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SUPSI

Understanding the perception of competition through the cognitive mapping approach

Case study: Swiss start-up Airlight Energy Holding

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The author is the solely responsible for the content of this work

Abstract

This master thesis is concentrated on understanding of the competition perception of the start-up management members. A Swiss start-up company active in renewable sector, Airlight Energy, is taken as case study and its actors have been submitted to the two-phases interviews in order to collect data about the firm's external conditions illustration.

Usually the management of a technology start-up is not aware of the competition where it is placed. The goal of this work was to study the actors' perception and analyze them in 2 different moments in order to evaluate degree of the competition awareness and see how they could change.

Cognitive maps were explored and compared to the results of the market research. With this research it is possible to see the way cognitive maps slightly changed and in what direction go new perceptions.

Index

List of Abbreviations

CSP	Concentrating Solar Power
TWh	Terawatt Hour
NOIC	Net-Oil Importing Countries
NOEC	Net-Oil Exporting Countries
kWh	Kilowatt Hour
DNI	Direct Solar Irradiation
PV	PhotoVoltaics
CPV	Concentrated PhotoVoltaics
TES	Thermal Energy Storage
HTF	Heat Transfer Fluid
UHPC	Ultra-High Performance Concrete
AA-CAES	Advanced Adiabatic Compressed Air Energy Storage
LCOE	Levelized Cost of Electricity
PPA	Power Purchase Agreement
EPC	Engineering, Procurement & Construction
O&M	Operation & Maintenance
IPP	Independent Power Producer
EOR	Enhanced Oil Recovery
BBBEE	South African Broad Based Black Economic Empowerment policy
ISCC	Integrated Solar Combined Cycle
ETFE	Ethylene TetrafFuoroEthylene

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Introduction

Technology start-ups are focused on product development and on technological improvement. Often this approach prevents a real understanding of the external environment and the adoption of a market orientation. All this causes the failure of many startups.

Therefore: awareness with regard to competition and the market are crucial to the survival of the enterprise. The analyses carried out by collaborators and consultants can provide interest subsidies, but this new information must be processed by key players, from decision-makers to gain actually greater market orientation.

This master thesis builds the whole research starting from three main concepts: start-up company, renewable energy sector and cognitive mapping approach.

The central idea of this thesis is to analyze actors' cognitive maps of the start-up taken as example in this research, Airlight Energy. Its employees with influence on decision making have a certain perception about external environment and company's market positioning. Cognitive maps about this kind of notion are explored and compared to the results of the market research. Main objective is to understand if the perception of competitiveness in the sector start up is integrated matches with the actual environment.

The objective was to find out whether the perception of competition is open to new information and if it is possible to expand existing cognitive maps as a result of in-depth analysis. Specific look for answers to the following questions:

- How are configured the management cognitive maps of a technology start-up?
- How much is different the competitive knowledge among the actors?
- How are large, detailed and articulated the cognitive maps of actors?
- Do the management perception change after the extensive competitive analysis?

To carry out this research work qualitative method is the chosen because it allows to work with numerous variables based on interaction between the subscribed as a researcher in this case and key actors that were interviewed.

1. Start-up companies and cognitive mapping approach

1.1 The start of the start-ups

"A startup company or startup is a company, a partnership or temporary organization designed to search for a repeatable and scalable business model"[1] which finds itself in phase of development and research for markets.

Co-founder and co-CEO of Warby Parker, American company of prescription and sunglasses founded in 2010, affirms that "a startup is a company working to solve a problem where the solution is not obvious and success is not guaranteed".

"Startup is a state of mind," says Adora Cheung, cofounder and CEO of Homejoy, one of the Hottest U.S. Startups of 2013. "It's when people join your company and are still making the explicit decision to forgo stability in exchange for the promise of tremendous growth and the excitement of making immediate impact"[2].

According to the study published by Chalmers University of Technology it is very important to consider start-up companies, especially high-tech start-ups, because of "their potential contributions to society if they become successful.

Aaboen and Dubois present in their study[3] the initial phase of the start-ups with particular focus on their networks research and development. According to the authors "the start-ups are a heterogeneous group of firms with varying needs, but being new always implies a shortage of resources". In the most start-up companies only few people beyond founder are able to understand the technology. For this reason the knowledge and skills of the person/ people who founded company are the base of a start-up: this capital has "both a direct effect on the initial capabilities of the firm and an indirect effect through its contribution to finding venture capital investors". Moreover very often start-ups suffer from lack of commercial knowledge and financing to invest in sustaining their innovativeness and growth. In fact their needs of any kind of resources, "path-dependent development and the cluster aspects" are the topics mostly concern their characteristics. The entry into the commercial phase of most start-up companies is "black-boxed". Thus, it assumes a critical role representing a decisional moment of life or death of the company. Very often it takes certain market response time and resources availability in this "stand-by" phase plays a crucial part.

Milanov and Fernhaber (2009) did a research on the way the new ventures' networks grow and become larger, the topic little covered by the literature. They introduce the concept of network imprinting, or more specifically, how the size and centrality of the initial alliance partners influence

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[1] http://en.wikipedia.org/wiki/Startup_company
[2] http://www.forbes.com/
[3] L. Aaboen, A. Dubois and F. Lind. (2011). *Start-ups starting up- Firms looking for a network*. The IMP Journal

the start-up companies' networks characteristics. These first interactions allow the firms important learning about market share gaining and financial resources access.

Every start-up should make a particular effort on the early development of customer relationships because these can have a strong impact on the further development and success of these firms. But this activity represents one of the greatest challenges for the start-ups since the willingness of the consolidated companies to work with the new, inexperience and poor resources firms is often limited. The next step, which consists in managing the installed relationships is not always as easy task as could seem. It requires continuous human and financial investments.

As exposed and well-known starting the companies and investing in start-ups involves a certain risk degree. According to Statistic Brain source, the percentage of the new established companies' failure is quite high: almost a half of new firms fail within three years of their foundation. The reasons are sometimes unclear, but surely very complicated: upper management composition and decisions, funding availability, unready markets, lack of market awareness, product characteristics or too rapid expansion. One of the "new trend in failed startups is the purchasing of patents by what are derogatorily known as "Patent trolls[4]"[5]. Statistic brain discovers that new company disappearance is caused mostly by incompetence and inexperience.

Since the innovation is exploding in various field, in the last years also "the green era is giving birth to a broad and bewildering array of new companies with big ambitions. If fact, many promising clean-energy startups are hitting the market with products and services that could radically alter how we think of, and consume, power."6 Green business information services, BusinessWeek and GreenBiz.com, "teamed up to pick 25 of the most intriguing up-and-coming U.S. energy companies … criteria: These picks are starting to gain traction with real, innovative products and services for sale, they are not yet publicly listed, they are not yet household names, and all have bona fide venture capital backing and other high-profile investors." Like these firms, many others exist in renewable energy sector, too. One of this is a Swiss start-up, Airlight Energy Holding, the case study of this thesis. This company will be studied through the next chapters.

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[4] Patent Assertion Entity (PAE) is a person or company who enforces patent rights against accused infringers in an attempt to collect licensing fees, but does no manufacture products or supply services based upon the patents in question, thus engaging in economic rent-seeking (http://en.wikipedia.org/wiki/Patent_troll)
[5] http://www.statisticbrain.com/startup-failure-by-industry/
[6] http://images.businessweek.com/ss/09/07/0714_sustainable_planet/1.htm

1.2 Cognitive mapping approach

Every person perceives and collects knowledge from the complex, dynamic and unpredictable source in a different way. The process of information acquisition and storage capacity and ability is obviously not the same in all people. These different processes are called cognitive mapping.

A concept of cognitive or mental map was introduced by Edward Tolman in 1948, and is generally defined as “a type of mental representation which serves an individual to acquire, code, store, recall, and decode information about the relative locations and attributes of phenomena in their everyday or metaphorical spatial environment”[7]. The term is used to refer to one’s internal illustration of the experienced world. In a very simple way it is possible to define it as an “overall mental image or representation of the space and layout of a setting”, whereas cognitive mapping as “the mental structuring process leading to the creation of a cognitive map”[8].

The way of human behaving is dependent on the individual’s cognitive map of the spatial environment. The environment is a huge and very complex space. It is full of different kind of information. On the other hand, individuals are “relatively small organism with limited mobility, stimulus seeking capabilities, information processing ability, storage capacity and available time[9]”.

It consists in “a spatial representation of the outside world that is kept within the mind, until an actual manifestation (usually, a drawing) of this perceived knowledge is generated (…) - implicit mental mapping of the explicit part of the same process”[10]. “Cognitive maps serve the construction and accumulation of spatial knowledge, allowing the "mind's eye" to visualize images in order to reduce cognitive load, enhance recall and learning of information. This type of spatial thinking can also be used as a metaphor for non-spatial tasks, where people performing non-spatial tasks involving memory and imaging use spatial knowledge to aid in processing the task”[11]. In numerous fields, such as psychology, education, planning, geography and cartography, cognitive maps have been studied.

As different definitions anticipate, the cognitive mapping is one of the frequently used methods for the reconstruction and analysis of the actors’ belief system. Downs and Stea believe that cognitive maps are fundamental and almost indispensable in various fields: “planners try to alter cognitive maps, astronauts need them, the news media use them, and advertisers tempt us with them; they are part of our everyday lives“[12].

The maps are the main point of the research and knowledge process of the complex reality. In fact, inside the map, two important moments meet: factuality of the reality which very often falsifies our

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[7] http://en.wikipedia.org/wiki/Cognitive_map
[8] http://richarddagan.com/cogmap.php#history-use
[9] M.R. Downs and D. Stea: Cognitive Maps and Spatial Behaviour Process and Products
[10] International Encyclopedia of Human Geography
[11] http://en.wikipedia.org/wiki/Cognitive_map
[12] Downs M. R. and Stea D.: Cognitive Maps and Spatial Behaviour Process and Product

beliefs we made previously, and subjective interpretation of the same. In the mapping process both, conscious and unconscious aspects can be considered. This demonstrates that the maps are the imperfect tool: the reality is much more complex than our ability to represent it theoretically. On the other side the simplifications is necessary because very articulated illustration might be confusing and ineffective for the practical use of the map. Exactly for this reason the balance between correspondence with reality and biased viewpoints is needed, and in this difficult research the effectiveness of the cognitive maps plays a fundamental role.

Awareness of the method imperfection, empirical connotation and strong practical orientation are three main characteristics of cognitive mapping approach.

Cognitive maps are used for different purposes, and have various functions such as:

- Reconstruction of the premises of one's behaviour to understand the reasons of the taken decisions, highlighting the potential distortions and limitations in the representation of the situation → **explicative function**.
- Prediction of one's future actions and decisions, or the arguments that one uses to explain any new events → **predictive function**.
- To help the decision maker to consider the representation of the situation in order to verify the adequacy and possibly encourage the introduction of the necessary changes → **reflective function.**
- Generation of a more accurate description of a problematic situation → **strategic function**.

In the literature different types of cognitive mapping techniques such as, causal, semantic and concept mapping have been described.

Causal mapping is one of the most commonly used method in the field of decision-making process. This kind of maps illustrate influence, causality, and system dynamics. Moreover, they "allow the map maker to focus on action; for example, how the respondent explains the current situation in terms of previous events and what changes she expects in the future"[13].

Semantic mapping is also known as idea mapping and "is used to explore an idea without constraints of a superimposed structure. To make a semantic map, one starts at the center of the paper with the main idea, and works outwards in all directions, producing a growing and organized structure composed of key words and key images. Around the main idea, five to ten ideas (child words) that are related to the central word are drawn (…)[14]". This secondary level serves as a bridge to the next level analysis. This kind of maps is also known as mind maps.

Concept mapping was exhaustively studied by authors like David Ausubel who put emphasis on the importance of prior knowledge in new concepts learning. Novak deepened Ausubel's work and "described concept mapping as a schematic device for representing meaning and understanding

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[13] B. Chaib-draa. *Causal Maps: Theory, Implementation, and Practical Applications in Multiagent Environments*.
[14] http://richarddagan.com/cogmap.php#history-use

relationships between concepts"[15]. This approach allows the concepts visual connection and development of deeper understanding of the relationships among the concepts.

As previously mentioned in the introduction, this thesis is concentrated on the cognitive maps analysis of the actors of the start-up taken in consideration. The main objective is to build and analyze the actors' belief system in order to understand their illustration of the external environment. Thanks to this short background theory on the cognitive mapping approach, some considerations on the actors' perceptions were done and will be explained in the VI chapter.

[15] Di Candice, L. Pickens. *Concept Mapping: Methods to Improve Critical Thinking*.

1.3 Role of the cognitive maps in decision making and strategy definition

Every year private firms spend millions of dollars on market research, but there is little knowledge about managers' information processing and use. Zaltman in his publication, "A Comparison of Factors Affecting Researcher and Manager Perceptions of Market Research Use", studies the factors affecting the use of the research. For a successful exchange of research information, both the researcher and consumer of the research, should contribute equally to develop a usable end product. For several reasons this situation may not occur.

Cognitive maps can contribute to improve significantly one's decisional process, especially in a company setting: a possibility to integrate more actors' visions and to synthetize them in a common strategy. In fact, cognitive mapping approach is one the richest and most important approach in in the field of decision-making.

First developments of this tool date back to early '70 thanks to Axelrod, Shapiro and Bonham and Hart[16] who analyzed the cognitive system of single policy-makers. To reconstruct "decision-making" of a single person, it is necessary to analyze the cognitive operations through which an individual builds and explains the surrounding reality. As essential tools to face the complexity of the environment through "simplified representations", they are part of the individual "belief system", or the structure of the casual beliefs ("cause maps") connecting possible choices to potential results. They are depending on human behaviour attributing causal relationships to the facts in order to have some control on the economic and social context to evaluate the alternative available options"[17].

Reconstruction of the belief-system of a given person is a delicate operation, and involves a number of significant methodological problems. The cognitive maps are built on the basis of statements made directly or indirectly by the decision maker as his/her situation representation. Those are so called revealed causal maps and exist numerous methods of "survey". Information can be picked up from the existing documentation such as published documents, public speech or press releases, or by researcher initiative through interviews, questionnaire or similar. The used tools is not irrelevant, but the final product is always the same: a text on which documentary coding method has to be applied. Therefore, the result consists in a list of concepts and causal relations from which is possible draw the cognitive map.

Clark and Gioia in their scientific publication, Strategic sensemaking and organizational performance, examine the question of how key cognitive processes (scanning, interpreting and responding) of top managers may be linked to organizational performances. First phase consisting in scanning involves searching the environment to identify information that is pertinent to the

[16] Different author who studied cognition and cognitive processes
[17] R. Axelrod: The structure of decision, Princeton University Press

organization. Whereas the interpretation includes comprehending the information and deciding which strategic issues to address. A response, or action, is a change in organizational practices.

“An examination of managers’ cognitive maps of their business’ market orientation can provide valuable insights. First, cognitive maps provide information regarding the relative ranking of concepts that managers consider important to new product success. Second, they offer insights about the relationship among concepts by illustrating the causal logic flow, centrality, and strength of the association between concepts. Finally, cognitive maps reveal a gestalt or pattern of managers’ understandings. This pattern provides an overall view of their perceptions of their firms’ market orientation”[18]. The authors claim that managers’ shared understanding is critical to new product success and cognitive structures influence their decisions and firm outcomes. They argue that “managers of innovative companies with a history of successful new products in moderately dynamic industries will have established market orientations, as reflected in cognitive maps, which emphasize customer orientations more than competitor or technological orientations” [19].

[18] B. Tyler and D. Gnyawali: Mapping managers' market orientations regarding new product success
[19] B. Tyler and D. Gnyawali: Mapping managers' market orientations regarding new product success

2. Renewable energy sector: focus on solar energy

2.1 Global trends in energy sector

The world population currently accounts for approximately seven billion people requiring a quantity of energy equivalent to about 150'000 TWh per year. By 2050 the population is expected to grow to 9 billion and total primary energy consumption to reach a level of 255'000 TWh. This means an almost double increase in energy demand. Global trends like population growth, urbanization increase and economic progress involve issues as water scarcity, need for energy security enhancement and more others. The growing needs have to be satisfied by a setting a combination of alternative energy resources and energy efficiency.

Current primary energy consumption is satisfied mostly by conventional fossil fuels (coal, oil and gas) accounting for almost 80% of total energy mix, followed by renewables representing about 17% and nuclear only 3%. The availability of the resources is not distributed uniformly: 60% of the world oil reserves are concentrated geographically in Saudi Arabia, Kuwait, Iraq and United Emirates. Moreover, the traditional resources are located in developing countries where the energy demand is growing exponentially and the request for resources is very high, generating an increase in fossil fuel prices. Double effect is provoked: steep bills for net-oil importing countries (NOIC) and opportunity cost for net-oil exporting countries (NOEC).

Global energy market become very dynamic and more and more countries aware of the current and future impacts of massive exploiting of the traditional resources as fossil fuels. Most developing countries are facing the energy insufficiency problems: continues blackout and shortages of supply due to the exponential rise of the consumptions. In some of them the economic growth is so high to transform the same from the exporter to the importer of a given energy resource. A good example of this inversion is China, a country which faces an economic growth of about 7.7%[20]: China was net oil exporter until the early 1990s and became the world's second-largest net importer of crude oil and petroleum products in 2009.

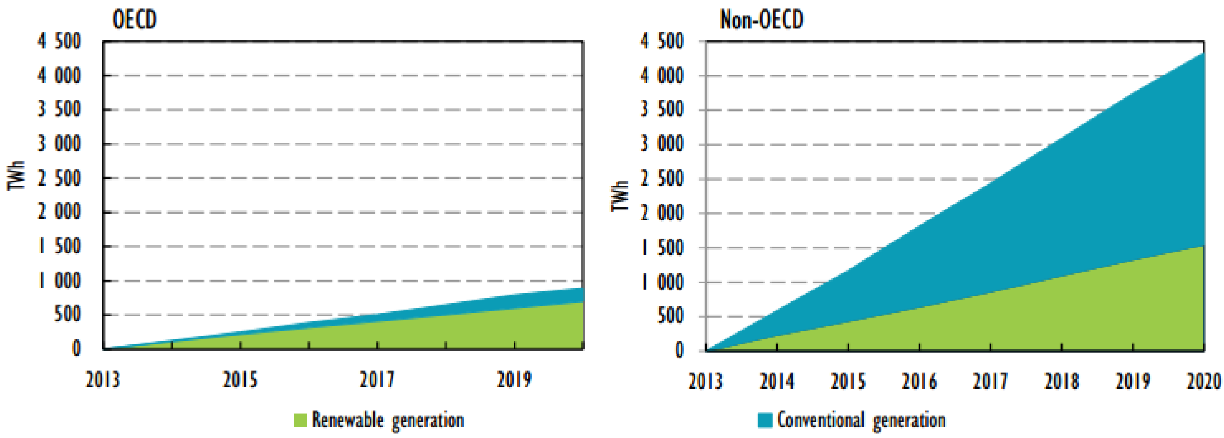
In order to diminish foreign supply dependency, different countries are opting to diversify its energy mix introducing new energy sources such as renewables. Renewables are "naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time"[21]. In this prospective, renewables become an attractive alternative to the conventional fuels but also an opportunity for industrial diversification, value chain alteration and, above all, improved environmental footprints. "Solar, wind, geothermal, hydropower,

[20] http://www.worldbank.org/en/news/press-release/2014/06/06/china-growth-moderates-with-continued-economic-transformation
[21] http://www.eia.gov/tools/glossary/index.cfm?id=R

bioenergy and ocean power are sources of renewable energy. The role of renewables continues to increase in the electricity, heating and cooling and transport sectors."[22]

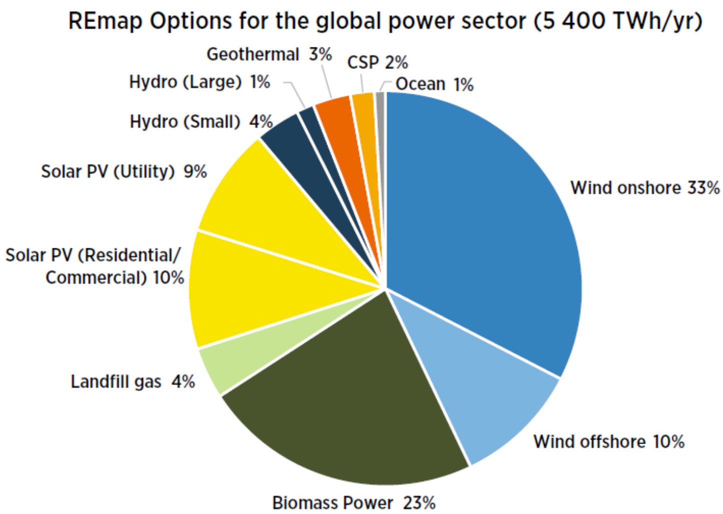
According to International Energy Agency electricity generated from renewables in 2013 accounted for approximately 20% of total power generation, reaching the level of natural gas deployment. This global trend is expected to grow at a CAGR of 5.4% per year. In fact, in the last few decades the entire world is assisting to the increase of the renewable energy share in the global energy mix.

Graphic 1: Cumulative change in gross power generation by source and region, 2013-20[23]



To exploit the potential of this kind of resources, different technologies such as solar, wind, hydro, geothermal and biomass have been developed. As shown in the figure below two thirds of renewable energy forecasts concern wind and solar energy.

Graphic 2: Global power generation by technology of REmap Options[24]



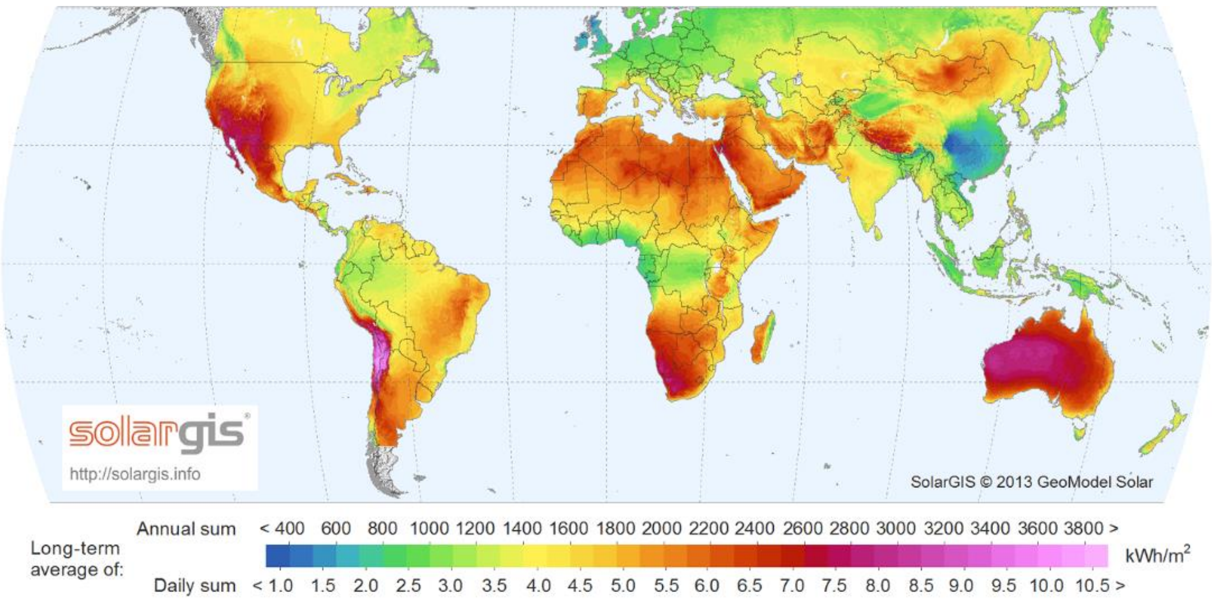
[22] http://www.iea.org/topics/renewables/
[23] International Energy Agency: Renewable energy- Medium-term market report
[24] IRENA: REmap 2030

1.2 Solar energy and technologies

The energy available from sunlight is one of the most abundant resources in the world. It is measured in kilowatt hours per square meter. Generally, this source of energy is deemed good to excellent between 10° and 40°, South or North, especially in some parts of USA, Chile, Australia, area MENA (Middle East and North Africa), India and in South Africa.

Direct Solar Irradiation (DNI) measures "the amount of solar radiation received per unit area that is always perpendicular (or normal) to the rays that come in a straight line from direct of the sun at its current position in the sky"[25]. On the map of DNI we can notice the most promising geographic zones colored in red and purple. Solar radiation, although plentiful, is dilute. The cumulative irradiation captured by a surface always facing the sun reaches 3,000 kWh/m2 a year in a few optimally placed dry areas, but in many others rarely goes beyond 1,500 kWh/m2 a year.

Figure 1: World map of direct normal irradiation[26]



Different kind of technologies to exploit the energy from the sun have been developed especially because the sun can be harnessed in several ways. Is it possible to identify two main categories of solar technologies?

- **Solar thermal**: solar radiation is used to heat a thermal fluid
- **Photovoltaic**: the sunlight is directly converted in electrical energy via the photovoltaic effect.

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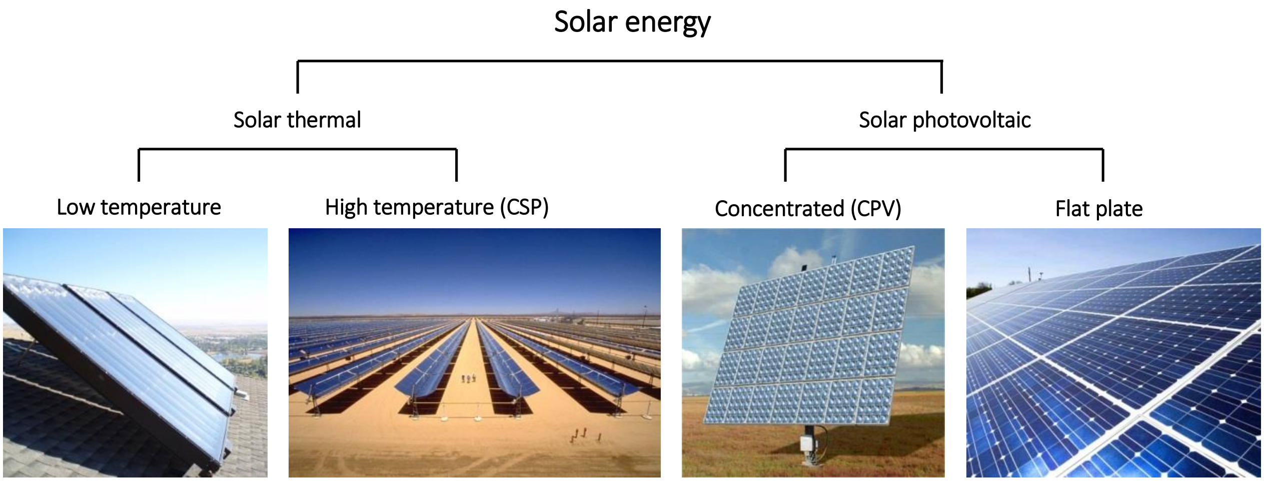
[25] http://www.3tier.com/en/support/solar-prospecting-tools/what-direct-normal-irradiance-solar-prospecting/
[26] www.solargis.info

This two main groups can be split in other subgroups. Solar thermal technologies branch in low temperature systems, which are static and perform no or little concentration, and high temperature systems where the incoming sunlight is concentrated several times. These latter systems are called for historical reasons concentrated solar power (CSP) technologies. However, concentrated solar radiation can also be used in combination with photovoltaic cells, and, besides the well-known flat-plate systems, we have concentrator photovoltaic (CPV) installations.

Figure 2: Different typologies of solar technologies



Low temperature

Operating temperatures <200°C
No concentration or low concentration, mainly installed on rooftops.

Main applications:
- Household hot water
- Low temperature process heat

High temperature (CSP)

Operating temperatures up to 650°C
Concentration (up to 100 times and more) with parabolic trough mirrors (picture above), Fresnel reflectors, dishes, or solar towers.

Main applications:
- Electricity generation
- Industrial process heat

Concentrated (CPV)

High efficiency (>25%)
Concentration (up to 1,000 times)
Multi-junction cells derived from space applications.
Ideal for dry areas with strong insolation

Main applications:
- Electricity generation

Flat plate

Effective with diffuse radiation, best suited for areas without strong insolation or with hazy skies.
Monocrystalline and polycrystalline silicon or thin-film cells.

Main applications:
- Electricity generation

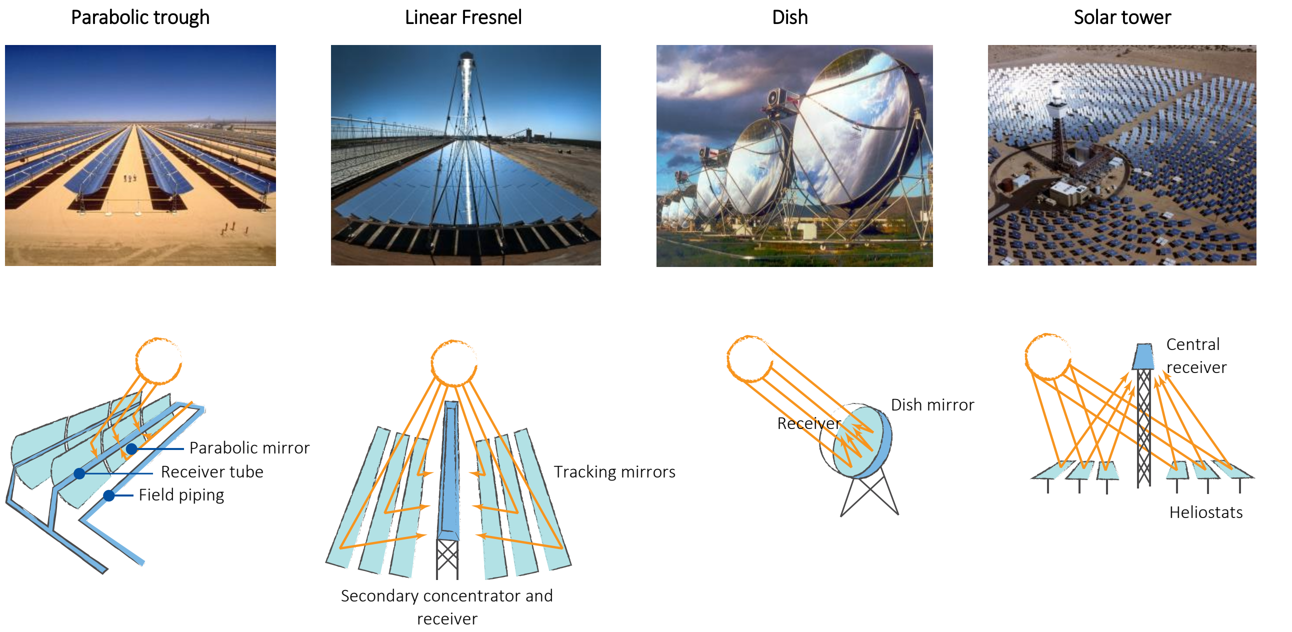
1.3 Concentrated Solar Power

Concentrated Solar Power is a technology that uses lenses or mirrors to concentrate a large amount of sunlight, or solar thermal energy, onto a small area. The system tracks the sun and focuses its light onto solar receiver to heat a working fluid. The captured heat can be converted to mechanical work in a turbine that drives a generator to produce electricity. CSP is not to be confused with CPV where “the concentrated sunlight is converted directly to electricity via the photovoltaic effect[27]”.

Four types of CSP technology can be identified: parabolic trough, solar tower, linear Fresnel and dish. The most deployed technologies in terms of installed capacity remain parabolic trough and solar tower.

Since the primary product of a CSP plant is thermal energy, the main distinctive advantage of CSP over the intermittent renewable energy such as wind and photovoltaic is represented by the ability to store and dispatch the thermal energy due to the integration with Thermal Energy Storage (TES) systems.

Figure 3: Different typologies of CSP technologies



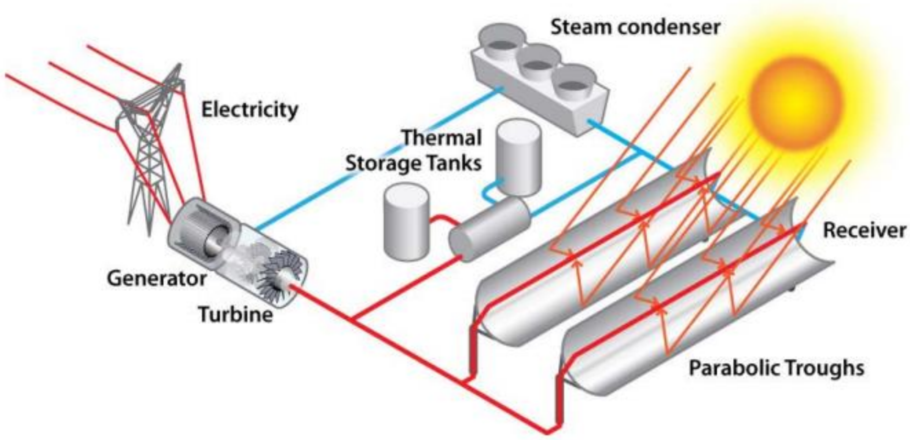
CSP is restricted to arid & semi-arid areas with clear skies. In fact, the production of electric power with this kind of plants is sensitive to the variables such as DNI, humidity, wind speed, ambient temperature and some other phenomena.

[27] http://en.wikipedia.org/wiki/Concentrated_solar_power

From a market point of view, parabolic trough is still the most mature and economically viable large scale technology to date. The first plants of this kind were installed almost thirty years ago. Since then the technology has undergone significant developments and it is rapidly evolving.

In this system solar irradiation is concentrated by a parabolic trough-shaped collectors which reflect sunlight onto an absorber tube running along the local axis of the trough. The reflective surfaces are usually mirrors, although they can consist of thin aluminum foil. The concentrated irradiation is transferred to a heat transfer fluid (HTF) circulating within the absorber tube called receiver, in order to achieve high temperatures. Usually as heat transfer fluid mineral oils or molten salts are used. In the next stage of the process, this fluids are used directly in case of direct steam generation or transferred to the heat exchanger for steam production. The steam is then sent to the turbine which drive generator for electricity production. The concept of TES can be comparable to hot water storage used in low temperature solar collectors, wherein excess thermal energy produced is stored in the hot water tank. In the case of TES applied in CSP plants, molten salts are typically used as the means of energy storage. Thermal energy is stored by heating the molten salts and released by cooling them to just above freezing point.

Figure 4: The principle of operation of parabolic trough technology[28]



[28] 2014: The Year of Concentrating Solar Power

3. CSP industry configuration

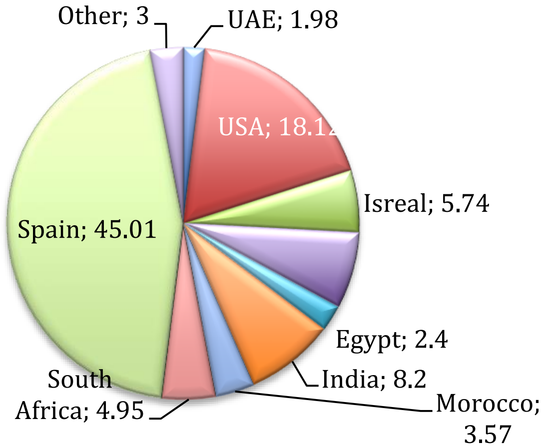
3.1 Sector overview

According to REN21[29] around 20% of global electricity production is generated by renewable source, and CSP accounts for 0.4% of total generation. Although this market share seems very small, in 2013 it rose at a rate of 36%, the highest after traditional PV. In the period between 2008 and 2013 CSP sector continued to advance at an average rate of 48% reaching a global installed capacity of 3.7 GW. The global market is dominated by parabolic trough plants with oil as HTF, which account for 90% of CSP plants and have more than 30 years of commercial operation. Majority of plants under construction by mid-2013 use such system. Overall market share of parabolic trough is equal to around 71% of the total CSP installed capacity.

United States and Spain keep the leadership of the CSP market. Almost 96% of the total installations are concentrated in Spain, United States and United Arab Emirates. At the end of 2013 approximately 3’700 MW of CSP was operational and other 10’000 MW under development[30].

In the mid-term CSP capacity is shifting from Europe to emerging markets with high DNI, such as India. Operational capacity concerns mainly Europe and North America, whereas almost 10 GW under development are collocated in developing geographic zones: Africa and Latin America. Countries such as South Africa, Tunisia, Morocco and Egypt are driving capacity additions in Africa. Market share of each country in the next years shows greater internationalization of the CSP industry as the number of countries boasting parabolic trough capacity is expected to rise from 12 countries at present to 20 countries five years from now[31].

Graphic 3: Market share of parabolic trough in the next five years



[29] Renewable Energy Policy Network for the 21st century
[30] www.csp-world.com
[31] CSP Today 2013

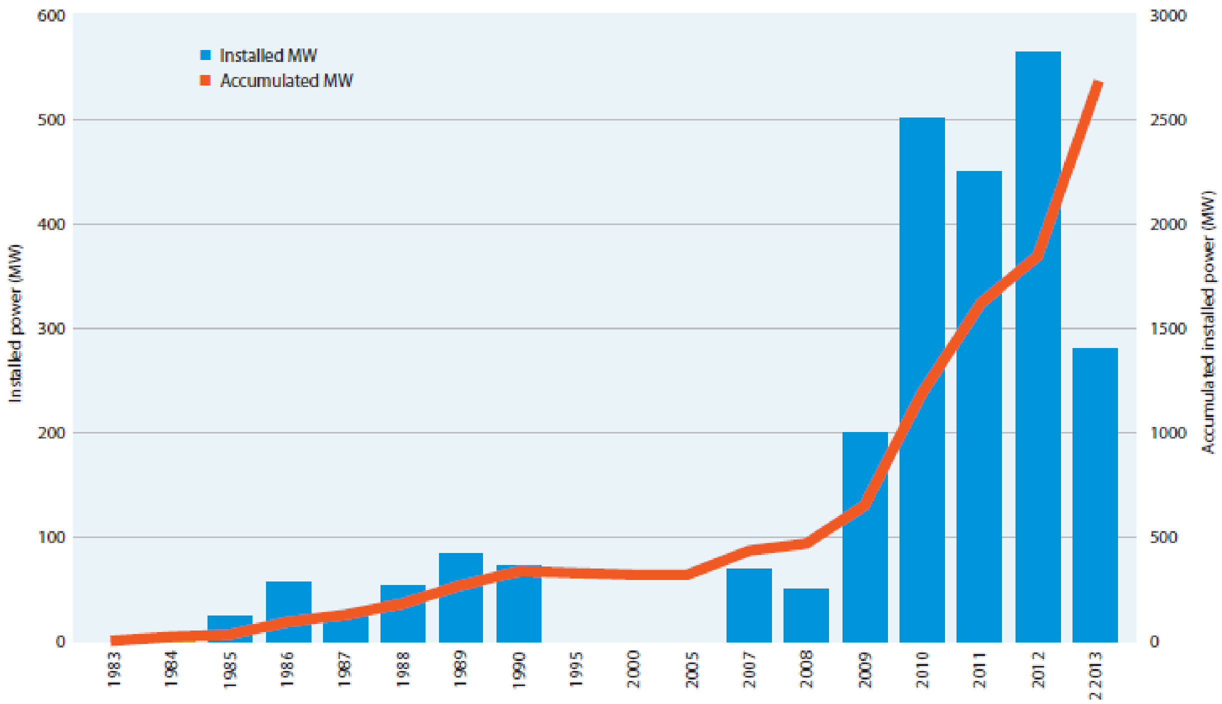
The category named "other" include small market shares of the emerging markets such as Algeria, Brazil, Chile, Mexico, Oman, Kuwait, Italy and Iran.

As mentioned before up to date, mainly parabolic trough power plants have been built but in the future solar tower applications growth in all regions is expected. This emerging technology is considered to be able to compete against parabolic trough during the next decades and could become a leading choice for solar power plants. Currently it accounts for around 20% of capacity under construction and 52% of planned projects[32].

Even though CSP, and in particular parabolic trough, market is growing due to different drivers such as technology improvements and government support, there are important barriers which are hindering its further progress. In actual scenario several challenges such as decreasing feed-in-tariff, end of Loan Guarantees, low gas prices, mass invasion of the traditional PV and bankability of the projects, appear. On the other hand renewable energy policies, high energy costs, price volatility, sustainability and many others support market growth and future deployment.

According to CSP Today, industry business intelligence provider, parabolic trough has grown considerably in the last seven years.

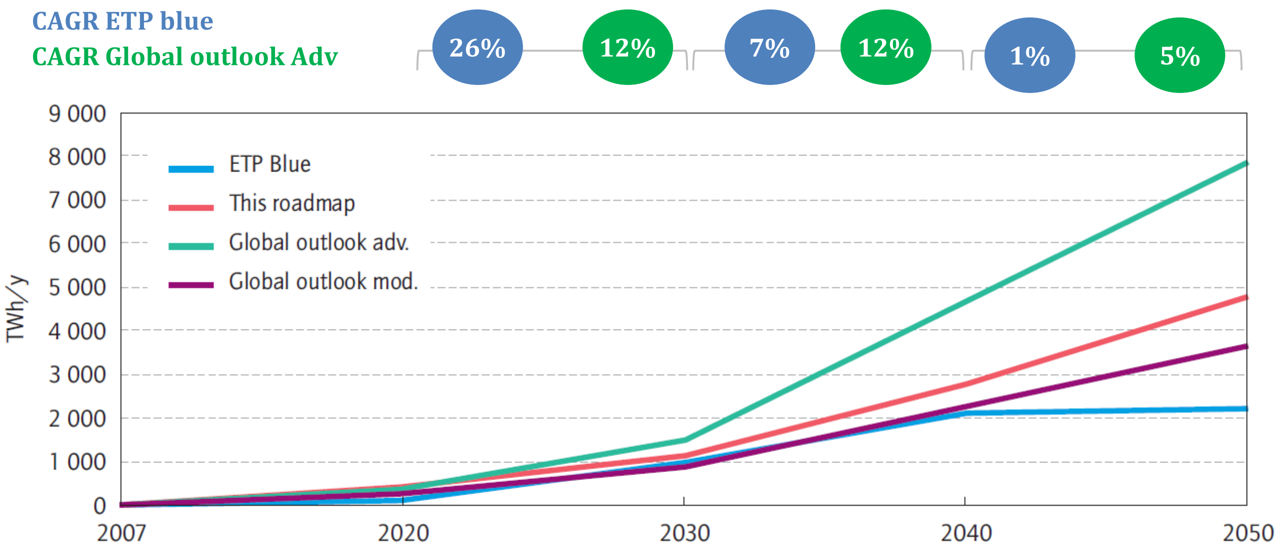
Graphic 4: Parabolic trough installed and accumulated capacity as of July 2013[33]



International Energy Agency in one of its scenarios foresees a 10 fold increase of electricity production from this kind of CSP technology.

[32] IEA SolarPaces Database, 1st March 2013
[33] CSP Today 2013

Graphic 5: Growth of CSP production in different scenarios by 2050[34]



[34] Technology Roadmap : Concentrating Solar Power, OECD/IEA, 2010

3.2 Competitive positioning of CSP technology

Inclination towards CSP technology is driven especially by higher degree of reliability, providing both electricity and process heat, and being able to reach greater plant size than other technologies. On the one hand stand-alone plants installation provide electricity in remote areas, too and on the other hand the technology is appropriate for a booster solution which generates thermal energy and feed the existing industrial process with heat. Thus, CSP technology has ability of integration with fossil-based generation sources in “hybrid” configuration, and this represents a great advantage over other renewables. Hybrid systems combine existing traditional fossil-fuel-powered plants with emissions-free CSP technology to improve the performance and reduce costs of power generation. Moreover it is scalable technology which offers greater flexibility in planning a balanced system.

Due to the size of investments and plants CSP is very suitable for large scale industrial applications. It can provide base-load electricity supply to energy intensive industries and from a government’s perspective it could allow to postpone investments in electricity grids, since the technology can be developed as an off-grid application too. CSP is therefore a real alternative to fossil fuels. CSP systems have an advantages to be able to offer bigger size of plants compared to other renewable energy technologies.

For thermodynamic reasons, the sunlight concentration allows increasing in the energy flux density of the solar radiation and consequently the operation at a very high temperature. The only limitation comes from the intrinsic characteristics of the thermal fluid. Operation at higher temperatures also means greater global efficiency.

With the addition of thermal energy storage units, CSP can provide energy on demand, even if the sun is not shining. This means continuous electricity production or heat supply to industrial processes with no impact on the grid, which means that it will not suffer from the short-notice unpredictable power shortages (overall grid-balancing costs reduced). But as the solar resource is very variable in the most parts of the world, producing energy without any need of backup capacity may be economically practical only in some world regions.

In economic terms concentrated solar power is more expensive than other technologies and it has yet to experience mass deployment such as wind and photovoltaics. To be competitive in the midterm with its other technologies, it needs new ways to close the Levelized Cost of Energy[35] (LCOE) gap.

[35] Levelized Cost of Energy is the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital, and is very useful in calculating the costs of generation from different sources. (wikipedia.org)

3.3 Overall evaluation

CSP market continues to advance after the record growth in 2012. It offers a variety of technology and applications such as electricity generation, Integrated Solar Combined Cycle (ISCC), industrial steam, enhanced oil recovery increase, desalination, and others. This means expanding and integration into new markets. As already mentioned it is quite young market and offers huge opportunities to be explored. It enhances new employment and support to local economies. This category of solar thermal plants uses almost obsolete technology and present several problems. Moreover, up to date it was not possible to reach the economies of scale as expected, maintaining CAPEX high.

New, reviewed and innovative technologies are needed because CSP technology is rapidly developing and has the potential of expansion into new markets. It represents high profitability, offers new employment for developing economies and contributes to secure energy supply resulting in a very attractive sector.

CSP is land-intensive technology and needs water for cleaning, maintenance. Very often desert areas suitable for CSP plants do not offer water access. Restriction to the optimal climate conditions plays an important role because a good DNI is the most important factor for the plants placement. Moreover, lack of the infrastructure in the remote areas sometimes slows CSP deployment. It is necessary to choose appropriate site for the plant construction and probably invest in transmission and distribution improvements in order to be able to supply the energy produced by the plants.

EPC contractors have strong market position for construction, energy, transport and infrastructure projects. Maximum twenty companies are active in this field and mainly on the Spain and the USA market. Normally these are large infrastructure companies with high turnover and existing supplier network. They have solid relationship networks, an important prerogative in the countries of the plant construction, and are well-established in the competitive landscape. This strong market set-ups, high initial capital requirement and previous experience (track record- important targets achieved in the past) make more difficult the market penetration.

Generally, as already said, CSP are large-size plants and involves huge investments. Very often developers are not transparent as much in assessing economics in order to win tenders and grab market share. At the execution stage the final costs significantly rose compared to the estimates. This suggest very aggressive competition in CSP sector and few big players setting to deploy their own technology in as many projects as possible. Reaching greater installed capacities, companies become more reliable and their projects are easier bankable. This trend had some negative impacts on the CSP deployment. In fact, the installed capacity did not rise as expected two or three years ago. Some countries such as United Arab Emirates and Chile, had not very positive experience and become more cautious when it comes to CSP.

Besides, all supply chain actors have invested huge capitals in R&D activities to reach technological improvements, higher efficiencies and better performances. As a result they have developed specific resource and competencies which are not simple to acquire. This also means further barriers rising, both technical and economic. Here are reported the characteristic of this kind of obstacles.

Table 1: Technical and economic barriers of the CSP components in most regions of deployment

COMPONENT	BARRIERS	LEVEL OF BARRIERS
Receiver	• characteristics • alternative working fluid • higher operating temperature	**HIGH**
Float glass production	• highly energy intensive • complex manufacturing line • high skilled workforce to run a line • capital intensive	**HIGH**
Mirror Flat (Float glass)	• complex manufacturing line • high skilled workforce to run a line • capital intensive	**HIGH**
Mirror parabolic	• complex manufacturing line • high skilled workforce to run a line • bending: highly automated production • capital intensive	**HIGH**
HTF	• chemical industry with large productions • very capital intensive	**HIGH**
Storage system	• alternative reservoir designs • storage medium compositions • complex design and architecture • salt is provided by large suppliers	**MEDIUM**

As concerns global industry analysis it is possible to summarize some crucial characteristics in the terms of the sector attractiveness.

Table 2: Global evaluation of CSP industry

Growing sector	
Many opportunities of technology deployment	
Large amount of announced project	
Scalability of the plant size	
Fossil fuels replacing	
Decrease dependency and imports of crude oil	
Air pollution and GHG emissions reduce	
Decreasing material prices - economies of scale	
Heat-transfer technologies are evolving	**ATTRACTIVE SECTOR NOT EASY TO ACCESS NOT EASY TO GAIN MARKET SHARE**
New employment	
Rural economic benefits	
Low O&M costs	
RES incentives	
High technical and economic barrier	
High initial cost compared to fossil fuels	
Land-intensive technology	
Need of flat site	
Only for good DNI	
Access to water required	
Relatively new market and small market share	
Difficult financing for capital-intensive projects	
Limited pool of CSP experts to develop projects	

As conclusion of the third chapter, the following are the salient considerations:

- CSP is promising and very attractive growing sector
- High technical and economic barriers do not permit easy access to the market
- Skepticism means that certain markets are no longer so easy to conquer as they used to be
- The presence of the few big well-established players discourages in some way new players to enter the market.

4. Case study: Airlight Energy

"Innovation in energy technology is happening more quickly than expected—and it could accelerate economic growth and improve sustainability as early as 2015[36]". Airlight Energy represents a real example of the fast process of innovation and huge contribution to the solar technologies sector. It brings to the market a completely revised solution from technological point of view, a new paradigm in concentrating solar power technology.

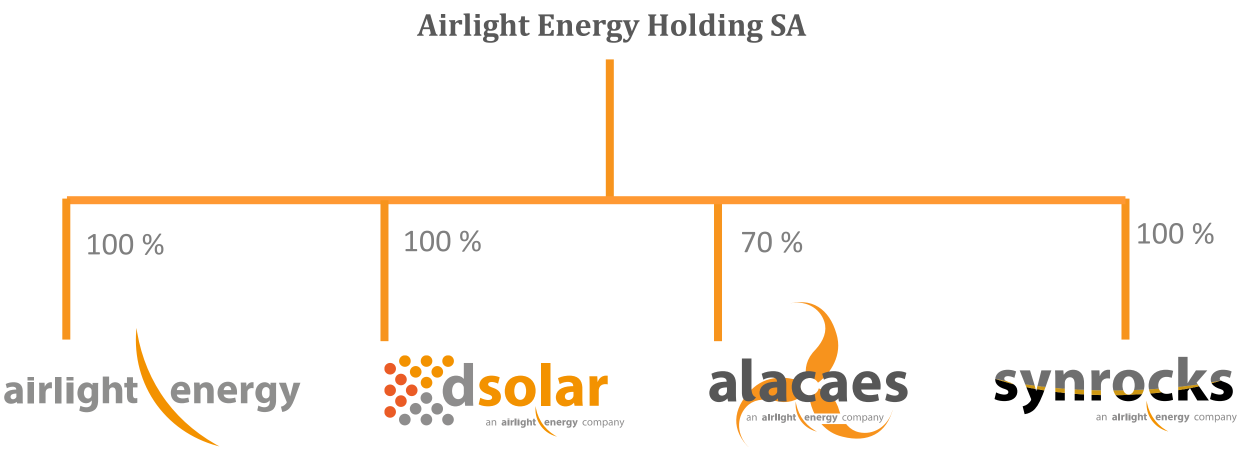
4.1 Airlight Energy overview

Airlight Energy is a Swiss private company established in 2007 and based in a small city in the north of Ticino, Biasca. It supplies proprietary technologies for large-scale production of electricity and thermal energy, and for energy storage. Its core business is CSP, but during the long and demanding research and development activity, some important "collateral effects" have come to light in the form of other innovative products such as CPV, AA-CAES and HCPVT. These new solutions are now contemplated in spin-off societies making the Airlight Energy Group a Holding company with six affiliates: Airlight Energy Manufacturing SA, Airlight Energy Maroc Sarl AU, Airlight Energy IP SA, Airlight Energy USA Ltd., Dsolar Ltd., ALACAES SA, Synrocks Ltd.

Since its incorporation, the company invested over CHF 100 million to develop innovative solutions for solar energy technologies. Airlight Energy is financed through private capital only and its share capital up to date is equal to approximately CHF 60 million. The promoters have a share of 51%. It accounts for approximately 60 employees.

Currently this is crucial period for Airlight Energy as it is moving from the start-up phase to the commercial stage.

Figure 5: Airlight Energy Holding SA structure



36 Matt Rogers, McKinsey & Company, 2012

4.2 Airlight Energy innovative CSP solution

Airlight Energy has been developing an innovative solution for CSP trough that leverages the potential of this technology and tackles some shortcomings of the conventional plants. Its value proposition is to break the current CSP paradigm on three dimensions: cost competitiveness, sustainability and security of supply. These are the basis to enter the current market.

Nowadays is fundamental to “submit” a cost competitive plant, easy to install and characterized by a long lifetime. As there are a variety of intermittent and lowly efficient renewable technologies unable to offer continuous operation it is necessary that new technologies brought to market have the capacity to produce energy on demand. Efficient, versatile and flexible product- this means to include energy storage system. Providing new solutions in a sustainable way is a prerogative to enter almost all markets becoming more and more to this topic. Environment-friendly companies should supply not only CO_2 free technologies, but also have consideration of non-polluting materials deployment, intelligent usage of land, local economies development, water recovery and more others. It is exactly what Airlight Energy is committed to do.

First of all, a significant improvement has been brought to the market thanks to the use of concrete structures, allowing to reduce the overall project investment (CAPEX). The structure lasts longer and has higher resistance compared to the construction materials traditionally used. Moreover its design is conceived to allow the incorporation of the whole system into a protective pneumatic transparent enclosure.

A second important innovation is the use of air as heat transfer fluid. Contrary to oil or molten salts, air has no issues connected to spillage into the environment or problems at high/low operating temperatures.

Another important step up compared with state-of-the-art CSP technologies is the substitution of glass mirrors with a multi-arc pneumatic mirror system made of 4 thin layers of polyester foils whose topmost is metallized. By substituting glass, the mirror cost decreases by almost 5 times and thanks to the wide availability of the films on the market there are no production bottlenecks.

Lastly, thanks to the development of a proprietary packed bed thermal energy storage the system can operate in absence of sunlight, at a very competitive cost (max. 8% of total CAPEX) and in highly secure conditions. The thermal storage consists basically in an insulated concrete tank filled with sedimentary rocks. Inside the tank, the air flows through the pebbles exchanging heat with them. Thermal losses are minimal, in the order of 1% over 24 hours.

5. Competitive landscape

5.1 Main players

As already mentioned CSP market is dominated by few big players, and competition is driven by disparate opportunities:

- Fossil-fuels dependent countries (Middle East, South Africa, Australia) with high solar irradiation looking to diversify their energy mix
- High power demand countries (China and India) able to follow industrial strategies.

Market is largely fragmented and composed by new or reviewed technologies promoters and project developers (62%), parabolic trough promoters and developers with global experience (28%) and leading CSP movers (10%).

The market leaders, such as Abengoa, Acciona and ACS Cobra, are well-positioned on the market thanks to the leveraged in-house construction capabilities and financial presence. This companies entered first the market and built their own experience. They managed to lay the foundation of technology and thus influenced the market. Moreover having the history, they become reliable and get the projects easier bankable.

As the market is not easy to access there are more and more emerging group of smaller technology Independent Power Producer (IPP) and technology promoters that are establishing themselves through the partnerships and joint ventures. Especially the entrance of the strong industrial power players, oil companies and large ECPs is very frequent. They have the advantage of the greater penetration to the market thanks to the financial capability and stability. In this case solar energy represent their supply portfolio diversification. National authority and utilities, however, account for approximately 15%.

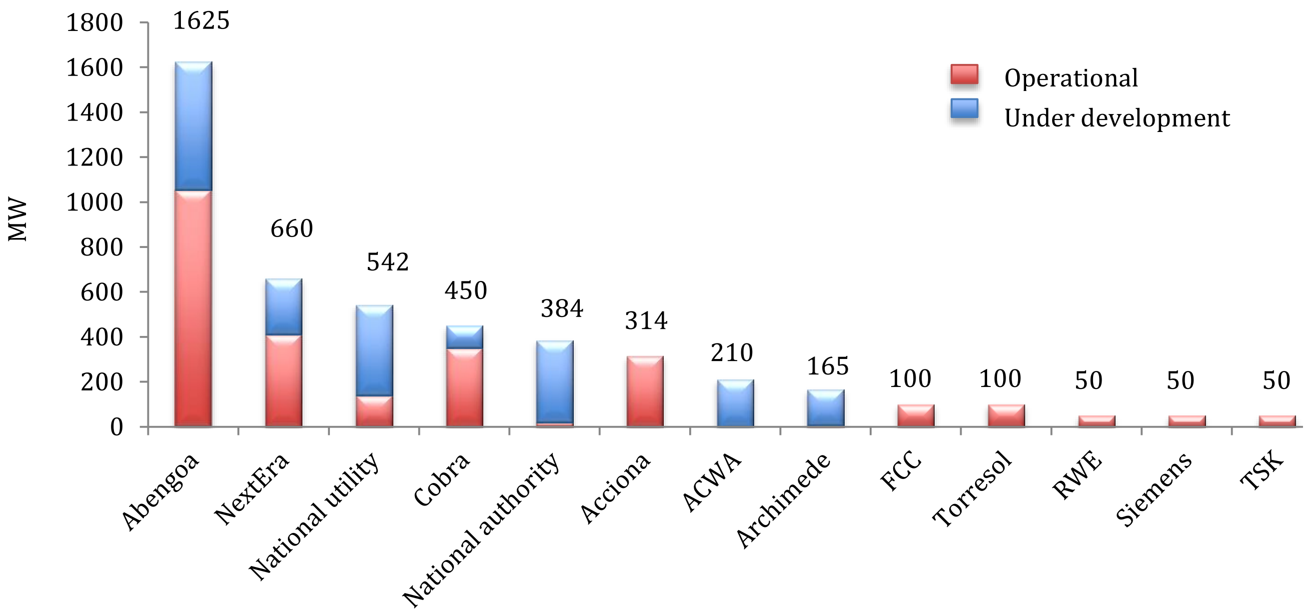
Spanish Engineering Procurement and Construction companies (EPCs) have the leadership in the CSP sector.

Key distinctive elements that make them successful in bidding rounds abroad:

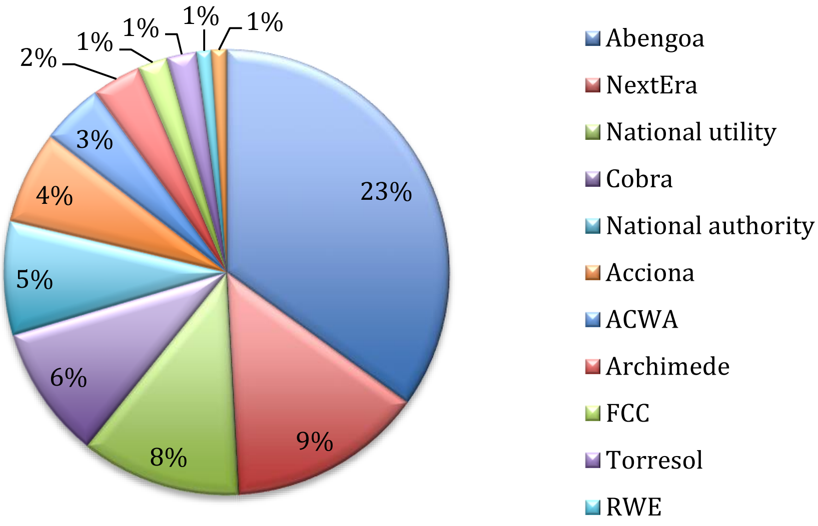
- Track record of more than fifty CSP plants built at home and abroad: they are able to offer clients an edge on the learning curve in terms of both operation and design. Spanish EPCs are participating in the deployment of 2’213 MW in the planning, development, construction, commissioning and operation phases in Algeria, Australia, China, Egypt, Israel, India, Kuwait, Mexico, Morocco, South Africa, the UAE and the U.S. In the total Spanish competitive landscape the following major actors are identified: Abengoa, Acciona, Cobra, Sener and TSK.
- Flexibility: strong and quick adaptation to particular requirements is key characteristic.

- Experience plays a key role in scaling up projects. Not only during engineering and construction phases, but also in planning and securing funds for the plant's construction.

Graphic 6: CSP parabolic trough capacity by player



Graphic 7: Market share by player



As shown on the graphics, there is dozen of key players in CSP market. High number of small companies involved in this segment of business accounts for around 33% of the total installed capacity and is not considered on the representation. This is one more demonstration how CSP market is fragmented.

5.2 CSP value chain

The core value chain of the CSP technology involves seven phases:

- The first one concerns project development which comprises suitable site choice, Power Purchase Agreement (PPA) and layout of the plant.
- The second and the third phases include materials and components supply.
- The following level concerns the Engineering, Procurement & Construction (EPC) part. This phase is normally executed by specialized company dedicated to this kind of activities.
- Operation & Maintenance (O&M) include all actions done during the plant operation, such as substitutions, cleaning and general, maintenance.
- The core activities consist in the purpose of the product: energy distribution.
- The last step, however, take in consideration dismantling of the plants at the end of its lifetime.

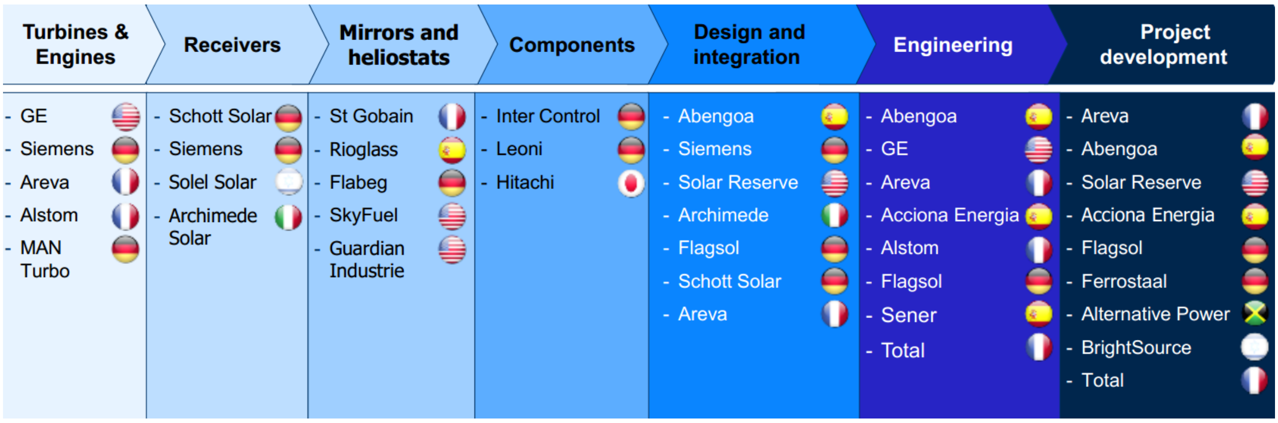
Table 3: Schematic representation of CSP value chain

Core value chain	Elements of the core value chain
Project Development	Climate data acquisition, site selection, feasibility study, environmental assessment, concept engineering, project financing, permission process
Materials	Concrete, steel, sand, glass, silver, copper, salt, thermal oil, other chemicals
Components	Mirrors, concrete foundation, pylons, metal support structure, tracker system, cabling, receiver, connection piping, thermal insulation, HTF, pumps, storage system, steam generator, heat exchanger, power block, grid connection
EPC	Engineering, procurement, civil works, collector assembly, installation of solar field
O&M	O&M, electricity generation
Distribution	Transport and distribution of electricity
Dismantling	Dismantling of the plant, disposal of waste materials

The main raw materials used in CSP plants are glass for mirrors, steel for support structure and piping, chemicals for the HTF, salt for storage and concrete for collector foundations. These resources are provided by the world market or local suppliers. Big differences in providers of given parts of the plant such as mirrors and receiver are evident. Mirrors contractors are large companies often from automotive sector with large factory output. They have big advantages of large turnover for a variety of mirror and glass production. On the other side, receiver for parabolic trough producers are two large players with no established market and strongly dependent on the market growth. They have invested huge capital in know-how improvement. Currently the competition is not very high.

It is important to say that CSP value chain involves highly integrated and specialized companies, too. Market leaders, such as Abengoa, manage to cover several phases of the value chain. On the figure is possible to notice the leaders of the supply of the main components deployed such as German, French, Spanish and American companies.

Figure 6: Main actors along the CSP value chain



5.3 The challenges of local content

Almost all governments have established certain conditions regarding local component supplies and human resources to boost their local economies. Very often CSP projects are built in the countries where the local supply chain is not fully developed and in this case local requirements could drive cost up.

Some example of the challenges met during the CSP plans construction:

- **Local component** supply: absence of a local CSP component manufacturing base which means difficulty in finding turbines, steam generators, air condensers, nitrogen, gas and DSD. This lack generates higher costs of getting the equipment that can be assembled by local branches of international companies. Another problem is caused by the transportation considering the isolated locations of the plants, permissions obtaining and finding of the consumable products. A possible solution to the described difficulty could be creating local enterprises to supply the demand for specific heavy industrial components.
- **The best local partner**: checking local partner's ability to perform, dealing with local communities, tackling labour and employment issues and achieving price competitiveness. Research and selection of the right local partner is necessary. Particularly important is to understand and deal with the local laws regulating the issues as employment preferences, training, ownership, management and preferential procurement. As a specific example South African Broad Based Black Economic Empowerment policy (BBBEE) can be considered.
- **Local communities**: offering the local people menial labour posts is not sufficient. The local population has to buy into the project to make it viable. Taking the procurement to the next level is required in order to make all more meaningful: deployment of the training and development programs to deal with local employment and labor relations. This direction can mitigate the risk of the strikes and lock-outs.
- **Expensive local materials and profitability**: sometimes buying the supplies in developing countries doesn't necessarily means lower cost materials or services.
- **Highly skilled workforce** is not easy to find in the countries where such technology is built. Moreover it is very novel technology and training centers are necessary. By way of this example the Spanish government's financing of the Industrial Development Corporation of South Africa can be mentioned.

5.4 Airlight Energy positioning in competitive landscape

As concluded from the market analysis parabolic trough conventional CSP plants have so far proven to be among the most viable options for large-scale solar power application. However, as identified by several technology reviews, these conventional CSP plants suffer from various technical and economical drawbacks. The fabrication of the concentrator involves expensive glass reflectors and metallic structures, which suffer from lack of rigidity at large trough apertures. Because of thermal stability, the maximum operating temperature of the HTF is restricted to below 450 °C, which in turn limits the attainable global efficiency. Troublesome thermal storage concepts involving molten salt coupled to the oil-based solar field via heat exchangers are required to extend the daily time span of energy generation.

The Airlight Energy CSP system uses concrete to enhance performance. It is based on an inflated multi-circular arc trough with an air-based receiver able to operate efficiently at temperatures up to 650 °C. The collector is built as an assembly of elementary modules, which constitute the basic constructive element. The load-bearing structure of the solar collector is constituted by pre-cast, pre-stressed fiber-reinforced ultra-high performance concrete (UHPC) components to be manufactured on site. The high-performance concrete mixtures allow significant restriction of creep and shrinkage effects while reducing to a minimum the need for reinforcement bars. Furthermore these structures are inherently long lasting and guarantee a lifetime of 60 years.

The formworks dedicated to the precast of different elements have been developed, assembled and tested in Biasca. They open and close automatically by means of hydraulics actuators controlled by numerical control software. At the time of casting, the concrete is injected into the formwork using a concrete pumping unit. After a short hardening time of 4 hours, the mold-sides are opened and the concrete element is extracted and stocked on site. The complete formwork is then cleaned and prepared for the next cast.

The collector concrete frame provides a rigid support for a stable operation of the primary mirror. This is constructed from a multi-layer stack of polyester films whose topmost membrane is vacuum coated with aluminum in order to obtain a highly reflective surface, with 90% total specular reflectance for the solar spectrum. Four tangentially adjacent mirror membranes create three intermediate pressure chambers. By applying gradually decreasing pressures from the uppermost to the lowermost pressure chambers, the metallized top mirror membrane forms a profile that approximates the shape of a parabola. The cumulative aperture width of such a mirror is 9.7 m, with a geometric concentration ratio of 66x. A proprietary auto-focus system is used to monitor the multi-arc mirror geometry and adjust the differential pressures to match the required mirror profile.

Figure 7: Concrete structure

The mirror foils and solar receiver are protected from external influence (e.g., wind, dust, rain) by an inflated film system, consisting of a transparent ethylene tetrafluoroethylene (ETFE) foil at the top, of 92% total transmittance for solar radiation, and a PVC-coated polyester film at the bottom.

The Airlight Energy's trough tracking sun system is driven by a chain transmission, actuating the externally geared concrete wheel and presenting minimal errors. Such system, directly installed on the foundation, is not only responsible for the rotation of the collector but serves also as anti-seismic mechanism able to withstand extreme earthquakes. The whole system behaves as a hanged structure, with the collector base under each wheel being suspended on four rods with spherical joints, and being therefore free to move in the collector longitudinal and transversal direction.

To overcome the operating temperature limit of 450 °C of oil-based parabolic trough receivers (which is primarily imposed by the thermal stability of the heat transfer fluid and the selective absorber tube coating), several fundamental modifications have been implemented:

- The thermal oil has been replaced by air as HTF, which is free, nonpolluting, and has practically no operating temperature limit.
- The selective coating has been eliminated by the use of a cavity-receiver.
- A novel receiver based on an array of absorber cavities has been designed for a maximum operating temperature of 650 °C.

The design is easily scalable and offers a high flexibility in the plant layout such as variable collector lengths. Thanks to the secondary optics an overall geometrical concentration of 97x is possible. Overall optical efficiency remains above 82%.

On-sun tests with a small-scale prototype receiver yielded air outlet temperatures beyond 600 °C. At normal incidence and a direct normal solar irradiance (DNI) of 1000 W/m2, and assuming air inlet and outlet temperatures of 120 °C and 650 °C respectively, the collector is expected to reach a maximum solar-to-thermal efficiency.

Figure 8: Air Receiver

The use of air as HTF enables the application of a proven and inexpensive thermal energy storage (TES) concept based on a packed bed of rocks that guarantees round-the-clock dispatchability of high-temperature heat to the downstream process. The tank is typically immersed in the ground and embedded in an external layer of concrete.

During the day, a part of the energy produced by the collector is diverted to the TES; the hot air is conveyed to the tank, percolates through the packed bed exchanging heat, and is collected at the bottom. At night, or during the absence of solar insulation, the flow direction is reversed; cold air is circulated through the tank from the bottom, is heated by the rocks and leaves as hot air from the top. The maximum operating temperature is about 800 °C, limited mainly by the materials of construction of the tank.

Figure 9: Storage view

To summarize, in the CSP-state-of-the-art technology extensive amounts of expensive steel, glass and aluminum are used. These raw materials are characteristic for significant lead time and “grey energy” use in manufacturing. Besides being produced by few manufacturers available on the market, they involve increasing maintenance costs. Exposed to the dust and scratching mirrors deteriorate quickly. Unrecovered water of mirrors cleaning is considerable issue, especially in the desert areas. Complexity of the handling the most activities require skilled workforce, not available everywhere. Tubes used in traditional receiver are technically complex and very expensive and heat fluid oil is degradable. It can reach only up to 400°C. In case of losses toxic oil will be released in the ambient. Permitting in Switzerland and Germany could not be achieved, as authorities are requesting double shell tube with leakage control. Especially in case of clouds control is very difficult and generally carried out manually by highly experienced personnel.

All this shows how other CSP technologies have a higher level of barriers to local manufacturing mainly because of the lack of capital intensive domestic production capacity for aforementioned key components. Moreover many European states such as Germany and Spain have invested heavily during the last 10 years in production capacity and they are looking to maximize their return on investment. It is therefore unlikely that they would like to invest in new de-localized capacity in the short-mid-term.

Airlight Energy technology is designed to maximize the use of local resources and manpower. Thanks to the use of locally available raw materials and the innovative product design it is able to overcome the major barriers that prevent the local manufacturing of CSP components, as shown in the table below.

Table 4: Airlight Energy vs. main CSP players' barriers level

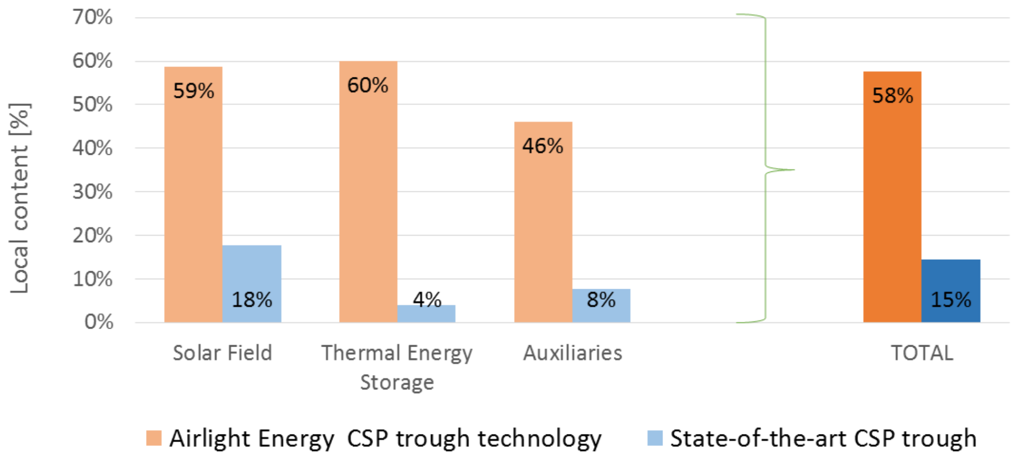
	State-of-the-art CSP technology	Ailright Energy CSP technology
Civil works	Low	Low
EPC	Medium	Medium
Assembly	Low	Very low: precast assembly
Receiver	High	Low: locally available materials, on-site assembly
Flat glass for mirrors	High	Not used: plastic foil mirrors (no glass)
Mirror (flat)	High	Not used: plastic foil mirrors (no glass)
Mirror (parabolic)	High	Not used: plastic foil mirrors (no glass)
Mounting structure	Low	Low
HTF	High	Not used: air as thermal vector
Connecting piping	Medium	Medium
Storage system	Medium	Low
Electronic equipment	Low	Low

With Airlight Energy technology more than 50% of the value of the project is generated locally thanks to the use of locally available materials and local manufacturing.

The collector frame is manufactured on site using cement and aggregates that can be sourced locally. The same is valid for the thermal energy storage. The receiver can potentially also be manufactured locally due to the use of widely available commercial pieces that can be sourced and assembled by local industries.

Considering a 50 MW standard solar power plant with Airlight Energy technology, the construction phase lasts for about 2 years. In this time-frame approximately 200 workmen are needed. And additional approx. 25 skilled and unskilled jobs created for the plant operation.

Graphic 8: Local content contribution of Airlight Energy and State-of-the-art CSP technology[37]



Sustainability means also environmental care. CSP plants are usually located in areas of drought and thus water use is generally a major. Airlight Energy collectors are covered with the transparent ETFE film that allows to recover washing water and collect rainwater into built-in drain pipes. Excess water can also be filtered and reused for agricultural purposes. In some cases, where annual precipitation is enough, the recovered water is even more than the water needed for washing purposes, so the plant has a positive water balance.

In this case is important to mention the logistic aspects, too. It is important issue considering that immense transports have to be organized being distant from manufacturing place. For example, a 50 MW plant building with traditional techniques and systems requires approximately 30’000 tons of steel and 300’000 mirrors. These have to be packed independently, transported and assembled on site. This very often implies logistical problems due to the fragility of the materials, additional costs for transports and sometimes construction delay. The most important parameter for evaluating a power plant with storage is not the power investment indicator but energy costs, due to the fact that the plant operation is almost independent from the energy source and the effective running hours are more than 7’000.

As per the "Concentrating Solar Power Outlook 2009", the cost of solar thermal power is dropping. Experience in the US shows that today’s generation costs are about 15 c$/kWh for solar generated electricity at sites with very good solar radiation. Airlight Energy is able to generate electricity with a very competitive price (sometimes more than 20% below the market). This is the result of countless innovations and attention in the use of appropriate materials and thanks to a business model that optimize the needs for resources.

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[37] For the purpose of this comparison the total investment cost does not include: EPC costs, power block and balance of plant (assumed to be the same for both technologies and therefore not considered for local content assessment).

6. Competitiveness perception analysis through cognitive mapping approach

6.1 Research design and methodology

The method of cognitive map was used to identify the perception of a given environment by Airlight Energy actors since it is designed to help perspectives understanding people have about a given issue: in this case competitiveness perception. These viewpoints are related to the networks and interactions people are involved in, and each person has an own one.

The purpose of this study was to derive management members' cognitive maps in two different moments: before the presentation of market research and assessments, and after the presentation of the results of the same. In the second moment the comparison of the cognitive maps was done to evaluate how much the maps from 2 different data collection differ. The idea consisted in understanding the management cognitive maps configuration: how are large, detailed and articulated. Do the management change its perception as a result of extensive competitive analysis? What are the main differences between the cognitive maps of actors before and after the result of the analysis? Are these new cognitive maps more extensive?

The research project took place over a period of 7 months and involved the researcher in some meetings with potential partners and/or customers and energy sector conferences (Solar Expo in Milan and Power GEN Middle East in Abu Dbahi).

For data collection the qualitative research methodology consisting in structured interviews was chosen. 5 interviews with management members with decision-making power were done in the first round and other 5 in the second round. They were composed by six questions oriented to comprehend the level of knowledge of a number of issues concerning the sector competition of each interviewer.

The work was mainly divided into 3 different activities:

- **Research activity**: a preliminary research was done to develop a global overview on the existing data sources, concepts and theories, in particular cognitive mapping literature was considered. Already at the early stage discovered information database from the most variegated sources was pretty rich. Exist numerous industry business intelligence providers and institutions which publish market reports, such as IRENA, IEA, EIA, World Bank, CSP Today and many others. These were used as support of the research.
- **Field data collection** consisted in 2 phases-interviews to collect sufficient data for maps drawing.
- **Data analysis and conclusions**: maps drawing and analysis

While the phases of overall research were these:

Table 5: Research phases

1st phase	First round of structured interviews was completed in April 2014 where preliminary information were collected.
2nd phase	Cognitive maps drawing based on the received information during the interviews in order to understand the actors' knowledge about the sector in which the start-up is inserted. The perception about the competitiveness level was put in evidence.
3rd phase	Market research was done in order to do global evaluation of the competitiveness level within identified sector. The results of the research were presented to the company.
4th phase	Second round of structured interviews was completed in November 2014 where further information were collected. This information are once again important for the new cognitive maps drawing.
5th phase	Comparison of the cognitive maps resulting from the first and the second round interviews.

6.2 Airlight Energy members’ cognitive maps analysis

Managers can recognize the importance of the coordination among the functions inside a given company because it influences the firm’s different orientations towards competitors, customers and technology. Thus, this is possible by facilitating sharing of important market information necessary for successful new product development.

Furthermore, the division of labor and functional specialization in a given company, results in predictable differences across cognitive maps of managers in different functions and levels of the organization. “Managers could use cognitive mapping to recognize and evaluate beliefs that inhibit the sharing and interpretation of information between managers, departments, and levels and could design appropriate interventions”[38].

Managers’ orientations are perceptual and their “understandings may vary across and within a business unit, and that difference in managers’ perceptions can influence their actions in both negative and positive ways”[39]. This is the case of the start-up taken in consideration. External environment in which the start-up is integrated is understood in partially different ways. With this study was discovered how the cognitive maps are configured and how they change in the minds of the participants.

Data analysis is descriptive since the primary goal of the research is to synthetize the most salient characteristics of the studied phenomena. The tables below list the questions and the answers given by the participants in 2 phases-interviews. For each question there are some answers (colored cells) that differ from the rest of the participants answers. As it is possible to notice the some given answers are common. This suggests that circulating information in the company are shared between the members. In the very first phase of this research, on one hand, it could mean that the actors do active market intelligence and are well aware of the sector in which they are inserted. On the other side it might be that available information are based on the gained experience during the activity but without real and deep look into the market.

Going through the answers following considerations for the first round interviews can be done:

- **Core business**: some people are concentrated only on Concentrated Solar Power technology, which actually is the main activity of Airlight Energy. The others consider energy production and storage activities which suggests contemplation of other products developed by the start-up.
- **Strategic markets**: Decision on where to move and promote the products is shared by all the interviewed people. Suitable geographic zones for this kind of products are vast. Some indicates geographic zones, whereas other list specific countries.

[38] B. Tyler and D. Gnyawali: Mapping managers' market orientations regarding new product success
[39] B. Tyler and D. Gnyawali: Mapping managers' market orientations regarding new product success

- **Main competitors:** indication about well-known big market players such as Abengoa, Acciona and ACWA Power. Only one specification which delimits in some way operating sectors and indicates competitive threats such as solar PV or wind.
- **Competitors' strategy:** The majority is convinced of the fact that the current major players dominate the market and hold competitive advantage for being entered the market for first. 2 responses show that some look at the competitors in a more "objective" way, as big companies that have grown over the time and have been able to develop the resources and the competencies to cover the whole or almost whole supply chain. This was possible thanks to the availability of own resources (economic and technical) or creating the proper alliance and partnerships to grow and gain market share.
- **Competitors' weaknesses:** Airlight Energy is a start-up that brings to the market a "breakthrough" technology with 5 important innovations. The biggest news and innovative changes that Airlight Energy present are based on the technical and environmental lacks of the state-of-the-art technology. The weaknesses considered by the participants to the interviews are based on Airlight Energy advantages. This thinking prospective is shared among all the interviewers.
- **Airlight Energy market positioning:** all participants are aware of the market penetration difficulty and some indispensable prerogatives such as huge capital need and track record requirement. The majority sees Airlight Energy commercially immature at the moment.

Whereas considerations for second round interviews are following:

- **Core business**: All people are more concentrated on CSP technology, company's core business. Less consideration about other product which are not as priority as others at the moment.
- **Strategic markets**: Indicated geographic zones are more specific. More information about incentives presence and favorable policies are known by participants. They seem much more aware of the market characteristics where is most suitable to propose developed technology.
- **Main competitors:** Once again big market players such as Abengoa, Acciona and ACWA Power are mentioned. But this time also the alternative technology as potential substitute is considered, in particular, attention on photovoltaic technology is put.
- **Competitors' strategy:** The fact that majority of the current players were established in the more favorable period, when CSP strategy was penetrating on the market, is not the most shared opinion in this round of interviews. It is more considered the tendency of the big companies to create proper partnerships to grow and gain market share.
- **Competitors' weaknesses:** Technical limits of the competitors' technology play an important role in their evaluation. They present in some way better Airlight Energy position on the learning curve in comparison to other CSP providers. Issue of low cost transparency

and lower performances than expected are the aspect not to underestimate. This is global tendency in CSP market which creates negative impacts of the reliability of this technology.

- **Airlight Energy market positioning:** End of the first full-scale plant in Morocco represents an important phase in Airlight Energy life. It is considered as crucial step which permits having first production curves and begin of some kind of "track record". This make the technology more reliable. All interviewed people mention this plant because it embodies a huge effort that was put in this first realization.

Figure 10: Example of a cognitive map

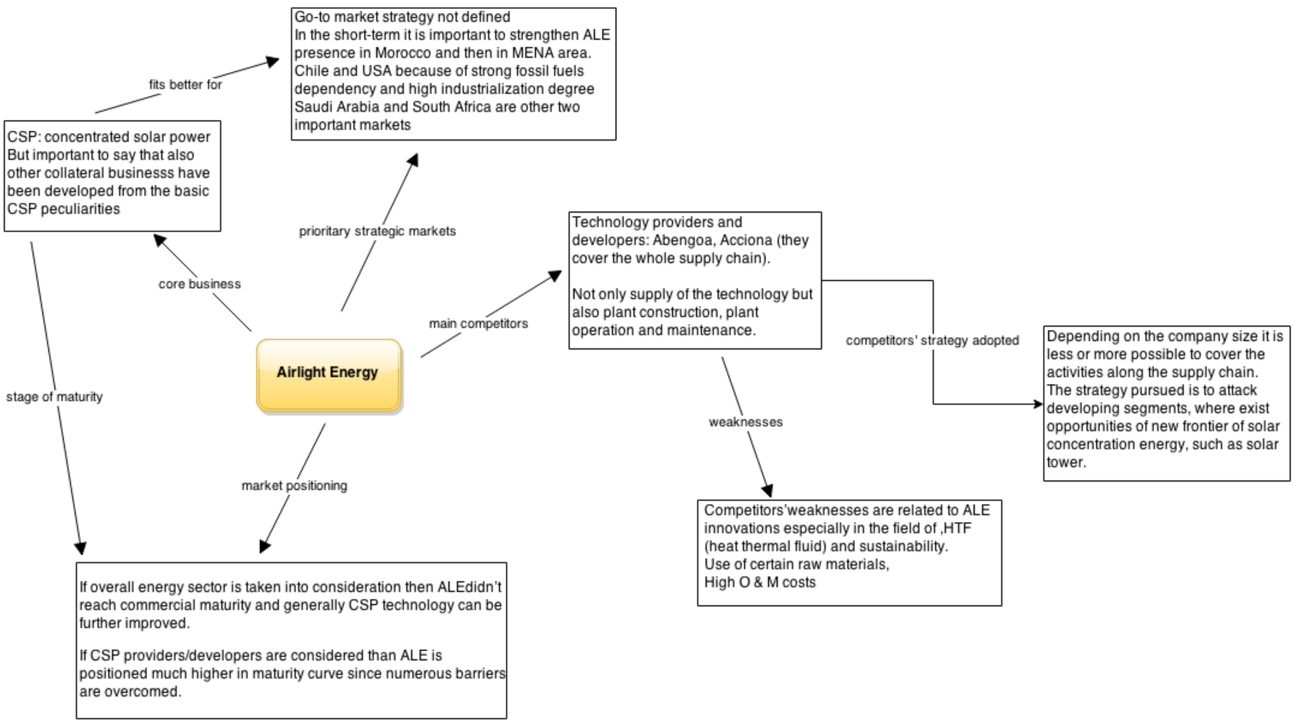

Table 6: 1st round interviews data collection

Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Core business	CSP: highly competitive and efficient solar concentrators	Solar energy and energy storage	CSP: concentrated solar power	CSP but also other "collateral business"	Production and energy storage using RES and natural systems.
Priority geographic markets	Geographic zones with very high DNI where process heat and electricity needs are high	MENA area, South Africa, USA, and other countries with optimal solar conditions	Morocco, South Africa, Chile, Australia, Sub-Saharan Africa	Go-to-market strategy not defined Short-term: Morocco and in general MENA area Chile, USA, Saudi Arabia, South Africa	Both, developed and emerging countries, Saharan zone, USA.
Main competitors	Direct: Abengoa, Acciona, Brightsource ,… Indirect: solar PV players "external": potential substitutes such as wind pharms	Solar technologies providers. Big competitors like Abengoa, ACWA Power, Brightsource who are both providers and producers	Abengoa, Glasspoint and other companies active in CSP sector. Solar tower technology developers and providers.	Technology providers and developers such as Abengoa and Acciona. Not only technology suppliers.	No knowledge about the companies- A.E. companies. Should be the same technology providers, in particular solar towers.
Competitors' strategy	"First entrants" in highly subsidized market with free market share	Big and well structures companies- well positioned on the market→ JV with big industrial in order to reach better market penetration	First entrants such as Abengoa- Spanish market was highly subsidized- track record building and easier commercialization.	Covering as much as possible activities along the supply chain. Developing segments attacking.	Historical advantage: first entrants and easier market share gaining.
Competitors' weaknesses	Weak and obsolete technology- not competitive with traditional PV, no storage integration, temperature limits	Do not know exactly. A.E. strengths based on the competitors' weaknesses: in particular "local content".	All that is different from A.E. 5 innovations.	Related to A.E. innovations especially in HTF and sustainability. High O&M costs, use of certain raw materials.	Technological disadvantages Overall costs, O&M costs, efficiency issue.
A.E. market positioning	Not easy market access, high capital need, track record and minimal plants size required	"Breakthrough technology" which doesn't necessarily mean lower costs. Competitive advantages over other actors	Weak from commercial point of view. Lack of aggressive marketing policy. Start-up phase too much concentrated on R&D e not on the market.	Commercial maturity not reached in overall RES sector. If considered CSP providers/developers ALE is much higher on maturity curve than its competitors.	Market ready only in presence of track record, such as Ait Baha production curves. Main obstacle: market penetration and new customer acquisition.

Table 7: 2nd round interviews data collection

Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Core business	CSP	CSP: commercialy ready product.	CSP-market ready product	CSP- market ready product	CSP technology with integrated energy storage
Priority geographic markets	Always geographic zones with high DNI. Particular attention to the countries with high energy needs and high energy costs, e.g. Italy, Chile	Priority: Morocco, South Africa and Italy Saudi Arabia, India, USA, Chile Australia, Sub-Saharan Africa, South America	Italy, Chile and South Africa in the short-term China in the medium term. Liberalized markets, easy use of capital.	South Africa, Morocco, Chile- huge CSP experience, incentives mechanism, high energy needs. Italy- priority because of the highest incentives on the world.	Morocco, Italy, South Africa, Saudi Arabia. Where DNI is high, but also optimal economic conditions.
Main competitors	Big players such as Abengoa. But important to take in consideration other renewable technologies which are gaining market share: especially wind and PV.	Other R&D firms active in this sector, e.g. Brightsource. Big players with heavy presence such as Abengoa.	Developers, investors and EPCs contractor are the main stakeholders whereas main competitors are developers of CSO solar towers and PV providers.	Technology developer such as Abengoa, Acciona and Cobra. Very important are governments and big industrials.	Companies active in CSP solar tower but also alternative technology providers. As concerns process heat A.E. has to compete with coal plants.
Competitors' strategy	Big players are creating the partnerships e.g. with components provider and propose the plants at very low cost (not very healthy strategy).	"Track record"- solar tower applications. Diversification of the CSP applications in desalination, enhanced oil recovery. Tender participation.	Mass investments in marketing, sales and commercial promotion of their systems. Huge investments in pilot projects.	CSP technology improvements- cost reduction and better performances. Bid participations, market share gaining. Alternative solution research.	Important partnerships with potential customer, components providers. Technology improvements.
Competitors' weaknesses	CSP providers are not competitive with potential substitutes such as wind or PV technology. Technical limits. Storage is a big issue.	Technology choices which don't put on the first place cost competitiveness. E.g. molten salts which are expensive and polluting.	"Lesson learnt": technology improvements not possible.	Low transparency about the costs and performances.	Low cost transparency Doubt on the efficiencies Performances are not as announced.
A.E. market positioning	Ait Baha plant is ready and operating: first production curves. This is very positive and represents an important step.	Optimally positioned to compete with solar tower technology and process heat applications.	Well positioned, extremely scalable product. Concentration on the priority markets and commercial plants construction.	Commercially ready for CSP technology selling. Launch of the new products, too.	Need of continuous production of our plant in Morocco in order to demonstrate that the technology is innovative and effective.

6.3 Cognitive maps comparison

Analyzing information from 2 round interviews cognitive maps were drawn. The maps derived from second phase interviews differ slightly from the first phase data collection. It seems to be present higher awareness of competitive environment in which the company is collocated. But also major conviction about the level of innovation and improvement that Airlight Energy brought to the CSP technology. Interviewees recognize better the company's core business, CSP, and are more oriented towards the priority of bringing as soon as possible of this new solution to the market. One of the main risks of multiproduct start-ups is danger of losing direction perception and lack of defined strategy. These conditions can bring the firm to the failure very quickly. For this reason is important that all actors have clear definition of the priority firm's activity.

Some of the members during the first interviews affirm that go-to-market strategy is not defined, but the same is also understandable from other answers. In fact, in the first interviews vast geographic zones were indicated, whereas in the second, specific countries were indicated. This suggest that more market perception and strategic orientation towards priority zone of action are born. Some decision about the most attractive markets and contacts/partnerships have been taken.

As concerns main sector players it seems problematic to define the precise field of the competition and what type of the companies are the real competitors. Scarce knowledge about the companies, their number, their core business and background can be observed in the first phase. Afterwards this situation changes and considered field of competition is wider. In fact, other variables were taken in consideration, such as potential substitutes and potential entrants.

Competitors' weaknesses seem be underrated. Thus, mainly technical disadvantages are mentiones. Probably deeper research about competitors' strategies and wrong decisions could be done as support to own strategy orientation.

Awareness of commercial "immaturity" is probably the consequence of the "stand-by phase" in which Airlight Energy finds itself today. In fact, the inaugurated full-scale plant has to demonstrate that the technology is effective and that it works. This process takes certain time and in the meantime Airlight Energy should define better its market strategy and promote own solution in the priority markets.

Conclusions

Studying managers' cognitive structures in different types of industries over time is very important. It is fundamental to understand how managers' cognitive structures may relate to their company's ability to learn. They can recognize the importance of the coordination among the functions inside a given company because it influences the firm's different orientations towards competitors, customers and technology. Thus, this is possible by facilitating sharing of important market information necessary for successful new product development. For this reason acquisition and dissemination of market intelligence is fundamental.

It is still unclear how market intelligence is structured in managers' minds. Organizations are information rich, complex and sometimes ambiguous. To avoid being overwhelmed, people simplify, quickly identifying the most salient characteristics or most plausible explanations and discarding others. Sometimes this bring to the wrong strategic decisions.

"Organizational reality produces a constant flow of signals — some observed directly (both verbal and nonverbal), some reported by others and some inferred from data. With too much information to process, individuals in organizations have to focus on what matters most"[40].

Dynamic environments, continuous changes and competitive pressures have often forced organizations to constantly adapt own orientation. Sometimes the firms are not ready for business process redesign, but they should always be available for new reshaping. This process in any case is not as simple as could seem. In fact, most organizations meet serious problems in this critical phase, but it is important to know that when the environment is well analyzed exist higher possibility to address these issues in the right direction. "A cognitive map-based method, called two-phase cognitive modelling, is proposed to help organizational members identify potential organizational conflicts, capture core business activities and suggest ways to support the necessary organizational change"[41].

Sometimes the problem consists in the individuals' tendency to change own belief system only when certify the failure of own forecast or perceptions. In this situations, too, it is possible that actors confirms own cognitive map and make only partial changes of the environment illustration, we speak then about second order change. When complete restyling of the cognitive map is executed then we speak about first order change. The radical reshaping of the cognitive maps happen only in the presence of the much better alternative because exists a certain resistance and scarce inclination to remove set values and concepts. In this research, too, we see that derived cognitive maps are not completely different. It is true that there is higher awareness of some concepts and issues but base convictions are the same. Certain time period for changes is needed. But it is possible to affirm that some start-up companies such as Airlight Energy have a

[40] http://sloanreview.mit.edu/article/are-your-subordinates-setting-you-up-to-fail/
[41] Kwahk and Kim: Supporting business process redesign using cognitive maps

given degree of dynamism and will to improve self-consciousness of the environment in which finds itself and design the future strategy for better results.

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