interaction and communication in real-world environments, for the purpose of performing goal-directed tasks" This applies to the development of perception-based decision making software.

# B.3 Potential Impact

### General Premise

The KiWiGen intends to contribute to the challenges arising from the need for renewable and sustainable energy imposed on the European area by industrial development.
Oil imports alone weigh on the Union at some EUR 300 billion; this figure is growing each year. The EU-15 is importing approximately 50% of this energy and, with the current development patterns, this dependency is expected to increase still further (up to 70 % by 2010).

A worrying description of the energy role in Europe's economy and safety is provided in the EU Green paper: "Towards a European strategy for the security of the energy supply." It addresses the urgency of projects, instruments and policy measures which make the effective exploitation of renewable energy sources a fundamental requirement for the future of the EU. Facing the energy emergency and climate change, the European Union has undertaken the Kyoto commitments to reduce by 8% the 1990 emissions of $CO_2$,.

World annual energy demand is predicted to double by the year 2030, as the developing countries grow. This scenario will be preceded by a dramatic increase in the energy price, due to the unbalanced level of supply and demand. Therefore it is the precise responsibility of developed Countries, by exploiting their proprietary high technologies and know-how, to reverse the current trends and achieve a truly sustainable energy system, while preserving the world-wide equilibrium of ecosystems and encouraging economic global development.

These elements make it evident, that today, to speak about RES is no longer an "environmentalist dream" but rather a necessary objective, which all of the decision makers will have to take into account in order to increase the economic and strategic security of the European States. The energy sources for the world will have to become **renewable** by definition, not as an alternative, but as an established standard.

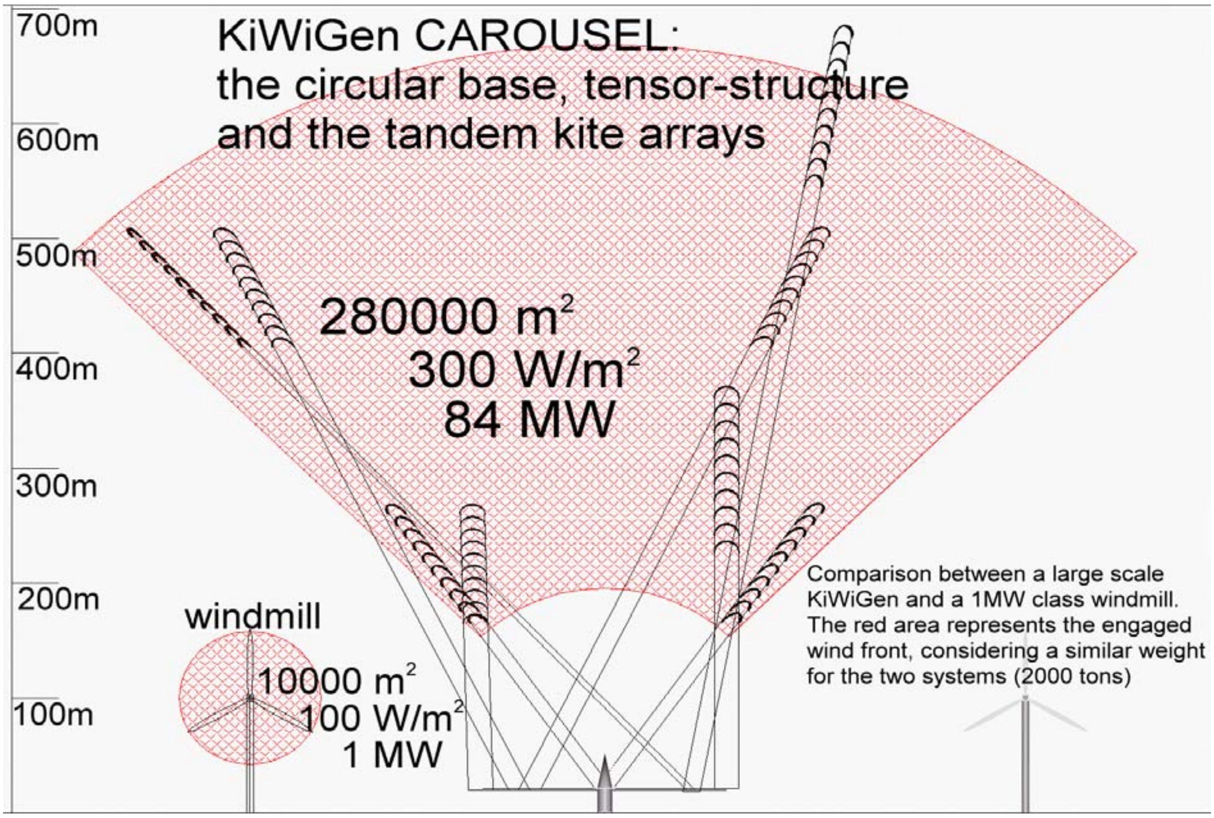
### The impact of the intelligent control system

The small demonstrator developed in the present project is the first test bed for the KiWiGen intelligent controlling core. The expected confirmation of the KiWiGen's performance, the feasibility of its design and the scalability of the demonstrator will have a high potential impact to trigger a revolutionary and shocking change in global energy perspectives and politics. The concept of freely driving kites via and untiring machines makes possible many different wind harnessing solutions, that can be scaled from very small to **promising huge** dimensions, with minor conceptual adaptations.
The control base station can act as a **pure kite pilot** without directly converting energy. The precious ability to drive a kite is used to thrust and modulate forces on a wider frame by dragging a **conventional alternator**. In this mode the driving force can be even used to propel ships and other means of transportation.

Without entering into design details, it is possible to make some preliminary evaluations on the energetic potential of a **KiWiGen very large scale application**:

- It is possible to build a system with an arbitrary number of wings,
- the area of each wing can reach hundred of square meters without loosing the kite's control capability.
- It is not required to over-dimension the components to gain a security margin, because in case of impulsive strong winds the KiWiGen core reels out the lines, thereby reducing the apparent wind acting on the wing. The lightweight of the inflatable structure provides the flexibility to handle local turbulence, while the attitude control can dampen the effects of wind bursts.
- The intercepted wind front can easily reach an area of a million of square meters with a specific

architecture and feasible, quite ordinary structures.




The Consortium expects the project to generate precise answers, but we have summarised some provisional figures, to support the legitimacy of this claim. Following are some rough approximations as to the energy captured by the kite horizontal wind turbine generator, or **KiWiGen Carousel**, in the large scale version outlined by this project.

- The values regarding the wind's absolute power per squared meter, in function of the speed and of the altitude, are easily computable.
- The KiWiGen kites swing at high speed large sections of the wind front, by disturbing the air stream kinetics and subtracting most of the inertial energy.
- The aerial part of the generator weighs only a few hundred kilos, even for the highest power applications.
- Special technological cables such as Dyneema, also enhance the feasibility, as their tensile strength is capable of resisting 30 tons per cm2, and these cables weigh only 100 kg per km.

### A Gigawatt example, kites and cables: required performances and effects.

The extraordinary features of the recently developed cables (such as Dyneema®) offer the missing link needed to achieve the Gigawatt power: an example of which could be roughly some 40 MN (4000 tons) applied tangentially on the **carousel generator** at a speed of 25m/s.
By considering a system with 20 kites in tandem assemblies, the maximum force applied on each of the 40 cables is about 100 tons. That means a diameter of 20mm and a cable weight of 300 Kg per Km. Each tandem kites assemblies have to exert a traction of 200 tons, which means, by considering a tandem composed of 10 kites, 20 tons applied by each kite. The surface of each kite with a traction of 100 kg per square meter can reaches the surface value of 200sqm, like the sails of a yacht.
Therefore, a wind of 10m/s, that is the European medium value at 1500mt of altitude, contains about 1kW per square meter. Assuming an efficiency factor of 25% and a sweep wind front surface of 1 square kilometre, the power generated could be 250MegaWatt.

Assuming a stronger wind with a 20m/s (70 km/h not rare in altitude) speed value as the power generated varies with the cube of the wind speed, the harnessed power can rise to 2 Gigawatt, against a total wind inertial power of 8 Gigawatt.

Everyone who approaches this new wind generator concept for the first time is fascinated and amused by the new perspective. However, everything becomes tremendously serious when a rough evaluation of the cost per installed Watt is performed and compared to the other power sources. First calculations show that the investment cost is approximately 100 times lower than the one necessary for conventional generation plants. A comprehensive technical and economical documentation will be produced to verify the project premises and offer all the decision making tools for the project follow-up.
The most important impact is foreseen for the **large scale application** of the KiWiGen. **However** in the short term horizon the project activities will already have an immediate impact, due to the development of the **small demonstrator** that can be shaped in different forms and be immediately proposed to market. It will be seen as an intermediate step towards full potentiality. The KiWiGen project can **directly** and immediately have several important potential impacts.

### Availability of a light and small wind generator with many special features

The proposed demonstrator represents a completely new product. The foreseen solution provides a high power portable generator that can be easily set up and mass produced. It can assume various configurations, shapes and embodiments in order to make effective the stand alone and automatic management. i.e. additional solutions for the automatic take-off or landing can be taken into account too. The adaptability of the system allows it being employed in areas which are traditionally not considered suitable for the exploitation of wind energy, due to the morphological or climate characteristics. Moreover, it is possible to think about eco-buildings, i.e. architectures enabling the integration of the KiWiGen directly into the building structure. The generator will be properly shaped in order to meet the energy requirements of the residential or industrial location in which it is integrated.
Rules and limitations in terms of occupation of the aerial space may limit the development of the system and the exploitation of the KiWiGen. They may oblige the proposal of a low profile solution, by requiring the implementation of a limited version, employing kites which do not exceed the maximum allowed flying altitude. (The authorities of the northern Dutch province have already assumed partnership in the Laddermill project and have indicated support for providing test grounds.)
Several levels of action can be identified according to the extent of the development activities:

1. A territorial license may be required during the first project phase for testing the prototype in a restricted and well identified area, with communication to the competent authority
2. Whether the results gained comply with present expectations, inputs and proposals for new regulatory measures will be provided, or departures from the rules will be required in order

to boost exploitation and development of the proposed technology

The consortium is confident that the proposed system can provide a real breakthrough and the EU and national legislation will have to be modified in order to build a framework for the development and the exploitation of the proposed technology.

### New employment and new industrial activities in building, installing and maintaining KiWiGens

Regardless of the level of development that will be achieved by the demonstrator, the proposed technology will provide an important contribution in terms of new employment and new industrial activities. Again, it is possible to envisage different scenarios.

- The KiWiGen development phase will be concluded successfully and the expected results fully achieved. It is possible to forecast that a very large number KiWiGen or sub-assemblies will be provided or installed world-wide, by realising KiWiGen wind farm or large scale generators or providing stand alone generators for communities which are currently excluded from the energy network,
- The work has led to the development of a demonstrator providing all the expected features and capabilities, but still requires more work and effort. This can likely result in the world-wide supply of thousands of sub-assemblies, to research Centres and Institutes committed to further develop the product and enhance the system features.

The KiWiGen can be a totally new product. Without strong overlapping or competition with other industry, it is suitable for installations were the conventional windmills are not applicable.

### Demonstration of effective soft computing in power applications

World-wide, the intelligent or soft computing theory is famous and has been successfully implemented only in non-material fields, such as search engines, OCR, voice recognition, biometrics, etc.. Instead, when applied to the real world and to concrete applications, the spectacular effects and performances are still awaited or not evident enough, (control techniques, autopilots, advanced toys). Effective application and exploitation of the soft computing theory for energy generation can demonstrate the effectiveness of soft computing and boost the implementation of systems based on this technology. The exportability of soft computing solutions for the exploitation of other RES energy sources (such as biomass) is one of the most relevant impacts deriving from the successful project implementation.

### Hydrogen production from the wind energy.

Wind speed has the natural characteristic of varying considerably. Its power changes subsequently, with a function that is the cube of the speed. Accordingly to the site where the installation is placed, periods of exuberance of power and others with lower energy availability can rapidly take place. This intrinsic, intermittent characteristic of the wind energy can be profitably exploited during the production peaks to synthesise Hydrogen or methane and achieve an accumulation effect. In this manner truly renewable Hydrogen production becomes a reality.

### Impact on developing Countries

The KiWiGen, by increasing the availability of renewable energy at low cost, can mean a real breakthrough for the economic advancement of developing Countries. Indeed, many of those Countries are building power plants at a high speed, most of which are conventional installations. Economic development causes a parallel growth of the energy need pro capita and consequently of the environmental pollution, by creating hazards for the whole Earth. The KiWiGen can be the key for building a sustainable energy system, as the exploitation of a renewable, indigenous source of energy can avoid the impoverishment of the country's resources, avoid harmful emissions and reduce dependency on fossil fuel.

Furthermore, the elements of the KiWiGen, i.e. ultra light flying structures as kites for energy production, are likely to receive general acceptance. Finally, it must be noted that in many developing countries the wind at high altitudes contains significant power, due to the whirling wind flows.

### Impact on the environment

One of the benefits of wind generated electricity is that it avoids most of the traditional negative environmental impacts associated with electricity generation. No emissions of particles and harmful gasses (like $CO_2$, $SO_2$ and $NO_x$), which result from the combustion of fossil fuels such as coal, oil and natural gas, take place. Similarly, wind power does not result in the risk of radioactive exposure, associated with nuclear power plants. These advantages are common to both the traditional windmills and the KiWiGen. However, the new technology that is envisaged by the project is able to overcome the traditional negative impact on the environment, which affects the windmill diffusion. The aesthetics of traditional wind mills is also questioned, resulting in the requirements for these structures to be placed far from areas which distinguish themselves for characteristic landscapes. Therefore, despite the windmills having known a large diffusion in Denmark, it is not possible to think about the same happening in Tuscany! By eliminating the invasive structure of the columns and moving the generator on the ground, the structure will receive general acceptance. It can even be argued that the employment of kites is pleasing to the eye.

### Exploitation plan

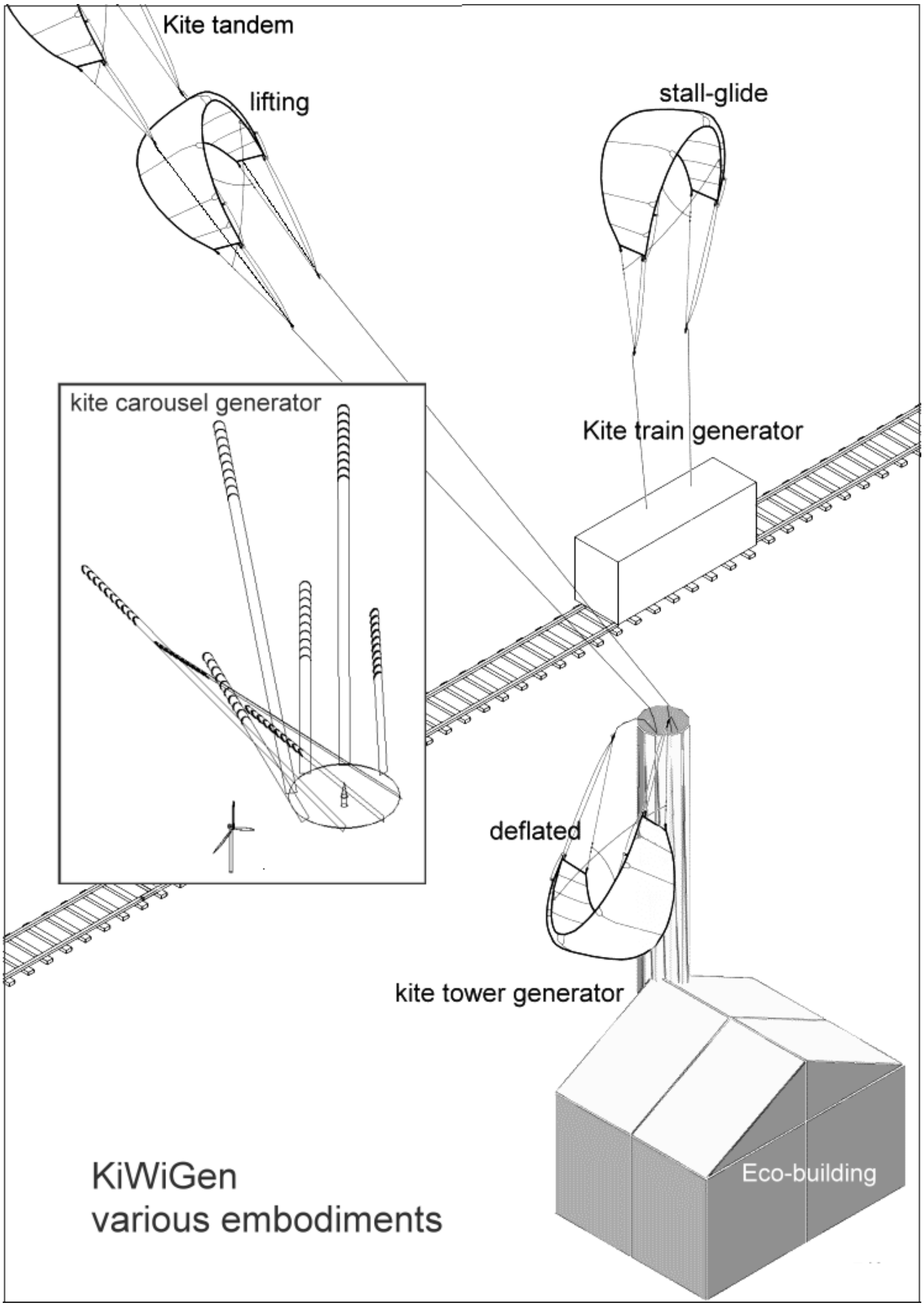
The Partners involved in the design and implementation of the KiWiGen demonstrator are determined to offer to the market a new product, that is considered compatible with their know-how, their own technologies and current machine, sensor and control production capabilities. The Consortium can relay on high competencies in electronic, mechanic and software design, simulations and aerodynamics. It has a wide experience in developing innovative solutions and drastically reducing the time to market.
The KiWiGen concept was born even with the idea of setting up an alternative wind RES generator for very low wind resources, such as the ones which are available in Northern Italy.
The demonstrator alone is a product that can be successfully placed on the market. Moreover, it can become one of the many identical modules building up large scale applications. Different solutions and demonstrator developments may be studied and produced by the Consortium as well. The Partners will be holders of a large amount of knowledge, that will be protected by patents if required by the project development pattern. This will provide them with a clear competitive advantage over any other Operator acting in the energy market. Whether the project is successful, the Partners will gain recognition and visibility at a global scale, by providing an effective solution to the energy emergency, which imposes a heavy burden on sustainable economic development. The exploitation plan of each partner will be detailed in section B.4.

### The European added value

The European added value for the proposed project comes from the scale and the ambition of the stated objectives and from the capacity to make a significant contribution to reinforcing competitiveness and increasing the volume of renewable energy supply within the EU. Moreover, the reduction in cost is expected to provide a major drive towards social and economical development and to allow for the construction of a truly sustainable energy system.
The project can have different development patterns. Whether limitations to the proposed approach are identified, sites, studies, research centres at a broad European level will be identified to overcome all the obstacles faced, and meet the stated project objectives. A successful development raised to different levels, requires research, modelling, optimisation, training and dissemination activities.

## B3.1 Contribution to standards

In the course of our project, the Consortium will be creating an entirely new set of standards, (regarding energy costs, measurements and efficiency,) as the standards for the specific technology that we are developing have not yet been established. Therefore, new standards for this kind of wind energy production should be created. The development of the prototype and foreseen large-scale applications will show in which area new or adapted standards are to be developed. Existing contacts with, e.g., the European Wind Energy Association will be used to define new standards.



## B.4 The consortium and project resources

The project consortium includes the following partners.

| Activity Code | Nr | Org. Name | Country | Nr of empl. | Business activity | RTD Role |
|---|---|---|---|---|---|---|
| RES | 1 | Sequoia automation | IT | 10 | SW & HW Engineering Electronic Design Sensor development | RTD on smart sensor, design of HW and SW modules, control and pilot system development. |
| IND | 2 | Fidia | IT | 150 | Manufacturer of Numerical Controls, high speed milling machines and CAM products | Integration of SW modules into NC and servo drives, manufacturing of the demonstrator. |
| IND | 3 | CE.S.I. | IT | 20 | Engineering Company (SME) specialised in machinery design and analysis | Mechanical design and analysis of the generator base station. |
| IND | 4 | Fatronik | ES | 60 | R&D in Mechatronics | RTD on design of base station and energy generation device. Fuzzy control of the system. |
| RES | 5 | Institute of Electric Technology | ES | 52 | Technology promotion in the energy, electric and electronic sectors | Rapid prototyping, development of electronic boards, programming of embedded systems |
| HE | 6 | Delft University of Technology | NL | 400 | Aerospace sustainable engineering & Technology Dissemination | Aerodynamics, simulations, control and stability, lightweight and inflatable structures. |
| HE | 7 | Utrecht University Copernicus Institute | NL | 120 | Scientific research on Sustainable Development and Innovation in relation to technology and society | Feasibility studies, life cycle assessments and life cycle costs, dissemination |

The specific expertise of the seven partners is complementary, and will cover all of the aspects of the work needed to complete the project. Two of the partners are SME's (Sequoia and Ce.S.I.). They will have an essential role in promoting innovation within the Consortium. Two Partners are academic institutions, two are large enterprises and one is a private association of enterprises . Their roles are detailed as follows:

**Sequoia Automation** Is the author of the KiWiGen concept and the promoter of the initiative. Based on its extensive experience in industrial automation it was the first to recognise that its existing partner team, in the areas of machining and mechanical engineering design, would be able to give this idea a concrete form.
Sequoia will contribute through its experience in the development of smart control systems and its capability for synthesis of complex projects involving the design of both hardware, software and mechatronics. One of the conceptual kernels of the KiWiGen project is the most recent and

innovative use of the SeTAC Triaxial Acceleration Computer created (within EC/RTD ESPRIT IV Project.) and produced by the company since 1999.
Based on the great acceptance of the SeTAC concept and following its customers' suggestions, Sequoia has already planned the implementation of several additional SeTAC applications in aerospace domains such as **drones** and **avionics subsystems**. These areas of development will co-finance the KiWiGen initiative, as they provide an excellent occasion to merge the development efforts of such instrumentation as artificial Horizon and inertial platforms, with the needs of research and development to be undertaken for the KiWiGen.

**Fidia** will produce the engineered version of the demonstrator, composed of the base control, the numerical control, and the servo drives. In particular, the servo drives will be modified to be used for the energy regeneration process, in addition to their traditional use of providing commands to the reels. Moreover  the software modules, for the implementation of the control logic that will generate these commands, will be integrated into the numerical control environment.

**Ce.S.I.** will provide its expertise for the design, the structural analysis and ground calculations of the base platform, for the mechanical verification of the demonstrator, the final tuning of the mechatronic solutions, the concept design and definition of large scale applications. CE.S.I. will also handle activities related to the dissemination of the project results.

**Fatronik** will contribute through its experience related to energy generation and conversion, mechanical design and intelligent control of machinery.

The **Institute of Electric Technology (IET)** will provide its contribution in the dissemination phase and in the promotion of the prototypes. It will be the project "spokesman" for the **Valencian Energy Agency**, whose Director, Dr. Antonio Cejalvo is the Vice President of the Institute. It will contribute actively to the verification of the project activities and to their large scale integration. The Valencian Energy Agency establishes and implements the large scale energy policy for the region, in keeping with the objectives of the European community, and with particular emphasis on the adoption of renewable energy as a large scale source.

**Delft University of Technology** will guaranteed a high academic profile. The ASSET chair (AeroSpace Sustainable Engineering and Technology) held by Prof. Wubbo Ockels will develop a simulator that  presents comprehensive explanations to the general public,  as well as a support for the design and analysis of the tests. The development of remotely controllable kites will be inserted into the research and education program. The ASSET chair will subcontract to **O-MILL BV**,  the startup company that develops the Laddermill in cooperation with the Delft University of Technology. The knowledge regarding kite behavior and the conceptual ideas regarding their control will be made available to the partners.

The **Utrecht University**, through its Department of Science, Technology and Society which is part of the Copernicus Institute for Sustainable Development and Innovation, further abbreviated as UU-STS, will further add to the already high academic profile of this project.  It will be active in nearly all Workpackages of the project, with special emphasis on feasibility and potential studies, Life Cycle Analysis and Life Cycle Costs analysis. Also, being a University, UU-STS has a large and consolidated experience in disseminating scientific knowledge to a broad audience, ranging from scientific colleagues all of the world, via graduate and undergraduate student courses, and via publications in popular magazines and/or newspapers.

Following is a more detailed description of the partner profiles and their contributions to the project. It shows that all partners are strongly committed to achieve the envisaged results, and will place all the needed resources (experienced researchers, laboratories,) at the project's disposal. The partnership has furthermore a strong industrial relevance, which will enhance the exploitation and transfer of results on to marketable products.

## Sequoia Automation

Sequoia Automation S.r.l. was originally founded in 1985 (as an Snc.): a research and development centre in electronic design, technical software development and mechanical engineering As it grew over the years it was reincorporated in 1997 as an S.r.l. in Chieri, in the Turin area. Today, it is a thriving company, offering technological and innovative solutions for industrial needs. It is presently manufacturing SeTAC, its proprietary Sequoia Triaxial Acceleration Computer.
Research activities carried out within Sequoia have allowed the Company to develop a core competence in building reliable automatic control and diagnostic systems. The in-house expertise allows the Company to develop both hardware and software solutions. Application fields are not limited to the industrial domains that characterise the Turin area, i.e. the automotive and the tooling machine industry, but extend to every kind of industrial and measurement problems. There are three main areas in which the research and development activities have been concentrated to date:

- Quality control and measurement: Sequoia has handled projects in this area both for public administrations and industries. The solutions engineered are at the cutting edge of innovation; they make use of electronic imaging and analysis, vibration and sound wave analysis, parallel robotics.
- Industrial automation: networking solutions for monitoring and controlling industrial processes have been successfully designed and implemented. Their main focus is the interface between the distributed software and the specific hardware, whether sensors or mechanical devices.
- Sensor production: the “ Triaxial Acceleration Computer ® ", is the main product derived directly from its research activity. It is a smart sensor capable of signal analysis, self diagnosis and digital communication.

The company’s expertise will allow it to deal with the high complexity associated with the implementation of the soft automation solutions, of the project. System design, software development and project management will be the fields in which the company’s know how will find relevant applications.
Sequoia Automation is a small-medium enterprise (SME), however it has gathered over the years, the experience with which to envision ambitious and complex projects, and to bring them to a successful conclusion. The opportunity of supplying equipment and devices, to make the implementation of the demonstrator possible and of providing a key contribution to the stated S&T objectives is the most relevant reason for the project proposition.
Through the KiWiGen project, Sequoia hopes to plant the seed for the development of future big plants for the generation of renewable energy. In such development, the Company will find a relevant place, thanks to the know how and the experience accumulated for the duration of the work. In the scenario of the actual mass production of the system, Sequoia foresees the supply of the wireless sensor kit (made of self powered inertial platforms, wireless connection, base receiver with multiple codified access for receiving the data from different groups of sensors), the relevant software packages and the control algorithm in a dedicated elaboration unit.

The key persons who will be involved in the project:
**Massimo Ippolito** has accumulated over the years an in depth understanding of the problems surrounding the production and distribution of electrical energy via a number of projects in this area Several of those most relevant to the KiWiGen are listed below:
- Turbo-gas generators:
He designed one of the first artificial vision systems in 1986, for quality monitoring during the turbine assembly. FIAT Aviazione
Continuing his work in this field, he developed a system of electronic control for the precise rotational linking on the fly, of the huge rotating alternators and turbines in the power plants. ENEL-FIAT Aviazione.
Energy transport—EHV grid:
He carried out a National Research Program, for the GRTN S.p.A: The Italian Extra High Voltage

line manager, for whom he built a robotic prototype, to autonomously ‘wash’ the line insulators, without interrupting the energy supply. This automation makes use of advanced parallel robotics to emulate human motion and ability.

The element that these. projects have in common, is that there was **no existing model** for their solution. They had to be envisioned (as well as carried out) from scratch..

**Florence Baptiste** received her Doctorate in Social and Economic History, from the University of Lyon, in 1985. She is presently a project manager,. specialised in missions for the public administration, focused on human resource development. She has co-ordinated and managed complex projects, within the public and private sector at the national and European level. Her specific responsibilities include: coaching of groups of social actors to pilot change; coaching and training of public managers and executives to acquire new competencies and capacities; equal opportunity projects; local economic development projects; analysis of the training needs of public administration managers concerning the changing competencies required by decentralisation. Beyond Italy, she has worked on a international level in France, the U.S.A, and, on behalf of the World Bank. for professional training programs for the Magreb.

**Jane R. Speiser** received her Master’s degree at Harvard University in 1966. Her work over the years has encompassed both science and the arts. Among the highlights of her activities, pertinent to this project, she designed, in 1969, one of the first educational films dealing 3-D descriptive geometry, based on the text for engineering students by Steven Slaby, professor at Princeton University. She was instrumental in the installation of one of the first computers for community use, in San Francisco in 1971. She collaborated with Massimo Ippolito in the development of software for 3-dimensional motion, a first for Italy in 1985. She worked as a. director of computer animation in Milan and Torino , conceived and developed a proprietary software for character animation SURF, for Pixel Graphics in 1991. More recently her own company EREO, dedicated to the transfer of renewable energy sources, led her to design and produce an innovative solar oven in Northern Bangladesh. She is the author and illustrator of books, both educational and satiric for which she has won several international awards. The animation and live action films which she has directed, have been shown in festivals in Italy, France and Czechoslovakia. The continuous experience she has accrued in the field of three dimensional visualisation, allied with software development, will serve the needs of the project, as well as her international experience in communicating concepts via words and images.

### Fidia S.p.A.

FIDIA is one of the European leaders in manufacturing Numerical Controls and High Speed Milling Machines for dies and moulds making. The company has also developed and offers CAM modules suitable in particular for on line generation of part programs (HIMILL).

FIDIA is present on the world Market of Numerical Controls and High Speed Milling Machines. FIDIA NC and Machine Tools are dedicated to mould and dies of medium/large size production.

FIDIA is committed to developing solutions aiming at improving the NC performances in several directions: Dynamics, Process Control, Man-Machine Interface, NC Architecture… Consequently, FIDIA is or has been participating in several research consortia. In particular, FIDIA was the prime contractor in the projects:

HIQU (EP 6293), KERNEL II (BE 7423), SENC (ESSI 10491), DIAMOND (BE 4886), PSP-NC (ESSI 24060), REINDEER (IST 20288), SEC&TEC (GRD 10227), PENGUIN PC (IST 28152), OCEAN (IST 37394 ).

In addition, FIDIA participated in FAME (EP 5471), OPTIMAL (EP 8643), ELCANO (EP 25297), SIMON (EP 22417), IMS-SIMON (EP 26504), MW-1 (BE 1818), MOSYN (BE 1532), AUTOMAT (EP 22273), MOTION (BE 3424), SMART (GRD 10717) and other Projects.

The key persons who will be involved in the project:

**Dr. Ing. Fabrizio Meo**, born on August 7th, 1959 in Naples, graduated in 1983 at University Federico II in Naples, in Electronic Engineering. He was software developer in Comau S.p.A. from 1984 to 1986 and carried out the same function in FIDIA S.p.A. since 1986. In 1989 he became the

manager for software development for the FIDIA Numerical Controls Division. In July 2001 he assumed the position of Research Technical Director, in June 2003 of Research Manager.
Fidia will produce the engineered version of the demonstrator, made of the base control, the numerical control, the modified servo drives for the regeneration of energy

### Ce.S.I.

Ce.S.I is a highly specialised engineering company (Italian SME) that operates in the mechanical engineering field.
Ce.S.I. is involved in mechanical design, CAE / FEM structural analysis, kinetic analysis, research and innovation activities for machinery, energy, aeronautics and automotive markets. The company's expertise, in the development of innovative products, has been applied to achieve high performances and provide new features in terms of modularity, flexibility, innovative material applications and quality. Ce.S.I. has assumed a key role at the international level in defining and designing systems, such as:

- high performances multi-axis modules for aerospace/automotive component machining;
- high speed milling machines;
- turning machining centers;
- 5 and multi-axis laser cutting machines;
- grinding machines;
- robotics and automation;
- ultra-light structure structures design and analysis;
- precision mechanic systems.

Ce.S.I. has participated in the past, and is presently engaged in several European and national R&D projects.
Ce.S.I. will bring to this project its wide experience in design and analysis of intelligent machines, and specifically its know-how in the field of mechatronic design and structural analysis of the ground platform of KiWiGen generator.
Ce.S.I. has recognised the strategic importance of developing intelligent and efficient wind generators, leading to a large scale facility capable, of producing energy at an affordable cost. In the course of the project, important knowledge and developments for a great number of related, technically specialised areas, (touched on during the project,) will have been attained.
Ce.S.I.'s stake in the exploitation is related to the potential for designing systems for applications on a much larger scale.

### Fatronik

Fatronik is a private technology centre, providing development and engineering services in the mechanical engineering filed. During the last 12 years, Fatronik is improving existing products and devising new solutions for several sector, aeronautical, renewable energy, machine tool. With 60 employers and more than 35 engineers, Fatronik is tacking the following activities:
Mechanical systems:

- New prototypes conception. Pre-design and analysis.
- Integration of manufacturing systems
- Technical feasibility. Technological market surveys.
- Executive design of machines and manufacturing systems.
- Development/evaluation of mechanical components.
- Development of techniques to evaluate and improve machine behaviour.
- Development of high efficient machining processes
- Development of techniques for monitoring machining processes

Aspects related to the energy generation and conversion:

- Design, development and installation of a 2.5kW micro-wind turbine, currently in the phase of testing and validation

- Development of a completely autonomous wind/PV hybrid system
- Collaboration in several projects with some of the main manufacturers around the world in areas like tower design, bedplate calculations, wind turbine components design and validation, etc.
- Design of hydraulic/electrical solar trackers for PV panels

About aspects related to the fuzzy control of the system, Fatronik have experience in 'intelligent machines'; having developed a SW platform that allow agent based management and remote access to the machine, improving efficiency. The machine can be commanded and monitored from remote access. The developed agent based 'intelligent SW' and human-machine interface, provide a easy machine management.
In addition, Fatronik has joined the partnership of several European-level projects, as well as carry out the leadership of many of them such as: NETCIM (ESPRIT,1994-1996), AUTOMAT (ESPRIT, 1996-1999), OPAL (ESPRIT, 1997-1999), SAM (BRITE/EURAM, 1998-2001), MACH21 (GROWTH, 2000-2003), SMART (GROWTH, 2000-2003), MANTYS (GROWTH, 2001-2004), XPERTS (IST, 2000-2002) and JOBBING CELL(CRAFT, 1998-2000).
Fatronik will produce the fuzzy control, mechanical aspects of the system and aspects related to the energy generation and conversion.

- fuzzy control of the system
- aspects related to the energy generation and conversion
- mechanical system

The key person who will be involved in the project:
**Ing. Rikardo Bueno** (14 years experience in research projects). Coordinator of several national and international research projects. Several publications at the national and international level in the field of mechanical engineering.

### Institute of Electric Technology

The IET will be involved in system design, demonstrator realisation, in the dissemination of the project’s results and knowledge.
The Institute of Electric Technology is a **private** Technological Centre with a non-profit economic system. Furthermore, ITE is an association of private companies. Currently, it counts on more than 100 associates, working in the electric, electronic and telecommunication sectors. ITE relies on the support of some public Institutions such as AVEN (Valencian Energy Agency), IMPIVA (Valencian Institute of Small and Medium-Sized Enterprise) and the Generalitat Valenciana (Valencian Government).

ITE’s goal is the promotion and the technological development of private companies. The main lines of research include:

- Integration and applications of clean energy systems.
- Active distribution. and Integration in the electric network
- Energetic efficiency and saving.
- Environmental impact assessment.
- Technological observatory.
- Forecasting and management of electricity demand.
- Power electronics and instrumentation. Development of industrial systems control and automation.
- Power supply quality and Electromagnetic Compatibility.
- Communication systems applied at the energetic sector. Network technologies.

The Institute of Electric Technology will make available to the Consortium its laboratory facilities, rapid prototyping and pre-series equipment. This can provide an important contribution in accelerating the development of new products. ITE has the capability to design, develop and build electronic boards even in multi-layer and SMD technology, and to program embedded devices based on microcontrollers and DSPs.

As an association of companies, ITE will have a key role in transferring and disseminating the scientific and technological knowledge generated by the project beyond the Consortium, particularly to SMEs, by means of courses, conferences and seminars. Indeed, ITE is the co-ordinator of the PhD Programme of Electric Technology held by the Polytechnic University of Valencia. IET will be the interface and the official representative of the Valencian Energy Agency, whose institutional role and knowledge of the energy market will contribute to leveraging the scope of the activities and providing visibility to the project.

Previous experience in organising courses related to fuel cells and RES will also be useful to the management of dissemination activities. Furthermore, ITE Office for Transferring Knowledge and the Commercial Department will be involved in the promotion of project activities especially in the sectors of energy, electronics and communications.

### Delft University of Technology, AeroSpace Sustainable Engineering and Technology Department

This newly established chair headed by **Prof.dr. Wubbo J. Ockels** (first Dutch astronaut and the key person who will be involved in the KiWiGen project) has demonstrated state-of-the-art capabilities for the integration of high technologies from space, aerodynamics, light weight structures etc. One of its major activities is the production and racing of solar driven cars, for which it has won both WSC 2001 and 2003. (Australia 3000km) Another major activity is the RTD of electronically controlled kites and the exploration of the combination of kite and airplane capabilities, named "kiteplanes." In this context, it investigates inflatable and pressure regulated deformations for stability and control.

The dissemination of the intriguing potential of kiteplanes and related energy and transport capabilities to youngsters, is a high priority activity. Through its courses, challenges and games a stimulus is brought to the next generation.

It has developed specific know-how related to radio control, in cooperation with another chair that studies unmanned flying objects for military observation purposes. The ongoing preliminary research includes the design of small radio controlled kites, their stability and dynamic parameters.

**OMILL BV,** is a startup company (W.J.Ockels) in which early development of the Laddermill has been performed. Several studies have been completed, particularly on the stability of the Laddermill in conditions of changing winds. The simulation program development will also be the basis for a simulator of the KiWiGen project. Within O-MILL several concepts of kites/wings and radio control have been developed, which are made available and will be adapted for the present KiWiGen project.

### Utrecht University, Copernicus Institute for Sustainable Development and Innovation, Department of Science, Technology and Society (UU-STS)

The Utrecht University, through its Department of Science, Technology and Society which is part of the Copernicus Institute for Sustainable Development and Innovation, (UU-STS), will further add to the already high academic profile of this project. The overall objective of the research activities of UU-STS is to obtain insight in and reflect critically upon the interaction between natural sciences and society. The mission of the department is to investigate which contributions science and technology can make to a sustainable development of society. Within the research cluster 'energy supply' the objective is to explore, identify and assess possibilities to deliver energy carriers (power, heat, fuels) at the lowest possible societal costs. This includes potential studies (for bio-energy, solar energy as well as fossil fuels and other options), modeling of energy systems, chain analyses, (economic and energetic) system optimisation and the conditions for actual application of sustainable energy supply options. The research covers both the shorter term

(detailed feasibility studies) and long term perspectives, which includes exploring the potential performance of advanced energy conversion options and potentials of renewable sources (linked to land-use issues, as well as solar radiation and wind regimes). Many studies have been performed on the environmental aspects of various technologies, using Life Cycle Analysis (LCA) methods. In addition, UU-STS has developed the model SOMES (Simulation and Optimisation Model for renewable Energy Systems), which can be used to improve the design of new systems (combined PV/wind/diesel) or to check the performance of existing systems. The UU-STS will subcontract to OJA-Services, Communication in the field of renewables. It is a small company well experienced in disseminating scientific knowledge to a broad audience, including the scientific community, policy makers, stakeholders and the general public. E.g., the highly acclaimed IEA-PVPS website (http://www.iea-pvps.org/) was developed and is still maintained by OJA-Services.
UU-STS will host and train two ESRs on modeling aspects of systems. Their research will generate fundamental knowledge on the quality (performance and reliability). The past comprehensive studies performed at UU-STS on another RES: (PV systems) will be applied and amplified to develop a model for performance evaluation with regard to the KiWiGen. UU-STS has developed the simulation model SOMES as a tool to improve system design and/or to check system performance. This tool will be upgraded with the results obtained throughout the course of this work.

The key persons who will be involved in the project:
**Dr. Wilfried van Sark** is assistant professor and group leader of the PV/wind group with a long experience on solar cell (fundamental) materials (a-Si, mc-SI, III-Vs) research. Recently, he initiated Third Generation solar cell research at UU-STS to extend the existing PV systems research and environmental assessments. He received the 1993 Teyler Inititiative prize for transfer of environmental knowledge.
**Dr. Evert Nieuwlaar** is an assistant professor with a long experience in LCA methodology and LCA studies of PV technology. He teaches energy related post-graduate courses at UU-STS.
**Drs. Martin Junginger** is a Ph.D. student active in the field of accelerated introduction of renewable energy options. He has extensively studied on- and off-shore wind energy projects using, a.o., experience or learning curve analysis.
**Prof. Wim Turkenburg** is department head of UU-STS and Scientific director of the Copernicus Institute for Sustainable Development and Innovation. He is (co-) author of more than 200 scientific articles and publications on energy and climate change issues. He has been key-note speaker on a number of conferences and presented numerous invited lectures. Recently he has been vice-chairperson of the UN Committee on Energy and Natural Resources for Development (UN-CENRD), chairperson of the Subcommittee on Energy of the UN-CENRD and member of the editorial board as well as convening lead author of the World Energy Assessment (WEA).
**N.N.** (Junior researcher) will be hired for the entire duration of the project on a full-time basis. Needed qualifications are experience in wind energy and Life Cycle Analysis. Most probably, one of the 15 Master students at UU-STS will be considered.

## STREP Project Effort Form

**Full duration of the project**
(insert the planned person-months for each activity in which a partner is involved)

Project acronym: -**KiWiGen**

| | SEQUOIA | FIDIA | CE.S.I. | FATRONIK | IET | TUDelft | UU-STS | TOTAL (ALL PARTNERS) |
|---|---|---|---|---|---|---|---|---|
| Research/innovation activities | | | | | | | | |
| WP 1 | 15 | 10 | 10 | 6 | 3 | 8 | 8 | 60 |
| WP 2 | 12 | 13 | 20 | 6 | 6 | 8 | 2 | 67 |
| WP 3 | 13 | 16 | 10 | 5 | 8 | 4 | 4 | 60 |
| WP 4 | 40 | 14 | 0 | 15 | 0 | 3 | 0 | 72 |
| WP 5 | 12 | 6 | 10 | 9 | 3 | 4 | 8 | 52 |
| WP 6 | 14 | 7 | 10 | 3 | 3 | 3 | 10 | 50 |
| | | | | | | | | |
| Total research/innovation | 106 | 66 | 60 | 44 | 23 | 30 | 32 | 361 |
| Demonstration activities | | | | | | | | |
| WP 7 | 17 | 5 | 5 | 4 | 12 | 6 | 10 | 59 |
| | | | | | | | | |
| Total demonstration | 17 | 5 | 5 | 4 | 12 | 6 | 10 | 59 |
| Management activities | | | | | | | | |
| WP 8 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| | | | | | | | | |
| Total management | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| TOTAL (ALL ACTIVITIES) | 141 | 71 | 65 | 48 | 35 | 36 | 42 | 438 |

## STREP-Project cost tables

The project cost sharing among the cost items (personnel, durable equipment, consumables,…) for each partner is shown in the table below:

| RTD/Innovation activities (WP1, WP2, WP3, WP4, WP5, WP6) | Costs in 1,000 € | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cost category | SEQUOIA | FIDIA | Ce.S.I. | FATRONIK | IET | TUDelft | UU-STS | TOTAL |
| Person months | 106 | 66 | 60 | 44 | 23 | 30 | 32 | 361 |
| Personnel costs | 795.0 | 336.6 | 450.0 | 158.4 | 138.2 | 180.0 | 179.2 | 2237.4 |
| Durable equipment | 50.0 | 101.5 | 18.0 | 0.0 | 20.0 | 23.0 | 0.0 | 212.5 |
| Consumables | 20.0 | 5.0 | 20.0 | 30.0 | 20.0 | 5.0 | 5.0 | 105.0 |
| Travel and subsistence | 36.0 | 30.0 | 30.0 | 25.0 | 15.0 | 20.0 | 15.0 | 171.0 |
| Computing | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.0 | 5.0 | 20.0 |
| Subcontracting | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 84.0 | 0.0 | 94.0 |
| Overhead costs | 181.2 | 207.3 | 103.6 | 219 | 27.6 | 46 | 39.8 | 824.6 |
| Cost basis (FC, FCF, ACF, AC) | FCF | FC | FCF | FC | FC | AC | AC | |
| **Total RTD/Innovation costs** | **1097.2** | **680.4** | **621.6** | **432.4** | **220.9** | **368.0** | **244** | **3664.5** |
| **Requested grant** | **548.6** | **340.2** | **310.8** | **216.2** | **110.4** | **368.0** | **244** | **2138.3** |

| Demonstration activities (WP7) | Costs in 1,000 € | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cost category | SEQUOIA | FIDIA | CE.S.I. | FATRONIK | IET | TUDelft | UU-STS | TOTAL |
| Person months | 17 | 5 | 5 | 4 | 12 | 6 | 10 | 59 |
| Personnel costs | 127.5 | 25.5 | 38.0 | 14.4 | 72.1 | 36.0 | 56.0 | 369.5 |
| Durable equipment | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 | 0.0 | 25.0 |
| Consumables | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 15.0 | 15.0 | 33.0 |
| Travel and subsistence | 15.0 | 0.0 | 3.0 | 0.0 | 15.0 | 20.0 | 10.0 | 63.0 |
| Computing | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 5.0 |
| Subcontracting | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 32.4 | 72.4 |
| Overhead costs | 30.5 | 22.1 | 8.2 | 22.0 | 14.4 | 23.0 | 16.2 | 136.4 |
| **Total Demonstration costs** | **223.0** | **47.6** | **49.2** | **36.4** | **104.5** | **109.0** | **134.6** | **704.3** |
| **Requested grant** | **78.1** | **16.7** | **17.2** | **12.7** | **36.6** | **109.0** | **134.6** | **404.9** |

| Consortium management activities (WP8) | Costs in 1,000 € | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cost category | SEQUOIA | FIDIA | CE.S.I. | FATRONIK | IET | TUDelft | UU-STS | TOTAL |
| Person months | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Personnel costs | 108.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 108.0 |
| Travel and subsistence | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.0 |
| Audit certification | 15.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 45.0 |
| Overhead costs | 26.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.6 |
| **Total RTD/Innovation costs** | **159.6** | **5.0** | **5.0** | **5.0** | **5.0** | **5.0** | **5.0** | **189.6** |
| **Requested grant** | **159.6** | **5.0** | **5.0** | **5.0** | **5.0** | **5.0** | **5.0** | **189.6** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TOTAL COST | **1479.8** | **733.0** | **675.8** | **473.8** | **330.4** | **482.0** | **383.6** | **4558.5** |
| **Total requested grant** | **786.3** | **361.9** | **333.0** | **233.9** | **152.0** | **482.0** | **383.6** | **2732.7** |

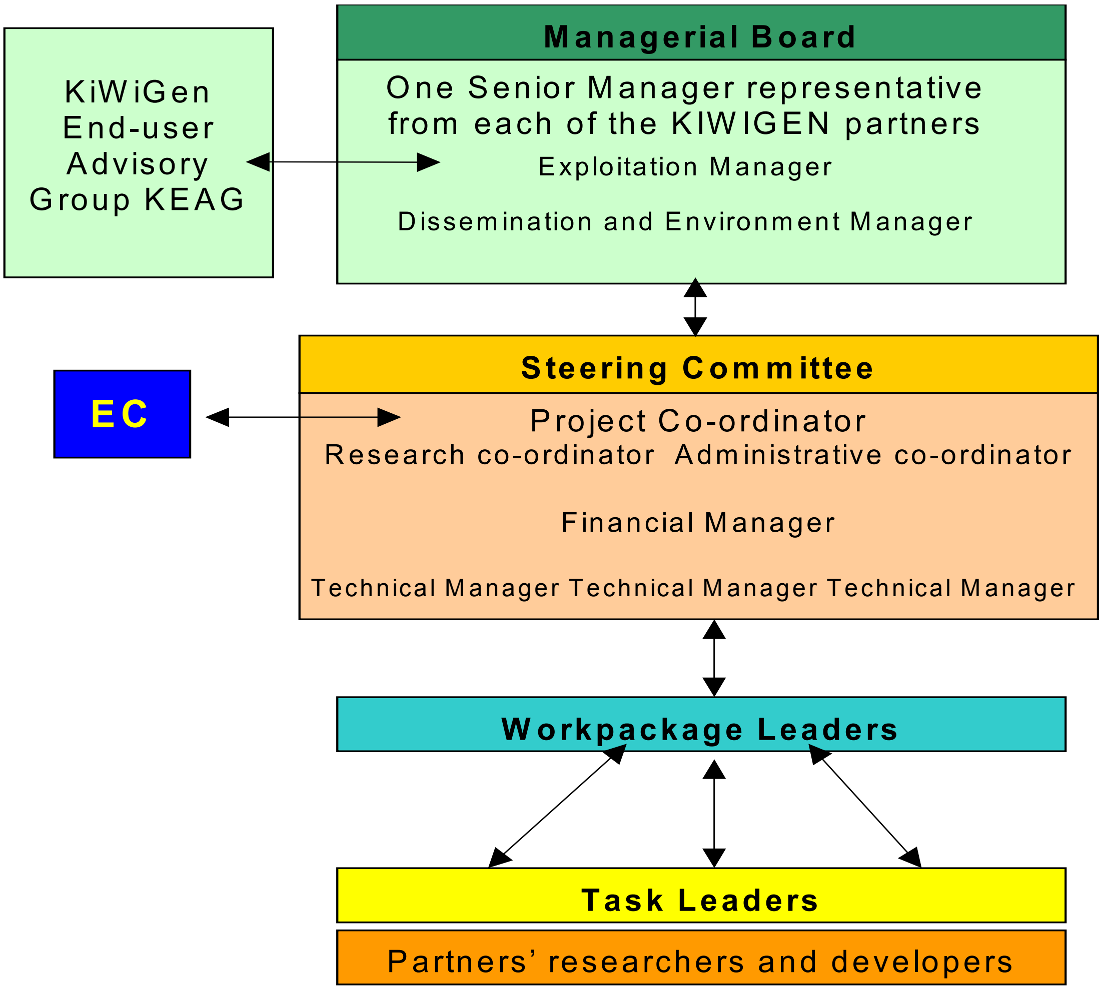
# B.5 Project Management

## Management Capability of the Co-ordinator

The Research Department of SEQUOIA AUTOMATION s.r.l. will lead the Consortium. Mr. Massimo Ippolito is the head of this Department. He has a strong background in mechatronic design, embedded software, scientific and analysis software development and product engineering.
He is the author of the patents for the kite carousel generator concept, which is one of the large scale embodiments, and the advanced automatic pilot system which is the core of the envisaged development.
The company has the experience for managing research activities and exploiting their practical results, as shown by the successful development of the Sequoia Triaxial Acceleration Computer (SeTAC) subsequent to the conclusion of a European research project.
The project organisation is based on collegiality
Therefore, the Company has the necessary capability to manage this project and achieve the expected results in the proposed time framework.

## Organisation and Management Structure

The KiWiGen management structure comprises a Managerial Board, a Steering Committee, chaired by the Project Co-ordinator, a group of Work package Leaders and Task leaders. The functions of the Steering Committee, Managerial Board and the Work package Leaders are described in the following sections. The complete management structure is shown in the following figure.




Management structure of the KiWiGen project.

### Managerial Board

The top level decisions in the project will be made by the Managerial Board, consisting of one senior management officer from each partner, by the Exploitation Manager and by the Dissemination and Environment Manager. The Managerial Board will meet at least once annually and more often in case of special issues. Overall, the Managerial Board will be responsible for the strategic direction of the project and for those issues which are relevant to the consortium as a whole.

The Exploitation Manager will be responsible for all of the aspects concerning the exploitation of the project results, such as patents, licenses etc. To this end, the Exploitation Manager will actively co-operate with the relevant technical and commercial staff of all the partners throughout the duration of the project. Moreover, he will be in charge of co-ordinating all of the negotiations concerning exploitation issues between the consortium and external parties. He will organise the liaison and structure the information transfer between KiWiGen and the over four hundred energy agencies and five hundred energy organisations in the world, (among which: the Socio-Economic Work Group of the Erasmus University, Rotterdam Thematic Network). He will deal with "KEAG – KiWiGen End-User Advisory Group" described in the next section. He will also draw up and constantly update the Technological Implementation Plan.

The Dissemination and Communication Manager will be responsible for the public diffusion of the Project's activities and results. She will draw up and maintain the Dissemination Plan for the whole duration of the project, .in conjunction with the partners. She will monitor and report, in regard to the communication impact of the Project's deliverables.

### Steering Committee

The KiWiGen project will be managed on a daily basis by the Steering Committee comprising the two Project Co-ordinators: Research Co-ordinator and Administrative Co-ordinator, the Financial Manager and three Technical Managers.
The Project Co-ordinators will be responsible for both Technical Management and Organisational Management throughout the KiWiGen project. They will serve as the main channel for correspondence between the KiWiGen consortium and the European Commission. Through the Steering Committee and utilising the contributions of the project partners, the Project Co-ordinators will consolidate project planning, progress reports, milestone reports, cost statements and budgetary overviews, etc.
The Steering Committee will include four co-operating managers, who will work under the direction of the Project Co-ordinators, supporting them in all technical and administrative issues. The Financial Manager will oversee all financial affairs of the project, e.g. EC payment distribution among partners, cost statement submission and project budgets audits. The three Technical Managers will serve to establish the links between the Project Co-ordinators and the Work package Leaders. They will structure and monitor the technical progress of the project according to defined project plans, and regular inform the Project Co-ordinator of the current project status. They will serve as the link between the separate work packages, thus keeping the project on schedule.

The Consortium has nominated the following persons as members of the Managerial Board and the Steering Committee:

Exploitation: .Fabrizio Meo Senior manager from Fidia S.p.A
Dissemination and Communication: Jane R. Speiser, Sequoia.
Research Co-ordinator: Massimo Ippolito, Chief researcher Sequoia
Administrative and organisational Co-ordinator, Florence Baptiste, Sequoia
Financial Manager: Giovanni Vergnano, Senior financial officer, Sequoia.
Technical Managers: Senior project managers: Prof. Dr. Wubbo Ockels, Delft University of Technology, Franco Taddei, Ce.S.I., Rikardo Bueno Fatronik

### KiWiGen End-User Advisory Group (KEAG)

In order to better assess the feed back on the results of the project, a Club of selected end-users will be created as described in the dissemination plan. They will be invited to demonstrations, and will continuously provide the consortium with a critical analysis of the achieved results . The relevant costs will be sustained by the Consortium. The KiWiGen End-User Advisory Group thus represents a unique opportunity to incorporate and exploit the wide end-user knowledge and experience from around Europe into the KiWiGen project. The members of the group will be representatives from the various European institutions from who transmit or produce electrical energy. The main tasks of KEAG are to:

- ensure that the technological goals and achievements of the project are in tune with the needs and requirements set by energy and environmental policies;
- comment on the validity and operation of the technology developed by the KiWiGen project;
- provide a single focal point of contact in the partners' countries for dissemination purposes;
- provide information on relevant European and member country specifications.

The KEAG will interface with the Exploitation Manager. Their Group meetings will be supported by financial contributions from all consortium partners.

### Work package Leaders

A Work package Leader from the participating partners will be assigned to each work package of the project's work programme. He will take responsibility for the detailed inter-work package and inter-work package planning, work package management and work package reports.

### Communication Strategy

All the partners will be fully informed regarding the planning, progress achieved and problems. The main basis for communication will be: meetings, as the main interactive means for communication, and on the other hand, electronic communications through E-mail and electronic file transfer using Internet.
Each Work package Leader will report on a three month basis to the Project Co-ordinator and the Technical Managers concerning work package progress, using a regularly updated detailed plan as a guideline. These reports will include information pertaining to the technical progress, achieved results (e.g. deliverables) and compliance with the work programme. The progress status of the work package will also be reported in terms of the percentage of completion, estimated time to completion, actual man-months spent and remaining man-months required for work package completion. The Project Co-ordinator will summarise the overall project status and planning.
The following reports will be provided:

| Report | Author(s) | Input from | Distribution |
|---|---|---|---|
| Three Month Reports | Work package Leader | Partners | Co-ordinator and Technical Managers |
| Six Month Progress Report | Co-ordinators | Work package leader | EC Scientific Officer, Partners |
| Annual Progress Report | Co-ordinators and Technical Managers<br>Partner (Annex) | Work package leader, Exploitation Manager, Partner | EC Scientific Officer, Partners |
| Annual Periodic Cost Statement | Financial Manager | Partners | EC Scientific Officer |
| Mid Term Report | Co-ordinator, Technical Managers, Exploitation Manager | Work package leader | EC Scientific Officer, Partners |
| Technological Implementation Plan (1st draft) | Co-ordinators, Exploitation manager | Work package Leaders | EC Scientific Officer, Partners |
| Final Technical Report | Co-ordinators, Technical Managers, Partner | Work package leader, Partners | EC Scientific Officer, Partners |
| Technological Implementation Plan: final edition | Exploitation manager | Work package Leaders | EC Scientific Officer, Partners |

### Quality Assurance Measures

The progress of the project is reviewed at the Milestone reviews, in which all the technical results achieved during the period will be compared with planned objectives described in the work plan.

## Decision Making

The *Managerial Board* will be in charge of the resolution of conflicts that could arise during the evolution of the project. The decisions will be taken based on the documents signed by the partners, i.e., the contract with the Commission of the EC and the Consortium Agreement to be signed if the present proposal is approved.

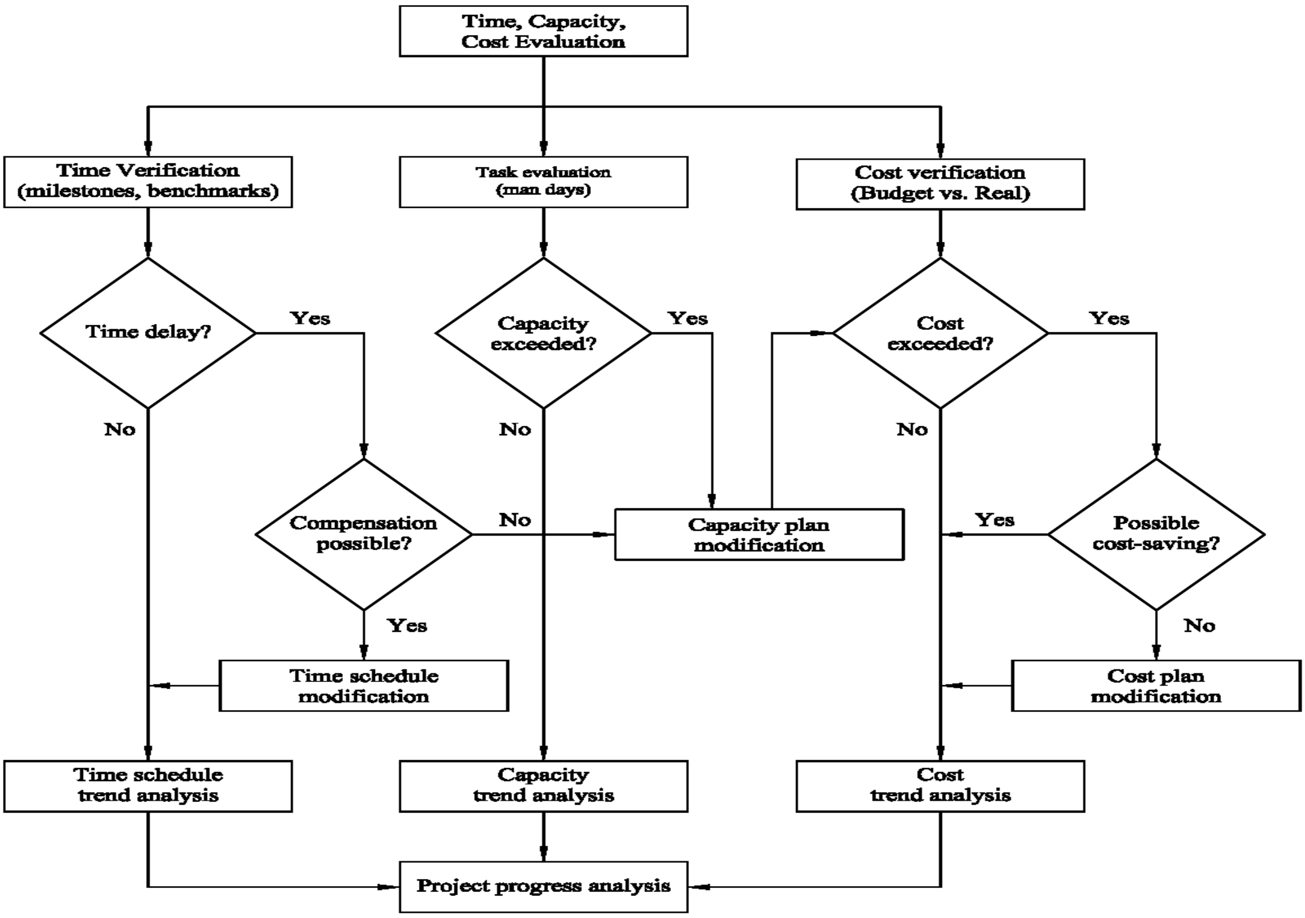
Therefore, the *Managerial Board* will be able to make decisions about:

1. Management of the Project; being entrusted with all the duties and executive responsibilities in carrying out the Project.
2. Review or amendment of the work plan, together with the allocation between the Parties of the funding provided by the Commission under the EC Contract, and the reallocation between the Parties at the end of the Project of any such funding which then remains unused.
3. Review or amendment of:

The terms of the EC Contract;
The costs and time schedules under the EC Contract;
The termination date of the EC Contract;
The procedures for publications and press releases.

Decisions concerning matters under points 1 and 2 above shall be taken by a single majority, provided that any Party whose Workpackages are thereby changed may veto such decisions. In case of an equal distribution of votes, the vote of the *Co-ordinator* decides. Decisions concerning point 3 shall be taken unanimously.

In order to achieve the project's goals, an evaluation procedure will be applied. The review and verification procedure for the KiWiGen project is shown in the following figure.




Review and verification procedure in KiWiGen.

# B.6 Work plan

The output of this project is the feasibility design and the simulation of a Megawatt class and Gigawatt class RES power plant capable of supplying continuous and modulated energy. This will be done through the demonstrator comprehensive features assessment, in terms of feasibility and investment/management cost.
To achieve the proposed objective, the project will have a duration of 36 months and is composed of eight interrelated work packages (WPs) which are listed below.
WP1 provides the general framework and the guidelines for the following project activities.
Four WPs are required for building and running the KiWiGen demonstrator. They are:

- System design (WP2)
- Demonstrator construction (WP3)
- Software development (WP4)
- System training (WP5)

WP6 includes all the activities providing for the completion of the project, through the feasibility study and the design of the large scale demonstrator, allied with a computer simulation.
The dissemination activity (WP7) and the project management one (WP8) are both transversal to the whole project.
The detailed WP list is provided in the following table.

## Workpackage list (full duration of the project)

| Work-package No[1] | Workpackage title | Lead contractor No[2] | Person-months[3] | Start month[4] | End month[5] | Deliv-erable No[6] |
|---|---|---|---|---|---|---|
| WP1 | Preliminary analysis of the system architecture & definition of the requirements | 6 | 60 | M1 | M6 | D1.1,D1.2, D1.3,D1.4, D1.5,D1.6 |
| WP2 | Mechanical and electronic design of the demonstrator | 3 | 67 | M2 | M8 | D2.1,D2.2, D2.3 |
| WP3 | Construction and first validation of the demonstrator | 2 | 60 | M7 | M16 | D3.1,D3.2, D3.3 |
| WP4 | Software development | 1 | 72 | M7 | M36 | D4.1,D4.2, D4.3,D4.4, D4.5 |
| WP5 | Field testing and validation | 4 | 52 | M18 | M36 | D5.1,D5.2, D5.3,D5.4 |
| WP6 | Large scale integration | 7 | 50 | M23 | M36 | D6.1,D6.2, D6.3,D6.4 |
| WP7 | Dissemination and exploitation related activities | 5 | 59 | M1 | M36 | D7.1,D7.2, D7.3,D7.4, D7.5 |
| WP8 | Project management | 1 | 18 | M1 | M36 | 3/6 Monthly Reporting |
| | TOTAL | | 438 | | | |

[1] Work package number: WP 1 – WP n.
[2] Number of the contractor leading the work in this work package.
[3] The total number of person-months allocated to each work package.
[4] Relative start date for the work in the specific work packages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[5] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[6] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the work package: D1 - Dn.

## Research, Technological development and innovation related activities

The approach taken by the project, i.e. harnessing the wind energy by ultra light structures such as tethered kites, is a consolidated idea, with solid theory behind it. The team proposing KiWiGen has already spent time refining the theoretical framework and some of the design aspects of such projects.
The step forward is that of physically producing a control base machine and dealing with the complex control functionality that turns the project into a stand-alone wind generator system.

The preliminary component list of the small demonstrator can be envisaged as follows:

a) A standard power kite of around 15 $m^2$ with an inflatable attack edge.
b) A set of sensors such as **SeTAC triaxial acceleration computer®**, anemometers aboard the kite and force/power at the base station.
c) Lines of 5000 Mt. in Kevlar® or Dyneema® with 20000 N of traction resistance and 5$mm^2$ of section.

SeTAC

d) Driven reels for rewinding, storing and manoeuvring the kites lines.
e) Two or three reduction gears from the motors to the power reels, in order to adapt the motors’ high rotating speed to the kites’ dragging/lifting force.
f) Two or three brush-less servomotors with permanent magnets neodymium-iron-boron, able to act even as generators, 5-10 kW - 100N/m.
g) A fan system to supplement the kites’ initial take off.
h) A rotating base support and frame that carries the other components.

i) Servo drives with full energy regeneration in the braking phase.
j) Numerical control with remote interface capabilities.

k) A multi-module software package, embedded and user interface.

Regardless of the defined final configuration, the KiWiGen demonstrator will be made of functional blocks interlaced throughout the general Workplan breakdown.

### Kites, lines, on board sensors and actuators

(Components a, b, c and relevant WP 1)
The Kite is the interface between the natural wind energy and the harnessing machine.
By capturing the wind kinetic energy, kites are able to supply a massive quantity of mechanical energy, which comes from the traction force exerted on the cable, and multiplied by kite’s arbitrary displacement. Thanks to the latest aerodynamic studies and applications, kites can provide particular features in terms of manoeuvrability and control; while the energy transferred from the wind can be modulated due to the kite manoeuvrability. Specific diagrams depict the maximum power and the stall areas of the kite in relation to the wind. Therefore, by steering the kite appropriately, it is possible to change its status from the condition of maximum power of traction to that of the “stall.” (“Stall” is used here as to indicate a situation with greatly reduced lift. This is obtained by guiding the kite into a steep downward motion with very small angle of attack; it therefore sails down without exerting a great force on the tether). The stall (or nearly stall) situation is particularly useful for hauling in the wing with a minimum loss of power. It is clear that, by alternating the conditions of maximum traction, with the cable unrolling and the traction exerted on the cable itself, and the condition close to the stall, enabling the retrieval of the wing, it is possible to produce active mechanical energy that can be converted to electrical energy by a generator. The whole definition of the kite combined with the aboard instrumentation will be carried out in **WP1**.

## The electro-mechanical systems for manoeuvring the kites and changing their attitude

(Components d, e, f, g, h and relevant WP 1, 2, 3)
The kite generator base station has a functional diagram very similar to that of an industrial machine. It can use more or less the same standard components of a 3 or 5 axis milling machine, as the technology employed in the realisation of the electro-mechanical group includes drives for servo motors and numerical controls, servomotors, encoders, driven reels, rotating table... together with a special set of wind self-powered sensors. The servo-drive will perform the energy regeneration function, whereas servomotors will work as generators. (The kites will be provided as well with a servo system at both sides to allow for forward/backward motion of the tether connection. It will be powered by the wind, via a small propeller. Standard systems will used such as those adopted in model aircraft).
The above listed components include all the functions and the actuations required for physically performing the manoeuvring functions of the wing, the cable rewinding and unwinding activities, the conversion of mechanical energy into electric energy. The traction exerted by the wing-cable system can occur through a linear, alternating or rotatory motion.
The resulting generation process, which will be put in place by the demonstrator, is an intermittent procedure that can be divided into two phases:

- Firstly, the wind causes an upward lift force to the kite, which exerts traction on the cable. This force is transmitted to the generator pulley and is converted into electrical energy.
- Secondly, the controller manoeuvres the kite through the lines in order to reach the quasi stall situation and reel-in the lines with much smaller energy consumption.

During both of these phases, an active control of the kite attitude, in combination with the control of the ground pulley, enhances the energy production during the release of the tethers, by increasing the apparent wind. It reduces the energy needed to retract the tethers through an optimisation of the aerodynamic forces on the kites.

## A smart control and piloting system.

(Components i, j and relevant WP 1, 2, 3)
The **control system is the core** of the project idea. It allows for the automatic control of the piloting, the alternation and the intermittence of one or more kites, in order to optimise the energy production. The piloting system will permit the adjustment of the kite trim, according to the wind direction, by changing it from maximum power to stall and by determining the kite position and the altitude with the activation of the servo systems.
It is expected that the addition of local kite attitude control will provide an alternative control methodology to enhance handling feasibility.

We presume that the function of measurement of the kites' altitude, speed, accelerations, horizon that normally require many different instruments such as GPS, Horizon sensing, and gyroscopes, will be fulfilled by SEQUOIA product SeTAC (Triaxial Acceleration Computer).
The above functional blocks belong to the **WP1, 2, 3** and performance indicators and verifications could be done in progress. Such as a life-cycle analysis will provide the benefits and possible drawbacks with respect to environmental factors. This LCA will be performed on all three functional blocks.
$CO_2$ mitigation is evident from the non-$CO_2$ emission electricity generator, viz. wind energy. However, the production of materials might constitute a certain amount of $CO_2$ related to production technology. A much-used parameter is the so-called energy pay back time, i.e., how long will it take to produce with the KiWiGen the amount of energy that was needed to produce it. In addition, the life cycle cost of the KiWiGen can be determined, with assumptions on expected lifetime and electric energy produced.

### Software package and its development activity

(Component k and relevant WP 4)
Lofti A. Zadeh – the fuzzy logic guru – is expecting to see many new apparati with high "MIQ" (Machine Intelligence Quotient) appearing in the near future. He has divided the applications requiring intelligence into Level 1 and Level 2.

- Level 1 applications emulate skilled human operators with logic controllers. This has already taken place successfully in different applications. This emulation complexity level matches the one incurred in controlling the kite during normal operations.
- Level II applications involve the replacement of human experts with computer logic. This is the today’s challenge. It is the additional level required for managing all the other operations, such as the kite take-off, landing and emergency procedures etc.

The attempt to characterise the field in which the proposed development can be allocated, leads to a collection of definitions, including:

- autonomous interaction in an unstructured environment;
- redundancy and robust automation;
- flexible automation;
- adaptive control;
- perception-based decision making;
- fuzzy logic;
- neural networking;
- probabilistic reasoning;
- evolutionary and DNA computing;
- uncertainty and vagueness data analysis.

The ensemble of the above concepts, theory and approaches can be summarised in the attempt to provide “soft computing” or “soft automation” solutions. The term Artificial Intelligence can be used as well, despite its having assumed a sceptical meaning (and having even disappeared from the technical literature, because the artificial intelligence label has been associated with everything that is still too complex to be computed by calculators.)
However, the complexity that can be managed through the computer has constantly increased.

- They did not understand the spoken language, and now they do.
- They could not understand the human writing, and now they are “able to read”.
- They are able to search in databases containing billions of documents in a fraction of second.

The complexity that has to be managed by the project is comprehensively included within current computing capabilities. The software development belongs to the **WP4** that is one of the more extended through the duration of the project.

## Field testing, validation and risk assessment

(relevant WP 5)
As stated in the project objectives, one of the results to be achieved through the implementation of the project proposal is to create the public awareness, which will follow the testing phase performed through the demonstrator.
The three phases of KiWiGen training, Human control, Instrumental flight and Automatic flight correspond to quite as many fundamental demonstration moments. All these phases will be able to produce RES energy in a quantity that can be calculated in a power of 10 kW. This represents the clear and measurable first result of this project. Maintaining the same energy production both in instrumental flight and in automatic flight are the other measurable results.

The aerial part of the kite generator, composed by the ultra light wings and lines, can reach heights of a thousand of meters. This could produce some concerns about the safety of the whole system. The prototype will be useful for exploring in depth all the relevant aspects, but several questions and consideration can be foreseen in advance and many possible answers are already available.

### Project risk, safety improvement

**Risk** - The tests reveals a generic lack in the design or in the device's expected functionality.
**Solution** - The partners are confident that all project assumptions are realistic. However, the KiWiGen project is not impotently safeguarded from the risks of failure or unforeseen factors taking place. In the case that this unlikely event occurs, investigation will be aimed at identifying the sources of the problem and prompt corrective actions will be studied in order to avoid a delay in meeting the project objectives.

**Risk** – Current legislation does not allow for occupying the airspace for testing the demonstrator, and the competent authority does not provide special licenses.
**Solution** – The prototype will be tested in aerostatics and stratosphere balloon ground-fields and in occasion of wind manifestations. Whether the results gained comply with present expectations, inputs and proposals for new regulatory measures will be provided. At present a test area in the north of the Netherlands is available, including the support of the local authorities, allowing for tests up to several hundreds of meters.

### Technical risk

**Risk** - The sensors, as well as the inertial platforms, have to provide all the information on acceleration, velocity and position of the kites in airspace. The measurement precision may result inadequate due to the required mathematical signal integration.
**Solution** - The traction cables can supply on the ground site the angular position, whereas the reel encoder can provide the distance of the kite, by making available an alternative position data source.

**Risk** - Failures during the flight may take place, for example during the software development, testing and validation phases.
**Solution** - An adequate number of sensors will be employed in order to always have backup devices in case of abnormal functioning and to ensure the full control of the system. Any problem will be already detected during the second phase of the instrumental flight

**Risk –** Wireless communication between the kite and the base station does not work due to the distance
**Solution** – Different ways for communication will be studied (through cable, laser…)

### Security and safety Issues

**Risk** - Safety issues can be raised by the cables. They are the components in which all the wind force is concentrated. During an anomalous ground sweep they could hit persons and objects.
**Solution** - An automatic clutch disjoint system can be integrated on one cable only in order to deflate kite and be operated wireless. This system can work even in tandem assemblies.

**Risk** - Motor power and/or speed may result inadequate to face strong wind by issuing the reaction on time
**Solution** – The employment of different and more powerful motors will be considered.

**Risk** – The wing and the lines could fall down onto neighbour's lands, due to the absence of wind
**Solution** - the control capabilities achieved through elaboration of the input signal provided by the sensors allow rewinding the lines fast enough to glide the kite home.

**Risk**- the wind could be so strong as to stretch or tear a line.
**Solution** - The control allows for more speed in reeling out the lines, in order to reduce the apparent wind acting on the kite.

**Risk** – a plane or a helicopter could collide with the wings or the lines

**Solution** – The control scans the sky with radar and, in case of collision route, rewinds the kite to a safe altitude in a few seconds

**Risk** – The kite base station, in particular the kite lines could be subject to vandalism and/or terrorist attacks.
**Solution** – Some of the embodiments presented could make the moving parts inaccessible.

From the dimensions and the territorial impact, the kite generator base station is the size and weight of a car. It is a relatively **small object** to be placed at the ground level, therefore no security and safety issues could realistically undermine it. By continuing with the car comparison, it can be argued that the kite generator base is no more invasive than a parked vehicle!

Our project is clearly ambitious. However, it has been structured with specific step by step objectives, each with its accompanying concrete output. Moreover, the complementarity of the competencies, provided by the partners, and the proposed work methodology makes the consortium confident of their ability to meet the project research and development objectives in the short term.

### Large Scale feasibility

(relevant WP 6)

Successful implementation of this system will lead to assessing the feasibility for implementing large scale applications and making possible the effective integration of RES within the energy system. This will mainly done in WP6. Large scale solutions may include the KiWiGen **large array** generators, KiWiGen **carousel** generators or KiWiGen **train** generators. These new embodiments are logical evolution of the concepts proposed in this project as they can actually offer the long awaited alternative energy source.

The KiWiGen **large array** is the concept of fitting several kite generators that share the same airspace, into a small area. The controls have to be closely co-ordinated in order to harness the wind at different altitudes and manoeuvre the kites without interference between the lines and the kites themselves.

The KiWiGen **Carousel** generator is a horizontal circular tensor-structure turning on a vertical axis, whose pivotal centre is geared with a **conventional alternator**. Several KiWiGen base stations control the kite tandems linked to the peripheral edge. The carousel can improve the kite's automatic take-off phase even in conditions of low ground wind. Kites sweep large sections of the wind front by increasing the energy collection area. In order to reach an installed power of about one GigaWatt, (like the one provided by a medium sized nuclear power plant,) the diameter of the frame has to be about one thousand meters. However the construction challenge is lower than the one required by large bridge, civil engineering technologies. Moreover, the territorial impact can be reduced by offshore installations.

The KiWiGen **train** generator can be conceived of only for on-shore installations. It is an application, which requires a fixed railway, whose position is relative to the dominant wind. The convoy, equipped with the control base stations, is dragged forward and backward by the kites and the alternator is powered by the relative movement of the railway-train.

These implementations, and other different embodiments, are achievable and easy to build, as the kite array's very low centre of gravity, provides a clear advantage, as compared to large windmills.

A list of the topics to be investigated for scaling up the system follows:

5. Possible interactions between different kite generators located in the same area
6. The opportunity of capturing wind at different altitudes
7. Multiple and co-ordinated controls
8. Over-flight rules and restrictions
9. Medium and maximum powers that can be achieved

10. Plant dimensioning
11. Flying path and process optimisation
12. Wing design and optimisation

Both the automatic pilot and control idea and the KiWiGen Carousel generator have been patented in Italy by the co-ordinator. During the project, the patent will be leveraged from the Italian to the European scale; access to this knowledge will be provided to all the partners for the successful implementation of the project. Moreover, knowledge arising from the research and technological development activities may lead to the opportunity of proposing new patents covering the mechanical, electronic, sensor and material subsystems. This new knowledge will be the property of the contractor carrying out the work leading to that knowledge, or joint ownership will be established. All the partners will be entitled access to this information, in order to offer the consortium an adequate framework and conditions for successfully carrying out the work.

## Dissemination activities and strategies (WP7)

It is presumed that the first demonstration phase, even that obtained only with the base station controlled by a human, could generate evidence that is sufficiently rigorous and disruptive of the current beliefs, commonly held by social actors and stakeholders.
The success of this first phase could happen at an early point of the project and it will allow the consortium to immediately start the dissemination activity.

The Consortium intends to involve a targeted number of decision makers, research centres and stakeholders plus the larger public in the dissemination phase, to create a **virtuous optimisation loop** - which can collect and get the collaboration of a larger number of relevant social actors.
It can exceed the boundaries set by the current concept and by the solutions developed and implemented during the project activities, as the soft computing concept requires successful applications in order to be widely recognised, to be accepted and to find applications in other strategic fields (mainly, sustainable management of the territory and biomasses, transport…). Moreover, successful conclusion of the project activities should facilitate dissemination activities as the project's potential outcomes have been long awaited.

The dissemination plan, an integral part of the project, will be aimed at achieving the following results:

- To spread the design thinking and challenge to the larger scientific community
- To provide large visibility for the project.
- To make clear to the general public, the potential returns in terms of energy generation resulting from the exploitation of wind energy through the proposed technologies.
- To show the very-low environmental impact even with respect to conventional wind turbines
- To provide evidence to the policy makers of the enormous energy potential resulting from the exploitation of the wind via the technology we have developed, and the potential returns in terms of sustainable development.
- To convince the largest European Companies, dealing with energy production and distribution, of the massive potential of the proposed technologies and their possible large scale integration.

To achieve these purposes, the project intends to actuate a dissemination plan that is articulated in different phases and points toward different targets. Each phase requires the production of support information for the final target, as to the specific aims to be achieved by the project activities.

### Promotion of the project to the large public

### Instruments:

Creation of a logo and a graphic line specific to the project, in order to make it recognisable and clearly identifiable.

Production of an informative brochure in English, Italian, Spanish and French aimed at the general public, describing the project objectives and the work plan.

Creation of a web site, under the Sequoia domain, which will recount in a simple format – comprehensible to a non-expert public – the project features and the proposed technologies, by detailing the main stages in the project implementation. Information about renewable energy, and particularly about the wind energy, will be made available to the general public, together with information on European current policies and on the political stance. A video, in animation, will show the principles of the proposed technology and their possible application within the energy field. A contact section will provide the e-mail address for writing and receiving more information about the project. The web site will be built in English. Sequoia will also handle the production of a definitive film to inform the large public of the concepts and results of the project.

Research for sponsors aimed at the organisation of a play-sport event, which will take place during the Turin 2006 Winter Olympics, scheduling sports, which are dependent on the wind - like kite skiing. During this event, a demonstration of the functioning prototype will be held, in order to prove the potential of the instrument. To this extent, preliminary presentation to the Toroc – the 2006 Winter Olympics promotion Agency -, to the Turin provincial Council and to the Piedmont Region will be made.

### Tools

a. Diffusion of the site through authorised links or pop-ups located in the web pages of the main environmental associations who work at the global scale for promotion of wind energy, in the sites of the main European and national Agencies which have the protection of the environment as their mission, in the pages of the Associations and sport Federations that support sports tied to the wind (e.g. sport kites, surf kites, sailing and so on).
b. Diffusion of the brochure through attendance at the main sport events, where the wind is the primary source of energy (e.g. kite surf league, through the involvement of the international federation of kite surfing which has already been contacted), that are taking place in each of the Partner Countries.
c. Dissemination of the results gained by the project and demonstration of the running prototype during a play-sport event in occasion of the Turin 2006 Winter Olympics.

### Agenda

1. The logo and the web site will be implemented at the beginning of the project and will be available by month 4
2. The dissemination activity will take place from month 5 to month 36.

### Promotion of the project to the scientific community

### Instruments:

Creation of an informative dossier with a scientific slant aimed at the scientific public.
Preparation of editorials to be published by the main scientific research magazines.

### Tools

d. 1. Disclosure of the scientific dossier in dedicated pages of the web site
e. 2. Creation of a dedicated mailing list for sending via e-mail the scientific dossier to those European research centres and Universities that are involved in research activities focused on renewable and wind energy sources.
f. 3. Screening and selection of the scientific magazines, which are suitable for publishing articles on the proposed topic.

g. 4. Informative seminars on the results gained through the participation of the consortium at some of the events/fairs focused on environmental themes and on the need for renewable energy sources. A preliminary analysis has identified the opportunity of participating in the following events:
   i. "Wind Energy International Trade Fair", Hamburg (Germany), May 2004
   ii. "European Wind Energy Conference", London (UK), November 2004
   iii. "National conference on Wind Energy", Reggio Calabria (Italy), 2006.

e. Invitations to attend the seminars listed in point 4 will be sent to all the interested researchers on the basis of the feedback gained after the dispatch of the scientific dossier (by mail to the list built during point 2).

### Agenda

1. Disclosure of the scientific dossier on the project web site is foreseen for month 5. The dossier will be regularly updated on the basis of the results achieved within the project framework.
2. Delivery of the informative mailings and the scientific dossier to the identified research centres and universities will take place starting from month 8, when the first target results in terms of demonstrator electronic and mechanical design will be achieved.
3. Release of editorials is foreseen simultaneous to the conclusion of WP 3
4. Seminars will be held in the period 2004 – 2006 under the framework of the major European events dedicated to renewable energy. A first list of Conferences has been listed in point 4 and a more comprehensive selection will be provided at the start up of the project activities.

### Promotion of the project to the policy makers

### Instruments:

Arrangement of the informative – scientific dossier for addressing aspects, which are relevant at the institutional level
Promotion of the project among the Institutions, which are closer to the partners forming the consortium (i.e. Provincial Councils, Regions, Ministry of Research & Development) and other Agencies within their respective Countries. A list of suitable contacts has already been made and new ones will be searched during the first stages in project development. The list includes

For Spain: AVEN (Valencian Energy Agency), **CENER** Renewable Energy National Centre, Generalitat Valenciana, European Agency for Safety and Health of Work located in Bilbao.

For Netherlands: ECN Energy Research Centre of the Netherlands, **NOVEM** Netherlands Organisation for Energy and the Environment, **NEWIN** Dutch Wind Energy Society.

For Italy: ENEA, Regione Piemonte, Provincia di Torino, Environmental Park.

### Tools

a. Dispatch of the informative dossier to the chosen panel of institutions and policy makers.
b. Meeting with the actors, which have shown interest in the dispatched informative material with the presentation of a dossier relevant for decision making.
c. Invitation to the selected panel to attend the informative seminars scheduled in the period 2004 – 2006.

### Agenda

1. Contacts with Agencies and the Centres which are relevant for decision making purposes

will start at the end of WP1.

2. Preliminary documentation for raising interest and create awareness on the proposed development will be issued at the end of WP1.
3. Disclosure of the informative dossier addressed to the policy makers will be released together with the mid term report in month 18, when the demonstrator and a preliminary version of the SW will be available. Updated versions of the report will be released in conjunction with the availability of the results deriving from the testing activities.
4. Seminars will be held in the period 2004 – 2006 under the framework of the major European events dedicated to renewable energy. A first list of Conferences has been listed in point 4 and a more comprehensive selection will be provided at the start up of the project activities.

## Promotion of the project to the stakeholders

## Instruments:

Arrangement of the informative dossier with a scientific slant.
Creation of a specific mailing list for dispatching the dossier to the research centres of the main European energy producers (e.g. Enel in Italy, EDF in France, Scottish Power in the UK)
Involvement of the researchers identified in point 2 in the internal seminars that will be held in occasion of the main project milestones. They will attend as actors responsible for technological monitoring activities.

## Tools

a. Sending of informative e-mails and of the scientific dossier to the selected research centres of the main European energy producers (refer to the point 2 listed above)
b. Invitation of the interested researchers working in the research centres of the main European energy producers to attend the seminars held in occasion of the main project milestones.

## Agenda

1. Dispatch of an informative e-mail and of the informative dossier with a scientific slant to the identified research centres will take place in month 8 with the achievement of the first targeted project results.
2. First invitation of the researchers to attend the project internal seminars will take place at the attainment of milestone 3.

## Deliverables list (full duration of the project)

| Deliverable No[7] | Deliverable title | Delivery date [8] | Nature [9] | Dissemination level [10] |
|---|---|---|---|---|
| D1.1 | Report on the project requirements | 2 | R | CO |
| D1.2 | Simulation | 6 | O | CO |
| D1.3 | Definition of the demonstrator architecture plus functional diagrams | 6 | O | CO |
| D1.4 | Report on component target performance and specifications | 6 | R | CO |
| D1.5 | Requirements for the NC subsystem | 6 | R | CO |
| D1.6 | Methods for the final validation | 6 | R | CO |
| D2.1 | Functional specifications | 4 | R | CO |
| D2.2 | Preliminary design | 5 | O | CO |
| D2.3 | Detailed design drawings | 8 | O | CO |
| D3.1 | Report on each demonstrator subsystem | 12 | R | CO |
| D3.2 | Demonstrator prototype | 16 | P | CO |
| D3.3 | Test and validation results | 16 | D | PU |
| D4.1 | Outline of the SW architecture | 16 | R | CO |
| D4.2 | Report on the original low level control algorithms | 18 | R | CO |
| D4.3 | Report on the second level remote control development | 24 | R | CO |
| D4.4 | Report on the third level soft automation | 36 | R | CO |
| D4.5 | SW modules | 36 | R | CO |
| D5.1 | Report on the human control of the kite | 22 | R | CO |
| D5.2 | Report on instrumental flight results | 28 | R | CO |
| D5.3 | Report on smart control techniques as applied to the kite | 36 | R | CO |
| D5.4 | Report on the project's results | 36 | R | PU |
| D6.1 | Report on the large scale application | 25 | R | CO |
| D6.2 | Design of the large scale application | 29 | O | CO |
| D6.3 | Computer simulation | 36 | O | CO |
| D6.4 | Report on final validation | 36 | R | PU |
| D7.1 | Web site, graphics, essays, films | 36 | R | PU |
| D7.2 | Conference papers and articles | 36 | R | PU |
| D7.3 | Report on public response | 36 | R | PU |
| D7.4 | Exploitation and dissemination plan (updated every year) | 36 | R | CO |
| D7.5 | Report on demonstration activities | 36 | R | CO |

[7] Deliverable numbers in order of delivery dates: D1 – Dn
[8] Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.
[9] Please indicate the nature of the deliverable using one of the following codes:
**R** = Report
**P** = Prototype
**D** = Demonstrator
**O** = Other
[10] Please indicate the dissemination level using one of the following codes:
**PU** = Public
**PP** = Restricted to other programme participants (including the Commission Services).
**RE** = Restricted to a group specified by the consortium (including the Commission Services).
**CO** = Confidential, only for members of the consortium (including the Commission Services).

## Expected results (milestones)

| Milestone No | Description | Delivery date | Nature | Dissemination level |
|---|---|---|---|---|
| M1 | **Definition of the demonstrator architecture** in terms of both structure and functionality. | M6 | R | CO |
| M2 | **Demonstrator design**, with the definition of each subsystem and of the different interfaces. | M8 | O | CO |
| M3 | **Demonstrator**, consisting of all the sensors, actuation, lines, mechanical components and structures required for manoeuvring the kite, changing its attitude and for the production of electrical energy. | M16 | P | CO |
| M4 | **Soft automation solutions** for automatically manoeuvring the kite and maximising the energy generation process. | M36 | O | CO |
| M5 | **Final verification of the HW and SW** modules through qualification test aimed at verifying that expected performance and results are achieved. | M36 | R | CO |
| M6 | **Assessment of the large scale application,** with evaluations in terms of feasibility, scalability of the design, investment/management cost. | M36 | R | CO |
| M7 | **Dissemination report**, with the details and the evaluation of the dissemination activities which have taken place and the outline of future dissemination and demonstration activities. | M36 | R | CO |
| M8 | **Mid-term and final assessment report**, according to the EU contractual rules. | M36 | R | CO |

# Work package 1: Preliminary Analysis of the System architecture & Definition of the requirements

| Work package number | 1 | Start date or starting event: | | | Month 1 | |
|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 15 | 10 | 10 | 6 | 3 | 8 | 8 |

## Objectives

The objective of this Work Package (WP1) is the comparison and assessment of the project idea against the current solutions for the generation of renewable energy, the definition of the project requirements, the investigation and analysis of the functional and structural materials and components, which will be employed to construct the mechanical demonstrator. The appropriate conditions required for running the demonstrator and identifying the site for testing will be defined as well.

## Description of the work

The research and investigation phase is aimed at providing a framework for the project, together with the knowledge base required for the development, implementation and demonstration activities. Within this WP the following tasks will be addressed:

**Task 1.1 Identification of the project requirements**: investigation of wind dynamics and requirements, study of the kite behaviour, definition of the required performance and comparison to the data, resulting from the analysis of the state of the art, will result from this task.

**Task 1.2 Simulation:** Development of a simple simulator to visualise the kinetics and dynamics of the array of kites. Assessment of the aerodynamics and the stability of the array, as well as the interaction between multiple kites.

**Task 1.3 Demonstrator definition**: the system architecture and the functional blocks needed to build the final prototype will be defined. The modularity and configurability of the system will be considered as priority criteria. Special attention will be paid to the environmental impacts and recyclability of the materials used.

**Task 1.4 Structural characterisation**: the identification of the components needed to build the system will come together with the definition of components' target performance and specifications. Particular relevance will be attributed to the self-powered sensors and actuators (such as the inertial platform, anemometer, electronic compass and servos) to be employed within the system. The ground based actuators, servo drive mechanism and the support structures will be studied. The investigation of diverse materials will be aimed at identifying the best solution for providing application-oriented properties (e.g. the opportunity of employing Dyneema, kevlar or lines made of different materials will be explored).

**Task 1.5 Definition of requirements for the NC subsystem**: the definition of the functional blocks will be integrated and completed, along with the selection of the numerical control solution and of the software environment, including the choice of the operating system (e.g. Linux or Windows), and the identification of the requirements for the human-machine interface.

**Task 1.6 Definition of the methods for the final validation:** Methods for the validation of the results will be defined. This will include the selection of the sites for testing. The climate and territorial criteria for selecting the most appropriate sites for experimentation will be defined. Consideration will be given to wind power, availability, atmospheric and ground conditions. The site identification will follow.

## Deliverables

D1.1 Report on the project requirements

D1.2 Simulation

D1.3 Definition of the demonstrator architecture plus functional diagrams

D1.4 Report on component target performance and specifications

D1.5 Requirements for the NC subsystem

D1.6 Methods for the final validation

## Milestones and expected result

M1: Definition of the demonstrator architecture in terms of both structure and functionality.

## Work package 2: Mechanical and Electronic Design of the Demonstrator

| **Work package number** | 2 | **Start date or starting event:** | | Month 2 | | | |
|---|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 12 | 13 | 20 | 6 | 6 | 8 | 2 |

### Objectives

The objective of this WP is to design the functional specifications of a demonstrator capable of freely driving the kite array, to outline the kite generator or base station’s final design and to define the interfaces between the different blocks composing the system.

### Description of the work

By building on the skills and experience provided by the partners who are specialised in the machine tool and robotic industry, the mechanical and electronic design of the demonstrator will be studied and validated.

**Task 2.1 Definition of the demonstrator functional specifications**: on the basis of the overall system architecture and the functional blocks resulting from the task 1.2, the functional and technical specifications will be defined.

**Task 2.2 Preliminary design of the functional blocks**: the technical and manufacturing solutions required for producing each demonstrator part will be addressed during the design phase using CAD applications. The hardware solutions will be studied, with reference to the solutions employed in the machine tool and robotics industry. Finally, consideration will be given to safety and impact issues, in order to design a prototype that provides effective answers to the questions of safety and security, that may be raised.

**Task 2.3 Final (detailed) design selection:** this task consists in the consolidation of the optimised solutions resulting from the previous tasks. The design of the single parts will be assembled into executive drawings, in order to obtain both the electronic and mechanical final design. Based on the materials used a quick LCA will be performed.

### Deliverables

D2.1 Functional specifications

D2.2 Preliminary design

D2.3 Detailed design drawings

### Milestones and expected result

M2: Demonstrator design, with the definition of each subsystem and of the different interfaces.

## Work package 3: Construction & First Validation of the Demonstrator

| Work package number | 3 | Start date or starting event: | | Month 7 | | | |
|---|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 13 | 16 | 10 | 5 | 8 | 4 | 4 |

### Objectives

The objective of this WP is to produce a mechanical prototype, in essence, a demonstrator, capable of freely driving a kite, implementing a procedure that will convert ca. 10 kW of wind energy, and to test it in the workshop

### Description of the work

A mechanical prototype, consisting of the assembly of the different subsystems, designed or identified in the previous WP, will be set up and tested in the workshop.

**Task 3.1 Production of the functional blocks**: the subsystems identified in the previous WPs will be produced and tested against the selected performance criteria. The suitable components and systems will be acquired or constructed in house. All of the enhancements necessary for making them compliant with the project requirements will be analysed and implemented. Sensors, actuators, drives, encoders and all of the system hardware will be available by the end of this WP. Based on the materials used a more thorough LCA now will be performed.

**Task 3.2 Subsystem integration**: during this task, the archetypes and modules built and enhanced during WP 3.1 will be integrated into the demonstrator.

**Task 3.3 System validation**: the demonstrator will be tested against the specifications and the performance criteria set during WP1.

### Deliverables

D3.1 Report on each demonstrator subsystem

D3.2 Demonstrator prototype

D3.3 Test and validation results

### Milestones and expected result

M3: Demonstrator, consisting of all the sensors, actuators, lines, mechanical components and structures required for manoeuvring the kite, changing its attitude, and for the production of electrical energy.

## Work package 4: Software Development

| Work package number | 4 | Start date or starting event: | | | Month 7 | |
|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 40 | 14 | 0 | 15 | 0 | 3 | 0 |

### Objectives

The objective of this WP is to develop the smart control techniques and algorithms required to implement the automatic control and pilot system. The advanced software solutions will actuate the position determination, aerodynamic control functions and will modify the operating parameters in order to maximise the production of energy, while ensuring the safety of the operations.

### Description of the work

The project has proposed a solution that is relatively simple from the mechanical and physical point of view, but much more challenging from the control and management side. The research and development work performed during this WP will demonstrate the applicability of the soft computing theory. Activities will be carried out in strict conjunction with the ones to be developed during WP5.

**Task 4.1 Analysis of the software architecture**: all the issues related to the system structure and to the expected operating modes will be addressed, in order to define the logic of the software architecture. Sensory signal information management, signal conditioning and processing solutions, transmission methods, non linear predictive and functional control, detection of changes and fault tolerant control systems will be elaborated during this task. Evaluations of the analytical or neural-fuzzy approaches will be made, in order to select the most suitable approach for software implementation.

**Task 4.2: Development of the low level control**: on the basis of the theoretical analysis carried out in the previous task, the algorithms required for manoeuvring the kite in real time, through a stick or pad interfaced with the control machine, will be developed. Data collected during this task will be used to precisely describe system operations and to build a virtual model, capable of simulating the kite’s behaviour under the different climatic conditions.

**Task 4.3: Remote control development:** the computer simulation resulting from the previous task and the experience resulting from Task 5.1 will make possible the simulation of the demonstrator’s operation and of the kite behaviour. It will take into account all of the actual sensing and actuating capabilities. The development of advanced mathematical algorithms for driving the kite in remote and the optimisation of such a control system will follow. To this end, the base station will provide information on the forces, energy, tilt, bending angles, wind speed and direction, winding speed etc. This data stream, plus the commands provided by the trainer, in response to the simulated behaviour, will be routed to build a historical database..

**Task 4.4: Implementation of a soft automation:** during this task, the soft computing, adaptive control and flexible automation concepts will be put into place. The mathematical algorithms will be further revised and refined and the history database will become the basis for setting-up the automatic control, capable of driving the kite and of reacting to any system changes.

**Task 4.5 Software Validation:** this is a recursive phase, in which all of the developed software modules will be tested and revised in order to meet the system specifications. This will allow for demonstrating the effectiveness of the proposed system, the feasibility of the soft computing theory and of the technology envisaged to control the prototype.

### Deliverables

D4.1 Outline of the SW architecture

D4.2 Report on the original low level control algorithms

D4.3 Report on the second level remote control development

D4.4 Report on the third level soft automation

D4.5 SW modules

### Milestones and expected result

M4: Soft automation solutions for automatically manoeuvring the kite and maximising the energy generation process.

## Work package 5: Field Testing and Validation

| Work package number | 5 | Start date or starting event: | | Month 18 | | | |
|---|---|---|---|---|---|---|---|
| Participant id | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Person-months per participant | 12 | 6 | 10 | 9 | 3 | 4 | 8 |

### Objectives

The objective of this WP is to build the core competencies in terms of system control and manoeuvring, by setting-up the knowledge and the skills required to drive a kite for energy generation. The ability to correctly react to unforeseen events and to natural wind variations must result from this process. The final goal of this development is to produce enough information through testing the demonstrator and to verify in the field the correspondence between the expected and the real behaviour of the prototype.

### Description of the work

During this WP the experimental results coming from the demonstrator hardware and software testing will be analysed and critically evaluated and will provide a well documented field experience. The results of the experimentation will allow us to progressively refine the work, validate the system's operation and build a reliable and effective platform.

**Task 5.1 Human control:** an expert will drive the kite through a stick or pad interfaced with the control machine (exploiting the results of Task 4.2) while directly looking at the result of the manoeuvring operation. Such a practice will allow for the collection of all the required information on kite behaviour and driving. It will be the basis for building the computer simulation system and techniques.

**Task 5.2 Instrumental flight:** the commands resulting from the human control practice – routed to build a history database – will be used for the remote control system. The instrumental information will be the only input available to the driver, who will have to pilot the wing accordingly. This task will lead to the validation of the data stream coming from the machine (signal acquisition and processing) and will provide the basis for building the automatic control system.

**Task 5.3 Automatic flight:** during this task the soft automation concept will be put into practice through testing and validation of the smart control techniques. The controller reproducing the behaviour of the kite expert and empowered with human skills will be tested and verified against the numerical calculations and the expected performance criteria. This is a recursive phase, which allows for verifying the progress achieved in the software development process. It is aimed at assessing and optimising the energy generation procedure.

**Task 5.4 Evaluation of the test results:** the aim of this task is the final evaluation and characterisation of the demonstrator and of the performance achieved by the system. A comparative assessment will be made between the experimental data and the simulator. Based on the materials used in the demonstrator through LCA and costs analysis will be performed.

### Deliverables

D5.1 Report on the human control of the kite

D5.2 Report on the instrumental flight results

D5.3 Report on the smart control techniques as applied to the kite

D5.4 Report on the project's result

**Milestones and expected result**

M5: Final verification of the HW and SW modules through qualification test aimed at verifying that expected performance and results are achieved.

## Work package 6: Large Scale Integration

| **Work package number** | 6 | **Start date or starting event:** | | | Month 23 | |
|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 14 | 7 | 10 | 3 | 3 | 3 | 10 |

### Objectives

The objective of this WP is to prove the feasibility and effectiveness of renewable energy production, at a very large scale and low cost. Different solutions will be explored and assessed in order to develop a system able to meet the energy requirements coming from large communities. The aim is to provide a real alternative to the current unsustainable pattern of development which characterises Europe's energy system. Further, the impact on the environment will be assessed for large-scale integration.

### Description of the work

**Task 6.1 Definition of large scale applications:** the knowledge built up during the project development will be used to develop the design of GigaWatt or MegaWatt plants. The solutions envisaged within the project proposal, like the KiWiGen carousel generator, the KiWiGen train generators or the KiWiGen large array generator will be further assessed and investigated in order to verify them, define their functional and technical impact and provides figures on the expected return. New solutions for the development of large scale applications may result from this stage as well. Environmental benefits and impacts will be determined using the data obtained in the WPs 1 to 5.

**Task 6.2 Application design:** the aim is to expand the KiWiGen idea, implemented in the first phase of the project, and to propose a new modelling of wind turbines, by designing larger scale applications, capable of supplying several MegaWatts or GigaWatts. Therefore, the solutions validated in the previous task will allow the consortium to design the first large scale kite generator.

**Task 6.3 Computer simulation of the new wind turbine:** simulation techniques will be used to reproduce system behaviour and to prove the effectiveness of the large scale technological solution, aimed at concentrating important amounts of dispersed energy into a single generation plant.

**Task 6.4 Validation of the large scale applications:** the demonstrator comprehensive feature assessment, in terms of feasibility, scalability of the design, environmental benefits and impacts, investment/management and life cycle, will lead to the final evaluation of the feasibility of employing the KiWiGen for large scale implementations. The open issues will be addressed, in order to provide a precise answer regarding the impact of this revolutionary process.

### Deliverables

D6.1 Report on the large scale application

D6.2 Design of the large scale application

D6.3 Computer simulation

D6.4 Report on final validation

### Milestones and expected result

M6 Assessment of the large scale application, with evaluations in terms of feasibility, scalability of the design, investment/management cost.

## Work package 7: Dissemination and exploitation related activities

| Work package number | 7 | Start date or starting event: | | Month 1 | | |
|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 17 | 5 | 5 | 4 | 12 | 6 | 10 |

### Objectives

The objective of this WP is to address all the exploitation and the dissemination activities required for the understanding and the diffusion of the proposed technology. Activities will be aimed at:

- Transmitting the concepts and activities of the consortium to the wider non-scientific public, the scientific professionals in the field and the policy makers.
- Enlarging the public awareness regarding the possibilities for energy generation, offered by the proposed technology, and the feasibility of employing the huge energy available in troposphere wind.
- Overcoming, through demonstration of the running prototype, disbelief or doubts that may be raised from social actors or stakeholders.
- Giving answers to questions like environmental impact, security and safety issues.
- Providing estimations about the economic impact of the new technology.

### Description of the work

The concept of energy generation through the employment of a kite has to receive acceptance and recognition. Therefore, project activities will be aimed at creating a broad awareness on the feasibility, the effectiveness, the social and economical impacts resulting from the proposed system. The following tasks will be addressed:

**Task 7.1 Creation of a co-ordinated visual and verbal documentation of the project's concepts and premises.** Through graphics, essays, a web site, and films, the progress of the project will be communicated to the various levels of the public**.** In particular, the filmed documentation will serve to transmit the concepts to the widest possible audience.

**Task 7.2 Participation in conferences and seminars:** this activity will be aimed at disseminating the project results as well as contributing to increasing the awareness as to the innovative technical approaches to the production, storage, integration and to the use of the wind and kites to generate electrical energy.

**Task 7.3 Involvement of large public** through attendance and organisation of play-sport events where the wind is the primary source of energy.

**Task 7.4 Exploitation and dissemination plan revision:** the exploitation and dissemination plan will be revised in the light of the project results, the extent of the performed activities and the interest raised by the project.

**Task 7.5 Field demonstrations:** the system for the production of renewable energy will be installed on moving structures and transferred to different sites and locations for demonstration purposes. This activity is required for the creation of a culture of creativity and interest in the development of new, innovative and environmental friendly systems for energy generation, for demonstrating system capabilities and envisaging the feasibility of setting up other demonstrators or wind farms for addressing local requirements in terms of energy.

### Deliverables

D7.1 Graphics, essays, films and web site

D7.2 Conference papers and articles

D7.3 Report on public response

D7.4 Exploitation and dissemination plan (updated every year)

D7.5 Report on demonstration activities

### Milestones and expected result

M7.1 Dissemination report, with the details and the evaluation of the dissemination activities which have taken place and the outline of future dissemination and demonstration activities

## Work package 8: Project Management

| **Work package number** | 8 | **Start date or starting event:** | | | Month 1 | |
|---|---|---|---|---|---|---|
| **Participant id** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Person-months per participant** | 18 | 0 | 0 | 0 | 6 | 0 | 0 |

**Objectives**

This WP will address the following topics:

- Technical management
- Administrative management
- Financial management
- Co-ordination activities
- Progress control
- Timely warning and management of unexpected problems
- Provision for the project results and of Deliverables to the EC at the due times.

**Description of work**

- Task 8.1 Project Management

Sequoia delegates two project managers within their company, who are responsible for managing the project with support of the consortium (especially the individual task leaders and the work package leaders) regarding:

- performance and progress,
- an adequate focus on the work approach,
- communication and interactions with the EC,
- reviews and meetings.

Standardised communication formats and rules will be defined in the Project Handbook. Monthly reports will be used for communication within the consortium and with the Commission.

**Deliverables**

3 month reports

6 month reports

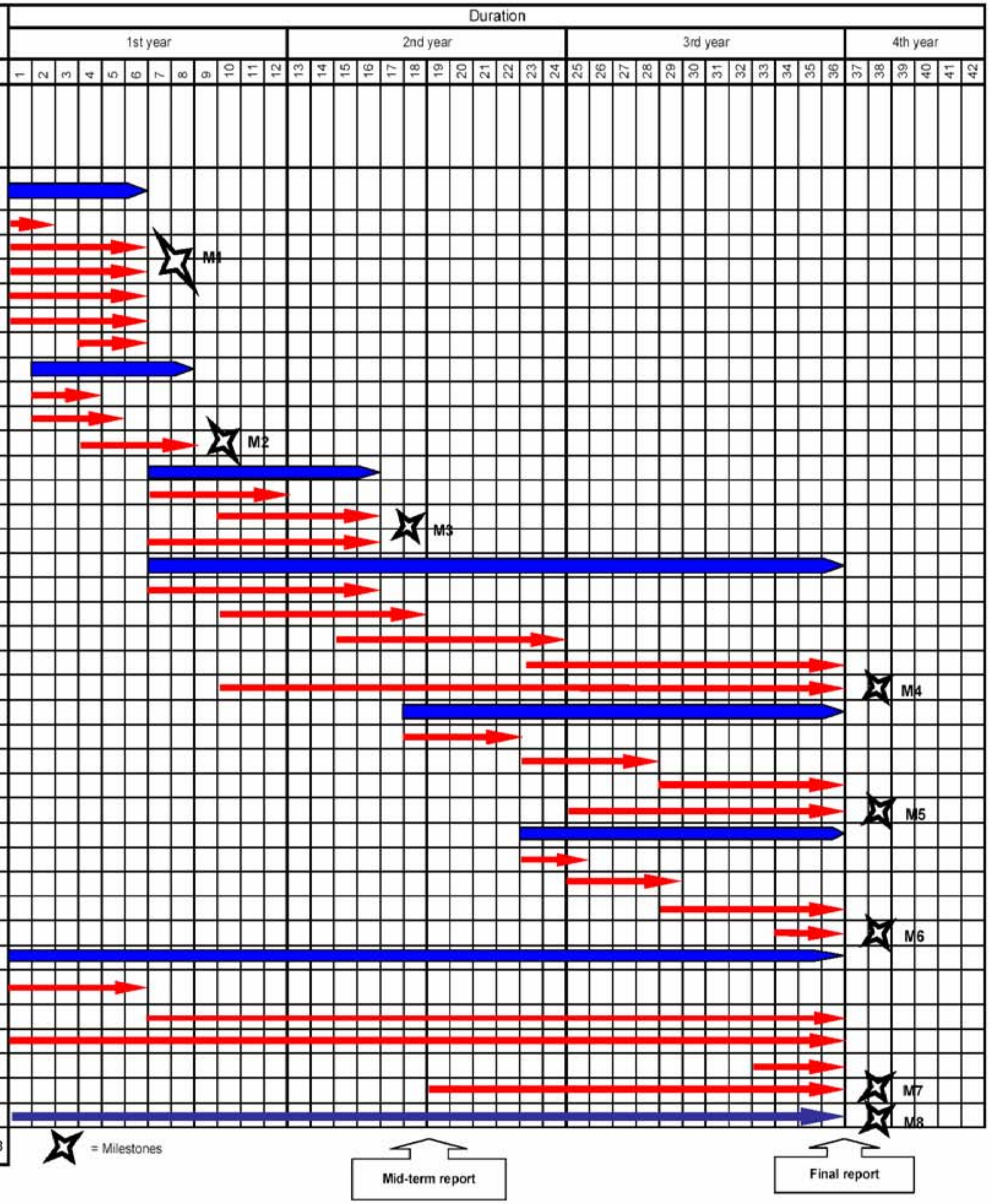
Annual cost statements

**Milestones and expected result**

M8.1 Mid-term assessment report

M8.2 Final assessment report

| Workpackage / Task description | | | Sequoia (1) | Fidia (2) | CeSI (3) | Fatronik (4) | IET (5) | TUDelft (6) | UU-STS (7) | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| WP1 | **Preliminary Analysis of the System Architecture and Definition of the Requirements** | | 15 | 10 | 10 | 6 | 3 | 8 | 8 | 60 |
| | Task 1.1 | Identification of the project requirements | | | | | | | | |
| | Task 1.2 | Simulation | | | | | | | | |
| | Task 1.3 | Demonstrator definition | | | | | | | | |
| | Task 1.4 | Structural characterisation | | | | | | | | |
| | Task 1.5 | Definition of requirements for the NC subsystem | | | | | | | | |
| | Task 1.6 | Definition of the methods for the final validation | | | | | | | | |
| WP2 | **Mechanical and Electronic Design of the Demonstrator** | | 12 | 13 | 20 | 6 | 6 | 8 | 2 | 67 |
| | Task 2.1 | Definition of the demonstrator functional specifications | | | | | | | | |
| | Task 2.2 | Preliminary design of the functional blocks | | | | | | | | |
| | Task 2.3 | Final (detailed) design selection | | | | | | | | |
| WP3 | **Construction & First Validation of the Demonstrator** | | 13 | 16 | 10 | 5 | 8 | 4 | 4 | 60 |
| | Task 3.1 | Production of the functional blocks | | | | | | | | |
| | Task 3.2 | Subsystem integration | | | | | | | | |
| | Task 3.3 | System validation | | | | | | | | |
| WP4 | **Software Development** | | 40 | 14 | 0 | 15 | 0 | 3 | 0 | 72 |
| | Task 4.1 | Analysis of the software architecture | | | | | | | | |
| | Task 4.2 | Development of the low level control | | | | | | | | |
| | Task 4.3 | Remote control development | | | | | | | | |
| | Task4.4 | Implementation of a soft automation | | | | | | | | |
| | Task4.5 | Software validation | | | | | | | | |
| WP5 | **Field Testing and Validation** | | 12 | 6 | 10 | 9 | 3 | 4 | 8 | 52 |
| | Task 5.1 | Human Control | | | | | | | | |
| | Task 5.2 | Instrumental flight | | | | | | | | |
| | Task 5.3 | Automatic flight | | | | | | | | |
| | Task 5.4 | Evaluation of the test results | | | | | | | | |
| WP6 | **Large Scale Integration** | | 14 | 7 | 10 | 3 | 3 | 3 | 10 | 50 |
| | Task 6.1 | Definition of large scale applications | | | | | | | | |
| | Task 6.2 | Application design | | | | | | | | |
| | Task 6.3 | Computer simulation of the new wind turbine | | | | | | | | |
| | Task 6.4 | Validation of the large scale applications | | | | | | | | |
| WP7 | **Dissemination and exploitation related activities** | | 17 | 5 | 5 | 4 | 12 | 6 | 10 | 59 |
| | Task 7.1 | Creation of a co-ordinated visual and verbal documentation of the project's concepts and premises | | | | | | | | |
| | Task 7.2 | Participation in conferences and seminars | | | | | | | | |
| | Task 7.3 | Involvement of large public | | | | | | | | |
| | Task 7.4 | Exploitation and dissemination plan revision | | | | | | | | |
| | Task 7.5 | Field demonstrations | | | | | | | | |
| WP8 | | **Project Management** | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| | | Total PM | 141 | 71 | 65 | 48 | 35 | 36 | 42 | 438 |



# B.7 Other issues

### ethical and gender issues associated with this proposal

One of the important social and ethical goals, allied to the proposal, is to ensure that the widest range of citizens can assume an active and informed role in the control and use of the assets and out put of the KiWiGen project.
As already explained, through the dissemination activities the Consortium intends to reach four levels of the public. The target is:

- the large public,
- the scientific community,
- the policies makers,
- the stakeholders.

It is a matter of fact, that women, for historical, cultural and social reasons, are less represented in the last three spheres of influence: specifically those which have a direct responsibility for the development and implementation of new technologies in Europe today.
As an effect of horizontal and vertical segregation, women are underrepresented in science, politics and higher management,

Therefore to insure an equal opportunity for women to take part in the process of influence, which could bring about the adoption of large scale implementation of the technology proposed by KiWiGen, it is necessary to develop a specific strategy.

The gender action plan in KiWiGen will be based on:

- a)a language and images approach,
- b)a balance between men and women, among the people contacted during the dissemination activities,
- c)a balance between men and women, among the people involved directly in the project.

a) a language and images approach.

Gender social research on language and images has shown that they are used differently by men and women. Moreover, it has been argued at times, that in scientific matters women in the greater public, do not observe or describe things as men do. Some of the time, these differences are linked with a different kind of representation at a symbolic and social level, rather than with the cognitive aspect.
In this prospective, all support material for the dissemination activities, and particularly for the large public target, will take in account gender representative matter.
Language will be revised and images processed in a gender prospective to assure equal accessibility to the subject and detect possible gaps. The communication plan will display models, images and language which takes into account gender aspects.
For this reason the dissemination plan, in its visual and graphics representation, will be carried out by two women experts.

b) a balance between men and women among the people contacted during the dissemination activities.

In the framework of the activities described in the dissemination plan, all partners involved will search for female experts and representatives at levels of policy makers, the scientific community and stakeholders, as they build a mail contact list and/or direct contact within in their own country. The Consortium intends to involve women's scientific networks such as WITEC (WOMEN Engineering in Technology and Science), that in Europe promotes women's access to science and technology matters and careers. This census of women, in the main spheres of influence, could guarantee that a minimum percentage of women among the decision makers, in science and politics, will take part in the decisional process needed, to adopt on a large scale the technology produced within the project.
The Consortium notes that the greater sensitivity of women to environmental matters and

renewable energy could have a major impact on the out-put of the project to society.

c) a balance between men and women among the people involved directly in the project.
The companies and universities involved in the Consortium reflect the average situation of women in the technical and scientific professions: their staffs are lacking in women. For this reason the Consortium has decided to counter balance this situation by introducing women, whom, for their professional background and competencies, can direct transversal activities within the project: **the dissemination activities, communication planning, co-ordination of the partners' activities and the project-management.**