Floating Solar Updraft Tower

José Antonio Molina
Licenciado en Ciencias Físicas, Máster en Energías Renovables OnLine
Email: josermolina999@hotmail.com
Fecha de redacción de este artículo: enero de 2012
Otros proyectos: www.saervi.com
Abstract:
This article presents an alternative to conventional solar towers which are projected for the next years. It suggests the use of aerostatic ballons to keep standing the towers, so they could be lighter, they wouldn't need foundations, they could be reusable, removable, so their impact upon the land and the landscape would be reversible.

Introduction

A solar updraft tower is a facility producing renewable electricity that basically consists of a large chimney in the center of a covered area like a large greenhouse.

Functional diagram of a solar updraft tower. On the right is shown the prototype built in Manzanares, Spain, in 1982.

The viability of these facilities has been demonstrated in experimental facilities, such as the one installed in Manzanares, Spain, with a tower of 195 meters, or as large projects to be carried out also in Spain, Australia, USA, etc. In the latter case the company EnviroMission plans to build a tower of 1,000 meters with a collecting area of 38 km² which is expected to reach 200 MW of electric power.

However, these installations requiring a huge infrastructure (a gigantic rigid tower whose sole purpose is to be a pipe for indoor air) and a large land area for the collecting area, all to generate electric power rather modest taking into account the dimensions of the installation.

This article proposes an alternative design, the **Floating Solar Updraft Tower**, as a proposal whose viability, efficiency, and costs should be compared with conventional solar towers before building the gigantic rigid towers that are been projected. In a FSUT (Floating Solar
Updraft Tower or TSAAF in Spanish) the chimney is held in a vertical position by leveraging balloons filled with helium or hydrogen.

A rendered image of a possible design Floating Solar Updraft Tower (FSUT) whose advantages over conventional solar towers are discussed in this article.

A Floating Solar Updraft Tower is a facility that combines two current technological trends: first, conventional solar towers, which have a demonstrated efficiency and feasibility according with projects that are been projected. Furthermore, the return of the great dirigibles, using designs that should be built in the coming years, for the transport of goods or passengers.
The Floating Solar Updraft Tower is a concept that uses existing technology of solar towers but adding a balloon (element existing also on the rise, as the model of the image) to keep the tower upright, which can represent certain advantages such as the absence of foundations, its modularity, its lowest land use and their reversibility and reusable.

The FSUT fits with the philosophy of 'tiptoe' over nature, that is, to make our time on earth may leave the slightest trace. This is because
a FSUT leaves no trace on the ground, once dismantled, and all elements are reusable.

The image above shows a hypothetical group of floating solar updraft towers. Under the circular greenhouses, soil is exploited for horticultural crops. The towers depend from aerostats, which do not require deep foundations of concrete. A similar installation of a conventional solar tower would forever mortgaged the land, planted with huge concrete chimneys remain even when the facilities were outdated or no longer operational. On the contrary, FSUTs can be dismantled and leave the field clear for future purposes, and also all the elements of a FSUT could be reused from the balloons to the chimney, which is composed of separable sections. Aesthetically, though this is subjective, FSUTs are more beautiful, they do not seem huge tree stumps as conventional solar towers. FSUTs are like high mushrooms or flowers but with the added bonus of being able to be removed or relocated, which is impossible with rigid towers. In the case of the image, it is an intensive installation, without mortgaging the ground for life and without sacrificing its agricultural use, produces renewable electricity to feed the cities of the region almost free of charge, once amortized installation costs. The sale of surplus energy also constitute an added value for the whole region.
Another FSUTs garden, this time in a semi-desert area. This area, previously disadvantaged by the absence of agriculture, livestock, industry, etc., would become an exporter of renewable electricity and that will improve the quality of life of its inhabitants.
FSUT implementation

To ask ourselves about the feasibility of such facilities we must consider the differences with conventional solar tower installations. And to ask about their convenience, we should discuss the advantages of FSUTs over conventional systems.

Focusing on the first question, the matter is whether it is possible for a balloon kept upright a tower height equal to or greater than 1,000 meters, with a diameter of several meters. The issue involves two factors, namely: the lifting capacity of the balloon, and the weight of the tower.

The aerostats

Broadly, the climbing ability of a balloon is given by the difference between the density of the gas contained and the density of atmospheric air. If the air density is $1.275 \text{ kg/m}^3$ and the density of helium is $0.18 \text{ kg m}^3$, then lift capacity of 1,095 helium would kg/m$^3$. This means that each cubic meter of helium would be able to lift more than a kilogram of mass, or what is the same, one gram of mass per liter of helium. In the case of hydrogen, a candidate to be considered for a higher abundance and its lower cost, (but taking into account the risk of flammability) its capacity is somewhat greater, of 1,185 kg/m$^3$.

We might wonder what are the balloons current capacity. A GoodYear brand blimp can have a wingspan of about 58 meters, and a volume of about 5740 m$^3$. With a gross weight of 5,800 kilos, could keep erect a tower of several tons, once devoid of gondola, engines, tanks, etc. There are bigger models, such as those built by Zeppelin NT with a length of 75 meters and a volume of 8225 m$^3$. With a gross weight of about 10,600 kg could keep erect a tower nearly 10 tons, depending on the weight of the balloon envelope. These numbers fall short of the capacity of the old dirigibles twentieth century, as the Hindenburg and the Graf Zeppelin, with capabilities that exceeded 100 tonnes in the first case and 60 in the second. However, there are several projects that plan to use large airships for carrying heavy loads as they would do with a much lower cost than a commercial airliner and faster than that of a sea freighter, besides not need runways. This is the case of CargoLifter CL160, although currently the project seems paralyzed, the SkyCat, the AirShipOne, which is a hybrid model the SkyLifter, very interesting design and according to its designers could carry 150 tons of cargo, which could have important humanitarian uses, etc.
Keep in mind that a balloon of a floating solar tower is a static device, designed to stay upright on a point indefinitely, so it does not require the installation of engines, fuel, or any complex avionics. This simplifies the design and determines its shape, which could be that of a dish to offer less wind drag in any direction. And as for its capacity, as we have seen, it depends of their volume. For example, a spherical balloon with a radius of 20 meters would have a volume of 33,500 cubic meters, which would give ability to lift a tower weighing thirty tons, depending on the weight of the balloon itself. Actually, instead of a globe of great proportions, the FSUT could use a set of smaller balloons, which would favor the scalability of the system, it may be cheaper and boost security of the whole. So, it seems technically feasible to maintain erect a vertical tower of a considerable weight by a balloon or a group of them laden with helium or hydrogen.

**The sustainer gas**

One issue to consider is the availability of gas breadwinner. The current airships use helium, a scarce resource on Earth, because when it is released it tends to escape into space. Its production is expensive and there are only a few bookings for decades. It is another example of human stupidity that this gas is wasted on frivolous uses such as advertising blimps, when in certain fields such as magnetic resonance imaging for medical and scientific research is irreplaceable. While it is true that there are spectacular dirigibles airships projects for the coming years, these projects do not clarify how they will cope with the problem of the lack of helium.

Early airships used hydrogen until the Hindenburg tragedy and the pressure of aircraft industry persuaded people against it. But much time has passed since 1937 and we can venture that today, a hydrogen dirigible could be constructed in a much more secure way. After all, in an airliner we are sitting very close to huge deposits of kerosene, however people don't stop flying, despite all the accidents. In fact, hydrogen is used in balloons for scientific, sporting, etc..

But in any case, against future shortage of helium and provided that the balloons of a FSUT are unmanned, we should consider the use of hydrogen in them, a gas plentiful, cheap, and with a carrying capacity greater than the helium.

**The chimney**

Given hydrogen or helium as breadwinner, an inherent disadvantage of a FSUT with high efficiency is that it requires big size balloons to raise big weighs. The feasibility of these designs is thus closely related to
the manufacturability of the sections in a very light material. It should be considered for such sections to be constructed of a flexible material, which could produce, among other advantages such as the possibility of winding, greater lightness. The use of ultralight materials for sections of the chimney, whether rigid or flexible, would be the key to the viability of these facilities, as more lightness of the chimney, the smaller size of the balloons needed to keep upright and therefore minor construction problems, management, and less need for sustaining gas.

One thing to note about the tower is that it does not need to hold their own weight, since each of the sections hangs of the cables anchored to ground and connected with balloons. This means that the lower section does not support the weight of the stack thousands of meters above it, but only has to bear its own weight. This allows each section to be built with a much lighter material and with a very small thickness. In a FSUT, the chimney is constructed as a duct for the internal wind without it being necessary to take into account other conditions that are unavoidable in a conventional solar tower, which must necessarily be constructed in a robustly way with large thicknesses to maintain the integrity of the enormous tower.

Always focusing in the implementation of a high chimney that has to be kept suspended by a balloon, it must be built with sufficiently lightweight materials with sufficient strength to maintain its structural integrity against the wind flow inside and the scourge of the winds in the outside. Regarding the internal flow we must take into account that this presents fairly low speeds of the order of 15 m/s $^{12}$, and not very different pressures from atmospheric one, therefore it does not constitute a high risk factor for the integrity of the chimney. Regarding the outside wind, the cylindrically shape of the chimney offers little drag so the material does not suffer too much thereby.

The chimney would be built with sections joined by flexible joints, which could be assembled onshore and then elevated by the balloon. This division in sections is important since it would be impossible to manage a chimney as long as it is needed, and this division is also a technical necessity, given that in the process of lifting the integrity of the material, if this is too long, it would threatened to deal with the change of angle from the horizontal to the vertical. In addition, part of a FSUT philosophy is to be dismantled and scalable, which immediately suggests the tranching of the tower.

Regarding the material it should be considered whether the PVC or polyethylene pipe materials usual in large light pipes, making possible the manufacture of the required large diameter pipe for a solar
chimney. In any case, the material chosen should exhibit a very low density, because if the density is high, the weight of the sections would be too large. Do not forget that the great airships of the last century were made of a rigid structure based duralumin, a kind of high strength and lightweight alloys, so it is not unreasonable to think that, today, new alloys could be available to us in order to build the rigid segments of a floating solar updraft tower.

There is, however, other possibility instead of rigid sections for a FSUT, and that are flexible sections. This choice would have some advantages such as the possibility of rolling, which would facilitate their management, transport and the elevation of the tower. That is, the pipe would coiled like a big fire hose, and in the lifting process it would be open throughout its diameter. As disadvantages can be mentioned that it would prevent twisting or kinking of the hose along its entire length, for which it would have to ensure that the balloon did not rotate about its vertical axis, or that, if so, its rotary movement not be transmitted to the hose. Another disadvantage it could be the phenomenon of vibration of the walls of the chimney. Being flexible, they may vibrate in the airflow within, or deformed due to external winds. Both could cause turbulent flow inside which decrease the efficiency of the installation. However, a priori flexible tower still seems a good alternative to rigid tower sections. Its implementation would be dependent on the ability to build sections of hose with such proportions and on the availability of suitable materials. A priori construction could be feasible when you consider that could be used the same materials, light and highly resistant, used today in blimps: tedlar, polyester, mylar, dacron, urethane, etc..

In light of all this, it seems that the technical feasibility of this type of installation is possible, as there is technology and materials to do so. The economic feasibility study, however, would require deeper quantitative studies and, if favorable, it would be compared with the cost/production expected from other conventional systems.

**Collecting area and turbines**

As we will see below, the production of a conventional solar updraft tower is proportional to the height of the tower and the collector surface area. Since a FSUT may have, a priori, greater heights than conventional rigid tower, it could require less collector area, then lower land use. This can be advantageous in places where there are abundant plains or where land prices are high. As FSUTs require less space in a given field so we could groupe there more FSUTs than conventional solar towers, bringing electricity production per unit area would be greater.
The turbines would be the same as the ones of a conventional tower, and the design of the turbine chamber would not be given by the ability to withstand a rigid tower a mile high, so that its implementation would be much more simple and light.

**System efficiency**

The physical principles that govern a FSUT are the same that govern a conventional solar updraft tower. There are ample studies which determine the electrical power that is capable of supplying an installation of these features, both from experimental data, as the prototypical installation in Manzanares (Spain), as from numerical modeling.

The equation that governs the power that an installation of this type is capable of delivering is given by the equation:

\[
P = G A_{coll} \frac{2}{3} \frac{gH}{c_p T_0} \eta_{coll} \eta_{turbine} \eta_{chim}
\]

where each coefficient \( \eta \) represents the efficiency of the main components: the collecting area of the turbine, and the chimney. We see that the power delivered by a conventional solar tower is directly proportional to the height of the tower \( H \) and the collector surface area of the greenhouse \( A_{coll} \).

From this we can guess that in the case of a FSUT, whose output is governed by the same equation, the production will also be determined by the height of the tower and the collector surface area. Since, in theory, a floating tower does not have the same structural disadvantages that a conventional rigid tower, whose height is determined by the depth of its foundations, thickness, etc., we can built the chimney of a FSUT higher than a conventional tower, which increases the production of a FSUT for a same area collector.

This has to be accepted, however, with discretion. While it is true that his character would achieve floating stack heights of several kilometers (as many as the height attainable by aerostats), in practice a chimney too high would have an enormous weight so require, too, a large number of balloons to keep it upright and stable.

Furthermore, although not shown in the previous equation, the radius of the chimney is an important design parameter because it determines
the flow conditions inside the tower, which affects the efficiency. It is known that decreasing the radius of the tower velocity airflow inside increases. However, for each numerical models indicate that there is a critical radius below which dramatically increase friction losses and the flow becomes turbulent, which subtract the installation efficiency. This assumption, calculations involving the flow rate of the column of rising air, must be taken into account in the design of the chimney sections of a FSUT. The advantage over a conventional installation is that the choice of the optimum radius only depend on the characteristics of the chimney as efficiently flow tube, and it does not depend on structural integrity of the stack as a whole. The chimney of a FSUT does not support its own weight and it has not to be built as sturdy and heavy as a rigid tower, which would also bear the force of the wind. In a FSUT, the chimney sections are supported by steel cables which hang of the aerostats.

**Advantages of floating solar updraft tower**

Listed below are the possible benefits of this kind of installations compared with conventional solar updraft towers:

- The FSUT not need deep concrete foundations to support a rigid tower whose sole purpose is to be an air line. His affectation on the ground is minimal and reversible. That is not true for rigid tower, which requires huge foundations that will be there forever.

- A FSUT can be folded if necessary, either for maintenance, well before atmospheric instability times either with the need for a clean landscape artificial elements during a season. With a conventional tower, this is impossible: its involvement on the landscape is permanent.

- A FSUT can be dismantled and its components can be reused, so the balloons, as the sections of the chimney. In contrast, the only way to dismantle a rigid tower is destroy and turn into rubble, and hardly anyone will assume the cost of this in the future.

- A FSUT can be designed to be scalable: it is possible to add new balloons and new sections of chimney from the ground to increase the working height. In a rigid tower that is impossible, the only variable would be the size of the collecting area, thus occupying more land, as its height is conditioned by its foundations and structural integrity.

- The sections making up a chimney of a FSUT not have to bear the
weight of the upper sections, since all of them hang from a steel cable connected to the balloons. This would let us to build these portions in a lighter and thinner material than in the case of a rigid tower, which must use large amounts of concrete and steel to ensure its stability.

- Building a FSUT is faster, since it requires little work on the ground, so it can pay for itself better than a conventional solar tower.

- A FSUT can change its location if necessary, for example if the legal occupation of the land is finished or want to dedicate this to other uses, or if another region with more energy demands purchase or rent for a while. The transfer of a conventional solar tower is unthinkable.

- FSUT-technology is organic, due to its modular and reversible. That is, an FSUT can grow if the energy needs of the region rises, by adding balloons and stack segments. A FSUT can move, ie can 'uprooted' of a location and 'stand' on the other. A FSUT could be divided into two, eg if a region wants to buy part of it to generate its own FSUT in their territory and make it grow as demand and profits from their exploitation.

- A group of FSUTs can be a nicer view than the corresponding conventional solar towers. If these seem gigantic fossil tree stumps, the FSUT resemble enormous mushrooms, flowers and exotic trees swaying slightly in the wind and whose presence does not have to be forever.
The picture above shows a solar tower of the type planned by EnviroMission in Australia, Arizona, etc. and a FSUT that would have the same energy production, introducing the same value of the product of the height of the chimney and the surface of collecting area. The conventional installation presents a tower height of 1 km and a diameter of 130 meters, on a collecting area of 38 km$^2$. Since FSUT does not have the same constructive limitations presented by conventional tower, this model is three times higher. Therefore, the collecting surface is three times lower than the left. This means that for the same production, FSUT presents a more efficient use of the soil. The collecting area of the conventional system, with a diameter of 7 km, forces that these large facilities have to be constructed in desolate plains. A FSUT, however, can be constructed more near to the points where the electrical output is consumed. Its lower land use also allows more intensive exploitation of a given area, as they can be installed in the same land more FSUTs that conventional solar towers. It is true that the greater the height of a FSUT more visible in the distance, so its impact on the landscape is greater. But this impact, unlike a conventional solar tower, is reversible, and a FSUT can be removed without leaving a trace, or move from place, for example by being rented by another region or country with more energy demands. Its modular nature makes them organic facilities, since they can grow in size depending on the needs, and it is even possible that an installed FSUT be divided into two units for two different areas. These possibilities are entirely absent in the case of rigid towers planned for the immediate future. The image also includes, to give an idea of the dimensions of work, scale figures of other artificial constructions that exist today.

**The first prototype of FSUT**

Since it does not require the construction of foundations for a rigid tower, installation is completely harmless to the ground and would, therefore, less administrative procedures. After finishing its purpose the dismantling would be quick and would not trail on the ground. Comparing with rigid tower prototype Manzanares we wouldn't have to worry, in this case, a storm toppled the tower, as it did there in 1989.

A first prototype could be built on a reduced scale with existing products on the market. This would be a temporary facility, relatively inexpensive and require no more than the rent of land, providing it with a plastic greenhouse way as was done in the Manzanares prototype for conventional solar tower, a set of PVC, polyethylene or other material on the market, flexible or not, the joints for joining the sections, turbine generating electricity, and rent a blimp or a balloon.
The sections of the chimney would join with flexible joints in the floor, out of the collection area, and would join the cables hanging from the blimp. Such cables would go slowly unwinding its rollers, thereby the ballon would go up dragging the chimney.

Once all sections assembled, the tower hangs vertically. Each section supports only its own weight, because all of them are hanging of the cables, attached to each of the flexible joints. In this situation, the tower can be moved into its operative position, in the center of the collector.
Una vez en el centro del área colectora, la base de la torre se ensambla a la cámara de turbinas y la instalación está lista para producir electricidad. Como puede verse, el prototipo no requiere otras construcciones en tierra que no sean la cámara de turbinas central y el invernadero. Lo demás (globo, chimenea) son partes desmontables y transportables. Once in the center of the collector, the base of the tower is assembled to the turbine chamber and the system is ready to produce electricity. As can be seen, the prototype requires no other structures on land other than the main turbine chamber and greenhouse. The rest (balloon, chimney) are removable and transportable parts.

Extrapolation of the results obtained with this prototype, and the evaluation of costs and efficiency, would assess the profitability of a floating solar updraft tower on a larger scale, and compared with a conventional solar tower as planned in different parts of world for the coming years.

**The FSUT against Greek floating tower proposal**

There is a different proposal for a floating solar tower, presented by Christos D. Papageorgiou, University of Athens. The design features a collecting area and a chimney flexible, which remains vertical because
its perimeter is filled with a gas lighter than air. It would be neccesary to ask the differences between the two initiatives and determine the advantages and disadvantages of each.

A first advantage of FSUTs presented in this article regarding the design of Dr. Papageorgiou is that this only reaches a maximum height of 500 meters. A FSUT not have this limitation. If we built the chimney in a lightweight material, and there are enough balloons available, it could reach theoretical heights of several kilometers. Therefore, for a given area of land, a FSUT present a substantially higher output power than the Greek design.

Since the Greek design the lift force is distributed throughout the whole chimney, it has the disadvantage of being subject to the prevailing winds, which would push along its entire length and could tilt it, which would reduce the effective height work, which could no longer be a constant. It also has the disadvantage of being a very high structure on the whim of the wind, so it can only be built in uninhabited and flat areas.

The designs presented in this article have, a priori, other advantages over the Greek proposal. On one hand, the stability. In a floating solar updraft tower upright using aerostats, the lift takes place at the top of the tower, where the balloons pull it up giving it stability. The wind load occurs on aerostats that have a streamlined shape that can rotate on its axis, so that the vertical may be more assured because the tower has two anchors, one at its base to ground and another at the top, to balloons, while the tower of the Greek proposal is anchored to the ground only.

Moreover, in the Greek proposal it would constitute a serious problem to avoid twisting grips in the flexible chimney because its entire length is at the mercy of the wind. Especially in times of low flow interior, like the night, this design may bend or twist out of control by the action of strong winds outside. In a FSUT as those presented in this article, however, these problems are avoidable. If the tower is rigid section, there is no possibility of twisting or pinching the material. If the tower is flexible, the integrity is maintained by steel cords, which are those that actually support the weight, and in the event that the aerostat themselves revolved on its movement is not transmitted to the chimney using a hook rotary. Moreover, the aerostats could have steering devices, rudders, flaps, or small electric motors (powered by photovoltaic cells in the surface of balloons, this configuration is being projected in some hybrid airships\textsuperscript{17}), ground control, to rectify any abnormal behavior. This possibility does not exist in Greek design.
In this design, the sustainer gas is distributed over a wide length. In case of lost or microtears due to aging of the material, which could be possible in a large infrastructure subject to random wind push, it would be very difficult to determine the vanishing point. In the case of a FSUT, the gas is concentrated in conventional airships, which shortens the time of inspection, and also balloons remain static and are not subjected to twisting or kinking that could age the material and cause leakage. In a FSUT, in case of damage to one of the balloons it could be replaced by another, and meanwhile the whole installation could continue working at lower altitudes, reducing tower sections to offset the loss in power lifting. In the case of the Greek proposal, the deterioration of the chimney force suspend production for as long as the repairs will last.

Finally, making the chimney of a FSUT could be simpler than in the case of Greek design, because it is a simple tunnel for the rising air, built in rigid or flexible sections. In the Greek proposal, the perimeter of the chimney must be conditioned to contain the gas breadwinner, so its design would be more complicated and more exclusive and expensive repairs, in addition to having to overcome a more exhaustive quality controls than a FSUT, whose chimney has no other role to be a lead pipe for air. The Greek floating chimney may present more problems of deterioration and aging than a FSUT, and it is not scalable, and once end of life may find it more difficult to reuse for other uses, given its particular design.

**Conclusion**

The designs presented here are merely proposals for work. As mentioned, the performance of these facilities is subject to a favorable compromise between the lifting capacity of the aerostat and the weight of the tower. However, in light of all this, it seems clear that today there are materials and technology to build such facilities.

As we said, a FSUT echoes currently proposed initiatives, both in the field of renewable energy production and in the field of air transport. First, there are large solar tower projects, which reveals the profitability of these facilities. And second, there are also large airships projects to transport tons of cargo at a very low price. The FSUT is a logical union of two innovations, and in this paper we have briefly reviewed in a purely qualitative level the benefits that these facilities could have compared to conventional systems.
Some current projects imagine filling large areas of Australia and Africa with huge towers of steel and concrete, structures that would break the landscape for centuries even dismantled, a task that hardly anyone would assume because of its cost, and it would leave millions of cubic meters cement in the virgin soil. Alternatives such FSUT should be evaluated before strike the earth with more steel and cement. The visual impact of a forest FSUT in a desert, for example, wouldn't be less noticeable than in the case of conventional towers, however, FSUT does not sting the field, but hanging over him, and at the end of his life they do not leave the soil with cement stigmas forever.

Conventional facilities have huge land occupations and present enormous rigid concrete and steel towers, whose only purpose is to be conduits of air to produce electricity. It seems a complete nonsense, especially in times of economic crisis, addressing the cost of a huge tower whose only use is to be, as we say, a conduit for indoor air, and everything to produce a small amount of electricity too if counterpose with the vast space that occupies the entire facility. If the operational principle of these facilities is based on a long vertical tunnel for conducting a flow of air, it is absurd to raise a gigantic work just to get that, especially when there are alternatives.

The FSUT is one such alternatives. It is not a whimsical folly, but something logical and reasonable. If what matters is to get a long air duct, which leads from the ground to the sky, then one must ask for cheaper and more simple ways to achieve this. Raise a huge concrete tower is not the easy option, requiring huge amounts of material and energy to get up, and once built there is no possibility to change it afterwards. What was to be an air line becomes instead in a huge structure that would take years to build and pay for itself and, once built, it would be a permanent impact because it can not be moved, removed or reused. it seems sensible to think of a light pipe, rigid or flexible material, which is held vertically by the effect of several balloons supporters. In this case the pipe is just what it must be: a line for indoor air, because the responsibility of keeping it vertical depends on the balloons. Clearly, this option is more reasonable, because it requires no foundation, the set is scalable because you can add new balloons and tower sections to increase the working height, all materials are reusable for being separable parts, the installation can change of place, so no mortgage soil forever, no height limitations, then you can use smaller greenhouses, and once dismantled leaves no trace on the ground.

The question is, why insist on the excessive solution if we can choose the most sensible solution? The answer may be that this civilization
loves concrete structures which inevitably become obsolete over time and can only dismantled turning into mountains of rubble. Or maybe we think at a ground level way, so large vertical air duct can only have an anchor (to the ground) therefore has to be built as a robust tower. Looking up a little more, we would realize that there are objects in front of our noses (the balloons) that could provide an anchor at the top of the chimney, so it could be only what it has to be, an air duct.

A field with several rigid solar towers as planned in Spain, Australia, etc., is meant to be a rigid infrastructure, fossil and dusty at the end of its useful life. Instead, a land full of floating solar towers is like a garden that blooms and then at the end of its operational life is dismantled and disappears, or is moved elsewhere, leaving the virgin land as you found it, without concrete fossil and steel, horrible sterile chimneys, like the bones of a decadent civilization.

A FSUTs group looks like a forest of exotic trees, which are planted on a site but can move to another, which can grow or can be divided into smaller ones for export and planted elsewhere, where they will grow according to the needs place. That's what allows costrucción modular, based on the use of detachable parts, from the balloons, the sections of the chimney, the gases and electricity generating turbines.

It is true that a conventional solar tower is a renewable energy source, if you omit the construction phase. But it is also true that there is not beauty and charm in a giant concrete and steel chimney planted in the
middle of a landscape, and that will be so for many promotional videos are made for this type of project. Rather, it is like a thorn, a giant thorn stuck in the ground, permanently, and anyone who loves a natural landscape wouldn't find attractive these facilities. In contrast, a FSUT does not seem a huge dead tree stump, but a huge mushroom, a huge flower with several petals (the balloons), or some exotic tree species. And almost everyone loves balloons, almost everyone takes delight watching these floating and silent masses. But the beauty of a FSUT, or a garden FSUTs, is also that the landscape alteration is temporary and it will not be forever. There are not thorns in the skin of the earth, but breezes of herb that rub it a moment and then are carried by the human caprice wind to another place.

FSUT technology is an example of organic technology, because a FSUT can grow as needed, or can be divided into other FSUTs that grow in size as power demand increases in regions where they are installed. In times of economic and environmental crisis technologies should be wagered on scalable, reusable, instead of posing pharaonic infrastructures with do a the permanent harm in the environment, even when obsolete. We shouldn't start enormous works take years to pay, and they could be half-built if funds are exhausted, when there are construction alternatives which can be built faster and can grow according to the needs and available funds. A FSUT presents a simple construction, available materials, and begins to produce immediately. Profits from the sale of electricity would pay for the new balloons and new tower sections, so the FSUT grow increasingly producing energy.

The purpose of producing renewable energy does not have to justify massive use of natural terrain and huge concrete structures remain there, dark and outdated, as witness of the arrogance of a civilization that believes itself with the right to use the land according to it will. The floating solar updraft tower is a reasonable alternative that has some advantages that should be considered. It is this kind of organic technologies which may be the key to a sustainable world. It is in this type of organic technologies in which we must insist, light and flexible, rather than those based on new works mammoth rigid, insecure funding, costly depreciation and permanent effects on the land and landscape. The time shows that all major engineering non modular works become obsolete and must be demolished or reduced to rubble by their inability to adapt to the changing world. The energy economic and environmental crisis should teach us once and for all that we should not build what we can not remove and reuse.
References:

1. EnviroMission
2. Wikipedia
5. Wikipedia
6. GoodYear
7. Zeppelin NT
8. CargoLifter CL160
9. SkyCat
10. AirShipOne
11. SkyLifter
13. Solar Updraft Towers: Their Role in Remote On-Site Generation
14. Experimental Analysis of a Velocity Field using Variable Vhimney Diameter for Solar Updraft Tower
15. Computer Simulation of Solar Updraft Tower Systems to Describe the Variation of Velocity with Essential Parameters of the Systems
16. Floating Solar Chimney Technology
17. SolarShip