This Project has received funding from European Commission by means of Horizon 2020,
the EU Framework Programme for Research and Innovation, under Grant Agreement no.727348

Grant Agreement No. 727348

Project Acronym:

SOCRATCES

Project title:

SOlar Calcium-looping integRAtion for Thermo-Chemical Energy Storage.

DELIVERABLE D8.8

Market Analysis

Funding scheme:	Research and Innovation Action (RIA)		
Project Coordinator:	USE		
Start date of the project:	01.01.2018	**Duration of the project:**	36 months
Contractual delivery date:	Month 12		
Actual delivery date:			
Contributing WP:	WP8		
Dissemination level:	*Public*		
Authors:	SPI		
Contributors:	USE, POLITO, CERTH, CLXHE, CSIC, ATR, TTZ, BIO, CNR, ISI, AUTH		
Version:	V3		
Document name:	SOCRATCES_D8.8_v3		

Table of contents:

1. Introduction 3
2. Market Information 3
2.1 The technology and market positioning 3
2.2 Customer segments and value proposition 5
2.3 Competitive analysis 15
3. Business Model Options 17
4. Key Partnerships 19
5. Business Model Canvas 20
6. Bibliography 22
Annex A 24
Annex B 37

1. INTRODUCTION

In regards to Concentrated Solar Power (CSP), the Ca-Looping (CaL) process based upon the reversible carbonation/calcination of CaO is one of the most promising technologies for thermochemical energy storage (TCES). The global objective of SOCRATCES project is to validate in a relevant environment, at prototype level, a highly cost competitive CSP/TCES technology: feasible, viable and sustainable for a real advance in the pathway to new generation of CSP tower plants.

This document is a public deliverable of task 8.6 (business plan elaboration) included in WP8. It aims to bring the market information to the ongoing work of SOCRATCES project. It intends to provide a competitive analysis to predict the real market conditions in which SOCRATCES will be exploited. This exercise must be dynamic, since important indicators can be improved and refined through the project development. Also, potential success will depend not only on market demand and competition but also on the business model adopted.

That is the reason why a draft of business model canvas was firstly presented and discussed among the consortium, together with a dynamic tool (both hereby presented). This tool will allow to test along the project different scenarios concerning market conditions but, above all, different business models that may be implemented, testing its feasibility.

2. MARKET INFORMATION

2.1 The technology and market positioning

Energy storage is one of the greatest challenges for a short-term deeper penetration of renewable energy sources, which are usually characterized by the intermittency of power production. In regard to Concentrated Solar Power (CSP), the Ca-Looping (CaL) process based upon the reversible carbonation/calcination of CaO is one of the most promising technologies for thermochemical energy storage (TCES). The wide availability of natural limestone (almost pure $CaCO_3$) and its low price (<10€/ton) are key factors for the feasibility of the CaL process.

SOCRATCES is a breakthrough project whose global objective is to develop a prototype that will reduce the core risks of scaling up the CaL process as TCES, and to solve the associated challenges. Lime (CaO) has been long proposed as an energy intensive material for the storage of energy in a chemical form by means of carbonation/calcination cycles. However, this potential has been inhibited by lime's propensity to sinter at the typical CaL conditions for CO_2 capture, which reduces dramatically its multicycle conversion up to reach a residual value of 0.07-0.08 (1). Nevertheless, CaO conversion is highly dependent on the carbonation-calcination conditions as well as on the CaO precursor. In the SOCRATCES configuration carbonation conditions can be chosen to minimize the negative impact of CaO deactivation.

These R&D results offer a revolutionary approach to the TCES challenge, and the benefits are based on fundamental thermodynamics and reaction kinetics, which have been quantified in preliminary studies by SOCRATCES's partners. Not only did they give rise to a new integration of CSP and TCES systems, but also resulted in a set of patents.

SOCRATCES is aimed at demonstrating the practical feasibility of the CaL-CSP integration scheme already obtained at laboratory scale, extending the research in this very promising field by erecting a pilot-scale plant that uses cheap, widely available and non-toxic materials as well as mature technologies used in the industry, such as fluidized bed reactor, cyclones or gas-solid heat exchangers.

The SOCRATCES concept goes beyond the current most advanced projects for developing next generation CSP concerning:

- Integrated systems concept is used to redefine the TCES design conditions allowing to use very cheap, abundant and non-toxic materials as heat transfer media.
- Solar receiver design to reduce the scale-up risk. Temperature in the solar particle receiver could reach 1000ºC.
- Higher temperature in the carbonator (>700ºC) usable for power generation. High efficiencies of power cycle.
- High density seasonal energy storage (theoretically ~3.2 GJ/m^3).
- Potential integration with commercially available technologies (real gas turbines in direct integration, Stirling, Rankine cycles for indirect integration) at commercial scale.
- The use of cheap, abundant and non-toxic materials minimizes plant construction impact on the full life-cycle assessment (LCA).

The new CaL conditions, layouts and performance of the systems allow for the use of a different strategy/pathway in developing the new generation of tower CSP plants. With **very cheap technologies for energy storage**, using cheap minerals CaO precursors such as limestone (<10 €/ton), the **power generation systems** based on **already commercial technologies** reduces technology development risks and will offer the capability for integrating future advances (if necessary) in power block and receiver systems.

All this gives a worldwide potentially large market for the developed solutions, both for overall integration and modules. SOCRATCES technologies, with outstanding performance and based on renewable sources and abundantly available cheap materials. This way, the concept may reduce the environmental impact of both energy production but also CSP power system construction, ending up being a significant technological contribution to economy decarbonisation, reducing GHG and fossil fuel emissions.

It will also be able to value the local economy and the quality of life in European regions, not only through job creation to answer the needs of manufacturing and maintenance of a new industry, but also because commerce and services around this new paradigm are expected to flourish. Also the development of a new generation of CSP tower technology may create a pathway to fostering the use of solar energy and reducing the EU energy dependency, thus improving security.

The achievement of these objectives will lead to significant contributions to the EU challenges in developing new generations of renewable technologies that are feasible, viable and sustainable, thus contributing to the goal of economy decarbonisation and reduction of GHG emissions.

SOCRATCES technology is being developed by a multidisciplinary highly skilled consortium, R&D centres and SMEs, where all the required capacities and complete value-chain for the successful development of the project are included, driving the TRL development pathway towards commercialisation.

2.2 Customer segments and value proposition

The customer segments for SOCRATCES solutions are mainly: power companies, electricity grid operator authorities and cement and mineral-based specialties (Ca-rich, ex. Lime (CaO)) for industry companies. In each customer segment is possible include different types of companies, for example Small and Medium-sized Enterprises (SME) / Large -sized Enterprises and private / public organizations.

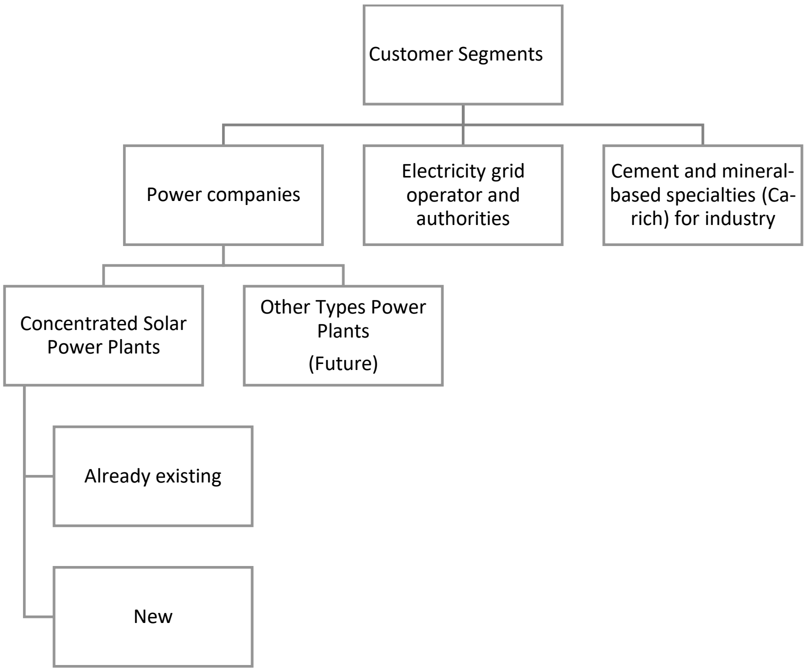

Figure 1. Customer Segments

Power companies

The main application of SOCRATCES solution, but not exclusive, is for energy storage in CSP plants. Among CSP power technologies, solar tower systems[1] are the most appropriate for $CaCO_3$ calcination because of the required temperature. The CaL process can be integrated in both already existing CSP power plants (retrofitting) or in new plants. In the future, additional applications to CSP can be studied. The global capacity of CSP was to around 4.9 GW in 2017 (Figure 2), being the two more relevant countries, like in previous years, Spain and United States.

[1] Solar Tower Systems—point-focus systems that use heliostats to focus sunlight on a tower-mounted receiver

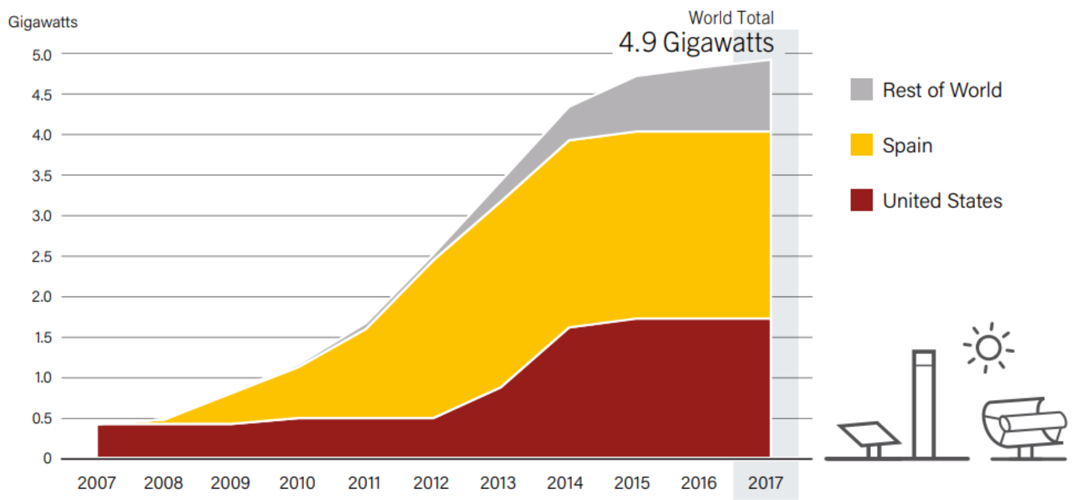

Figure 2. Concentrating Solar Thermal Power Global Capacity, by Country and Region, 2007-2017 (2)

Spain remains the global leader in existing CSP capacity, with 2.3 GW in operation at the end of the year, followed by the United States with 1.7 GW. Spain's CSP plants achieved a record output of 5.35 TWh in 2017. Even representing 80% of global installed capacity at the end of 2017, these two countries had no capacity entering commercial operation in the recent years (in Spain since 2013 and in the United States since 2015). Neither country had new facilities under construction at year's end. However, global capacity increased by just over 2% in 2017, and the CSP industry was active, with a pipeline of about 2 GW of projects under construction around the world, particularly in China and in the Middle East and North Africa (MENA). For the second year running, South Africa led the market in new additions in 2017, being the only country to offer new CSP capacity online. Several projects that were due to enter in operation during the year were delayed until 2018 and later (2).

Some examples of recent, ongoing and future CSP project are summarized in the Figure 3.

Parabolic trough[2] and tower technologies continued to dominate the market, with approximately 0.9 GW of trough systems and 0.8 GW of tower systems under construction by the end of 2017. In addition, Fresnel plants[3] totalling approximately 0.1 GW were at various stages of construction, mainly in China, but also small plants in France and India. Although no other CSP capacity came online in 2017, several facilities were approaching commercial operation in countries with high direct solar irradiation level (2).

---

[2] Parabolic Trough Systems—line-focus systems that use curved mirrors to focus sunlight on a receiver
[3] Linear Fresnel Reflector Systems—line-focus systems that use relaxed and flat mirrors arranged to focus sunlight on a receiver

Europe

- In **Denmark**, a hybrid combined heat and power facility that includes CSP technology, biomass boilers, heat pumps and oil-fired units began operation in early 2018. The facility, which is connected to a district heating system, can alternate between providing heat and power at peak price periods, and heat only.
- A 9 MW Fresnel facility was under construction in **France**'s Pyrenees Orientales district

Africa

- **South Africa** commissioned the 100 MW plant (with 5.5 hours of TES; 500 MWh) during 2017, increasing total capacity by 50% to 300 MW. A further 200 MW was under construction at year's end: the 100 MW Kathu Solar Park (4.5 hours; 450 MWh) was expected to commence operations in 2018, and the 100 MW Ilanga 1 facility (4.5 hours; 450 MWh) was scheduled for commissioning in 2020. Several additional CSP projects under development faced ongoing uncertainty in 2017 as the state-owned utility, Eskom, continued to delay the signing of PPAs under the Department of Energy's Renewable Energy Independent Power Producer Procurement Program. However, progress was made in April 2018, when the department signed 27 renewable project contracts with independent power producers, including one for a 100 MW CSP project.
- **Morocco's** total capacity will exceed 0.5 GW: 200 MW Noor II facility (7 hours; 1,400 MWh) entered the final stages of construction during 2017 and commenced commissioning in early 2018; the adjacent 150 MW Noor III plant (7 hours; 1,200 MWh) was also at an advanced stage of construction.

America

- In Latin America, construction resumed at **Chile**'s 110 MW (17.5 hours; 1,925 MWh) Atacama 1 plant. Construction was halted in 2016 due to financial challenges faced by Spain's Abengoa, the initial developer, and owner of the facility. The plant is expected to enter operations in 2019.

Asia

- **China**'s CSP market continued to gather momentum with the announcement of 20 projects – including parabolic trough, tower and Fresnel facilities – with a combined capacity of 1 GW. Although not all are expected to be constructed, five projects totalling 300 MW are targeting commercial operation before the end of 2018, which will qualify them for a higher FIT. Several other projects are aiming for completion before the end of 2020.
- **India** was the only other country in Asia with CSP capacity under construction by the end of 2017, with the 14 MW Dadri Integrated Solar Combined-Cycle plant expected to begin operation in 2018.
- In **Saudi Arabia**, construction continued on the 43 MW Duba 1 ISCC facility and on the 50 MW Waad al-Shamal ISCC plants. Kuwait's 50 MW (10 hours; 500 MWh) Shagaya plant also progressed during 2017.
- In the **United Arab Emirates**, a CSP tender was awarded for what is expected to be the largest CSP facility in the world when completed. The 700 MW CSP plant in the Mohammed bin Rashid Al Maktoum Solar Park was designed to incorporate a 260-meter solar tower along with parabolic trough capacity and is expected to enter commissioning in 2020.

Australia

- **Australia** added no new capacity during 2017, the South Australian government signed a generation project agreement for the Aurora Power Plant, a 100 MW system (8 hours; 1,100 MWh) that is scheduled for completion in 2020. Some CSP activity continued in Europe in 2017.

Figure 3. Examples of recent, ongoing and future CPS project (2)

Information about the individual plants can be consult at Annex A and the website of National Renewable Energy Laboratory (NREL) a national laboratory of the United States Department of Energy (https://solarpaces.nrel.gov/). The prominent engineering and construction companies working on CSP are presented in the Table 1.

Table 1. Prominent engineering and construction companies working on CSP projects included (in order of MW developed or built in 2017) (2)

Company	Website	Country
Sener	http://www.poweroilandgas.sener/solar	Spain
GE	https://www.ge.com/renewableenergy/innovative-solutions/solar-energy/concentrated-solar-power	United States
Abengoa	http://www.abengoa.com/web/en/negocio/energia/electricidad_solar/termosolar/index.htm	Spain
ACS Cobra	http://www.grupocobra.com/areas-de-negocio/proyectos-integrados/plantas-de-generacion-electrica/renovables/solar/	
Acciona	https://www.acciona.com/news/acciona-sells-its-solar-thermal-assets-spain-contourglobal/	
TSK	http://www.flagsol.com/flagsol/cms/	
Lanzhou Dacheng Technology Company	http://www.lzdcsolar.com/EN/About%20Dacheng/about/	China
NWEPDI	http://www.nwepdi.com/EnNwepdi/SitePages/ywgk/NewEnergyDesign/NewEnergy.aspx?nid=3	
Beijing Shouhang IHW Resources Saving Technology (SunCan, its CSP co-company)	http://en.sh-ihw.com/product_class/pmcId=43.html	

Electricity grid operator and Authorities

Another target group of SOCRATCES technology is the electricity grid operator, public or private. The tables below (Table 3 and Table 4) show energy system operators, grid operators and grid access providers by European country, respectively. More information may be consulted in www.acer.europa.eu.

Table 2. Energy system operator by country (3)

Name	Country	Name	Country
OST	Albania	**TERNA**	Italy
TIWAG-Netz AG		**Stogit Spa**	
Vorarlberger Übertragungsnetz GmbH		**LITGRID**	
Elia	Belgium	**AS Augstsprieguma tīkls**	Latvia
European Network of Transmission System Operators for Electricity		**JSC Latvijas Gāze**	Latvia
Huberator SO		**CREOS Luxembourg**	Luxembourg
FLUXYS Belgium		**MEPSO - Operator na elektroprenosniot sistem na Makedonija. AD. vo dr**	Macedonia
Nezavisni Operator Sistema u Bosni i Hercegovini	Bosnia and Herzegovina	**SE Moldelectrica**	Moldova
Elektroenergien Sistemen Opeator EAD	Bulgaria	**Crnogorski elektroprenosni sistem AD**	Montenegro
Croatian Transmission System Operator Ltd.	Croatia	**TenneT TSO B.V.**	Netherlands
Cyprus Transmission System Operator	Cyprus	**ZEBRA TSO**	
ČEPS, a.s.	Czech Republic	**NOGAT B.V.**	
Greenex s.r.o.		**STATNETT SF**	Norway
International Commerce Corporation a.s.		**Polskie Sieci Elektroenergetyczne Spółka Akcyjna**	Poland
Energinet.dk	Denmark	**Operator Gazociągów Przesyłowych GAZ-SYSTEM S.A.**	
Elering AS	Estonia	**Blue Cold Sp. z o.o.**	
Fingrid Oyj	Finland	**Rede Eléctrica Nacional, S.A**	Portugal
Réseau de Transport d'Electricité (RTE)	France	**REN Atlantico S.A.**	
EnBW Transportnetze AG	Germany	**REN - ARMAZENAGEM S A**	
Amprion GmbH		**CNTEE TRANSELECTRICA SA**	Romania
Nowega GmbH		**Depomures SA**	
Uniper Energy Storage GmbH		**OAO GAZPROM**	Russian
Fluxys TENP TSO		**SLOVENSKA ELEKTRIZACNA PRENOSOVA SUSTAVA a.s.**	Slovakia
terranets bw GmbH		**Slovenska elektrizacna prenosova sustava, a.s.**	
DEA Speicher GmbH		**SPP – distribúcia, a.s.**	
Fluxys Deutschland GmbH		**ELES, d.o.o.**	
Open Grid Regional GmbH		**Plinovodi**	
TEP Thüringer Energie Speichergesellschaft mbH		**Red Eléctrica de España S.A.U.**	Spain
Equinor Storage Deutschland GmbH		**SWAP ENERGIA S.A**	
HanseWerk AG		**BAHÍA DE BIZKAIA GAS S.L.**	
Bayernets		**EUROPE MAGHREB PIPELINE LIMITED**	
Open Grid Europe GmbH		**Svenska kraftnät**	Sweden
Ontras		**TEIAS (TURKISH ELECTRICITY TRANSMISSION CORPORATION)**	Ukraine
GASCADE Gastransport GmbH		**State Enterprise ''National Power Company Ukrenergo''**	
MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zrt.	Hungary	**UKRENERGO, WESTERN POWER SYSTEM**	
MAGYAR FÖLDGÁZTÁROLÓ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZVÉNYTÁRSASÁG		**National Grid Electricity Transmission plc**	United Kingdom
MMBF FÖLDGÁZTÁROLÓ ZÁRTKÖRŰEN MŰKÖDŐ RÉSZVÉNYTÁRSASÁG		**System Operator Northern Ireland Ltd**	
Landsnet	Iceland	**Premier Transmission Limited**	
EirGrid Plc.	Ireland	**Uniper Energy Storage Limited**	

Table 3. Grid Operator by country (3)

Name	Country	Name	Country
INFRAX	Belgium	**ERDF**	France
ASSOCIATION INTERCOMMUNALE D'ETUDE ET D'EXPLOITATION D'ELECTRICITE ET		**Oberhausener Netzgesellschaft mbH**	Germany
Autonoom Gemeentebedrijf Elektriciteitsnet Merksplas		**Bocholter Energie- und Wasserversorgung GmbH**	
ASSOCIATION LIEGEOISE D ELECTRICITE		**Energienetze Bayern GmbH & Co. KG**	
BOREALIS POLYMERS NV		**energis-Netzgesellschaft mbH**	
IVEG		**GREEN TRADING 3 SRL**	Italy
PROVINCIALE BRABANTSE ENERGIEMAATSCHAPPIJ		**GREEN TRADING 1 SRL**	
REGIE DE WAVRE		**GREEN TRADING 2 SRL**	
ANNE SOOJUS AS	Estonia	**SOCIETA' GASDOTTI ITALIA**	
Anne Soojus AS		**Metanodotto Alpino Srl**	
AS Sillamae-Veevark		**Consorzio della Media Valtellina per il Trasporto del Gas**	
Tarbegaas OÜ		**ENERGIE S.R.L**	
Phoenix Land AS		**Liechtensteinische Gasversorgung**	Liechtenstein
Gaasienergia AS		**AB LESTO**	Lithuania
Alfatom Gaasi ja Soojuse OU		**Sotel RÃ©seau et Cie**	Luxembourg
AS ELVESO		**BritNed Development Limited**	Netherlands
AS ELME		**G.EN. Gaz Energia Sp. z o.o.**	Poland
ENTEK AS		**ENAGAS TRANSPORTE DEL NORTE S.L.**	Spain
AS ESRO		**Nemo Link Limited**	United Kingdom
Toostus Investeeringute AS		**SGN**	
Imatra Elekter AS		**SGN NATURAL GAS LIMITED**	
Adven Eesti AS		**ALUMAN SA**	
Elektrilevi OU		**EPALME SA**	
Loo Elekter AS			
Maardu Elekter AS			
SILPOWER AS			
TS Energia OU			
VKG ENERGIA OU			
VKG Elektrivorgud OU			

Table 4. Grid Access Provider in Iberian Peninsula (Spain and Portugal) (3)

Name	Name	Name	Name
Agri-Energia Electrica, SA	ELECTRA DEL MAESTRAZGO, S.A.	Electricidad Nuestra Sra de los Remedios S.L.	LERSA ELECTRICITAT, S.L.
ASEME SERVICIOS AIE	Electra San Bartolomé, s. l.	Empresa de Alumbrado Eléctrico de Ceuta Distribución, S.A.U.	LLUM D'AIN, S.L.
CENTRAL ELECTRICA SESTELO Y CIA, S.A.	ELECTRICA ALGIMIA DE ALFARA, Sdad.Coop.v.	ENDESA DISTRIBUCIÓN ELÉCTRICA, S.L.	Medina Garvey Electricidad SLU
CIDE Asociación de Distribuidores	ELECTRICA DE CALLOSA DE SEGURA, COOPERATIVA VALENCIANA	ENERGIA DE MIAJADAS, SA	Municipal Eléctrica Viloria, s. l.
COMPAÑIA DE ELECTRIFICACION, S.L.	ELECTRICA DE CARBAYIN,S.A.	ENERGIAS DE ARAGON I, S. L. UNIPERSONAL	NEXUS CONNECT SL
COMPAÑIA MELILLENSE DE GAS Y ELECTRICIDAD, S.A.	ELECTRICA DE GUADASSUAR COOP. V.	ENERGIAS DE LA VILLA DE CAMPO, S.L.U.	Planta de Regasificación de Sagunto, S.A.
COOP.VCIANA.E.D.F.A. SERRALLO, S.COOP.V.	ELECTRICA DE GUIXES, S.L.	EON DISTRIBUCIÓN, S.L.	RUIZ DE LA TORRE, S.L.
CRECIMIENTOEUROPEO	ELECTRICA DE SOT DE CHERA, SCV	ESCAL UGS S.L.	SALTOS DEL CABRERA, SL
DECAIL ENERGÍA, SOCIEDAD LIMITADA	Eléctrica del Guadalfeo, SL	FLUIDO ELECTRICO MUSEROS, S.COOP.V.	SERVILIANO GARCÍA, S.A.
Distribución de Electricidad Valle de Santa Ana, SL	ELÉCTRICA DEL OESTE DISTRIBUCIÓN, S.L.U.	FUCIÑOS RIVAS, S.L.	SOCIEDAD ELECTRICISTA DE TUY, S.A.
Distribuidora Eléctrica Bermejales, SA	ELECTRICA DEL POZO, S. COOP. MAD.	FUERZAS ELECTRICAS DE VALENCIA, S.A	SOLANAR DISTRIBUIDORA ELECTRICA, S.L.
E.D.F.A. Casablanca S.Coop.V.	ELECTRICA NUESTAR SEÑORA DE GRACIA, S.C.V.	GAS NATURAL ALMACENAMIENTOS ANDALUCIA, S.A.	SUMINSTROS ESPECIALES ALGINETENSES, SOCIEDAD COOPERATIVA VALENCIANA
EDP Distribuição Energia, S.A. * (actividad Dist)	ELECTRICA SALAS DE PALLARS SLU	HIDROCANTÁBRICO DISTRIBUCIÓN ELÉCTRICA, S.A.	TALARN DISTRIBUCIO MUNICIPAL ELECTRICA SLU
EELCTRCIA POPULAR,S.COOP.MAD	Eléctrica San Gregorio, SL	HIDROELECTRICA DEL CABRERA, SL	UNION DISTRIBUIDORES ELECTRICIDAD, S.A.
ELECTRA ADURIZ SA	ELECTRICAS COLLADO BLANCO, S.L.	Hidroeléctrica San Buenaventura, SL	UNIÓN FENOSA DISTRIBUCIÓN S.A.
ELECTRA AUTOL, S.A.	Eléctricas Hidrobesora, S.L.	IBERDROLA DISTRIBUCIÓN ELÉCTRICA, S.A.U.	UNION FENOSA DISTRIBUCIÓN, S.A
ELECTRA CALDENSE, S.A.	Eléctricas La Enguerina, S.L.	IGNALUZ JIMENEZ DE TORRES, S.L.	VALL DE SOLLER ENERGIA SL
ELECTRA DEL LLOBREGAT ENERGIA SL	ELÉCTRICAS PITARCH DISTRIBUCIÓN, S.L.U.	Instalaciones Eléctricas Río Isábena, S.L.	LERSA ELECTRICITAT, S.L.

Cement and mineral-based specialties (Ca-rich) for industry

Calcination is a well-known reaction which is at the basis of the cement industry while the CaL process has many other applications, e.g. thermochemical energy storage, CO_2 capture or enhanced oil recovery.

Cement is a high quality, cost-effective building material and a key component of construction projects throughout the world. The raw materials needed to make cement are calcium carbonate, silica, alumina and iron ore, being this a highly resource and energy intensive process, with approximately 1.5 tons of raw materials needed to produce 1 ton of cement.

One major advantage of the CaL technology is that the purged CaO (sintered sorbent after many carbonation/calcination cycles) can be used as a raw material in cement production, showing even better performance as cement binder than CaO directly derived from limestone calcination. In this context, the synergy between cement production and the CaL process is viewed as an opportunity to partially decarbonize both power generation and the cement process (4).

Simulations indicate that a reasonable purge rate of ~48.9 kg/s (5) would require a power of 144MWth just to calcine, thus it is theoretically possible to reduce the energy required for clinker manufacture in the cement production industry from approximately 50%.

The cement industry is capital intensive, as construction of a new production line represents more than two years of its full capacity sales. Consequently, the cement industry witnessed a trend towards concentration beginning in the 1970s. Over the past twenty years, worldwide cement consumption has significantly increased with an average growth rate above 5% per year, representing up to 4,060 Million of tons.

Despite this decade's economic and financial instability in the construction sector, global cement demand grew by approximately 3% in 2014, supported by the dynamism of many emerging markets, particularly China and Sub-Saharan Africa, as well as the progressive recovery in the United States. Mid and long-term prospects for cement demand remain favourable, especially in these markets, where demography, urbanization and economic growth drive the needs for housing and infrastructure (6).

SOCRATCES will tackle this market opportunity through the partnership with Calix and their Catalytic Flash Calcination (CFC) Technology. This form of calcination shows numerous advantages such as the possibility of direct CO_2 capture, enhanced calcination kinetics and increased reactivity of CaO. The use of CFC in SOCRATCES is expected to bring about new synergies between cement production and the CaL process.

The most important cement producer is China (Figure 4).The more relevant cement producer companies, origin, capacity and number of plants are present in Table 5.

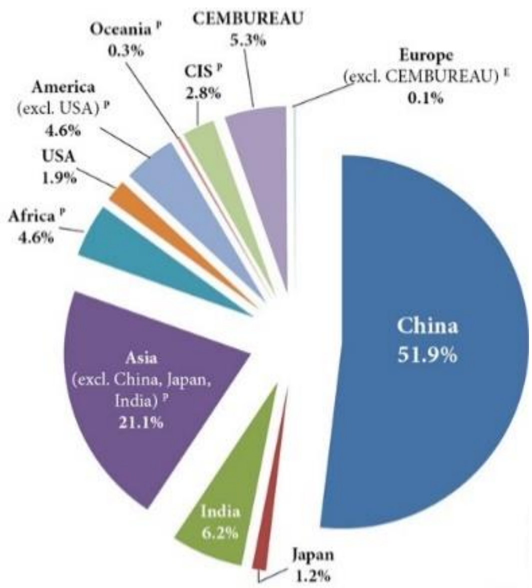

Figure 4. World cement production (4.65 billion tonnes) by region and main countries (Notes: CEMBUREAU- European Cement Association, P- preliminary, E-estimate) (7)

Table 5. The more relevant cement producers, origin, capacity and number of plants (8)

Producer	Origin	Capacity (Mt/yr)	Number of plants
Lafarge Holcim	Switzerland	345	220
Anhui Conch	China	217	32
Heidelberg Cement	Germany	185	141
China National Building Materials (CNBM)	China	176	64
Cemex	Mexico	92	61
UltraTech Cement	India	91	39
China Resources	China	79	133
Votorantim	Brazil	71	59
Taiwan Cement	China	69	
Inter Cement	Brazil	54	42
CRH	Ireland	51	54
Buzzi Unicem	Italy	49	37
Eurocement	Russia	47	19
Dangote Cement	Nigeria	44	12
Siam Cement Group	Thailand	40	10
Taiheiyo Cement	Japan	40	1
VICAT Group	France	35	16
Semen Indonesia	Indonesia	30	7
VICEM	China	29	12
Titan Cement	Greece	23	13
Fars and Khuzestan	Iran	20	13
Cementos Argos	Colombia	19	15
Dalmia Bharat	India	17	7
OYAK Group	Turkey	16	7

As is the case of the cement industry the first global producer of lime and limestone is China Figure 5. Some examples of European companies of mineral-based specialties for industry that work with Ca rich powder materials are Carmeuse, Imerys, lhoist, Omya and Sibelco.

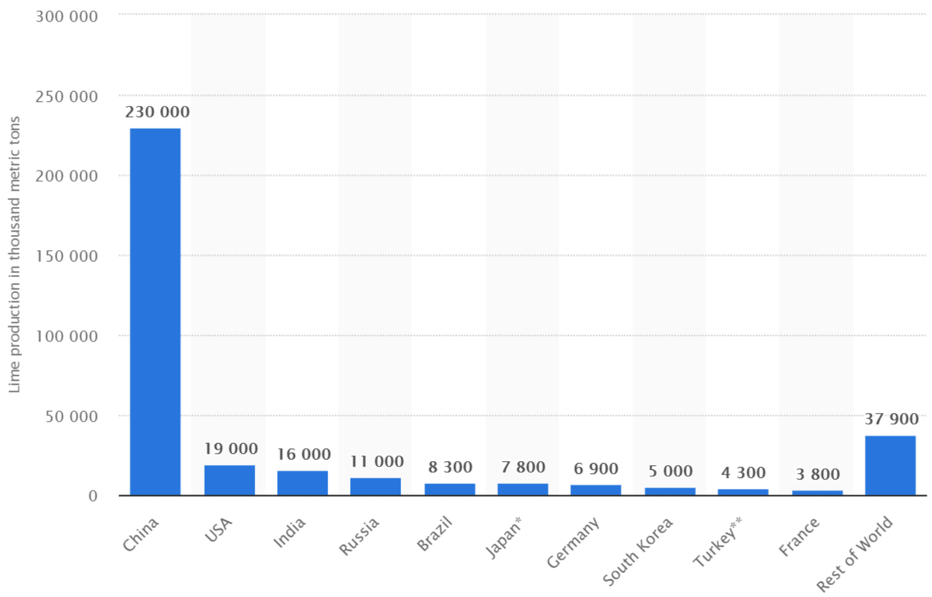

Figure 5. Lime and limestone production by country in 2015 (in thousand metric tons) (9)

Value Proposition

The SOCRATCES technology could become significant added value for all market segments at environment and economical level. However, for each customer segment a specific value proposition may be pointed (Figure 6).

Power companies

- Integrated CSP/TCES technology
- Natural very cheap (< 0.01* €/kg), stable, non-toxic granular heat transfer media (CaO precursors such as limestone and other cheap Ca-based large industry waste materials)
- Low cost storage (<12€/kWh*)
- Long term storage with possible long time gaps between load and discharge
- High storage energy density (theoretically 3.2 GJ/m^3*)
- Possibility for seasonal storage capacity
- Storage at ambient temperatures (decrease of isolation cost)
- Energy storage at large scale
- CaO conversion > 40%* (after 1000 cycles)
- High efficiency CSP plants (>45%*), with potential of higher values when improved SCO_2 cycles become available
- Exergetic efficiency ≥ 95%*
- LCOE< 0.07€/kWh*
- CO2 closed loop
- Integrated design allows redesign of component to suit the new operation conditions, and adaptation to new improvement
- Modular systems to be integrated in both existing and new CPS and large or small plants/companies

Electricity grid operator and authorities

- Lower electricity price
- Energy storage capability

Cement and mineral-based specialties (Ca-rich) for industry

- Increase of circular economy
- Cheaper Ca-rich powder materials
- Better performance of the purged CaO as cement binder than CaO directly derived from limestone calcination
- Reduction of energy required for clinker manufacture (theoretically the reduction is approximately 50%).

Figure 6. Value Proposition for each customer segment (* values can be actualized during the project)

2.3 Competitive analysis

An estimated 13 GWh of Thermal Energy Storage (TES) based almost entirely on molten salts was operational in conjunction with CSP plants across five continents by the end of 2017 (Figure 7).

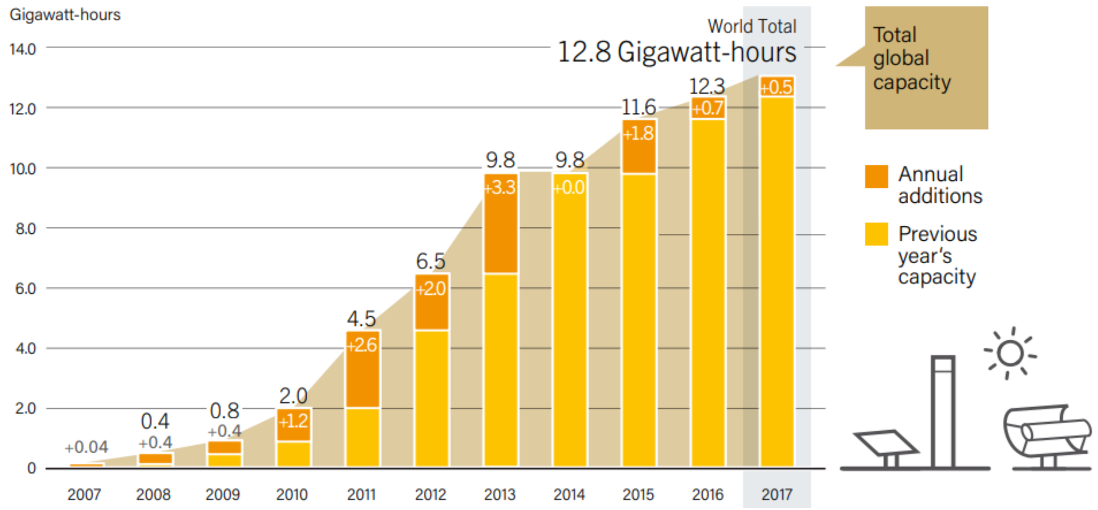

Figure 7. CSP Thermal Energy Storage Global Capacity and Annual Additions, 2007-2017 (2)

A half of CSP plants built in Spain since 2006 have been equipped with thermal energy storage using molten salts, with 7 hours of nominal capacity average. The Andasol CSP plant in Spain, was the first commercial CSP plant with TES in the world (it started operation in 2008). This is now a fully mature technology though the storage capacity over time remains low (10). Most of new CSP plants have some ability to store heat for short periods of time and thus have a "buffering" capacity to smooth electricity production and eliminate the short-term variations that solar power technology exhibits during cloudy days. These storage systems have been designed almost exclusively using sensible heat storage in a mixture of molten salts.

The vast majority of CSP plants still under construction will incorporate some form of TES, which continues to be viewed as central to the competitiveness of CSP because it improves the overall operational value of the technology through the provision of dispatchable or baseload power. In fact, solar thermal electricity (STE) generated by CSP plants with energy storage is expected to become one of the main pillars supporting the renewable energies movement in electricity production. According to the International Energy Agency (IEA), STE's share of global electricity is to reach 11% by 2050. Adding STE to PV, solar power could provide up to 27% of global electricity by 2050, and become the leading source of electricity globally as early as 2040 (11). Among various types of CSPs, solar tower power technologies are becoming the front runners especially in the United States and around the world with the possibility to compete with traditional power generation technologies in terms of efficiency and levelized cost of electricity (LCOE) (12). SOCRATCES may be an important driving-force and make the definitive difference to the commercial expansion of this technology.

Lately, costs of CSP plants have dropped but at a lesser rate than those of Photovoltaic (PV). However, new CSP components and systems are reaching commercial maturity, holding the promise of increased efficiency, which together with the development of efficient storage technologies (such as technologies to be developed in SOCRATCES) could foreseeably decrease investment and O&M costs.

Investment costs for CSP plants have remained high, from **USD 4000/kW to 9000/kW**, depending on the solar resource, the capacity factor, the plant size and the type of energy storage system. At the same time, these costs are expected to decrease as CSP commercial expansion progresses, following a learning rate of 10% (i.e., 10% cost reduction for each cumulative capacity doubling). Still, **O&M costs have been assessed in the Spanish plants as USD 50/MWh**, including fuel costs for backup and water consumption for mirror cleaning, feedwater make-up and condenser cooling (11). For a real deployment of CSP plants, it would be necessary to reduce costs per MW, as it is being proposed by SOCRATCES. Taking into account that energy storage systems in CSP tower plants lead to higher efficiencies and reductions in backup fuel, these new energy storage systems could **decrease the O&M costs, enhancing the competiveness of CSP plants** in comparison to fuel-based ones.

Recently obtained experimental results under these new SOCRATCES conditions have shown an outstanding behaviour of natural materials with long and sustained cycles, well above those used in any other approach. The capacity of the SOCRATCES cycle for enabling power production at 850ºC (increasing power cycle performance) shows a huge potential for increase the plants efficiencies. In already commercial molten salts-based plants, the maximum working temperature is limited to 560ºC to avoid salt degradation, which reduces the power cycle efficiency.

SOCRATCES commercial technology aspires to reach a Levelized Cost of Energy (**LCOE cost) <7c€/kWh**, being fully competitive with future fossil fuel plants, whilst maintaining the cornerstones of higher efficiency and cleaner technology. Moreover, no alternative to SOCRATCES has been detected with similar capacity for cost reduction (13).

This trait primarily stems from the use of very cheap materials for heat transfer (with reduced abrasion), high energy storage capacity, relatively low temperatures at receiver/calciner and high temperatures at carbonator/power cycle. Furthermore, estimated cost for commercial scaling also supposes a reduction >50% from current technology costs. Thus, no feed-in tariffs will be required for fully competitive CSP 24h/365d power plants.

On the other hand, SOCRATCES total investment (with TCES <12€/kWh_{th}) in commercial scaling long-term (up to 2050) with seasonal storage is estimated to cost around **2000 USD/kW**, which is about **half** the IEA estimations for CSP with 6h storage.

CSP developers have focused on TES as a key competitive advantage of CSP for providing competitively priced, dispatch able power. This focus has been driven by the increasing cost-competitiveness of solar photovoltaics compared to CSP without TES, but also by the emerging role of CSP with TES as a viable competitor with traditional (gas, coal and nuclear) thermal power plants (1). This is an opportunity for SOCRATCES, but technology development has been also introducing a strong evolution in the market, that must be closely followed by SOCRATCES consortium.

Currently, Spanish plants benefit from feed-in tariffs of around EUR 300/MWh, while recent long-term power purchase agreements are at half of that level or below (10). For example, a recent CSP plant in the United States secured power purchase agreements at USD 135/MWh, which, taking investment tax credit into account, results in an actual remuneration of USD 190/MWh. In Chile, successive rounds of solar auctions in March and October 2017 attracted bids for CSP with TES at USD 63 per MWh and under USD 50 per MWh, respectively. In the UAE, a 700 MW project was awarded at a bid tariff of USD 73 per MWh (2).

These figures must be fully framed in political and economic contexts, which does not invalidate that they are observed as possible future market values. Also to make an effective competitive analysis is good to monitor LCOE for each market solution, since it measures lifetime costs divided by energy production, allowing a complete and accurate comparison.

3. BUSINESS MODEL OPTIONS

SOCRATCES technology can be transferred to the market through different business models, that are not exclusive, but represent significantly different approaches and respective effects on the business plan and its main indicators.

First of all, there are three main ways to present SOCRATCES solution to the market:

- **As a product / asset sale:**
  Selling ownership rights to a physical product (valid for SOCRATCES technological solution and its by-products)
- **Licensing**:
  Grant permission to use protected intellectual property in exchange for licensing fees. Licensing allows rights-holders to generate revenues from their property without having to manufacture a product or commercialize a service. In technology sectors, patent-holders grant other companies the right to use a patented technology in return for a license fee.
- **As a service**
  Being a more flexible option, it can be implemented by different ways:
    - **Usage fee**: customer pays to use of a particular service, the more a service is used, the more the customer pays. This fee may be defined following different criteria and maybe fixed or variable. **One possible way would be to index the fees to the corresponding increase in energy supply, associated with the energy storage capacity.**
    - **Lending/Renting/Leasing**: temporarily granting the exclusive right to use the technology for a fixed period in return for a fee. For the lender this provides the advantage of recurring revenues. Renters or lessees, on the other hand, enjoy the benefits of incurring expenses for only a limited time rather than bearing the full costs (14).

Table 6. Main Risks of business model options (in ascending order of the associated risk)

Licensing	Lending/Renting/Leasing	Usage fee	Product sale
Disability to have a strict control of the usage of the technology by third parts.	High initial investment for the manufacture of the technology. Possible loss of business control to potential future investors	High initial investment for the manufacture of the technology. Possible loss of business control to potential future investors Disability to have a strict control of the usage of the technology by clients	High initial investment for the manufacture of the technology. Possible loss of business control to potential future investors High initial investment required to potential customers

SPI developed a model to evaluate each one of these scenarios, including the main variables to be estimated in each case (Annex B).

To proceed with this evaluation the partnership must contribute with the expectable life-cycle cost and margin (minimum selling price) that make the technology economically feasible.

Channels

The market channels are intimately correlated with the business model to be adopted, knowing that two types of channel can be used: direct (own) and indirect (partners). In case of the **direct** channel, the sales force focus in the market is very important, while in case of the **indirect** channel the partnerships with key players of the market like authorities and companies (ex. Engineering, Procurement as Construction - EPC) is a way to facilitate the approach of the market.

Customer Relationships

For all customer segments the relationships are **Business-to-Business** (B2B). To stimulate long-term relationships, focus in necessities of each client and personal assistance are compulsory, mainly in case of big CPS companies.

To have an effective response to client's necessities, the high dynamism and growing performance of the new CSP plants must be strongly followed by SOCRATCES technology. This leads to a continuous R&D, product/service development with different customers, establishing **co-creation** relationships, beyond the traditional customer-vendor ones.

Revenue Streams

As referred before, SOCRATCES solution can be made available to the market following different business models, that must be evaluated taking in to account the characteristics and conditions of each segment:

Power companies

- Asset sale (equipment)
- Usage fee (equipment)
- Lending/Renting/Leasing (equipment)
- Licensing (technology)

Electricity grid operator and authorities

- Asset sale (storage equipment)
- Usage fee (energy storage)
- Licensing (storage technology)

Cement and mineral-based specialties (Ca-rich) for industry

- Asset sale (CaO, Flash Calcination reactor)
- Licensing (Flash Calcination technology)

Figure 8. Revenue possible streams for each customer segment

4. KEY PARTNERSHIPS

The three main motivations for creating partnerships are:

- **Optimization and economy of scale:** It is illogical for a company to own all resources or perform every activity by itself. Optimization and economy of scale partnerships are usually formed to reduce costs, and often involve outsourcing or sharing infrastructure.
- **Reduction of risk and uncertainty:** Partnerships can help reduce risk in a competitive environment characterized by uncertainty. It is not unusual for competitors to form a strategic alliance in one area while competing in another.
- **Acquisition of particular resources and activities:** Few companies own all the resources or perform all the activities described by their business models. Rather, they extend their own capabilities by relying on other firms to furnish particular resources or perform certain activities. Such partnerships can be motivated by needs to acquire knowledge, licenses, or access to customers (14).

Considering these motivations and SOCRATCES nature, is possible to name the most important models of partnerships to be considered and evaluated:

- o To produce SOCRATCES solution, will imply a strong financial effort in equipment, building capacity and materials, being strongly advisable to consider the possibility of establishing a partnership with suitable and reliable engineering companies.
- o The market entrance could be facilitated if an initial and exclusive collaboration is established with an important client, in order to demonstrate the applicability of the solution.
- o Being R&D a strategic area, it would be also strategic to consolidate and give continuity to the consortium already established to develop the technology in project SOCRATCES, reinforcing international leadership in the area and allowing future developments

Besides these, examples for the different types of partnerships relevant to the SOCRATCES solution are presented in Table 7.

Table 7. Different types of partnerships and examples

Types Key Partnerships	Examples
Strategic alliances between non-competitors	Industrial associations (Figure 9) Companies (Figure 10) Research and innovation community (professional societies, research institutions, universities) Authorities and regulators and others (Figure 11)
Coopetition: strategic partnerships between competitors	CSP, energy storage companies
Joint ventures to develop new businesses	CSP, Energy grid operator, Environmental, Renewable Energy Companies, solar thermal systems manufacturers
Buyer-supplier relationships to assure reliable supplies	Companies (ex. Engineering and construction, Industrial minerals producers, and chemical companies - Figure 10)

Energy	Others
• Energy Storage Association (ESA) • European Network of Transmission System Operators for Electricity (ENTSOE) • European Renewable Energy Research Centres Agency (EUREC) • European Solar Thermal Electricity Association (ESTELA) • European Solar Thermal Industry Federation (ESTIF) • International Renewable Energy Agency (IRENA) • International Solar Energy Society	• European Cement Association (Cembureau) • European Chemical Industry Council (CEFIC) • European Lime Association (EuLA) • Industrial Minerals Association (IMA)

Figure 9. Examples of industrial associations

Energy	Others
• Concentrated Solar Power Plants (ex. Sener, GE, Abengoa, ACS Cobra, Acciona, TSK, Lanzhou Dacheng Technology Company, NWEPDI, Beijing Shouhang IHW Resources Saving Technology) • Energy grid operator • Environmental consultancies (ex. DNV GL Energy, Envirometrics Ltd) • Renewable Energy Companies (ex. Iberdrola, Helpe Renewables) • Solar thermal systems manufacturers (ex. Termicol)	• Cement producers (ex. Lafarge Holcim, Heidelberg Cement, CRH, Buzzi Unicem, Eurocement) • Chemical Companies (ex. BASF, DOW, Solvay, Clariant) • Engineering and construction companies (Abengoa) • Industrial minerals producers (ex. Carmeuse, Imerys, lhoist, Omya and Sibelco)

Figure 10. Examples of companies

Authorities and regulators	Others
• EC Directorate General (DG Health and Food safety, DG Clima, DG Environment, DG Energy) • European organisms (Council of European Municipalities and Regions) • Federations of Municipalities • Municipalities and regional governments in European Countries	• Renewable Energy Policy Network for the 21st Century (REN21) • Agency for the Cooperation of Energy Regulators (ACER)

Figure 11. Examples of authorities and regulators and others

5. BUSINESS MODEL CANVAS

As mentioned before, the previous sections represent all parts that form the Canvas business model. The Business Model Canvas of SOCRATCES' solution is summarized in Figure 12.

Key Partners

- **Industrial associations** (ex ESA, ENTSOE, EUREC, ESTELA, ESTIF, IRENA, Cembureau, CEFIC, EuLA, IMA)
- **Companies** (ex. CSP, EPC, energy grid operator, environmental consultancies, renewable energy companies, solar thermal systems manufacturers)
- **Research and innovation community** (ex. professional societies, research institutions, universities)
- **Authorities and regulators** (ex. EC Directorate General, European organisms, municipalities and regional governments in European Countries) and **others** (ex. REN21, ACER)

Key Activities

- **R&D**
- **Manufacturing**
- **Installation and maintenance** (in case of usage asset sale)
- **Installation, operation and maintenance** (in case of usage fee)

Key Resources

- **Physical**: R&D equipment and facilities
- **Intellectual**: proprietary knowledge and patents
- **Human**: R&D, technical, engineering and sales human resources
- **Financial**: funders, projects and partners

Value Proposition

- Integrated CSP/TCES technology
- Low cost storage (<12€/kWh*)
- Long term storage
- High storage energy density (3.2 GJ/m^3*)
- Seasonal storage capacity
- Storage at ambient temperatures
- - Natural very cheap (< 0.01* €/kg), stable, non-toxic granular heat transfer media
Energy storage at large scale
- CaO conversion > 40%*
- Not energy losses
- Exergetic efficiency ≥ 95%*
- LCOE< 0.07€/kWh*
- CO_2 closed loop
- Integrated design
- Modular systems : integrated in existing and new CPS (large or small)
- Energy cheaper
- Energy storage capability
- Increase of removable energy
- Increase of circular economy
- Ca-rich powder materials cheaper
- The purged CaO showed better performance as cement binder than CaO directly derived from limestone calcination
- Reducing the energy required for clinker manufacture

Customer Relationships

- B2B
- Dedicated personal assistance
- Co-creation

Channels

- **Direct** (own): sales force
- **Indirect** (partners): authorities and companies (ex. Engineering, Procurement as Construction - EPC)

Customer Segments

- **Power companies, mainly CSP** (ex.: Sener, GE, Abengoa, ACS Cobra, Acciona, TSK, Lanzhou Dacheng Technology Company, NWEPDI and Beijing Shouhang IHW Resources Saving Technology)
- **Electricity grid operator and authorities**
- **Cement** (Lafarge Holcim, Anhui Conch, Heidelberg Cement, CNBM and Cemex) and **mineral-based specialties (Ca-rich) for industry** (ex. Carmeuse, Imerys, Ihoist, Omya and Sibelco)

Cost Structure

- Salaries
- Rents
- Physical manufacturing facilities
- R&D equipment
- Patents
- Grid connection
- Raw materials
- Utilities

Revenue Streams

- Asset sale (equipment)
- Usage fee(equipment)
- Lending/Renting/Leasing (equipment)
- Licensing (technology)
- Asset sale (storage equipment)
- Usage fee (energy storage)
- Licensing (storage technology)
- Asset sale (CaO, Flash Calcination reactor)
- Licensing (Flash Calcination technology)

Figure 12. Business Model Canvas (* values can be actualized during the project)

6. BIBLIOGRAPHY

1. *Ca-looping for postcombustion CO2 capture: A comparative analysis on the performances of dolomite and limestone.* **Valverde JM, Sanchez-Jimenez PE, Perez-Maqueda L.** 2015, Appl Energy, Vol. 138, pp. 202-125.

2. **REN21 - Renewable Energy Policy Network for the 21st Century.** *Renewables 2018 Global Status Report.* France : s.n. pp. 100-102.

3. **ENTSO-E.** [Online] [Cited: 27 August 2018.] https://www.entsoe.eu/data/energy-identification-codes-eic/eic-approved-codes/.

4. *Demonstration of steady state CO2 capture in a 1.7MWth calcium looping pilot.* **Arias, B., et al.** 2013, Int. J. Greenh Gas Control, pp. 237–245.

5. *Oxyfuel carbonation/calcination cycle for low cost CO2 capture in existing power plants.* **Romeo LM, Abanades JC, Escosa JM, Pano J, Giménez A, Sanchez-Biezma A, Ballesteros JC.** 2008, Energy Conversion and Management, Vol. 49, pp. 2809–2814.

6. **LAFARGE.** *Annual Report Registration Document LAFARGE 2014.* 2015.

7. **Cembureau.** [Online] [Cited: 27 August 2018.] https://cembureau.eu/cement-101/key-facts-figures/.

8. **Global Cement.** Global Cement Top 100 Report 2017 - 2018. [Online] 4 December 2017. [Cited: 27 August 2018.] http://www.globalcement.com/magazine/articles/1054-global-cement-top-100-report-2017-2018.

9. **Lime and limestone production by country in 2015 (in thousand metric tons). [Online] [Cited: 27 august 2018.] https://www.statista.com/statistics/657049/production-of-lime-worldwide/.**

10. *Cheap , efficient and non-toxic Thermochemical Energy Storage of Concentrated Solar Power.* Sarrion, B., et al. 2016.

11. International Energy Agency. *Technology Roadmap Solar Thermal Electricity.* 2014.

12. *Prospects and problems of concentrating solar power technologies for power generation in the desert regions.* Xinhai Xu, K. Vignarooban, Ben Xu, K. Hsu. 2016, Renewable and Sustainable Energy Reviews, Vol. 53.

13. *Thermochemical energy storage of concentrated solar power by integration of the calcium looping process and a CO2 power cycle.* Chacartegui, R., et al. 2015, Appl. Energy.

14. Alexander Osterwalder, Yves Pigneur. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers.* s.l. : John Wiley & Sons, Inc., 2010.

15. ***Development of new CaO based sorbent materials for CO2 removal at high temperature.*** **Martavaltzi, C. S. and Lemonidou, A. A. 1, 2008, Microporous Mesoporous Mater, Vol. 110, pp. 119–127.**

16. ***Oxyfuel carbonation/calcination cycle for low cost CO2 capture in existing power plants.*** **Romeo, L. M., et al. 10, 2008, Energy Convers. Manag, Vol. 49, pp. 2809–2814.**

17. ***Relevant Influence of Limestone Crystallinity on CO2 Capture in The Ca-Looping Technology at Realistic.*** **Valverde, J. M. 2014.**

18. ***Enhancement of CO2 capture at Ca-looping conditions by high-intensity acoustic fields.*** **Valverde, J. M., et al. 2013, Appl. Energy, pp. 538–549.**

ANNEX A

Table A1 - CSP with tower technologies.

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Planta Solar 10	Spain	Operational	20/03/2017	2007	2012	23400	Expected/ Planned	Abengoa Solar	11.02		Other	1	
Planta Solar 20	Spain	Operational	20/03/2017	2009	2012	48000	Expected/ Planned	Abengoa Solar	20.0		Other	1	
Gemasolar Thermosolar Plant	Spain	Operational	20/03/2017	2011	2100	80000		Sener	19.9		2-tank direct	15	One cold-salts tank (290ºC) from where salts are pumped to the tower receiver and heated up to 565ºC, to be stored in one hot-salts tank (565ºC). Annual equivalent hours = 5,000.
Alpine SunTower	United States	Under development	06/11/2009	2012		192000							
Crescent Dunes Solar Energy Project	United States	Operational	09/03/2016	2015	2685	500000	Expected	SolarReserve	110.0		2-tank direct	10	Thermal energy storage achieved by raising salt temperature from 550 to 1050 F. Thermal storage efficiency is 99%
Ivanpah Solar Electric Generating System	United States	Operational	20/11/2014	2014	2717	1079232	Expected/ Planned	BrightSource Energy	392.0	28.72	None		
New Mexico SunTower	United States	Under development	12/02/2010		2540			eSolar					
Khi Solar One	South Africa	Operational	08/02/2016	2016		180000	Expected	Abengoa Solar	50.0		Other	2	Saturated steam

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Jülich Solar Tower	Germany	Operational	12/02/2013	2008	902				1.5		Other	1.5	Ceramic heat sink
Supcon Solar Project	China	Under construction	26/09/2016			120000	Expected		50.0		2-tank direct	6	Molten Salt
Dahan Power Plant	China	Operational	13/02/2014	2012	1290	1950		Institute of Electrical Engineering of Chinese Academy of Sciences	1.0	13.7	Other	1	Two stages: saturated steam/oil
ACME Solar Tower	India	Operational	13/02/2014	2011					2.5		None		
Ashalim Plot B	Israel	Under construction	22/03/2016	2017					121.0		None		
Atacama-1	Chile	Under construction	01/07/2015	2018				Abengoa Solar	110.0		2-tank direct	17.5	Molten salt
Greenway CSP Mersin Tower Plant	Turkey	Operational	24/11/2014	2012				Greenway CSP	1.4		Other	4	Molten salt. Single 3-phase tank, natural circulation, super steam junction design
Jemalong Solar Thermal Station	Australia	Operational	24/11/2017	2017		2200		Vast Solar	1.1		2-tank direct	3	Liquid sodium
Redstone Solar Thermal Power Plant	South Africa	Under development	08/09/2016	2018		480000			100.0		2-tank direct	12	Molten salt
NOOR III	Morocco	Under construction	23/03/2017	2017					150.0		2-tank direct	7	Molten salt
Huanghe Qinghai Delingha 135 MW DSG Tower CSP Project	China	Under development	10/11/2016	2017		628448			135.0		2-tank indirect	3.7	Molten salt
Copiapó	Chile	Under development	25/11/2015	2019		1800000	Expected	Solar Reserve	260.0		2-tank direct	14	Molten salt
Golmud	China	Under construction	25/02/2016	2018	2158	1120000			200.0		2-tank direct	15	Molten salt

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Sundrop CSP Project	Australia	Operational	26/10/2016	2016		1700			1.5		None		
SunCan Dunhuang 100 MW Phase II	China	Under construction	11/01/2017						100.0		2-tank direct	11	Molten Salt
Qinghai Gonghe 50 MW CSP Plant	China	Under development	26/09/2016						50.0		2-tank direct	6	Molten Salt
Hami 50 MW CSP Project	China	Under construction	06/04/2018						50.0		2-tank direct	8	Molten Salt
Golden Tower 100MW Molten Salt project	China	Under development	26/09/2016						100.0		2-tank direct	8	Molten Salt
Yumen 50MW Molten Salt Tower CSP project	China	Under construction	12/07/2017	2018		216000			50.0		2-tank direct	9	Molten Salt
Yumen 100MW Molten Salt Tower CSP project	China	Under development	27/09/2016						100.0		2-tank direct	10	Molten Salt
Shangyi 50MW DSG Tower CSP project	China	Under development	27/09/2016						50.0		2-tank indirect	4	Molten Salt
SunCan Dunhuang 10 MW Phase I	China	Operational	21/02/2018	2016					10.0		2-tank direct	15	Molten salt
MINOS	Greece	Under development	05/04/2017	2020	2200			Nur Energie	52.0		2-tank indirect	5	60% sodium nitrate, 40% potassium nitrate
Aurora Solar Energy Project	Australia	Under development	23/10/2017	2020		495000	Expected		150.0		2-tank direct	8	Molten salt
Likana Solar Energy Project	Chile	Under development	31/10/2017	2021		2800000	Expected		390.0		2-tank direct	13	Molten Salt
Tamarugal Solar Energy Project	Chile	Under development	31/10/2017	2021		2600000	Expected		450.0		2-tank direct	13	Molten Salt
DEWA CSP Tower Project	United Arab Emirates	Under development	24/11/2017	2020					100.0		2-tank direct	15	Molten salt

Source: https://solarpaces.nrel.gov/ (23/08/2018)

Table A2. CSP with Parabolic trough technologies.

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Andasol-1	Spain	Operational	20/03/2017	2008	2136	158000	Expected/ Planned	ACS/Cobra Group	50.0	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 1,010 MWh. Tanks are 14 m high and 36 m in diameter.
Andasol-2	Spain	Operational	20/03/2017	2009	2136	158000	Expected/ Planned	ACS/Cobra Group	50.0	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 1,010 MWh. Tanks are 14 m high and 36 m in diameter.
La Risca	Spain	Operational	20/03/2017	2009	2174	105200	Estimated	Acciona Energía	50.0		None		
Palma del Río II	Spain	Operational	18/03/2013	2010	2291	114500	Estimated	Acciona Energía	50.0		None		
Manchasol-1	Spain	Operational	20/03/2017	2011	2208	158000	Expected/ Planned	ACS/Cobra Group	49.9	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 375 MWh. Tanks are 14 m high and 36 m in diameter.
Manchasol-2	Spain	Operational	20/03/2017	2011	2208	158000	Expected/ Planned	ACS/Cobra Group	50.0	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 375 MWh. Tanks are 14 m high and 36 m in diameter.

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Majadas I	Spain	Operational	20/03/2017	2010	2142	104500	Estimated	Acciona Energía	50.0		None		
Extresol-1	Spain	Operational	20/03/2017	2010	2168	158000	Expected/ Planned	ACS/Cobra Group	50.0	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 1,010 MWh. Tanks are 14 m high and 36 m in diameter.
Extresol-2	Spain	Operational	20/03/2017	2010	2168	158000	Expected/Planned	ACS/Cobra Group	49.9	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 1,010 MWh. Tanks are 14 m high and 36 m in diameter.
Arcosol 50	Spain	Operational	20/03/2017	2011	2097	175000	Expected	Torresol	49.9		2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate.
Termesol 50	Spain	Operational	20/03/2017	2011	2097	175000	Expected	Torresol	49.9		2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate.
Extresol-3	Spain	Operational	20/03/2017	2012	2168	158000	Expected/ Planned	ACS/Cobra Group	50.0	16	2-tank indirect	7.5	28,500 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. 1,010 MWh. Tanks are 14 m high and 36 m in diameter.
Palma del Río I	Spain	Operational	18/03/2013	2011	2291	114500	Estimated	Acciona Energía	50.0		None		

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Lebrija 1	Spain	Operational	20/03/2017	2011	1992.7	120000	Expected/ Planned	Soleval	50.0		None		
Ibersol Ciudad Real (Puertollano)	Spain	Operational	20/03/2017	2009	2061	103000	Expected/ Planned		50.0		None		
Archimede	Italy	Operational	03/08/2012	2010	1936	9200	Expected/ Planned	ENEL	5.0	15.6	2-tank direct	8	Total of 1,580 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate. Capacity 100 MWh (thermal). Tanks are 6.5 m high and 13.5 m in diameter.
Nevada Solar One	United States	Operational	07/09/2011	2007	2606	134000	Expected/ Planned	Acciona Energía	75.0			0.5	0.5 hours full-load storage
Solnova 1	Spain	Operational	20/03/2017	2009	2012	113520	Expected/ Planned	Abengoa Solar	50.0		None		
Solnova 3	Spain	Operational	20/03/2017	2009	2012	113520	Expected/ Planned	Abengoa Solar	50.0		None		
Solana Generating Station	United States	Operational	19/08/2015	2013		944000		Abengoa Solar	280.0		2-tank indirect	6	Molten salts
Solnova 4	Spain	Operational	20/03/2017	2009	2012	113520	Expected/ Planned	Abengoa Solar	50.0		None		
La Dehesa	Spain	Operational	20/03/2017	2011		175000	Estimated	Renovables SAMCA	49.9	13.81	2-tank indirect	7.5	29,000 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate.
La Florida	Spain	Operational	20/03/2017	2010		175000	Estimated	Renovables SAMCA	50.0	13.81	2-tank indirect	7.5	29,000 tons of molten salt. 60% sodium nitrate, 40% potassium nitrate.
Solar Electric Generating Station++3++ III	United States	Operational	01/10/2015	1985	2725			NextEra Energy	33.0				

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Solar Electric Generating Station++4++ IV	United States	Operational	01/10/2015	1989	2725			NextEra Energy	33.0				
Solar Electric Generating Station++5++ V	United States	Operational	01/10/2015	1989	2725			NextEra Energy	33.0				
Solar Electric Generating Station++6++ VI	United States	Operational	01/10/2015	1989	2725			NextEra Energy	35.0				
Solar Electric Generating Station++7++ VII	United States	Operational	01/10/2015	1989	2725			NextEra Energy	35.0				
Solar Electric Generating Station++8++ VIII	United States	Operational	01/10/2015	1989	2725			NextEra Energy	89.0				
Solar Electric Generating Station++9++ IX	United States	Operational	01/10/2015	1990	2725			NextEra Energy	89.0				
ISCC Ain Beni Mathar	Morocco	Operational	24/01/2013	2010		55000		Abener	20.0		None		
ISCC Hassi R'mel	Algeria	Operational	15/04/2015	2011				Abener	20.0		None		
Martin Next Generation Solar Energy Center	United States	Operational	23/08/2012	2010		155000	Estimated	Florida Power & Light Company	75.0		None		
Helios I	Spain	Operational	18/03/2013	2012	2217	97000	Expected/ Planned	Helios I HYPERION Energy Investments, S.L.	50.0		None		
Helios II	Spain	Operational	19/08/2015	2012	2217	97000	Expected/ Planned	Helios II HYPERION Energy Investments, S.L.	50.0		None		
Blythe Solar Power Project	United States	Under development	08/03/2011	2013		525000	Expected/ Planned		1000.0			0	

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Ridgecrest Solar Power Project	United States	Under development	18/11/2009	2013		500000	Expected/ Planned					0	
Genesis Solar Energy Project	United States	Operational	09/08/2017	2014		580000	Expected/ Planned	NextEra Energy Resources	250.0		None		
Mojave Solar Project	United States	Operational	01/07/2015	2014		600000	Expected/ Planned	Abengoa Solar	280.0		None		
ISCC Kuraymat	Spain	Operational	12/02/2013	2011	2431	34000	Expected	NREA	20.0		None		
Shams 1	United Arab Emirates	Operational	21/10/2016	2013	1934	210000			100.0		None		
Sonoran Solar Energy Project - no PPA yet	United States	Under development	17/02/2011	2020				BLM Phoenix District Office	375.0				
Andasol-3	Spain	Operational	08/10/2013	2011	2200	175000	Estimated		50.0		2-tank indirect	7.5	Molten salts
Agua Prieta II	Mexico	Under construction	30/10/2013	2014		34000			14.0		None		
Thai Solar Energy 1	Thailand	Operational	23/01/2015	2012		8000	Expected	Solarlite GmbH	5.0	12	None		
Helioenergy 1	Spain	Operational	20/03/2017	2011		95000	Expected/ Planned	Abengoa Solar	50.0		None		
Helioenergy 2	Spain	Operational	20/03/2017	2012		95000	Expected/ Planned	Abengoa Solar	50.0		None		
Aste 1A	Spain	Operational	09/08/2017	2012	2019	170000	Expected/ Planned		50.0	15	2-tank indirect	8	Molten salts; 60% Sodium Nitrate, 40% Potassium Nitrate
Aste 1B	Spain	Operational	03/08/2012	2012		150000	Expected/ Planned		50.0		2-tank indirect	7.5	60% Sodium Nitrate, 40% Potassium Nitrate. 1,010 MWht
Aste 1B	Spain	Operational	20/03/2017	2012	2019	170000	Expected/ Planned		50.0	15	2-tank indirect	8	Molten salts; 60% Sodium Nitrate, 40% Potassium Nitrate

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Solacor 1	Spain	Operational	20/03/2017	2012		100000	Estimated	Abengoa Solar	50.0		None		
Solacor 2	Spain	Operational	20/03/2017	2012		100000	Estimated	Abengoa Solar	50.0		None		
Morón	Spain	Operational	27/03/2018	2012		100000	Estimated		50.0		None		
Olivenza 1	Spain	Operational	27/03/2018	2012		100000	Estimated		50.0		None		
Astexol II	Spain	Operational	20/03/2017	2012	2052	170000			50.0	15	2-tank indirect	8	60% Sodium Nitrate, 40% Potassium Nitrate
Solaben 1	Spain	Operational	20/03/2017	2013		100000	Estimated	Abengoa Solar	50.0		None		
Solaben 2	Spain	Operational	20/03/2017	2012		100000	Estimated	Abengoa Solar	50.0		None		
Solaben 3	Spain	Operational	20/03/2017	2012		100000	Estimated	Abengoa Solar	50.0		None		
Solaben 6	Spain	Operational	20/03/2017	2013		100000	Estimated	Abengoa Solar	50.0		None		
Enerstar	Spain	Operational	20/03/2017	2013		100000	Estimated	FCC Energy	50.0		None		
Guzmán	Spain	Operational	20/03/2017	2012		104000	Estimated	FCC Energy	50.0		None		
La Africana	Spain	Operational	24/11/2012	2012	1950	170000	Estimated		50.0		2-tank indirect	7.5	60% Sodium Nitrate, 40% Potassium Nitrate.
Orellana	Spain	Operational	20/03/2017	2012		118000	Estimated		50.0		None		
Termosol 1	Spain	Operational	20/03/2017	2013		180000	Estimated		50.0		2-tank indirect	9	60% Sodium Nitrate, 40% Potassium Nitrate.
Termosol 2	Spain	Operational	20/03/2017	2013		180000	Estimated		50.0		2-tank indirect	9	60% Sodium Nitrate, 40% Potassium Nitrate.
Casablanca	Spain	Operational	20/03/2017	2013		160000	Estimated	COBRA	50.0		2-tank indirect	7.5	60% Sodium Nitrate, 40% Potassium Nitrate.

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Arenales	Spain	Operational	20/03/2017	2013		166000	Estimated		50.0		2-tank indirect	7	Molten salts; 60% Sodium Nitrate, 40% Potassium Nitrate.
Borges Termosolar	Spain	Operational	27/09/2013	2012		98000	Estimated	Abantia	25.0		None		
KaXu Solar One	South Africa	Operational	14/04/2015	2015		330000	Expected	Abengoa Solar	100.0		2-tank indirect	2.5	Molten salts
Godawari Solar Project	India	Operational	13/02/2014	2013		118000	Estimated		50.0		None		
Abhijeet Solar Project	India	Under construction	27/07/2015	2015				Ener-t International Ltd.	50.0		None		
Diwakar	India	Under construction	12/02/2013	2013					100.0		2-tank indirect	4	1010 MWht, Molten Salt
KVK Energy Solar Project	India	Under construction	12/02/2013	2013					100.0		2-tank indirect	4	1010 MWht, Molten Salt
Gujarat Solar One	India	Under construction	12/02/2014	2014		130000	Expected		28.0		2-tank indirect	9	Molten Salt
Megha Solar Plant	India	Operational	21/11/2014	2014		110000	Expected/ Planned		50.0		None		
Martin Next Generation Solar Energy Center	United States	Operational	25/01/2013	2010		155000	Estimated	Florida Power & Light Company	75.0		None		
NOOR I	Morocco	Operational	23/03/2017	2015	2635				160.0		2-tank indirect	3	Molten Salt
Bokpoort	South Africa	Operational	17/04/2017	2016		230000	Estimated		55.0		2-tank indirect	9.3	Molten salts (1300 MWht)
Airlight Energy Ait-Baha Pilot Plant	Morocco	Operational	16/02/2015	2014	2200	2390	Estimated	Airlight Energy	3.0		Other	5	Packed-bed of rocks
Xina Solar One	South Africa	Operational	18/10/2017	2017		400000	Estimated		100.0		2-tank indirect	5.5	Molten salt
Ashalim	Israel	Under development	21/07/2015	2018					110.0		2-tank indirect	4.5	Molten salts
City of Medicine Hat ISCC Project	Canada	Operational	03/08/2015	2014		1500	Estimated		1.1		None		

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
National Solar Thermal Power Facility	India	Operational	13/02/2014	2012					1.0		None		
Stillwater GeoSolar Hybrid Plant	United States	Operational	21/10/2016	2015		3000	Estimated	NREL	2.0		None		
ASE Demo Plant	Italy	Operational	22/01/2015	2013	1527	275			0.35		2-tank direct	4.27	Molten salt
Kathu Solar Park	South Africa	Operational	01/03/2018	2018					100.0		2-tank indirect	4.5	Molten salt
Ilanga I	South Africa	Under development	22/05/2017	2020					100.0		2-tank indirect	4.5	Molten salt
NOOR II	Morocco	Operational	16/01/2018	2018					200.0		2-tank indirect	7	Molten salt
Delingha 50MW Thermal Oil Parabolic Trough project	China	Operational	26/07/2018	2018	1976				50.0		2-tank indirect	9	Molten salt
Shagaya CSP Project	Kuwait	Under construction	22/05/2018	2018		180000			50.0		2-tank indirect	10	Molten salt
ISCC Duba 1	Saudi Arabia	Under construction	31/01/2017	2017					43.0		None		
Yumen 50MW Thermal Oil Trough CSP project	China	Under development	28/09/2016						50.0		2-tank indirect	7	Molten Salt
Gansu Akesai 50MW Molten Salt Trough project	China	Under development	28/09/2016						50.0		2-tank direct	15	Molten Salt
Rayspower Yumen 50MW Thermal Oil Trough project	China	Under construction	31/01/2017						50.0		2-tank indirect	7	Molten Salt
Urat Middle Banner 100MW Thermal Oil Parabolic Trough project	China	Under construction	12/05/2017	2018					100.0		2-tank indirect	4	Molten Salt

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Gulang 100MW Thermal Oil Parabolic Trough project	China	Under development	29/09/2016						100.0		2-tank indirect	7	Molten Salt
Chabei 64MW Molten Salt Parabolic Trough project	China	Under development	29/09/2016						64.0		2-tank direct	16	Molten Salt
Waad Al Shamal ISCC Plant	Saudi Arabia	Under construction	07/02/2017	2018					50.0		None		
Aalborg CSP-Brønderslev CSP with ORC project	Denmark	Operational	17/05/2017	2016					16.6		None		
DEWA CSP Trough Project	United Arab Emirates	Under development	24/11/2017	2020					600.0		2-tank indirect	10	Molten salt

Source: https://solarpaces.nrel.gov/ (23/08/2018)

Table A3. CSP with Linear Fresnel Reflector technologies.

Project Name	Country	Status	Status Date	Production Start Year	Solar Resource (MWh/m²/yr)	Electricity Generation (MWh/yr)	Electricity Generation Basis	Contact Company	Gross Turbine Capacity (MW)	Annual Solar Electric Efficiency (%)	Storage Type	Storage Capacity (h)	Storage Description
Puerto Errado 1 Thermosolar Power Plant	Spain	Operational	07/09/2011	2009	2100	2000	Expected/Planned	Novatec Solar GmbH	1.4		Single-tank thermocline		Ruths tank
Puerto Errado 2 Thermosolar Power Plant	Spain	Operational	26/04/2013	2012	2095	49000	Expected/Planned	Tubo Sol PE 2, S.L.	30.0		Single-tank thermocline	0.5	Ruths tank
eLLO Solar Thermal Project	France	Under construction	04/08/2017	2018	1930	20200	Expected	SUNCNIM	9.0		Other	4	Steam drum
eCare Solar Thermal Project	Morocco	Under contract	27/11/2012	2014	2600	1600	Expected	CNIM	1.0		Other	2	Steam drum
Dhursar	India	Operational	14/11/2014	2014		280000	Expected		125.0		None		
IRESEN 1 MWe CSP-ORC pilot project	Morocco	Under construction	26/07/2016	2016		1700			1.0		Other	0.3	Buffer
Rende-CSP Plant	Italy	Operational	16/02/2015	2014	1700	3000	Estimated		1.0		None		
Dacheng Dunhuang 50MW Molten Salt Fresnel project	China	Under development	29/09/2016						50.0		2-tank direct	13	Molten Salt
Zhangbei 50MW CSG Fresnel CSP project	China	Under development	29/09/2016						50.0		Other	14	Solid state formulated concrete
Zhangjiakou 50MW CSG Fresnel project	China	Under development	29/09/2016						50.0		Other	14	Solid state formulated concrete
Urat 50MW Fresnel CSP project	China	Under development	29/09/2016						50.0		2-tank indirect	6	Molten Salt
Dadri ISCC Plant	India	Under construction	23/11/2016	2017		14000			14.0		None		

Source: https://solarpaces.nrel.gov/ (23/08/2018)

ANNEX B

Input sheet to the spreadsheet developed to evaluate different business models

Sales and Services

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Rate of change of Prices											

SALES - DOMESTIC MARKET	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Product A *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold			0	0	0	0	0	0	0	0	0
Growth rate of units sold											
Unit Price			0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Product B *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold		0	0	0	0	0	0	0	0	0	0
Growth rate of units sold											
Unit Price		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Product C *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold		0	0	0	0	0	0	0	0	0	0
Growth rate of units sold											

Unit Price		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Product D *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold		0	0	0	0	0	0	0	0	0	0
Growth rate of units sold											
Unit Price		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

SALES - EXPORTS	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Product A *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold		0	0	0	0	0	0	0	0	0	0
Growth rate of units sold											
Unit Price		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Product B *	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Quantity sold		0	0	0	0	0	0	0	0	0	0
Growth rate of units sold											
Unit Price		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

* Products / Product Families / Commodities

NOTE: If Quantities are unavailable, fill-in "Quantity sold" with the SALES VALUE and fill-in "Unit Price" with "1".

SERVICES - DOMESTIC MARKET	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Service A		0	0	0	0	0	0	0	0	0	0
Growth rate											

Service B		0	0	0	0	0	0	0	0	0	0
Growth rate											
Service C		0	0	0	0	0	0	0	0	0	0
Growth rate											
Service D		0	0	0	0	0	0	0	0	0	0
Growth rate											
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

SERVICES - EXPORTS	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Service A		0	0	0	0	0	0	0	0	0	0
Growth rate											
Service B		0	0	0	0	0	0	0	0	0	0
Growth rate											
Service C		0	0	0	0	0	0	0	0	0	0
Growth rate											
Service D		0	0	0	0	0	0	0	0	0	0
Growth rate											
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TOTAL SALES - DOMESTIC MARKET	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SALES - EXPORTS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL SALES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

VAT SALES	23,0%	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TOTAL SERVICES - DOMESTIC MARKET		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL SERVICES - EXPORTS		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL SERVICES		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
VAT SERVICES	23,0%	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TOTAL SALES & SERVICES		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

VAT		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TOTAL SALES & SERVICES + VAT		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Disparity losses	0,0%	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Since it will be reflected in "Clients", "Working Capital", "Income Statement" and "Financial Statement", it is recommended to fill-in with "0%"