Macroeconomic impact of the Solar Thermal Electricity Industry in Spain

PROTERMO SOLAR

Deloitte.

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Executive Summary

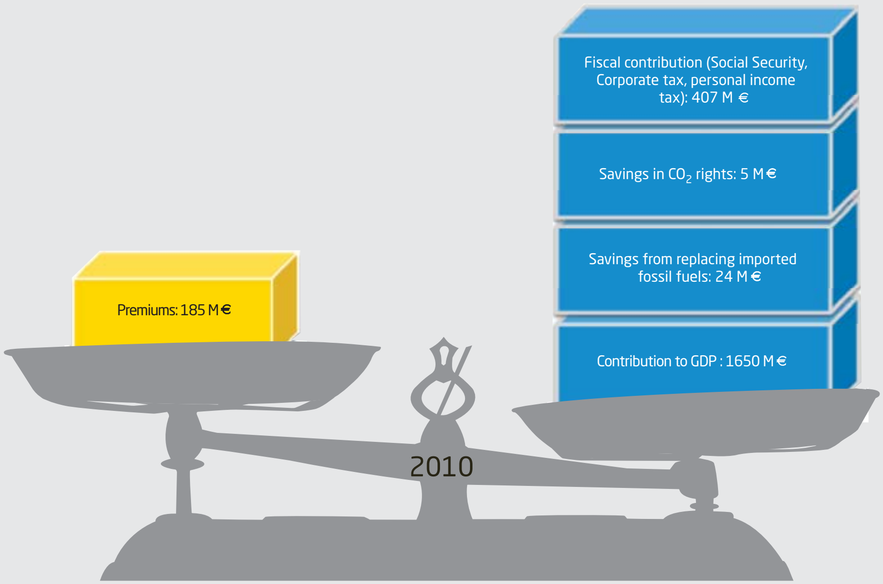
In the last three years, Solar Thermal Electricity (STE) in Spain has grown significantly. Its weight within the renewables mix is becoming relevant, and even more so, its impact on economics, society, the environment, and reducing energy dependence.

This report was carried out by Deloitte for Protermosolar to quantitatively and qualitatively evaluate the main macroeconomic variables derived from the development of this technology in Spain from 2008 to 2010, and forecast its possible future impact. The main results of the study are the following:

- In 2010, the total contribution to the Spanish GDP was 1 650.4 million Euros of which 89.3% were in construction activities and the rest in plant operation. If the support necessary to reach the penetration targets set in the 2011-2020 PER (Plan for Renewable Energy in Spain) draft is maintained, the contribution to the GDP could be as high as 3 516.8 million Euros in 2020.
- The total number of people employed by the industry came to 23,844 in 2010. The STE industry, according to the targets set in the PER, would maintain this level throughout the decade, and could sustain annual employment of nearly 20 000 jobs in 2020.
- The Research, Development and Innovation (RD&I) effort is significant and represents 2.67% of the industry's contribution to the GDP. This figure is twice the average in Spain and even higher than worldwide percentages in countries such as Germany and the United States.
- In terms of environmental impact, STE avoided 361 262 tons of CO_2 emissions into the atmosphere in 2010. The power plants in operation at the end of 2010 would avoid annual emissions of 1 236 170 tons of CO_2.
  If the targets set in the 2011-2020 PER draft are met, the power generated in STE plants will avoid about 3.1 million tons of CO_2 in 2015 and over 5.3 million tons of CO_2 in 2020, which would result in a total savings in emissions of 152.5 million Euros in 2020 using the hypothetic value of 28.66€ per ton as considered by the International Energy Agency: World Energy Outlook 2010.

- In 2010, STE production in Spain avoided import of around 140 692 tons oil equivalent (toe). The power plants in operation at the end of 2010 replaced 481 421 toe a year.
  By 2015 and 2020, STE would replace the import of about 1.6 and 2.7 million toe, respectively.
- The amounts received as premium feed-in tariffs in 2008-2010 are observed to be far below the returns derived from the construction of the STE plants.

This balance does not reflect two important transcendental macroeconomic concepts: the employment of nearly 24 000 people in 2010, a large part of which were in industries heavily affected by the economic crisis; and the ranking achieved by Spanish industry in important STE plant markets opening all over the



world. The impact of this is difficult to evaluate quantitatively as the participation of Spanish companies in the distribution of projects in other countries is not yet known. However, the unemployment subsidies corresponding to 23 844 people can be estimated, and would have amounted to 176 million Euros in 2010.

The technology

1

Solar energy is the cleanest, most abundant renewable energy resource existing. The main challenge confronting renewables in general, and those using solar radiation in particular, is for the production and distribution of this energy to have the dispatchability, and price equivalent to traditional fossil fuel resources.

At the present time, there are three main groups of technologies for making use of solar energy: photovoltaic, STE plants for generating electricity, and low-temperature thermal energy for heating and hot water. The concentrating technologies used for STE plants can also be applied to medium or high temperature industrial heat.

While the photovoltaic technology converts solar radiation directly into electricity and thermal technology converts it into heat, the STE technology concentrates the direct component of solar radiation in order to heat a fluid and then generate electricity.

In most of the commercial technologies, devices called heliostats, parabolic troughs, Fresnel reflectors or parabolic dishes - collect the solar radiation and concentrate it to heat a working fluid, which may differ according to the case, and that in turn is used to generate steam. The steam is then expanded in a conventional turbine to generate electricity the same way any conventional power plant does. In the case of parabolic dishes the fluid is a gas, and electricity is generated directly by the Stirling engine located in the focus of the parabola.

Although STE may seem recent, it is really a proven technology. The first commercial plants began operating in California in the mid-eighties; however, the market was paralyzed due to the fall in fossil fuel prices and the cancellation of public incentives.

While other renewable resource based technologies for electricity generation began to receive support at the end of the nineties, it was only in 2004 that a framework making commercial power plant construction possible was established in Spain. This was also the case in the US, although based on different models. The first plants to go into operation were the PS10 in Spain at the beginning of 2007, and a short time later, the Nevada Solar One in the US.

This solar thermal renaissance in Spain and the United States came in response to the need to meet renewable energy penetration targets and reduce energy dependence. It was also influenced by the fact that these two countries had made the strongest RD&I efforts (PSA and Sandia). Furthermore, interest in this technology was awoken by the establishment of a series of incentives, such as the premium feed-in tariffs for renewables, the requirement to use renewables, along with the existence of the resource in both countries.

Figure 1.
Power plant PS10 in Sevilla. Owned by Abengoa.

The position of leadership achieved by the industry in Spainresults from a combination of three factors:

- Continuous support for research and technological development since the end of the seventies, as described in detail in the book published by Protermosolar, "STE. History of a research success."
- The regulatory framework established in 2004 and consolidated in 2007, with which STE began to receive premiums for generation in Spain; almost ten years after other technologies such as wind, photovoltaic, biomass and mini-hydraulic.
- The response capability of Spanish companies due to their well-prepared human resources and commitmentedinvestments - these financed mostly through "Project Finance" (in commercial terms) and not public subsidies.

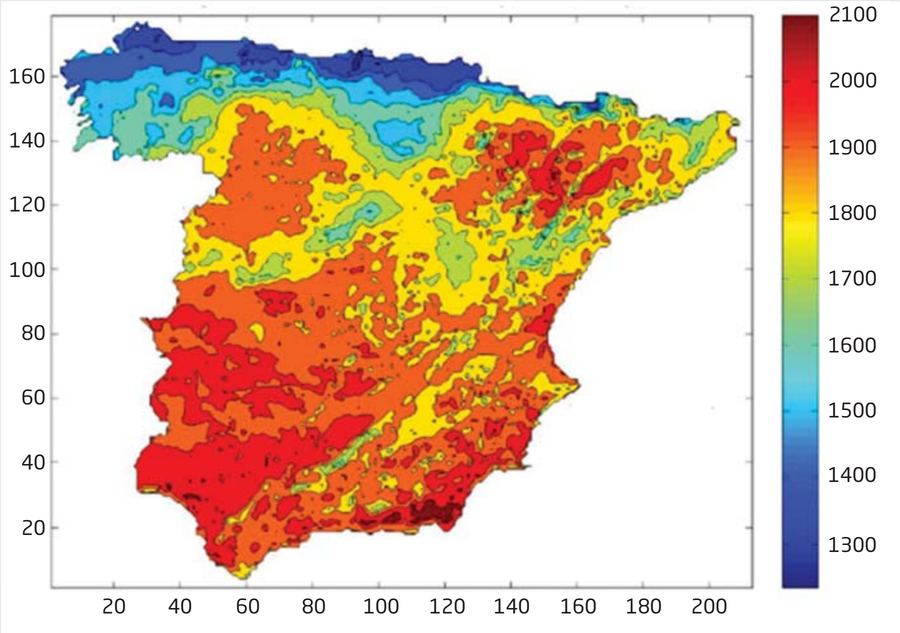
The resource

Direct radiation represents about 80% to 90% of the solar energy that reaches the Earth's surface on a clear day. On a cloudy day, the direct radiation component is almost zero and at those times electricity production in an STE plant is nil. STE requires the direct component of solar radiation since it can only concentrate the energy if the mirrors in the solar fields receive this type of irradiation (unlike photovoltaic which can also use the diffuse component). Therefore, ideal sites for installation of STE plants have to have many sunny days (without many clouds or fog) per year, mainly in semiarid areas and located at latitudes below 40º, either in the northern or southern hemisphere.

In this sense, the regions with the most potential are the deserts of North Africa and South Africa, the Middle East, northwest India, southern United States, Mexico, Peru, Chile, western China, Australia and southern Europe. InSpain there are only about 2 000 $kWh/m^2/yr$ compared to 2 600 $kWh/m^2/yr$ at sites in the countries mentioned with the best solar resources on the planet.

Usable energy is measured in terms of direct normal irradiation, which is defined as the energy that arrives on the surface perpendicular to the Sun's rays during a given period of time. At present, the minimum necessary for one of these plants to be promoted would be slightly over 1 900 kWh/m²/yr.

Figure 2.
Map of annual direct solar radiation (kWh/m²/year). Source: PER 2011-2012 draft.



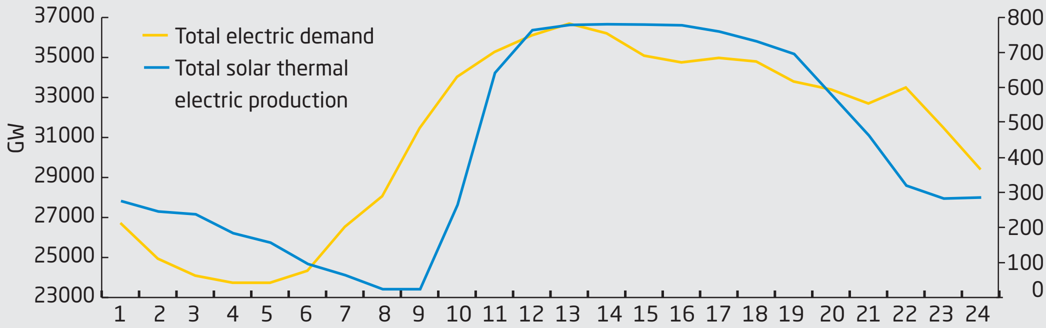
1.1. Value Proposition of STE plants

In the first place, STE is dispatchable, and can be delivered to the grid even when there is no solar radiation by making use of thermal storage or hybrid systems. This characteristic makes STE more flexible than other renewable technologies, thereby **contributing to operator management of the power system according to demand.** Furthermore, the interface with the grid in STE plants is made up of generating equipment with high mechanical inertia which contributes to its stability during short incidents.

STE can be considered a facilitator for integrating other technologies into the grid, such as photovoltaics or wind, avoiding the need for fossil fuel backupas it can be easily hybridized with other forms of renewable energy, such as biomass, or fossil fuels such as natural gas. In this waythe use of the same generating equipment, the efficiency and reliability of power generation is considerably increased.

Power production using these technologies avoids greenhouse gas emissions, alleviating the effects of these gases on climate change and helping achieve emissions reduction targets. Their operation and maintenance are safe and clean, and their role in contributing to an emissions-free system is growing daily. In addition itavoids the risks associated with the transport of crude oil, nuclear power plant accidents or radioactive waste management.

As a resource found inside the territory, it contributes to reducing the import of fossil fuels. The advantages go beyond simple economic savings, since it also r**educes the risk of negative impacts associated with volatile fossil fuel prices and the vulnerability of energy itself.** This



Source: REE

Figure 3.
Electricity demand and CSP production on July 28th, 2011.

advantage is especially important in Spain, as it is one of the European countries most dependent on foreign oil.

In terms of the socioeconomic impact, as observed throughout this document, **STE is a strong generator of jobs within the territory where the plants are built, during construction, and operation and maintenance.This is largely due to the high domestic component associated with the execution of the investment.**

The International Energy Agency predicts that, while most of the STE contribution will come from large power plants connected to the grid, these technologies could also supply a good part of the demand for industrial process power and heat, cooling, and desalination of brackish or seawater.

Possible further smaller-scale applications in urban or residential environments could become very important in locations with limited access to electricity.

1.2. Technological solutions

At the present time there are four technological solutions for the development of STE, which can be classified by the way in which they concentrate the direct solar irradiation:

- Parabolic trough
- Solar towers with central receiver and heliostat field
- Linear Fresnel reflectors
- Parabolic dishes with Stirling engines

Parabolic-trough power plants

This is currently the technology most widely used worldwide; most predominantly in Spain and the United States where over 900 MW and 430 MW are in operation respectively.

It consists of installing rows, or loops, of parabolic trough-shaped mirrors that collect the solar radiation and concentrate it onto a receiver tube where a fluid is heated to about 400ºC. This fluid is later used either to generate steam to drive a turbine connected to a generator, or to heat a storage system consisting of two tanks of molten salt. Alternatively, if the current developments are successful, the thermal energy resulting from the solar thermal conversion could generate steam directly in the solar field, eliminating the need for heat exchangers and other fluids.

The rows of concentrators in these power plants are usually oriented north-south in order to maximize the amount of energy collected during the year. The angle of inclination of a one-axis system can be adjusted from east to west during the day, thus ensuring the most favorable angle of incidence of the direct solar irradiation on the mirrors. This technology also admits the inclusion of thermal storage systems for use when there is no solar irradiation.

Moreover, **the technology also allows for the rather simple hybridization with other technologies, which means that it can be used with a traditional fossil fuel or biomass to produce electricity during the night or on cloudy days, or to boost solar operation.** The advantages of hybridization are that it maximizes the use of the turbine generator, with economies of scale in many stages of the project, such as during construction (for example, power lines) and operation.

Current power plants in Spain are limited to 50 MW per unit by the Special Regime. In the United States however, power plants are being built with much larger turbines, taking advantage of the fact that in this technology, energy collection performance is practically unaffected by size, while costs of generation are lowered considerably.

Figure 4.
Power plant La Risca in Badajoz.
Owned by Acciona.

Solar towers with central receiver and heliostat field

Solar towers with with central receiver, use hundreds or thousands (depending on their size and power) of flat– or almost flat – mirrors called heliostats, which reflect the solar radiation onto a receiver located at the top of a tower. A heat transfer fluid, which in current power plants is either steam or molten salt, is heated in the receiver and used to generate electricity in a conventional steam turbine.

The performance of these plants is usually better than parabolic trough plants because fluid temperatures are higher, from 500ºC to 600ºC, leading to higher thermodynamic performance, and at the same time also facilitating storage capacity by decreasing the volume necessary.

Figure 5.
Power plant in Sevilla.
Owned by Torresol Energy.

At the present time, there are only three power plants of this type in Spain, while in the United States several larger projects are currently underway.

Although commercial experience with this type of power plant is limited, **it is estimated that the ratio of per kWh generation cost could be lower than parabolic trough plants,** even though land use is slightly less efficient. Growing confidence for this type of plant is perceived, as more of them go into operation. These plants could have a rated power of over 100 MW_e.

Linear Fresnel reflector plants

This technology is also based on rows or loops of solar collectors, however in this case, they are flat – or have a very slight curvature. The radiation is reflected and **concentrated onto receivers located over the mirrors. The main advantage of this technology is that it facilitates direct steam generation,**

Figure 6.
Power plant in Puerto Errado 1, Murcia. Majority ownership by EBL, developed by NOVATEC.

mainly because the absorber tube is fixed, eliminating the need of heat transfer fluids and heat exchangers.

This technology is currently the least extended as concentration and the temperature of the fluid in the solar field – to date saturated steam – is lower than the other two technologies mentioned above, and due to the use of steam as working fluid it is more difficult to incorporate storage systems. Its future deployment will depend on the ability to lower investment and generation costs and, given its lower performance, to become more competitive. It is estimated that to reach similar cost of electricity than parabolic troughs, costs of the solar field would have to be 40% lower.

Dish/Stirling plants

Power plants using parabolic dishes with Stirling engines consist of two basic components, a concentrator or solar dish, and a power generator. Each complete unit produces electricity by itself, and the power of the current devices varies from 3 kW to 25 kW per unit, with a 10-kW version.

The concentrators collect the solar radiation directly and reflect it onto a receiver located over the dish. The structure rotates, tracking the Sun and concentrating its rays onto the focus where the receiver - connected to the engine - is located. The most common thermomechanical converter used is a Stirling engine connected to an alternator. The Stirling engine uses a heated gas, usually helium or hydrogen, to generate mechanical energy in its shaft.

This design eliminates the need for water in generating energy. This is an advantage compared to the usual designs employed by other typologies – which could however also be built with dry cooling systems. As they are single units, **parabolic dishes are not as suitable as the other technologies**

for use in large power plants. However, they could be a solution for distributed generation, since they can be used as modules, and it is easier to position them on land that is not flat.

Figure 7.
Power plant in Casas de los Pinos, Cuenca. Owned by Renovalia, with engines Infinia.

Storage systems

One of the main challenges for renewable energies is finding solutions to problems derived from their variability due to the nature of the resource. The hours of solar radiation are more predictable than other energy sources such as the wind. Furthermore, neither wind nor photovoltaic are dispatchable, that is, the power plants cannot produce when there is no resource, nor can the electricity produced be stored competitively when there is no demand for it.

STE offers solutions in this regard, since the energy collected can be stored in the form of the internal energy of a substance. If the fluid used to transfer heat from the solar field to the generator is oil or molten salt, the energy collected can be stored for later use during the night or on cloudy days. In particular, in the systems that use molten salt as the working fluid, storage enables solar energy collection to be separated from electricity generation, and therefore it may be said that the storage system has virtually a 100% yield.

Daily peak demand during the day coincides with the hours of highest solar radiation availability. Depending on the season, for a few hours after sundown there is a second peak demand. Plants with storage capacity usually have in Spain up to seven and a half additional hours, which are generally only in operation during the summer, allowing operation of the solar thermal plant to be extended, thus making it more competitive by reaching capacity factors near 50%.

It should also be mentioned that practically all solar thermal plants have reserve devices or possibilities for hybridization with other technologies, which helps regulate production and guarantee power, especially during peak demand hours.

Figure 8.
BOP and storage system of the power plant La Florida in Badajoz. Owned by Renovables SAMCA.

Water and cooling requirements

Like other thermal power plants, **STE plants usually employ a constant water supply for cooling the steam cycle condenser.** Although STE plants can also be designed with dry cooling systems, their performance is slightly lower. Depending on the technology used, STE usually requires about 3 000 liters of water per MWh[1], ratios similar to nuclear power plants, compared to the 2 000 liters per MWh of coal plants or 800 liters of combined cycles with natural gas.

Figure 9.
Power plant Ibersol Puertollano in Ciudad Real.
Owned by Iberdrola.

1. Central receiver or power tower plants require less water and parabolic dishes use only air cooling.

It should also be mentioned that when STE plants are built on agricultural land, the final consumption of water per hectare per year is lower than for crops. An STE plant consumes a total of 260 000 liters /ha*yr, while agricultural land in the Guadalquivir Basin consumes around 600 000 liters/ha*yr for growing corn and 404 000 liters/ha*yr for cotton[2].

Access to such amounts of water is a challenge that will have to be met by STE, especially when located in arid regions. A possible solution is air cooling, but the thermodynamic conversion performance is slightly affected.

There are currently some studies for the reduction of water use which offer mixed solutions, such as the use of water in summer and air in winter, and other different techniques being developed by technology centres.

Evolution of costs

In the future, the cost of generation per kWh is expected to fall as components become cheaper, lager plants are constructed and plant performance increases. Whereas the wind energy technology has a worldwide installed power of 100 GW, and photovoltaic has accumulated around 50 GW, solar thermal has not yet reached 2 GW, and therefore has a great potential for advancing on the learning curve specifically regarding the factor of scale and innovation improvements.

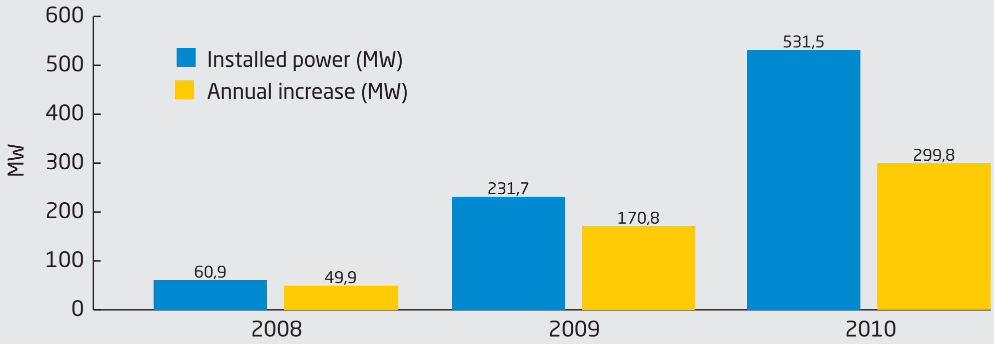
2. Source: Spanish Ministry of the Environment and Rural and Marine Affairs - General Directorate of Water: *Confederación Hidrográfica del Guadalquivir.*

1.3. The STE Situation

At the end of 2010, installed solar thermal power in Spain had grown to 531.5 MW[3], from 299.8 MW the year before. Although it is a technology which has been under testing since the eighties, the first commercial MW in Spain were not produced until February 2007 at the 11-MW PS10 power plant in Sanlúcar la Mayor, Seville province.

It should be pointed out that in 2011, 420 MW more had gone into operation by the end of September, increasing the installed capacity to nearly 1000 MW. Furthermore, about 1200 MW more are under construction, and nearly 2500 MW already entered in the Pre-allocation Register are expected to be installed by the end of 2013.

Figure 10.
STE power installed, cumulative and percentage increase (2008-2010).



3. Source: Installed capacity published by the National Energy Commission. This information is collected by the CNE from power plants when their registration is finalized. These data are slightly different from the database used for the economic study, which also includes plants which were built and had tested their grid connections months before this registration, and which would have raised installed power to 749.4 MW.

Practically all of the power plants use the parabolic trough technology. There are only three power tower plants and one 1.4-MW Fresnel plant. About two-thirds of the plants include 7.5 hours of storage, making the typical power plant under construction or operation in Spain a 50-MW parabolic trough plant with 7.5 hours storage capacity.

Most of the plants are logically concentrated where the highest resource is available, that is, at the end of 2010, in the autonomous regions of Andalucía, Extremadura, Castilla-La Mancha and Murcia. It should be mentioned that a hybrid solar thermal biomass plant under construction in Borges Blanques, Lérida, and another parabolic trough plant in Villena, Alicante, are due to go into production at the beginning of 2013.

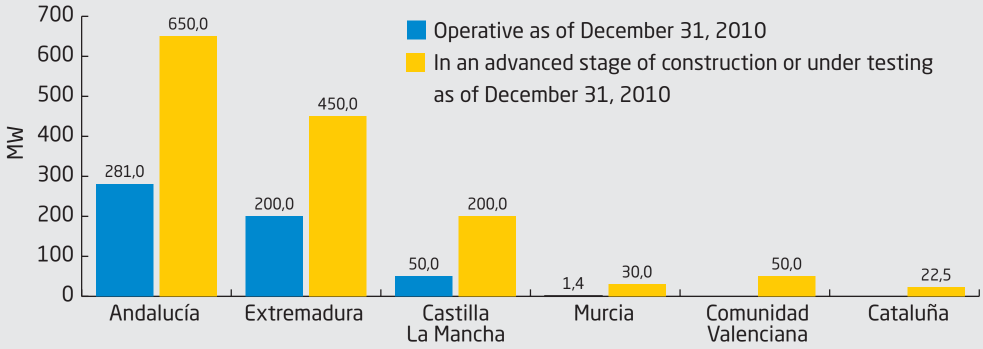
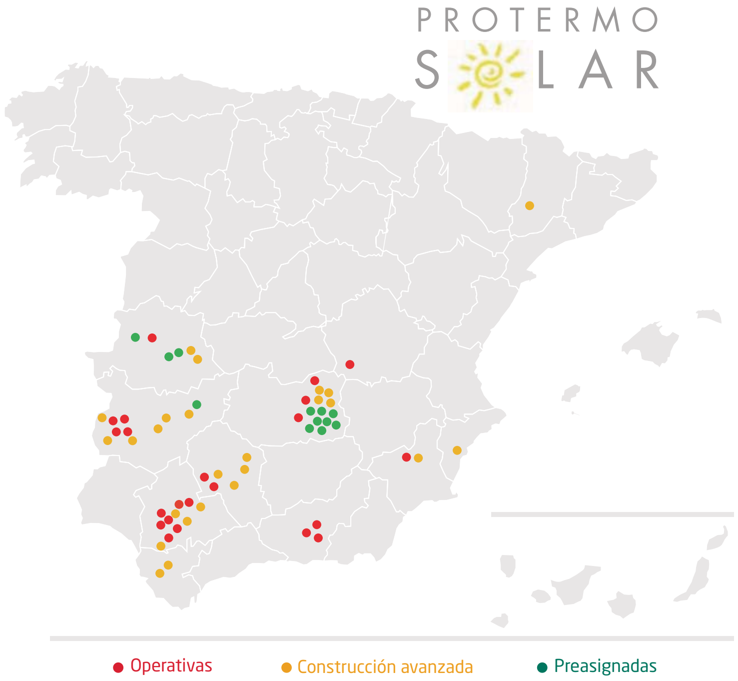


Figure 11.
STE power, plants installed and built by autonomous regions in Spain as of 2010.

The map of Spain below shows the locations of these STE plants.

LOCALIZACIÓN DE CENTRALES SOLARES TERMOELÉCTRICAS EN ESPAÑA



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LOCALIZACIÓN DE CENTRALES SOLARES TERMOELÉCTRICAS EN ESPAÑA

Propietario	Nombre	Población	Provincia	Tecnología	Potencia (MW)	Almacenamiento (horas a carga nominal)	Producción estimada (GWh/año)	Emisiones evitadas (t/año CO2)	Fase pre registro	Fechas 1ª conexión en pruebas (m-a)	Superficie de terreno ocupada (Ha)	Área de captación solar (m2)
Abengoa Solar	PS10	Sanlúcar la Mayor	Sevilla	TVS	10	1	24	11.424	n/a	nov-06	65	75.000
COBRA	Andasol-1	Aldeire	Granada	CCP	50	7,5	175	83.300	n/a	nov-08	200	510.120
Abengoa Solar	PS20	Sanlúcar la Mayor	Sevilla	TVS	20	1	44	20.944	n/a	abr-09	90	150.000
Novatec	Puerto Errado I	Calasparra	Murcia	Fresnel	1,4	0,5	2	1.120	1	abr-09	3	18.000
COBRA	Andasol-2	Aldeire y La Calahorra	Granada	CCP	50	7,5	175	83.300	1	jun-09	200	510.120
Iberdrola Energía Solar de Puertollano	Ibersol Puertollano	Puertollano	Ciudad Real	CCP	50	n/a	103	49.028	n/a	jun-09	150	290.000
Acciona/ Mitsubishi Corp	La Risca	Alvarado	Badajoz	CCP	50	n/a	103	49.028	1	sep-09	130	390.000
COBRA	Extresol-1	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	177	84.252	1	sep-09	200	510.120
COBRA	Extresol-2	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	177	84.252	2	abr-10	200	510.120
Abengoa Solar	Solnova 1	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	110	52.360	1	may-10	115	350.000
Abengoa Solar	Solnova 3	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	110	52.360	1	jun-10	115	350.000
Renovables SAMCA, S.A.	La Florida	Badajoz	Badajoz	CCP	50	7,5	180	85.680	1	jul-10	220	550.000
Abengoa Solar	Solnova 4	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	110	52.360	1	ago-10	115	350.000
Acciona/ Mitsubishi Corp	Majadas	Majadas	Cáceres	CCP	50	n/a	108	51.408	1	oct-10	110	380.000
Renovables SAMCA, S.A.	La Dehesa	La Garrovilla	Badajoz	CCP	50	7,5	180	85.680	1	oct-10	220	550.000
Acciona/ Mitsubishi Corp	Palma del Río II	Palma del Río	Córdoba	CCP	50	n/a	116	55.216	1	dic-10	135	380.000
COBRA	Manchasol-1	Alcázar de San Juan	Ciudad Real	CCP	50	7,5	185	88.060	2	dic-10	200	510.120
Renovalia	Casa de los Pinos	Casa de los Pinos	Cuenca	DS	1	n/a	2,25	1.260	3	mar-11	3,5	5.280
COBRA	Manchasol-2	Alcázar de San Juan	Ciudad Real	CCP	50	7,5	185	88.060	3	abr-11	200	510.120
Torresol	Gemasolar	Fuentes de Andalucía	Sevilla	TS	20	15	100	47.600	2	abr-11	195	304.750
Acciona/ Mitsubishi Corp	Palma del Río I	Palma del Río	Córdoba	CCP	50	n/a	116	55.216	1	jul-11	135	380.000
Solar Millennium,Ferrostaal,RWE,Rhein Energy,SWM	Andasol 3	Aldeire/la Calahorra	Granada	CCP	50	7,5	170	80.920	1	ago-11	220	512.000
Abengoa Solar/EON	Helioenergy 1	Écija	Sevilla	CCP	50	6	140	66.640	2	sep-11	180	500.000
En operación 23					952,4		2.792	1.329.468			3.402	8.595.750
Valoriza/Siemens	Lebrija 1	Lebrija	Sevilla	CCP	50	n/a	122	58.072	2	jul-11	188	412.000
Elecnor/Eiser/Aries	Astexol II	Badajoz	Badajoz	CCP	50	7,5	188	89.488	3	nov-11	190	510.120
Torresol	Arcosol-50	San José del Valle	Cádiz	CCP	50	7,5	160	76.160	3	nov-11	180	510.000
Torresol	Termosol-50	San José del Valle	Cádiz	CCP	50	7,5	160	76.160	3	dic-11	180	510.000
Elecnor/Eiser/Aries	Aste 1A	Alcázar de San Juan	Ciudad Real	CCP	50	8	187	89.012	2	ene-12	180	510.120
Elecnor/Eiser/Aries	Aste 1B	Alcázar de San Juan	Ciudad Real	CCP	50	8	187	89.012	2	ene-12	180	510.120
Abengoa Solar/EON	Helioenergy 2	Écija	Sevilla	CCP	50	6	140	66.640	2	ene-12	180	500.000
Abengoa Solar/JGC Corporation	Solacor 1	El Carpio	Córdoba	CCP	50	n/a	110	52.360	2	feb-12	115	350.000
Novatec, EBL, IWB, EWZ,EKZ y EWB	Puerto Errado II	Calasparra	Murcia	Fresnel	30	0,5	50	28.000	2	mar-12	60	302.000
Abengoa Solar/JGC Corporation	Solarcor 2	El Carpio	Córdoba	CCP	50	6	140	66.640	2	mar-12	180	500.000
Abengoa Solar	Helios 1	Ciudad Real	Ciudad Real	CCP	50	7	150	71.400	1	may-12	180	500.000
Ibereólica	Morón	Morón de la Frontera	Sevilla	CCP	50	n/a	122	58.072	2	may-12	161	380.000
Abengoa Solar/ITOCHU	Solaben 3	Logrosán	Cáceres	CCP	50	4	130	61.880	3	jun-12	180	500.000
Grupo Ortiz-Grupo TSK-Magtel	La Africana	Posadas	Córdoba	CCP	50	7,5	173	82.348	1	jul-12	230	549.360
FCC/Mitsui	Guzman	Palma del Río	Córdoba	CCP	50	n/a	110	52.360	3	jul-12	200	310.406
Ibereolica	Olivenza 1	Olivenza	Badajoz	CCP	50	n/a	120	57.120	3	jul-12	198	402.000
Acciona	Orellana	Orellana	Badajoz	CCP	50	n/a	117	55.692	1	ago-12	130	405.480
COBRA	Extresol-3	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	177	84.252	3	ago-12	200	510.120
Abengoa Solar	Helios 2	Ciudad Real	Ciudad Real	CCP	50	7	150	71.400	2	ago-12	180	500.000
Abengoa Solar/ITOCHU	Solaben 2	Logrosán	Cáceres	CCP	50	n/a	110	52.360	3	oct-12	115	350.000
Abantia /Comsa EMTE	Termosolar Borges	Borges Blanques	Lleida	CCP+HB	22,5	n/a	98	24.696	3	dic-12	70	181.000
COBRA	Casablanca	Casablanca	Cáceres	CCP	50	7,5	175	83.300	3	jul-13	200	510.120
FCC/Otros	Enerstar	Villena	Alicante	CCP	50	n/a	99	47.124	4	jul-13	214	327.000
Solar Millennium/Ferrostaal	Extremasol 1	Villanueva de la Serena	Badajoz	CCP	50	7,5	160	76.160	4	jul-13	220	497.040
Solar Millennium/OHL	Arenales	Morón de la Frontera	Sevilla	CCP	50	7	167	79.492	4	mar-13	220	510.000
Nextera-FPL	Termosol 1	Navalvillar de Pela	Badajoz	CCP	50	9	175	83.300	4	oct-13	205	523.200
Construcción avanzada 26					1.252,5		3.677	1.732.500			4.536	11.570.086
Renovalia	Puertollano 1	Puertollano	Ciudad Real	DS	8	n/a	18,1	10.136	3	mar-12	270	44.704
Renovalia	Puertollano 2	Puertollano	Ciudad Real	DS	10	n/a	22,6	12.656	3	mar-12	330	54.080
Renovalia	Puertollano 3	Puertollano	Ciudad Real	DS	10	n/a	22,6	12.656	3	mar-12	330	54.080
Renovalia	Puertollano 4	Puertollano	Ciudad Real	DS	10	n/a	22,6	12.656	3	mar-12	330	54.080
Abengoa Solar/ITOCHU	Solaben 1	Logrosán	Cáceres	CCP	50	4	130	61.880	4	mar-13	180	500.000
Renovables SAMCA, S.A.	Cáceres	Galisteo y Valdeobispo	Cáceres	CCP	50	7,5	185	88.060	4	mar-13	220	550.000
Renovalia	Puertollano 5	Puertollano	Ciudad Real	DS	10	n/a	22,6	12.656	4	mar-13	330	54.080
Renovalia	Puertollano 6	Puertollano	Ciudad Real	DS	10	n/a	22,6	12.656	4	mar-13	330	54.080
Renovalia	Puertollano 7	Puertollano	Ciudad Real	DS	12,4	n/a	27,9	15.624	4	mar-13	419	68.768
Abengoa Solar/ITOCHU	Solaben 6	Logrosán	Cáceres	CCP	50	n/a	110	52.360	44	ago-13	115	350.000
Nextera-FPL	Termosol 2	Navalvillar de Pela	Badajoz	CCP	50	9	175	83.300	4	jul-13	212	523.200
Termosolar Alcazar S.L.	Alcázar	Alcázar de San Juan	Ciudad Real	TS	50	20	320	152.320	n/a	jul-14	600	1.082.640
Preasignadas 12					320,4		1.079	526.960			3.666	3.389.712
Total 61					2.525,30		7.548	3.588.928			11.604	23.555.548

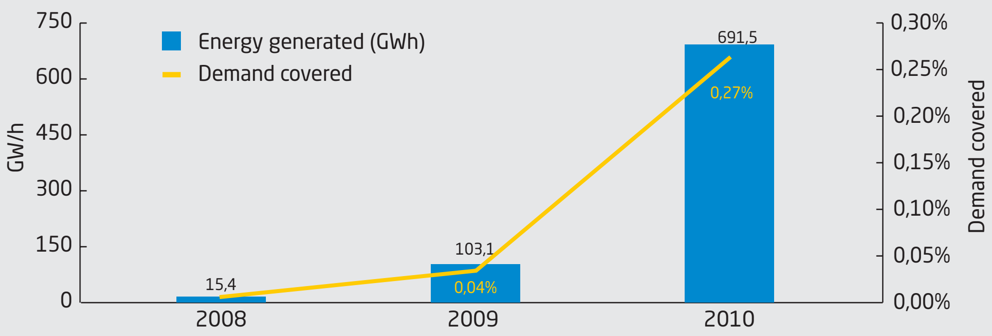
Tecnologías:	
TVS	- Torre Vapor Saturado
TS	- Torre con Sales
CCP	- Canales Parabólicos
CCP+HB	- Canales Parabólicos + Hibridación con Biomasa
DS	- Disco/Stirling
FRESNEL	- Fresnel

Figure 12.
List and map of the location of the CSP centrals in Spain.
Source: www.protermosolar.com

Spain is the world leader in this technology. The United States has almost 500 MW installed power (most of this for over twenty years) and is undertaking the construction of new plants, in many of which Spanish companies are the contractors or builders. Projects are also in operation, or under construction, in Morocco, Algeria, Egypt, United Arab Emirates, Italy, Australia, China and India. **The total capacity installed worldwide is around 2 GW.**

In terms of power generated, **STE in Spain totaled 691.5 GWh in 2010, while annual power generated by all the plants in operation at the end of 2010- if they had been in operation all year long- would have been 2 366.3 GWh**. Cover of demand is still insignificant compared to the rest of the technologies in the energy mix, although its weight increased notably in 2010 and 2011, having reached nearly 1.5% in summer 2011. By 2020, if PER forecasts are realized, electricity generated by STE plants would represent 3% of the total in Spain.

Figure 13.
Power generation and percentage of demand covered by STE



Six European countries have announced STE installation targets in their National Renewable Energy Action Plans (NREAPs), accumulating a power of 3 573 MW in 2015 and 7 044 MW in 2020 (including the Spanish targets, which are slightly lower in the PER 2011-2020 draft).

In addition to Spain, France, Italy, Portugal, Greece and Cyprus have presented an installation plan. It is estimated that the electricity produced by these power plants will be close to 20 TWh per year.

1.4. Regulatory Framework

At present, the Pre-allocation Register for Remuneration of power to which STE is subject is closed. The registration procedure, introduced by the Royal Decree-Law 6/2009 of April 30th, adopting certain measures in the power industry, and approving the rates subsidy, gave the central government the power of registration, although the administrative authorizations continued to be a function of the autonomous regions.

The Royal Decree 1614/2010, regulating and modifying certain aspects related to power production from STE and wind technologies, was also published on December 7, 2010, guaranteeing the framework for payment in the Royal Decree 661/2007 to all projects entered in the Pre-allocation Register, and setting a limit to the number of equivalent hours of operation depending on the technology and storage capacity.

Technology	Equivalent reference hours / Year
Parabolic trough, no storage	2 855
Parabolic trough + 9 hours storage	4 000
Parabolic trough + 7 hours storage	3 950
Parabolic trough + 4 hours storage	3 450
Tower/saturated steam	2 750
Tower/salt + 15 hours storage	6 450
Fresnel	2 450
Stirling	2 350

1.5. Meeting energy policy targets

The Spanish Plan for Renewable Energy (PER 2005-2010) set a target of 500 MW STE, and electricity production of 1 144 GWh by 2010. The power target has been met. The Plan's power production target was not met, although it should be clarified that most of the power incorporated in 2010 was not in operation all year, and if it had been, the target would have been surpassed.

In the future, the PER 2011-2020 draft, which is now in the public information stage, makes a slight reduction in the prospects originally set by the NREAP 2011-2020 sent to Europe containing the actions to be carried out (non-binding) to meet the European energy policy targets (known as the 20/20 targets).

STE penetration levels are therefore set at **3 001 MW and 4 800 MW in 2015 and 2020 respectively, and power production of 8 287 GWh and 14 379 GWh in 2015 and 2020 respectively.**

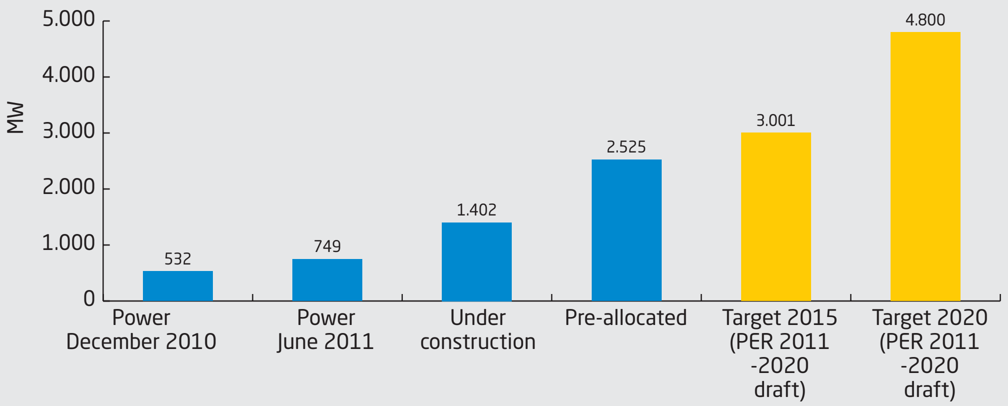


Figure 14.
Evolution of cumulative power planned and PER 2011-2011 draft targets.

Furthermore, international installation of renewable power in general, and of STE -as its special storage and hybridization qualities ensure its dispatchability - is predicted to accelerate and advance on the learning curve, reducing investment costs with system and component innovations.

The 2009 International Energy Agency roadmap set the 2020 world target at 148 GW, with a mean 2 800 equivalent hours of operation, and electricity production of 414 TWh. There is therefore a significant opportunity for the Spanish industry, which is now ranking so well, to contribute significantly to the development of this important emerging market.

Macroeconomic results

2

2.1. Methodology

This section describes the methodology used to estimate the STE Industry contribution to the GDP and employment, describing the tools used and the calculations made.

According to Spanish accounting methods, the **contribution to an economy's GDP may be calculated using three methods,** the results of which must be equivalent.

• Sum of **added value**
• Sum of **payment for production factors**
• Sum of the **final demand**

The added value of an activity is calculated by subtracting the cost of necessary supplies for producing products, and/or services from the income from their sale. The sum of the difference between the income and operating costs of all those companies/activities included in an industry represents that industry's contribution to the GDP.

The **difference can also be broken down into production factors used for producing said products and/or services, mainly labor and capital**. In this sense, the estimation of the contribution to the GDP by industry/company is also the sum of the payments for each of these factors: the total expenses in wages and salaries, plus the company's gross operating overhead[4].

4. The gross operating overhead is defined as payments made for other production factors in addition to labor: benefits, rent, interest, consumption of fixed assets and other incomes.

Finally, **the sum of the final demand considers the final expense in goods and services produced: internal demand plus net external demand.** Internal demand is defined as the final consumption of goods and services plus gross fixed capital formation, and the net external demand is equivalent to net exports (exports less imports).

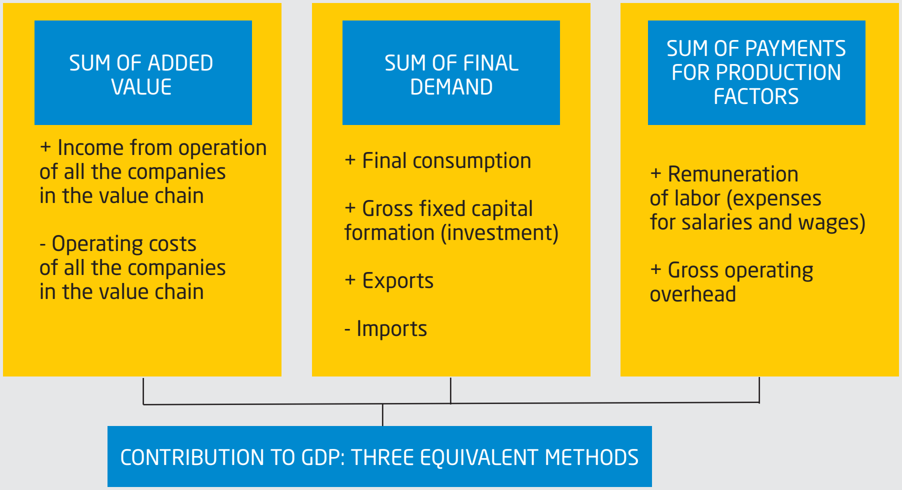


Figure 15.
Methodology for calculating the contribution to the GDP.

Definition of direct and indirect impact

The design, contracting, construction and operation of STE power plants involves a large number of agents, which though specifically devoted to this task, also produce an additional impact on the rest of the economy derived from the bandwagon effect.

In this study, **direct impact is defined as the quantification of activities of companies that make and provide specific goods and/or services to industry.** The activities included in this section are:

- Design of power plants and R&D activities
- Project contracting
- Prior studies: technical reliability, environmental impact, economic and financial estimates
- Engineering, site management, safety, health and quality services
- Manufacture of components and specific equipment

  - Solar field: support frames, trackers, mirrors, tubes, HTF oil
  - Turbine and alternator
  - Other plant equipment and/or materials: cooling tower, auxiliary boiler, steam generator, hydraulic pumps, accumulator, condenser, circuits, storage systems.

- Instrumentation and control
- Plant civil engineering work: groundwork, foundations, channeling, water supply, buildings
- Plant assembly and commissioning
- Grid connection electrical infrastructure: power lines, substation, etc.
- Sale of electricity
- Plant operation and maintenance
- Others: permitting and licensing, taxes and fees.

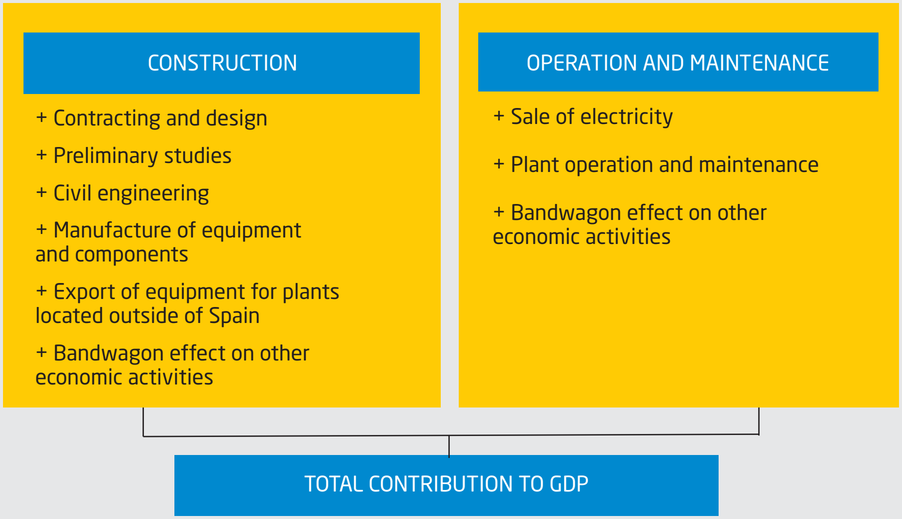


Figure 16.
Activities included in construction and operation and maintenance.

Quantification of the direct impact was carried out using the information from a questionnaire given to contractors (described below). The comparison between this information and the company's profit and loss accounts, and coefficients found from national accounting for each of the activities described above.

On the contrary, the indirect impact includes all of those activities involved in the supply of goods and/or services to the economic activities mentioned above. The study describes the impact that STE has had on each of these industries.

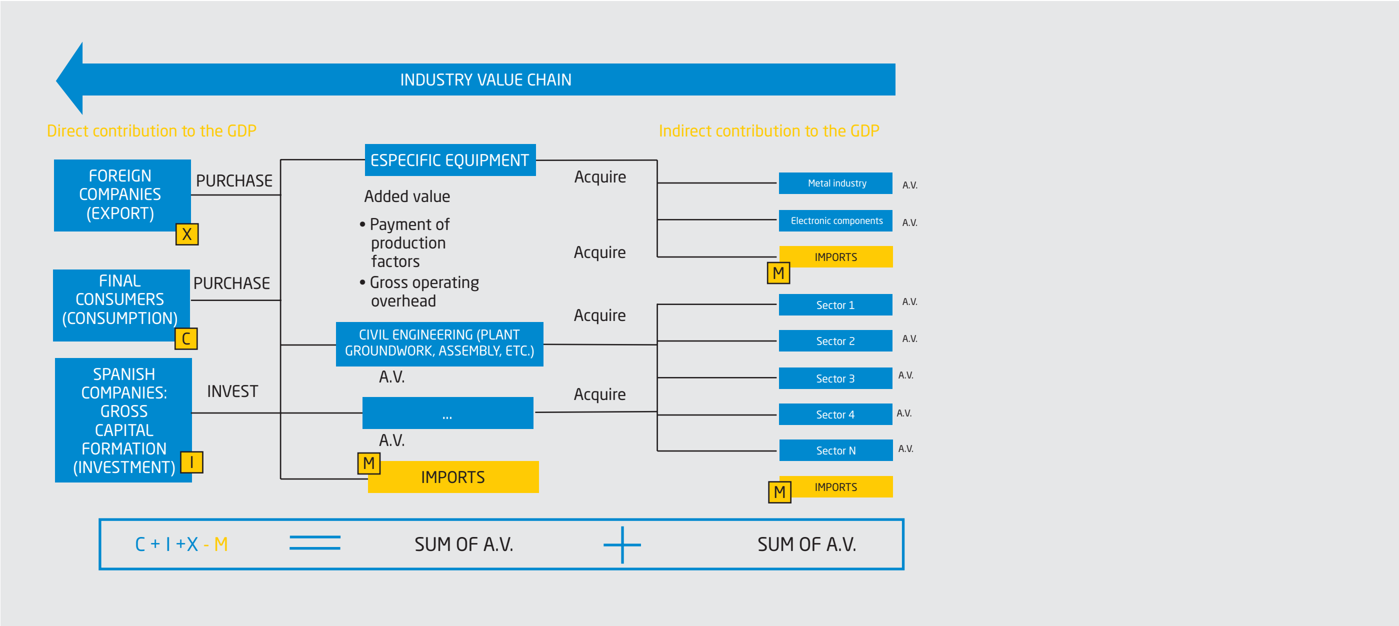


Figure 17.
Activities included in construction and operation and maintenance.

Collection of information

For the economy as a whole, company profit and loss accounts bring together the variables necessary to quantify the contribution to the individual GDP of each: operating income, operating expenses, salaries and wages paid, benefits, consumption of fixed assets (depreciation).

However, as a general rule, in Spain this technology is not the only activity of companies working in STE, which also work in general construction, contracting other power technologies, engineering services, etc.

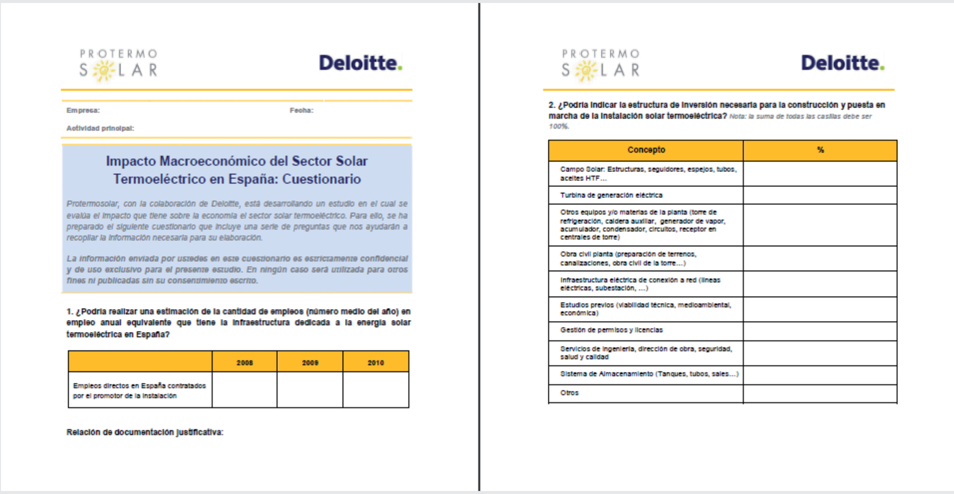
As it is impossible to separate the information on activities related to STE contained in the companies' financial statements, a questionnaire

was prepared in which they were asked in detail about the concepts necessary to calculate the contribution to the GDP. These questionnaires were filled out along with interviews given by appointment with industry agents.

The questionnaire included the following items:

- **Investment structure of a solar thermal power plant,** broken down into items imported or produced in Spain. The companies were also asked about the evolution of the amounts invested in 2008-2010 in this kind of facility.
- ***Ad hoc* profit and loss sheet of power plant operation:** income, margins, consumption of fixed assets, personnel expenses, benefits, supply structure including the percentage imported.
- **Direct employment** for plant design, contracting, construction and operation.
- **Percentage turnover of companies related to STE** to compare the information received with the information published in the companies' financial statements.
- Employment and economic effort invested in **research, development and innovation (RD&I).**
- **International presence** of Spanish companies.

The sample includes information from the questionnaires received from twelve STE power plant contractors, which represents about 64% of the companies involved in this activity in Spain. The technologies studied include parabolic-trough and tower, with and without storage.



PROTERMO SOLAR Deloitte.

Empresa: Fecha:

Actividad principal:

Impacto Macroeconómico del Sector Solar Termoeléctrico en España: Cuestionario

Protermosolar, con la colaboración de Deloitte, está desarrollando un estudio en el cual se evalúa el impacto que tiene sobre la economía el sector solar termoeléctrico. Para ello, se ha preparado el siguiente cuestionario que incluye una serie de preguntas que nos ayudarán a recopilar la información necesaria para su elaboración.

La información enviada por ustedes en este cuestionario es estrictamente confidencial y de uso exclusivo para el presente estudio. En ningún caso será utilizada para otros fines ni publicadas sin su consentimiento escrito.

1. ¿Podría realizar una estimación de la cantidad de empleos (número medio del año) en empleo anual equivalente que tiene la infraestructura dedicada a la energía solar termoeléctrica en España?

	2008	2009	2010
Empleos directos en España contratados por el promotor de la instalación			

Relación de documentación justificativa:

PROTERMO SOLAR Deloitte.

2. ¿Podría indicar la estructura de inversión necesaria para la construcción y puesta en marcha de la instalación solar termoeléctrica? *Nota: la suma de todas las casillas debe ser 100%.*

Concepto	%
Campo Solar: Estructuras, seguidores, espejos, tubos, aceites HTF…	
Turbina de generación eléctrica	
Otros equipos y/o materias de la planta (torre de refrigeración, caldera auxiliar, generador de vapor, acumulador, condensador, circuitos, receptor en centrales de torre)	
Obra civil planta (preparación de terrenos, canalizaciones, obra civil de la torre…)	
Infraestructura eléctrica de conexión a red (líneas eléctricas, subestación, …)	
Estudios previos (viabilidad técnica, medioambiental, económica)	
Gestión de permisos y licencias	
Servicios de ingeniería, dirección de obra, seguridad, salud y calidad	
Sistema de Almacenamiento (Tanques, tubos, sales…)	
Otros	

Figure 18.
Questionnaire given to the companies.

Data were also collected from power plants in operation and under construction in Spain, along with the start dates of construction and operation, assuming an average of 30 months for plants under construction. Thus, the number of MW under construction and in operation could be found on a monthly basis for 2008-2010.

The average investment per MW was calculated based on the information collected in the questionnaires, distinguishing between the different power plant technologies, and those with storage systems from those without. Later these averages were applied to the installed power each year to find the total investment in Spain.

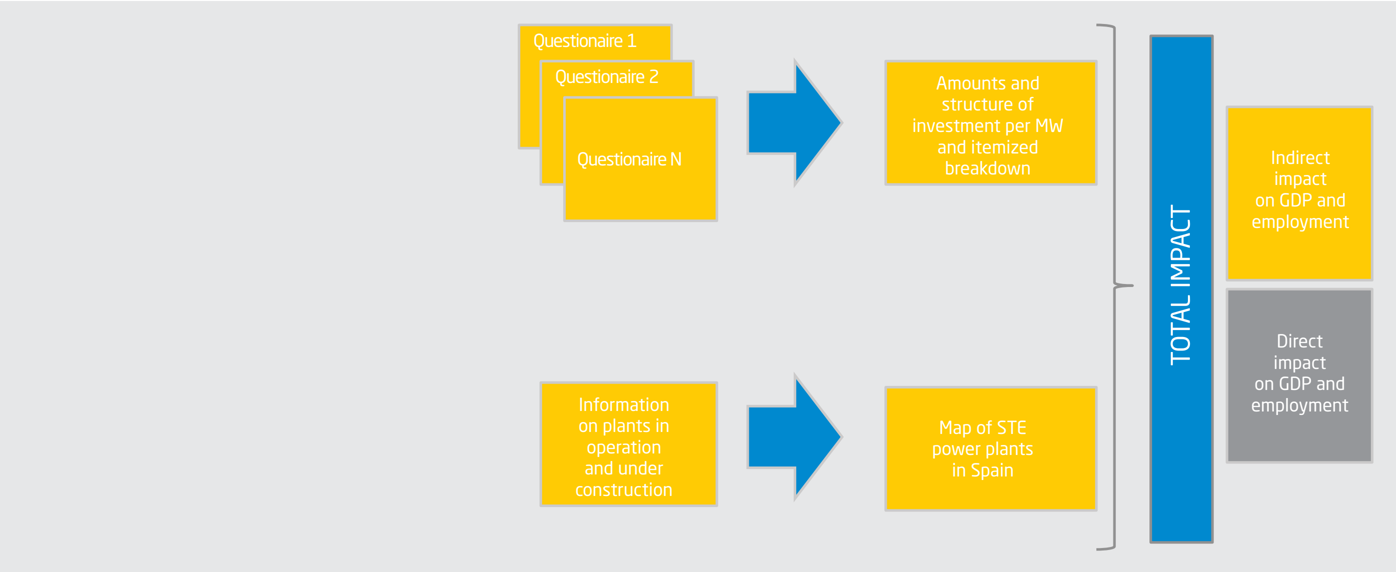


Figure 19.
Diagram of how the contribution to the GDP was calculated.

The questionnaire was distributed and interviews were held with component manufacturers and specific service providers in the industry. Using the data and a classification of these industries by their National Classification of Economic Activities code (CNAE), as well as the classification used by national accounting to make the input-output tables the contribution to the GDP and the number of jobs can be broken down by industry.

In this sense, the industries considered in the direct impact are given in the following table.

5. Input-output tables are a statistical-accounting instrument that shows the exchanges between different branches of the economy in a certain period of time. Based on the calculation of the technical coefficients and production multipliers, the bandwagon effect or indirect impact the industry has on the rest of the economy may be found.

Investment item	CNAE Code (93)	input-output table code
Solar Field		
Receiver tubes	Code 272. Tube manufacture	Metallurgy
Mirrors	Code 26120. Manipulation and transformation of flat glass	Manufacture of glass and glass products
Rotating joints	Code 27212. Production of iron tube accessories	Metallurgy
Hydraulic unit + local control	Code 2912. Manufacture of pumps, compressors and hydraulic systems	Machinery and mechanical equipment
Metal support frame	Code 28110. Manufacture of metal structures and their parts	Manufacture of metal products
Foundations	Code 45252. Foundations and pillars	Construction and assembly
Frame assembly	Code 45251. Assembly of frames and metal structures	Construction and assembly
Groundwork	Code 2811. Manufacture of metal structures and their parts	Manufacture of metal products
Assembly bay	Code 45217. Other construction work	Construction and assembly
Thermal oil	Code 24661. Treatment of oils and greases for industrial use.	Chemical industry
Header pipes, accessories, valves, etc.	Code 272. Manufacture of pipes	Metallurgy

Input-output tables also contain a breakdown by branch of activity of the composition of its contribution to the GDP (income, intermediate products, personnel expenses, production surplus) which allows ratios to be calculated: Gross Added Value / Production, jobs per million € Added Value, etc.

Investment item	CNAE Code (93)	input-output table code
Storage with salt		
Tanks	Code 28210. Manufacture of cisterns, large tanks and metal containers	Manufacture of metal products
Salt/HTF heat exchangers	Code 29230. Manufacture of non-residential ventilation and cooling machinery	Machinery and mechanical equipment
Salt heaters	Code 28300. Manufacture of steam generators	Manufacture of metal products
Salt	Code 24130. Manufacture of products based on inorganic chemistry	Chemical industry
Civil Engineering work	Code 45253. Other specialized construction work	Construction and assembly
Investment in the Power Island		
Civil Engineering work	Code 45253. Other specialized construction work	Construction and assembly
Mechanical equipment	Code 29. Machinery and mechanical industry equipment construction	Machinery and mechanical equipment
Electrical equipment	Code 31100. Manufacture of electrical motors, transformers and generators	Manufacture of electrical machinery and materials
Mechanical assembly	Code 45217. Other construction work	Construction and assembly
Electrical assembly	Code 45217. Other construction work	Construction and assembly
Instrumentation equipment	Code 312. Manufacture of electric control devices	Manufacture of and control electric machinery and material

Investment item	CNAE Code (93)	input-output table code
Instrumentation and control assembly	Code 45217. Other construction work	Construction and assembly
Piping, valves and supports	Code 272. Manufacture of pipes	Metallurgy
Others (Engineering, Contracting, etc.)		
Preliminary studies	Code 742. Architectural and engineering technical services and other activities related to technical consulting.	Other business activities/professional consulting, legal advisory and engineering services
Permitting and licensing	Code 74111. Consulting, advisory and legal practice Code 74112. Notaries and registries	Other business activities/professional consulting, legal advisory and engineering services
Engineering, site management, health, safety and quality services	Code 742. Architectural and engineering technical services and other activities related to technical consulting	Other business activities/professional consulting, legal advisory and engineering services
Other	Spanish economic environment	Spanish economic environment

2.2. Total impact on the Gross Domestic Product (GDP)

The contribution to the GDP by the STE Industry in 2010 was 1 650.4 million €. This figure is derived from plant contracting and construction, the sale of power, export of equipment related to the industry and the bandwagon effect on the rest of the economy[6]:

Contribution to GDP (millions of current €)	2008	2009	2010
Internal demand	1.616,0	2.243,9	2.872,8
Net exports	-893,4	-1.062,4	-1.222,4
Exports	40,7	85,2	133,7
Imports	934,1	1.147,6	1.356,1
Final demand	**722,6**	**1.181,6**	**1.650,4**
Income from operation	2.891,5	4.648,3	6.033,1
Consumption by operation	2.168,9	3.466,7	4.382,7
Added value	**722,6**	**1.181,6**	**1.650,4**
Payment of employees	621,3	988,0	1.274,1
Gross operating surplus	101,3	193,5	376,3
Payment for production factors	**722,6**	**1.181,6**	**1.650,4**

6. It should be mentioned that the study covers a completely known universe of power plants in operation and under construction, with precise figures provided by the companies themselves and compared with their financial statements.

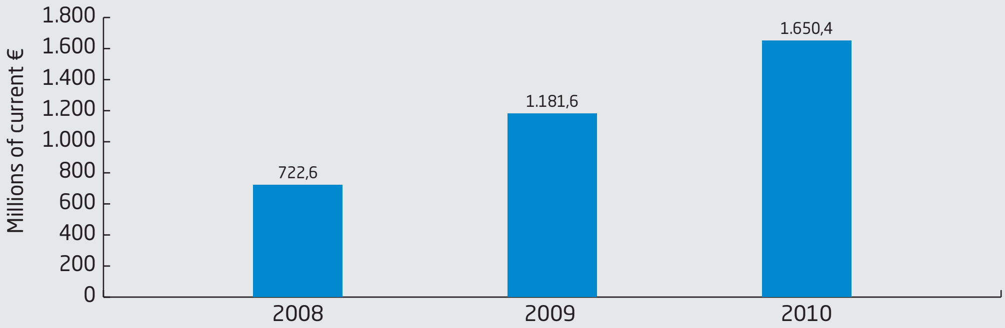


Figure 20.
Contribution to the GDP by the STE Industry (2008-2010) in millions of current Euros.

The STE Industry grew very considerably in 2008-2010. Its real contribution to the GDP went from 734.0 million € in 2008 to 1 650.4 million constant € (based on 2010) in 2010.

The percentage growth of the industry was very significant both in 2009 and in 2010. This was derived from the investment made in new power plants, and gradually, as the first plants built entered into operation, from the sale of power. Specifically, the industry's contribution to the GDP grew 62.5% in 2009 and 38.3% in 2010.

The difference in the growth rates is because in absolute terms, at the starting point (2008), the contribution to the GDP was considerably less, and therefore, the percentage growth in 2009 over that year was very high. It should be mentioned that these differences in growth rates do not mean the industry was slowing down, since absolute growth was practically identical in 2009 and 2010, around 450 million Euros more than the year before.

These data are especially important when compared to growth in other economic industries, or the economy on a whole, which in 2009 and 2010 accumulated a 3.7% and 0.1% fall in the GDP, respectively.

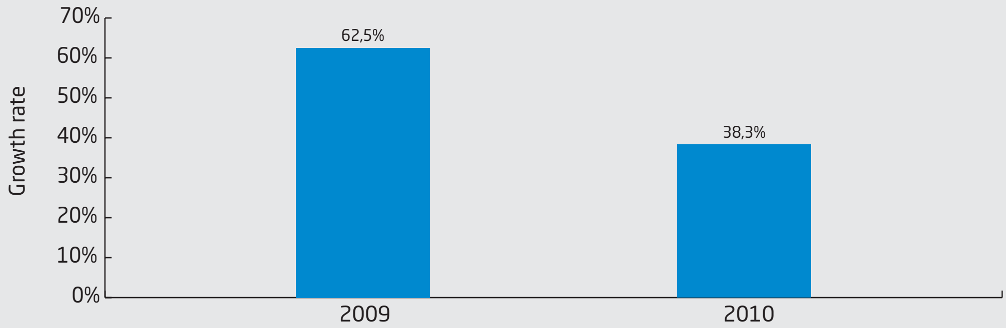


Figure 21.
Growth rate in the total contribution to the GDP by the STE industry (2009 and 2010).

The importance of the industry can be more clearly observed when comparing it to the whole economy and to other economic activities. As a result of STE industry growth and the moment in the Spanish economy, its relative weight went from 0.07% in 2008 to 0.16% recorded in 2010.

It may also be observed that the STE industry is comparable to other economic activities such as "extraction of energy products".

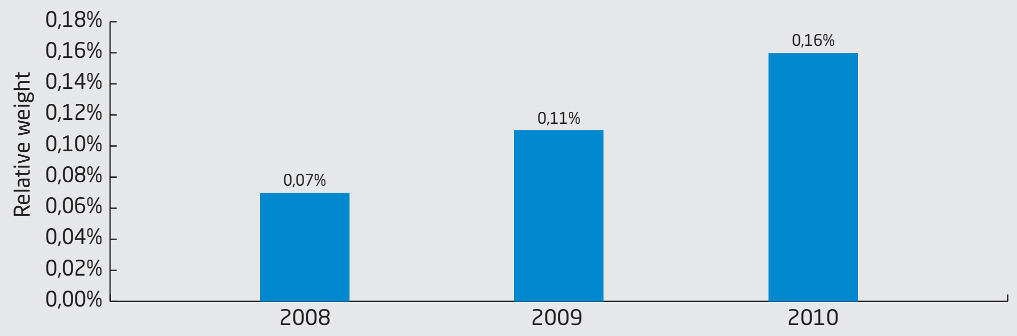


Figure 22.
Relative weight of the STE Industry compared to the whole Spanish economy (2008-2010).

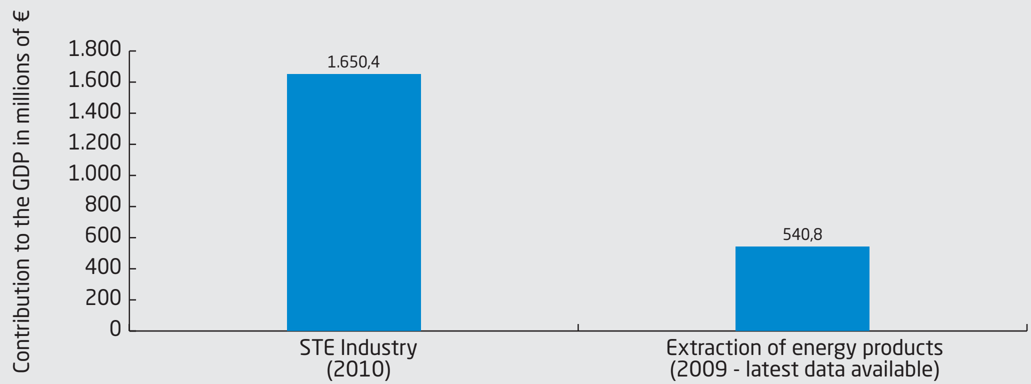


Figure 23.
Comparison of the STE industry and other economic activities.

The trade balance in the industry is negative, although these data are explained by observing the concentration of the investment in Spain: as it is the largest developer of this technology, equipment is imported from abroad to supply internal demand; as there is no important external demand, exports are minor. Imported equipment represents less than 30% of the whole investment in power plants both with and without storage.

At present, **Spanish companies can supply most of the equipment and services necessary in the STE value chain.** In this sense, the development of this technology in Spain could mean a very significant opportunity to achieve a competitive advantage and a position of world leadership.

Furthermore **there is a direct international presence of Spanish companies in the major markets:** they are currently present either because they are building power plants or because they have opened offices in the United States, India, North Africa, Mexico, Venezuela, Brazil, Chile, Italy, the Middle East, South Africa and Australia.

2.3. Contribution to the GDP during construction

The impact of STE Industry activities is divided between two very different stages: plant construction, and operation. This section describes the effects derived from construction, including the following tasks:

- Plant design and R&D activities
- Contracting projects
- Preliminary studies: technical feasibility, environmental impact, economic and financial estimates
- Engineering, site management, health, safety and quality services

- Component and specific equipment manufacturing

  - Solar field: support frames, trackers, mirrors, tubes, HTF oil
  - Turbine and alternator
  - Other plant equipment and/or materials: cooling tower, secondary boiler, steam generator, hydraulic pumps, accumulator, condenser, circuits, storage systems, etc.

- Instrumentation and control
- Plant civil engineering work: groundwork, foundations, channeling, water supply, buildings
- Plant assembly and commissioning
- Grid connection electrical infrastructure: power lines, substation, etc.

The procedure followed for calculating the economic impact of plant construction was as follows:

1) **An inventory was taken of all the plants under construction and in operation in 2008-2010, giving construction start and completion dates** and differentiating between plants with and without storage.

   A period of 30 months from the start of construction to completion was estimated for plants under construction as of December 2010. The figures below show month by month, which plants were under construction and which in operation from 2008-2010.

Power plant	Commis-sioned 2010	Capacity (MW)	Storage	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08
EXTRESOL 2	Yes	50	Yes	X	X	X	X	X	X	X	X	X	X	X
SOLNOVA 1	Yes	50	No	O	O	O	O	O	O	O	O	O	O	O
SOLNOVA 3	Yes	50	No	O	O	O	O	O	O	O	O	O	O	O
LA FLORIDA	Yes	50	Yes	X	X	X	X	X	X	X	X	X	X	X
SOLNOVA 4	Yes	50	No		O	O	O	O	O	O	O	O	O	O
MAJADAS	Yes	50	No				O	O	O	O	O	O	O	O
LA DEHESA	Yes	50	Yes				X	X	X	X	X	X	X	X
MANCHASOL 1	Yes	50	Yes					X	X	X	X	X	X	X
PALMA DEL RÍO II	Yes	50	No						O	O	O	O	O	O
ANDASOL 3	No	50	Yes			X	X	X	X	X	X	X	X	X
GEMASOLAR	No	17	Yes										X	X
ARCOSOL-50	No	50	Yes											
ASTE 1A	No	50	Yes											
ASTE 1B	No	50	Yes											
ASTEXOL II	No	50	Yes											
CASA DE LOS PINOS	No	1	No											
HELIOENERGY 1	No	50	Yes											
HELIOENERGY 2	No	50	Yes											
HELIOS 1	No	50	Yes											
HELIOS 2	No	50	Yes											
LEBRIJA 1	No	50	No											O
PALMA DEL RÍO I	No	50	No											
PUERTO ERRADO II	No	30	Yes											
GUZMÁN	No	50	Yes											
SOLABEN 2	No	50	No											
SOLABEN 3	No	50	Yes											
SOLACOR 2	No	50	Yes											
SOLACOR 1	No	50	No											
TERMESOL-50	No	50	Yes											
GUZMAN	No	50	Yes											
LA AFRICANA	No	50	Yes											
ORELLANA	No	50	No											
EXTRESOL 3	No	50	Yes											
MANCHASOL 2	No	50	Yes											
MORÓN	No	50	Yes											
OLIVENZA 1	No	50	Yes											

O: Without storage
X: With storage

Figure 24.
Resume of the CSP plants under construction.

Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O							
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O						
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O				
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
											O	O	O	O	O	O	O	O	O	O	O	O	O	O
								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
																	X	X	X	X	X	X	X	X
																							X	X
																		O	O	O	O	O	O	O
																		X	X	X	X	X	X	X
															X	X	X	X	X	X	X	X	X	X
														O	O	O	O	O	O	O	O	O	O	O
												X	X	X	X	X	X	X	X	X	X	X	X	X
																X	X	X	X	X	X	X	X	X
																	X	X	X	X	X	X	X	X
																								O
																				X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
																X	X	X	X	X	X	X	X	X

Power plant	Commis-sioned 2010	Capacity (MW)	Storage	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08
PS10	Yes	11	Yes											
ANDASOL-1	Yes	50	Yes											
PS20	Yes	20	Yes											
PUERTO ERRADO I	Yes	1,4	Yes											
IBERSOL PUERTOLLANO	Yes	50	No											
LA RISCA	Yes	50	No											
ANDASOL-2	Yes	50	Yes											
EXTRESOL 1	Yes	50	Yes											
EXTRESOL 2	Yes	50	Yes											
SOLNOVA 1	Yes	50	No											
SOLNOVA 3	Yes	50	No											
LA FLORIDA	Yes	50	Yes											
SOLNOVA 4	Yes	50	No											
MAJADAS	Yes	50	No											
LA DEHESA	Yes	50	Yes											
MANCHASOL 1	Yes	50	Yes											
PALMA DEL RÍO II	Yes	50	No											

Without storage
With storage

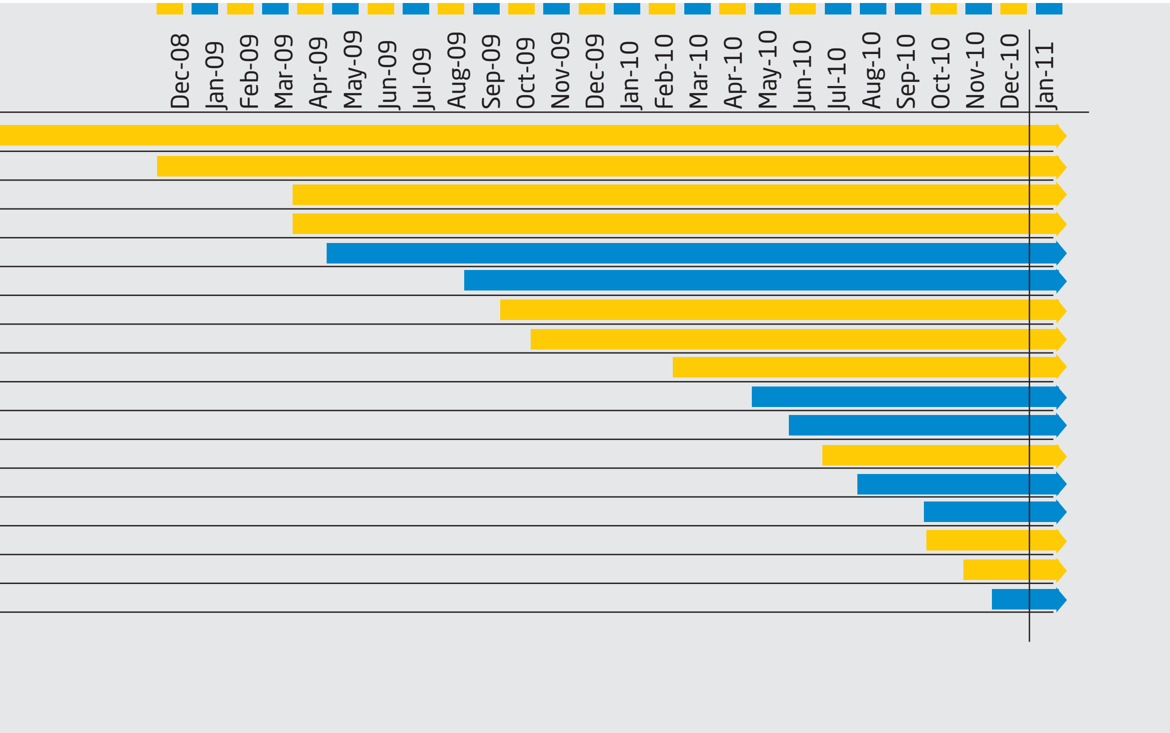


Figure 25.
Resume of the CSP plants in operation on December 2010.

2) An **itemized solar thermal power plant investment structure, including parts** acquired in Spain and those that had to be imported, was conceived based on the questionnaire and interviews mentioned above.

During the interviews, the companies were asked how the invested amounts had evolved in 2008, 2009 and 2010.

According to the data collected, the investment structure and the amounts necessary for the typical 50-MW parabolic-trough plant, which presently makes up the majority in Spain, are the following:

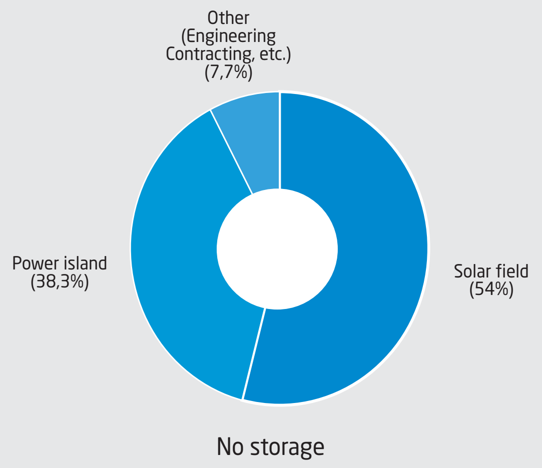


Figure 26.
Investment structure for a parabolic-trough plant without storage.

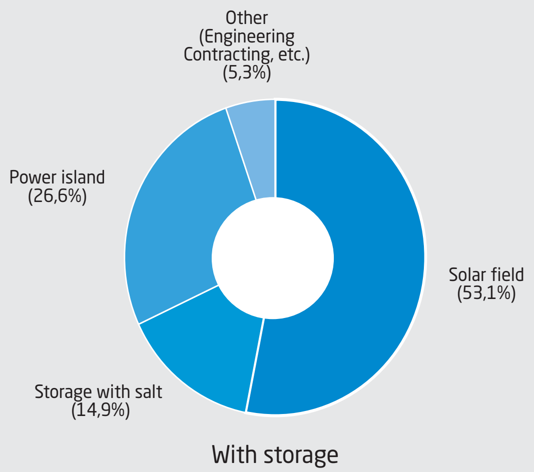


Figure 27.
Investment structure for a parabolic-trough plant with storage.

In 2010, investments in plants with and without storage were 531 and 2 130 million €, respectively.

This situation with respect to investment in the technology should be limited to Spain and the parabolic-trough technology. Today, taking tenders for innovative projects in 2010 as a reference, there would be new items for future plants that would make electricity generated 15-20% cheaper.

Electricity would also now cost 30% less in plants installed outside of Spain at sites with 2 600 kWh/yr. The companies surveyed estimated a 15% reduction in the cost per MW installed if the size of the plant were 100 MW instead of the 50 MW to which they are limited by the Special Regime's regulations.

3) The **average of MW under construction during the years studied** was calculated with the data collected in the two points above. Using the necessary investment and the percentage made in Spain, it was possible to quantify the total direct investment in this technology.

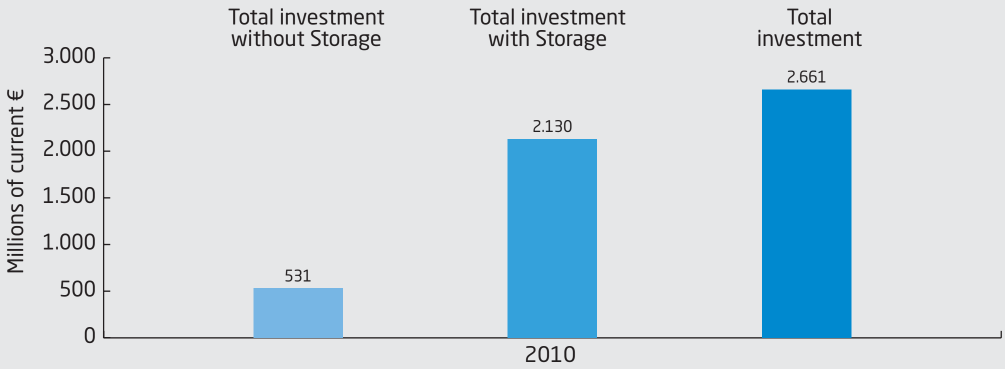


Figure 28.
Total investment and average MW under construction (2010).

4) When the total investment was found, **it was itemized, differentiating between domestic and foreign purchasing.**

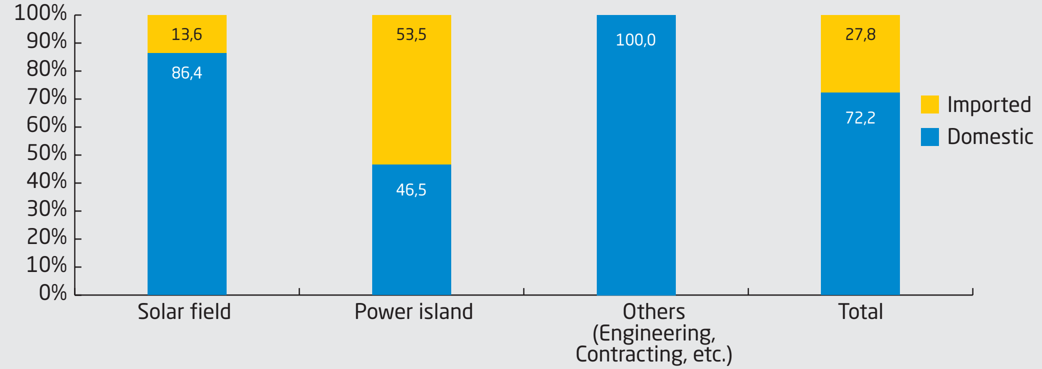


Figure 29.
Itemized percentage of investment which remains in Spain for plants without storage (2010).

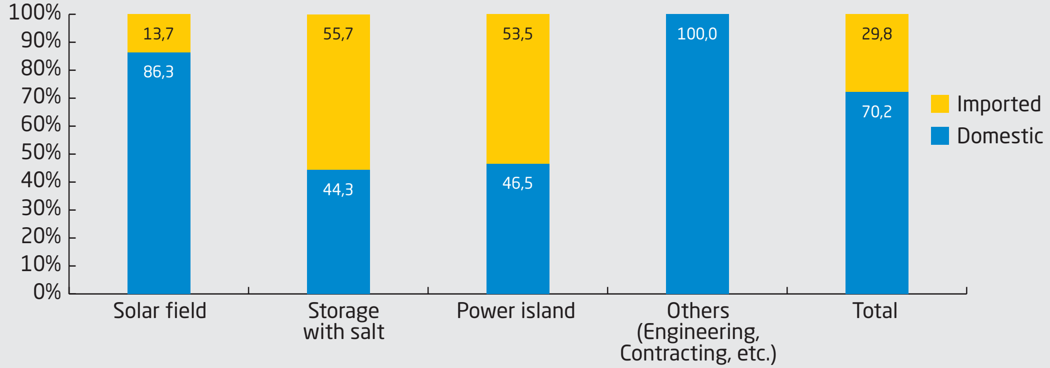
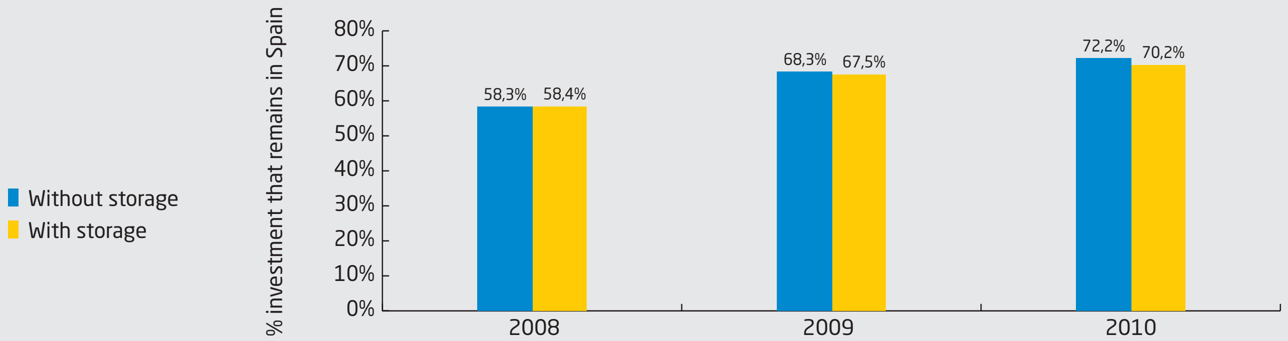


Figure 30.
Itemized percentage of investment which remains in Spain for a plant with storage (2010).

Figure 31.
Evolution of the percentage investment that remains in Spain (2008-2010).

According to the data collected for plants built during 2008-2010, **over 70% of the investment in plants, with and without storage systems, would remain in Spain in 2010.**



It should be pointed out that these percentages represent the reality associated with plants built up to 2010, some of which had a stock of equipment imported before construction was begun. At the present time, except for the turbine, and certain very minor fluids and components, the great majority of the value chain can be manufactured in Spain.

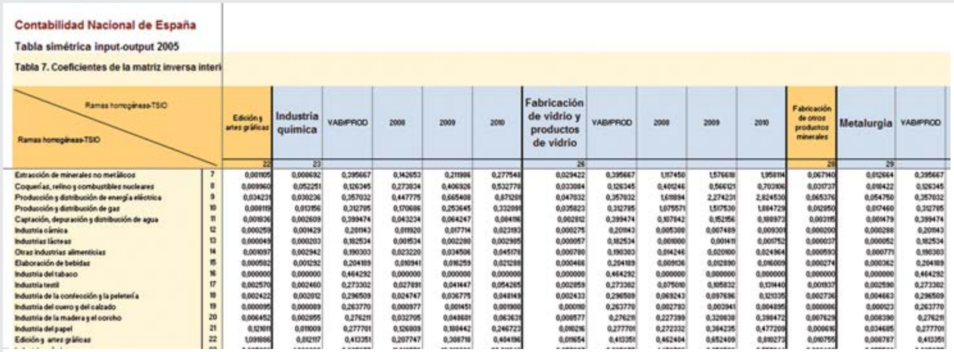
With regards to the future, this is a very important subject, as Spain should take advantage of its position and create an auxiliary industry able to innovate at the level of components and equipment, in addition to systems, to consolidate its position of leadership in this technology.

5) Based on the breakdown above, and using added value coefficients for production, personnel costs, and operating surplus, specific to each industry the investments are allocated to, it was possible to quantify the contribution to the GDP during this stage.

Exports of equipment from Spain to the rest of the world were added to these items, which in 2010, were beginning to be significant.

6) Finally, **the bandwagon effect on the rest of the economy was quantified** by using the input-output tables model published by the National Institute of Statistics.

Figure 32.
Image of the inner table of coefficients of the Leontief matrix.



Contabilidad Nacional de España

Tabla simétrica input-output 2005

Tabla 7. Coeficientes de la matriz inversa interi

Ramas homogéneas-TSIO / Ramas homogéneas-TSIO		Edición y artes gráficas	Industria química	VAB/PROD	2008	2009	2010	Fabricación de vidrio y productos de vidrio	VAB/PROD	2008	2009	2010	Fabricación de otros productos minerales	Metalurgia	VAB/PROD
		22	23					26					28	29	
Extracción de minerales no metálicos	7	0,001105	0,008692	0,395667	0,142653	0,211986	0,277548	0,029422	0,395667	1,117450	1,576618	1,958114	0,067140	0,012664	0,395667
Coquerías, refino y combustibles nucleares	8	0,009960	0,052251	0,126345	0,273834	0,406926	0,532778	0,033084	0,126345	0,401246	0,566121	0,703106	0,031737	0,018422	0,126345
Producción y distribución de energía eléctrica	9	0,034231	0,030236	0,357032	0,447775	0,665408	0,871201	0,047032	0,357032	1,611894	2,274231	2,824530	0,065376	0,054750	0,357032
Producción y distribución de gas	10	0,008119	0,013156	0,312785	0,170686	0,253645	0,332091	0,035823	0,312785	1,075571	1,517530	1,884729	0,012950	0,017460	0,312785
Captación, depuración y distribución de agua	11	0,001836	0,002609	0,399474	0,043234	0,064247	0,084116	0,002812	0,399474	0,107842	0,152156	0,188973	0,003115	0,001479	0,399474
Industria cárnica	12	0,000259	0,001429	0,201143	0,011920	0,017714	0,023193	0,000275	0,201143	0,005308	0,007489	0,009301	0,000200	0,000298	0,201143
Industrias lácteas	13	0,000049	0,000203	0,182534	0,001534	0,002280	0,002985	0,000057	0,182534	0,001000	0,001411	0,001752	0,000037	0,000052	0,182534
Otras industrias alimenticias	14	0,001097	0,002942	0,190303	0,023220	0,034506	0,045178	0,000780	0,190303	0,014246	0,020100	0,024964	0,000593	0,000771	0,190303
Elaboración de bebidas	15	0,000582	0,001292	0,204189	0,010941	0,016259	0,021288	0,000466	0,204189	0,009136	0,012890	0,016009	0,000274	0,000362	0,204189
Industria del tabaco	16	0,000000	0,000000	0,464292	0,000000	0,000000	0,000000	0,000000	0,464292	0,000000	0,000000	0,000000	0,000000	0,000000	0,464292
Industria textil	17	0,002570	0,002460	0,273302	0,027891	0,041447	0,054265	0,002859	0,273302	0,075010	0,105832	0,131440	0,001937	0,002590	0,273302
Industria de la confección y la peletería	18	0,002422	0,002012	0,296509	0,024747	0,036775	0,048149	0,002433	0,296509	0,069243	0,097696	0,121335	0,002736	0,004663	0,296509
Industria del cuero y del calzado	19	0,000095	0,000089	0,263770	0,000977	0,001451	0,001900	0,000110	0,263770	0,002793	0,003941	0,004895	0,000006	0,000123	0,263770
Industria de la madera y el corcho	20	0,006452	0,002955	0,276211	0,032705	0,048601	0,063631	0,008577	0,276211	0,227399	0,320838	0,398472	0,007629	0,008390	0,276211
Industria del papel	21	0,121011	0,011009	0,277701	0,126809	0,188442	0,246723	0,010216	0,277701	0,272332	0,384235	0,477209	0,000616	0,034685	0,277701
Edición y artes gráficas	22	1,091886	0,012117	0,413351	0,207747	0,308718	0,404196	0,011654	0,413351	0,462404	0,652409	0,810273	0,010755	0,008787	0,413351

According to these calculations, **the contribution to the GDP during construction came to 1 475.2 million current € in 2010,** which represented about 89.4% of the total for the STE industry.

Figure 33.
Contribution to the GDP during construction (2008-2010) in millions of current Euros.

Contribution to GDP in millions of current €	2008	2009	2010
Income from operation	2.886,1	4.612,1	5.790,1
Consumption by operation	2.167,4	3.456,6	4.314,9
Added value	718,7	1.155,5	1.475,2
Payment of employees	620,6	982,1	1.251,7
Operation surplus	98,1	173,4	223,5
Payment for productions factors	718,7	1.155,5	1.475,2

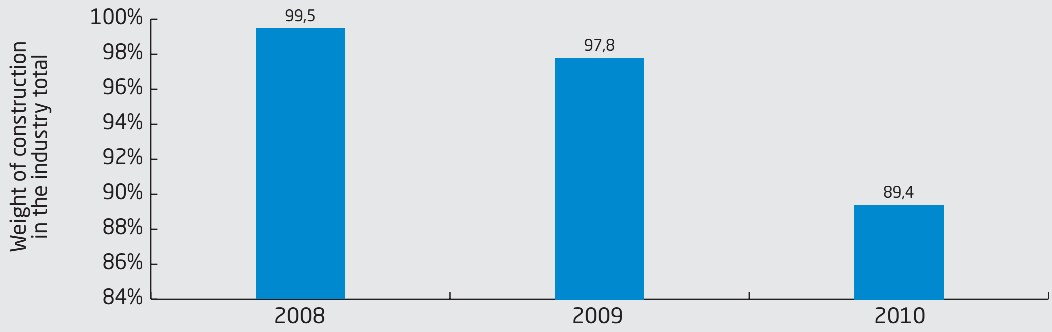


Figure 34.
Relative weight of construction in the STE Industry.

Real industry growth in 2009 and 2010 was 59.8% and 26.4%, respectively. As mentioned above, the difference in growth rates is that, in absolute terms, at the starting point (2008), the contribution to the GDP was considerably less, and therefore the percentage growth in 2009 with respect to that year is very high.

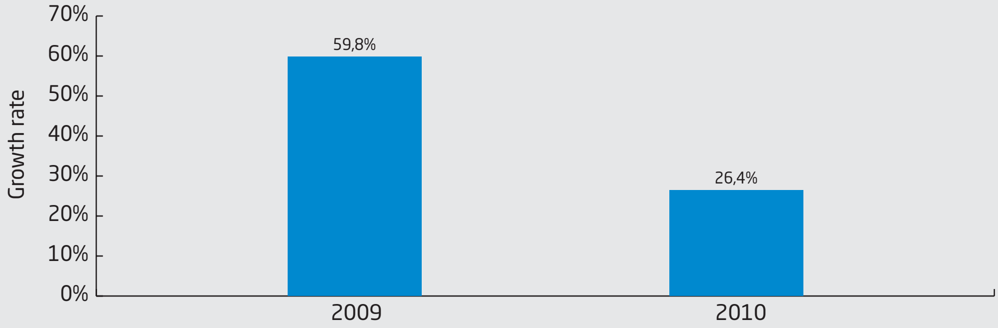


Figure 35.
Growth rate of the total contribution to the GDP during construction (2009 and 2010).

Broken down by industry, **it is observed that the GDP contribution concentrated on industries, such as manufacture of metal products, manufacture of glass, and metallurgy, and those which were heavily affected by the economic crisis in Spain, as for example construction and assembly.**

In this context, STE has contributed significantly to alleviating the diminished activity recorded in these industries, contributing to revaluing the economy, and to generating employment.

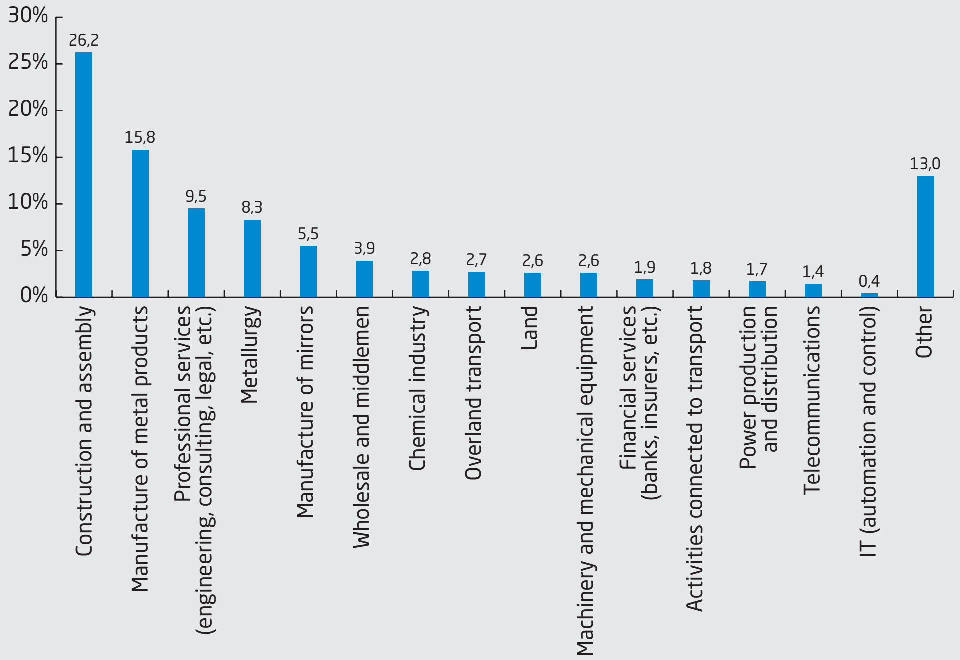


Figure 36.
Percentage contribution to the GDP by other economic industries during construction.

2.4. Contribution to the GDP during operation and maintenance

At the beginning of 2008, only the 10-MW PS10 in Seville was in operation. At the end of 2010, according to information from the National Energy Commission, there were 531.5 MW of STE in operation, and 200 MW more that went into operation in early 2011 would have to be added to that.

The growth in this technology is observed to be very significant. **In terms of power sold, in 2008, STE produced 15.4 GWh, while in 2010, this figure multiplied 44 times to 691.5 GWh.**

This evolution means that income of the companies that operate solar thermal power plants increased. The contribution to the GDP by operation and maintenance can be quantified using the average company operating margins acquired from interviews and questionnaires.

According to calculations, the contribution to the GDP during this stage was 175.2 million €, derived from the sale of electricity and the bandwagon effect in other economic industries.

Contribution to GDP in millions of current €	2008	2009	2010
Income from operation	5,4	36,2	243,0
Consumption by operation	1,5	10,1	67,8
Added value	**3,9**	**26,1**	**175,2**
Income from operation	0,6	6,0	22,4
Consumption by operation 3,2	20,1	152,8	
Payment for production factors	**3,9**	**26,1**	**175,2**

Figure 37.
Contribution to the GDP by O&M (2008-2010) en millions of current Euros.

It is important to mention that income from operation is consistent with what is published by the National Energy Commission, since the 243.0 million € includes the total payment to STE plants plus income recorded by their suppliers.

Figure 38.
Mirror cleaning process in a parabolic through CSP plant.

Gross operating surplus, which includes plant amortization and the returns received by investors that make their investment profitable, is outstanding. In real terms, **the industry has grown in 2009 and 2010, by 567.0% and 564.1%, respectively.**

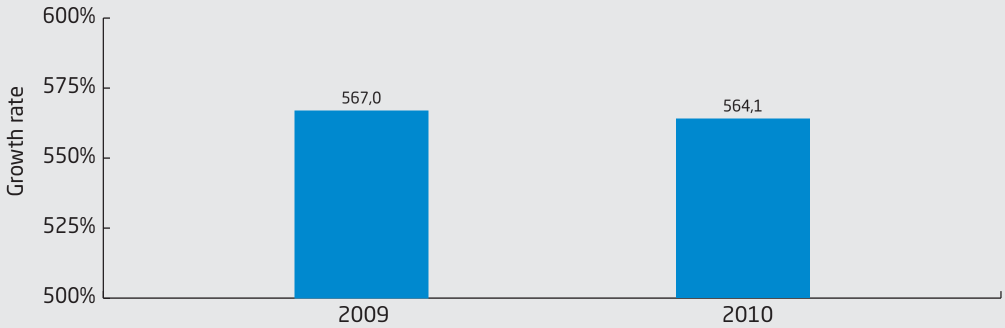


Figure 39.
Growth rate of the total contribution to the GDP by O&M (2009 and 2010).

2.5. Employment

Growth of STE in Spain is also observed in the number of jobs it has created in recent years, both during construction, where they are mostly concentrated, and during operation and maintenance. The study shows that jobs are derived from contracting, construction and maintenance, as well as jobs generated in the rest of the economy as a consequence of all these activities[8].

The number of equivalent jobs generated during 2008-2010 has been quantified in terms of equivalent jobs per year[9], and was acquired from the following sources of information:

- For specific plant construction, assembly and commissioning activities, inquiries were made of the construction companies and verified with records of plant income.
  Coefficients of employment per unit of added value specific to each industry were also used to quantify employment generated in those industries and in the rest of the economy by the bandwagon effect.
- For plant operation and maintenance activities, the owners were asked: in this case, employment not only by the company itself but also by the subcontractors in charge of operation and maintenance was included.
  The impact on other economic industries (power supply, water, gas, insurance, etc.) from the bandwagon effect was added to this based on employment multipliers.

7. The study does not include jobs derived from the investment necessary to adapt infrastructures unrelated to STE, but that could be affected by the existence and development of this technology (accommodations, restaurants, etc.).
8. In this sense, at certain times of the year, the number of people employed could be higher or lower, depending mainly on the stage of construction of the plant.

According to the information collected, the STE industry employed a total of 23 844 people in 2010: 23 398 people during construction and 446 people during operation.

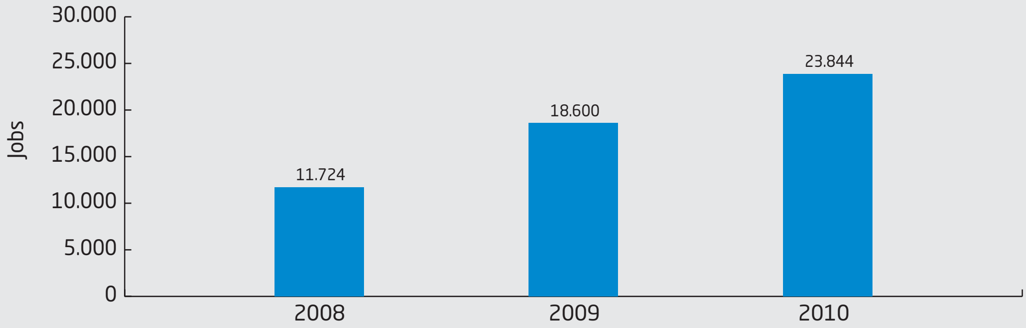


Figure 40.
Total number of jobs created by the STE industry (2008-2010).

Jobs	2008	2009	2010
Construction	11.713	18.492	23.398
- Plan contracting, construction and assembly	4.399	6.447	8.049
- Components and equipment	4.515	7.442	9.542
- Jobs in the rest of the economy	2.799	4.603	5.807
Power production - O&M	13	123	446
- Plant operation and maintenance	11	108	344
- Jobs in the rest of the economy	2	15	102
TOTAL JOBS	11.724	18.600	23.844

Figure 41.
Breakdown by industry activity of jobs created by the STE Industry (2008-2010)[9].

9. "Plant contracting, construction and assembly" includes people employed by the plant and also in other construction work or professional activities (technical and economic studies, consulting and advisory services, etc.).

"Components and equipment" includes manufacture of machinery specific to the solar field and the rest of the equipment (Manufacture of glass and glass products, metallurgy, manufacture of metal products, machinery and mechanical equipment, office machinery and IT equipment, manufacture of electric machinery and material.

"Jobs in the rest of the economy" includes the rest of the jobs created by the bandwagon effect in other economic industries.

2.6. Contribution to the GDP and employment forecasted for 2020

The forecasted STE contribution to the GDP and employment presented below is based on a scenario of evolving remuneration of the technology and the following assumptions:

- **Related to installed power**

  - Installed power between 2014 and 2020 evolves linearly. This means that 360 MW will be installed in 2020, the same number of megawatts installed in previous years.
  - By 2020, there will be a 40% reduction in the investment cost in respect to 2010.
  - The total percentage of the investment supplied by Spanish companies is estimated at 75%.
  - The ratio of total employment per MW is the same recorded in 2010, 40.1 jobs per MW/year. This includes jobs in contracting, design, construction, assembly, manufacture of equipment and other components, as well as in other industries.

- **Related to plant operation**

  - Remuneration of STE: 25% reduction in the feed-in tariff received by producers for electricity generated from STE in 2014, and linear decrease to 140 €/MWh in 2020.
  - The operating margin and coefficient of indirect impact are the same as in 2010.
  - The jobs/GWh ratio is the same as in 2010.

According to the assumptions listed above, STE would have the impact on the GDP and on employment in Spain described in the figures below:

Figure 42.
Forecasted STE contribution to the GDP (2020).

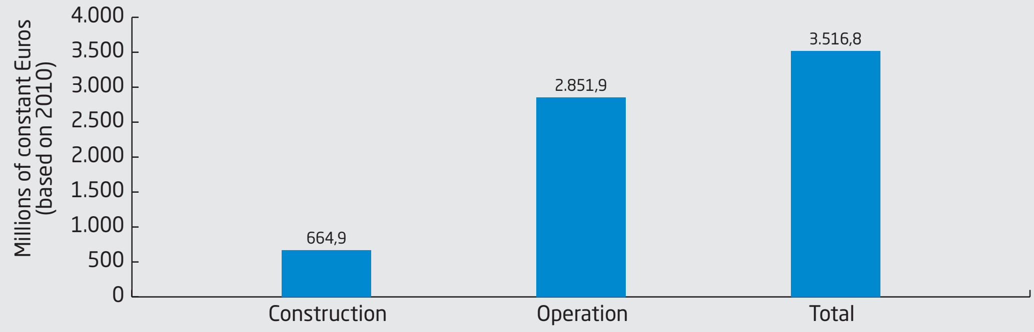
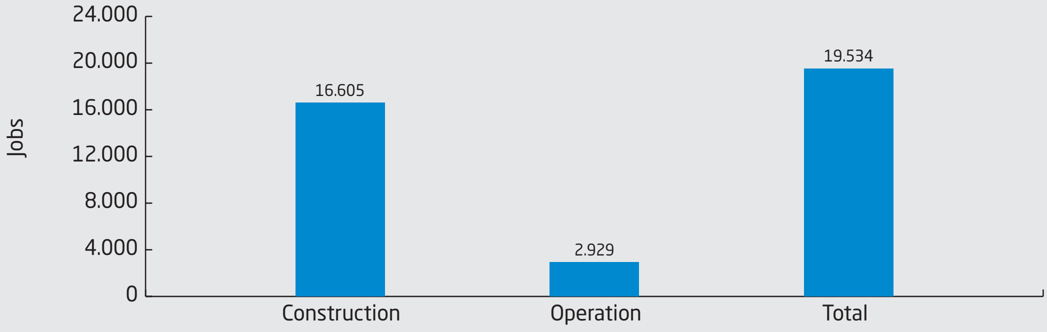


Figure 43.
Forecasted employment generated by STE (2020).



2.7. STE contribution to Social Security, Corporate and Personal Income Tax (IRPF)

Based on the quantification of items such as salaries and wages and company benefits (gross operating surplus less amortization), and mean industry coefficients, it is possible to estimate the amounts paid to social security, corporate tax and personal income tax (IRPF).

Social Security payments

As mentioned above, the contribution to the GDP can be calculated based on three equivalent methods: added value, final demand and payment for production factors. The last method is the sum of the gross operating surplus and payment of employees, which in turn can be divided into gross salaries and wages and social security payments.

In the sections above, the salaries paid to employees were itemized. Using industry coefficients for social security payments on this item, we find that:

- The activities performed by the STE Industry (construction, operation and associated indirect impact) **contributed over 269.7 million € to social security in 2010.**
- This represented 21.2% of the total remuneration of employees in 2010.

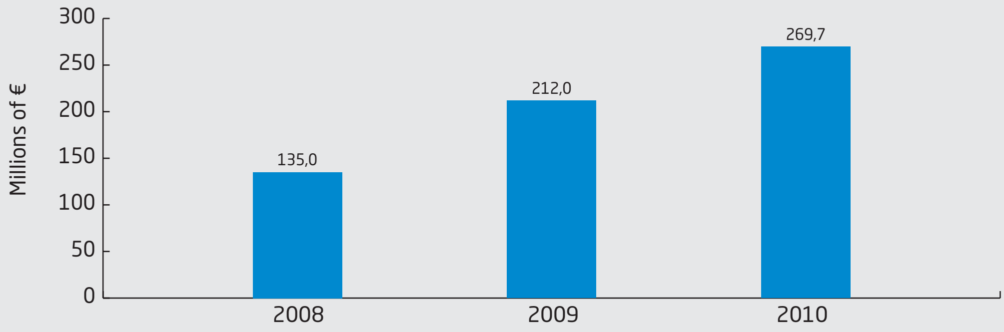


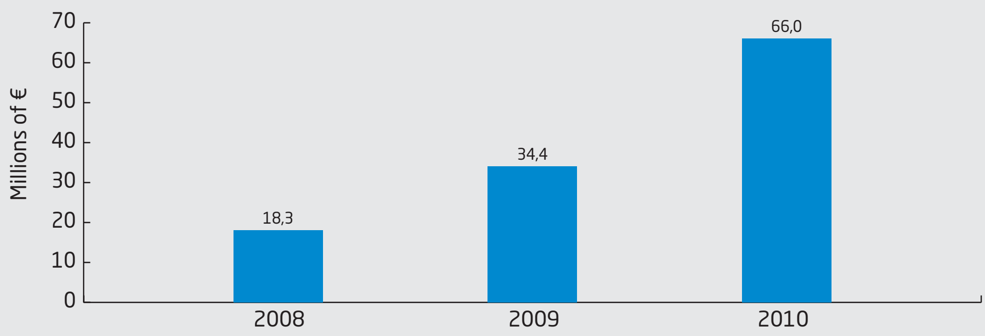
Figure 44.
Social security payments in the STE Industry.

Corporate tax

The corporate tax paid by companies in the STE Industry has been estimated[10]. To do this, an average rate was calculated from the profit and loss sheets of the main companies weighted by their importance in the industry. Then this coefficient was multiplied by the net operating surplus[11].

The result is that companies in the STE Industry have paid a total of 66.0 million € in 2010. It is important to point out the significant increase in the amounts paid for this item in 2010, consequence of the increase in revenues from sale of electricity as new plants went into production.

Figure 45.
Corporate taxes paid.



10. Corporate taxes attributable to activities in the STE Industry.
11. The net operating surplus is found by subtracting consumption of fixed assets (depreciation) from the gross operating surplus. Although in macroeconomics, this concept also includes income of free-lance workers and unincorporated companies, for the purposes of this report, it may be understood as equivalent to company profit derived from production.

Personal income tax

Finally, personal income tax paid (IRPF) was estimated. It should be mentioned that as this tax varies according to the particular situation of each contributor (number of children, purchase of home, etc.), a mean coefficient of contribution was calculated by dividing the total collected by the total number of payments in the Spanish economy, and then multiplying this quotient by the number of workers in the STE industry.

According to these estimates, in 2010, workers in the Industry would have contributed 70.8 million € in personal income tax.

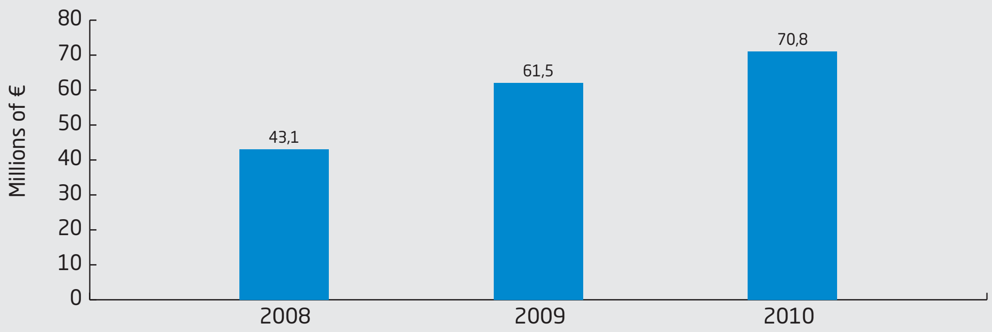


Figure 46.
Personal income tax paid (IRPF).

2.8. Contribution to the GDP and to employment by a 50-MW parabolic trough plant with 7.5 hours salt storage

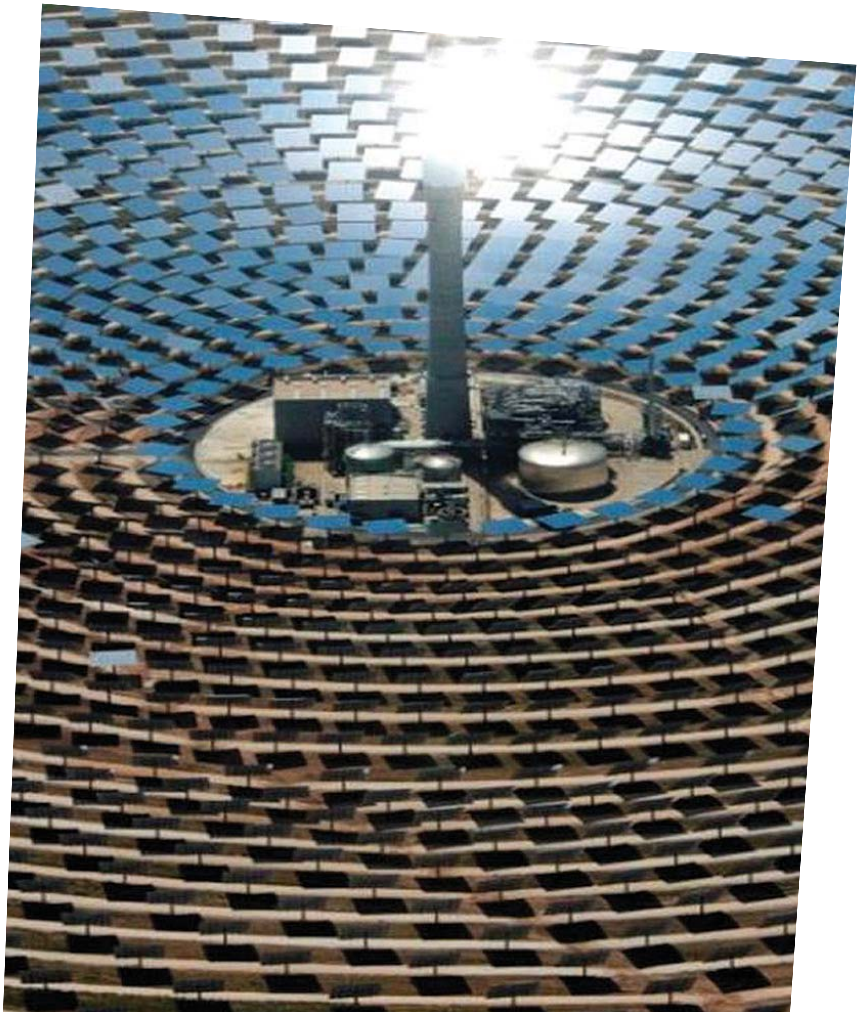
In the above sections, the economic impact of the whole STE Industry in Spain was described in terms of its contribution to the GDP, and employment associated with the deployment of STE plants. However, it would be especially illustrative to observe the individual impact of the construction of a single plant.

The results for a "typical" 50-MW parabolic-trough plant with 7.5 hours storage capacity, the most widespread type in Spain, are presented below. The same methodology, and data collected in the questionnaires for the whole Industry (referring to 2010), were applied.

According to the calculations, a typical plant has the following results:

- A **total GDP contribution during construction of 192.1 million €** in 30 months (76.8 million €/year).
- **A total GDP contribution during operation of 44.3 million €/year**
- **A total of 2 214 equivalent jobs per year during contracting and construction,** including contracting, construction and assembly, as well as manufacture of components and equipment, supply of services and indirect employment.
- **A total of 47 equivalent jobs** per year during operation.

RD&I effort



3

3.1. Importance of the contribution to RD&I

The opportunities for innovation in STE technology are substantial.Even though the technology has existed since the eighties, it is only since 2006 that it has taken off, mainly in Spain and in the United States.

In this sense, it is fundamental that economic incentives be established to facilitate RD&I, ensuring the technology's process and avoiding future projects being a repetition of current plants.

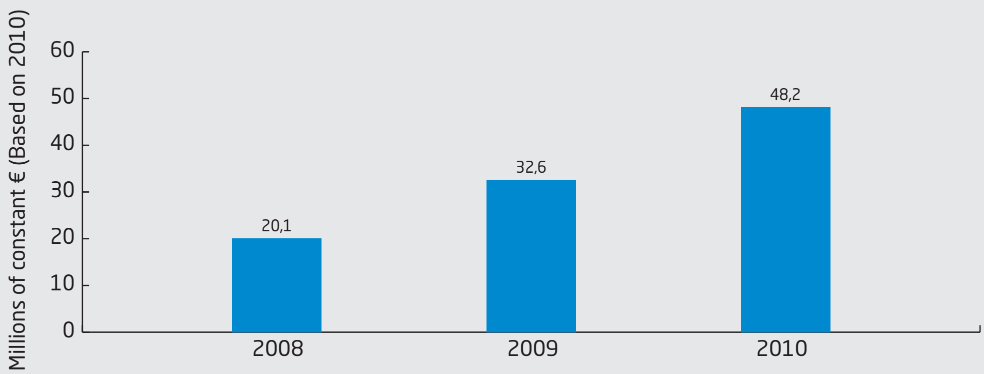
Spanish companies are participating, along with public entities, in national and European projects developing solutions applied to STE, such as NER300, the 7th Framework Program and national and regional programs.

The effort made by many companies to develop solutions for their plants is also considerable.

- **New plant concepts;** considering the eventual advantages of other designs over those most used at present
- **Technological development of the solar field**
  - Test loops for direct heat generation
  - Improved oil flow management
  - Development of more efficient parabolic-troughs and heliostats
- **Modernization of plant design processes**
  - Plant-specific technological solutions
  - Improved land use
- **Modernization of equipment manufacturing processes**

In economic terms, the RD&I effort for 2010 was 48.2 million €, which represents 2.9% of the total contribution to the GDP. This figure was calculated from the interviews held with companies in the Industry and represents, in relative terms with respect to its contribution to the GDP, about double the average contribution to RD&I recorded for the whole Spanish economy, and is above the average in countries like Germany or the United States.

Figure 47.
RD&I effort in the Solar Thermal Industry (2008-2010).



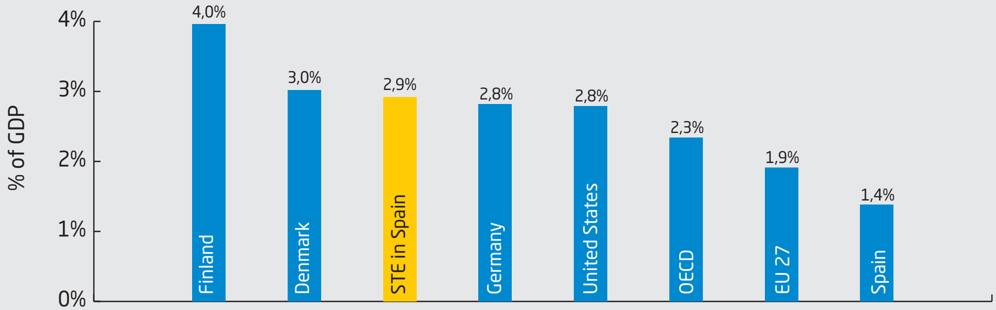


Figure 48.
RD&I effort compared to the GDP. Data for Denmark, Finland, STE, Germany, EU27 and Spain are from 2009; the United States and OECD 2008.

3.2. Possibilities for future development

Spain could have a fundamental role in the technological development of STE, by contributing innovative solutions that enable it to increase performance, and thereby, investment and operating costs. There are opportunities in all of the STE technologies, since each of them could find its specific niche in the market.

Technology	Line of Research	Advances
All	Startup and variations during the day	• Management of startup procedures, operating modes and use of reserve power to optimize production
Parabolic trough	Solar field	• New more efficient, resistant, and cheaper materials • Larger collectors
	Heat Transfer Fluids	• Raise the maximum temperature of fluids • Use of other types of fluids (e.g., water/steam or molten salt as the working fluid
Fresnel	All	• Still an incipient technology, many possible improvements • It is estimated that costs should be around 40% and 50% lower than parabolic-trough plants to compensate for its lower production performance
Tower	Solar field	• Design of more effective, cheaper heliostat fields. Evolution of sizes and concepts
	Working fluids	• Use of fluids enabling higher temperatures and better efficiency in later thermodynamic conversion
Parabolic dish	All	• Lower production costs due to economies of scale and demonstrated long-term reliability

Technology	Line of Research	Advances
Storage	New devices	• Research in new concepts •Research in newer materials • Increased storage temperatures and performance

3.3. Technology centers

Spain's network of technology centers is among the finest in the world, and represents one of the main assets of STE in the country. Technological innovations developed at these centers can later be applied to all stages of the value chain. It is important to point out that many of the centers have been carrying out R&D for a long time, long before the technology renaissance in 2006. The main Spanish technology centers related to the solar thermal power plant industry are:

Plataforma Solar de Almería

The Plataforma Solar de Almería (PSA) is the largest research, development and test center in the world devoted to concentrating solar technologies. The PSA carries out its activities as an R&D Division of the CIEMAT Department of Renewable Energy.

As of 2010, the PSA had an RD&I research team of 123 people, in addition to an important capital in the form of traineeships and visiting researchers which is managed by the Director's Office.

The PSA's budget shows an upward trend, in large part due to more income from projects funded by the European Commission and the National RD&I Plan, although the most significant factor has been the growth in income from research contracted by business.

The CIEMAT contribution increased in the past two years to undertake activities approved under the 2006-2009 PSA Plan for Infrastructure improvement. This plan was devoted to large improvements that were necessary in its most important infrastructures, buildings, heliostat fields, etc.

The PSA budget in 2008 was 8.1 million € (not including R&D personnel costs) and in 2009 it was 8.5 million €.

CENER

The Centro Nacional de Energías Renovables (CENER) is a technology center specialized in applied research, development and promotion of renewable energies with a specific department devoted to consulting and research related to solar thermal power plants. Its activity has been growing since 2002 and the Ministry of Industry, the Ministry of Science and Innovation, the CIEMAT and the Government of Navarra are on its Board of Trustees.

CTAER

The main purpose of the Centro Tecnológico Avanzado de Energáis Renovables (CTAER) is to contribute to the development of renewable energy technologies. At the instigation of the Andalusian Government (through its agencies IDEA and AAE), it was set up as a foundation to which CIEMAT also belongs, as well as leading companies in the renewable energies industry, and STE in particular.

The CTAER has three basic areas of activity (solar, wind and biomass) of which solar thermal is the one to which it is devoting the most resources. Specifically, it has a 100-hectare estate adjacent to the PSA where it will carry out innovative demonstration projects for business and build its own research and test facilities.

The EU-SOLARIS proposal directed by the CTAER, in collaboration with the PSA and other research centers in Germany, France, Italy, Portugal, Greece, Cyprus, Turkey and Israel has been included in the ESFRI roadmap of scientific research infrastructures.

Tekniker

Tekniker is a private non-profit technology center which reinvests its profit in equipment and investments for the center. It has been in business for the last 30 years, originally performing services to capital equipment companies, although it has also gradually been covering other industries, especially renewable energy.

Tekniker has a very extensive technology offer in the field of renewables, in which low, mid and high-temperature STE projects weigh heavily. These projects are both national and international.

Universities

The work of Spanish universities, such as the University of Seville's School of Engineering, which pioneered STE in Spain and more recently, the Polytechnic Universities of Madrid and Carlos III, and the University of Almería, among others, must be added to the technology centers described above.

STE's Impact in the territory

4

The chapters above described the macroeconomic impact that the installation of STE has had on Spain, and shown how it has contributed positively to the economy and the creation of jobs in other industries. However, the significant amounts invested in the country in this technology in recent years have also had a positive repercussion on the towns and regions where the plants were installed.

Located mainly in regions where the level of unemployment is higher than the Spanish mean, the construction of the solar power plants has contributed to significantly alleviating the effects of the economic crisis, generating work in sectors heavily affected by it, such as construction, industry, hotels and restaurants.

Furthermore, once the plants go into operation, the need for their maintenance creates many highly qualified permanent jobs.

Not only the direct impact is relevant, but also the impact on the economy in industries not directly related to STE. The improvement and dynamism of the economy has led to an increase in population in the towns where the technology is installed and has allowed the town councils to carry out projects that improve the quality of life of the population that would otherwise have been impossible.

As an example, *Torre de Miguel Sesmero* in Extremadura is described below:

Torre de Miguel Sesmero

There are now two 50-MW parabolic-trough solar thermal power plants with 7.5 hours storage each in operation and another under construction, called Extresol 1, 2 and 3, in Torre de Miguel Sesmero in the district of Llanos de Olivenza in Badajoz Province.

Figure 49.
Image of a parabolic-trough solar thermal power plants in Extresol 1. Owned by ACS-Cobra.

The construction of these plants coincided precisely with the economic crisis, and their development generated enough jobs to relieve its effects almost completely. The population and authorities in Torre de Miguel Sesmero are completely satisfied with the positive economic and social impact generated by the development of solar thermal power in their town.

The figure below shows how since2007, the year construction of the plants begun, the town of Torre de Miguel Sesmero has grown by about 50 people, making the negative trend in 2000-2005 positive.

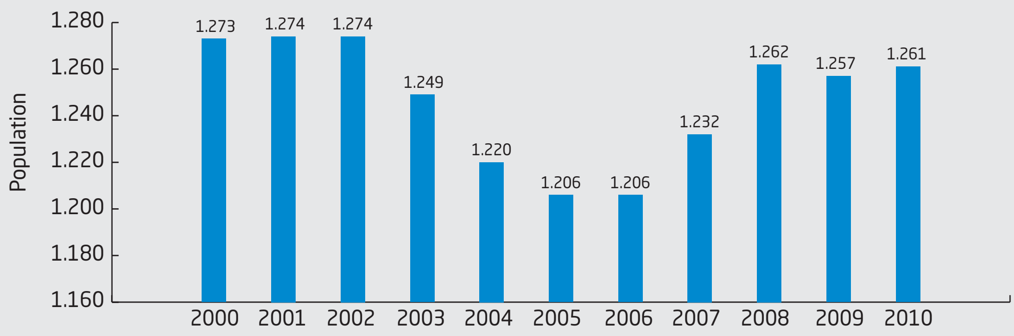


Figure 50.
Evolution of the population of Torre de Miguel Sesmero (2000-2009).

According to the figures provided by the Town Council, the construction of Extresol 1 and 2 together generated from 600 to 700 direct jobs during two years, a figure very near the average calculated in this report: 355 jobs in construction for a 50-MW plant. It is important to point out that employment was generated throughout the district and not only in the town, where 115 to 120 new jobs were recorded.

In this sense, the percentage of unemployment in Torre de Miguel Sesmero was considerably less than in the rest of Badajoz Province in 2008-2010, as observed in the figure below, which shows the significant change in the trend starting with the beginning of construction of the solar thermal power plants.

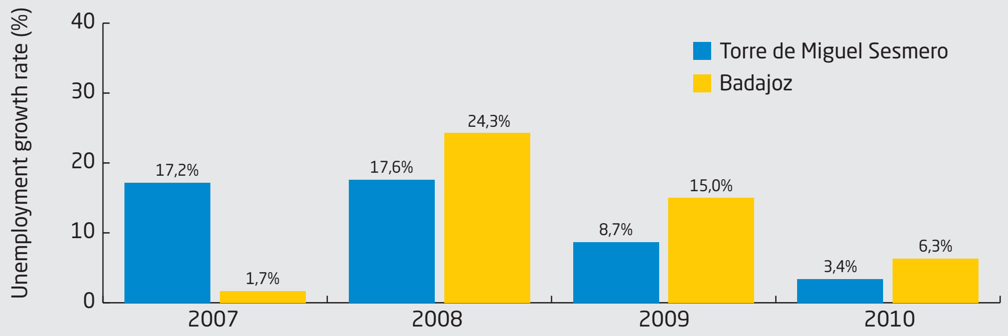


Figure 51.
Comparison of the percentage of unemployment in Torre de Miguel Sesmero and Badajoz (2007-2010). Source: State Public Employment Service, data as of December each year.

The main industries directly or indirectly affected have been manufacturing, sales and rental of machinery, tractors, metalwork, as well as hotels and restaurants.

In addition, plant construction has had a relevant indirect impact on accommodation (hotels, hostels, rental housing) and restaurant services. In this sense, restaurant services have been supplied by other towns in the district, since Torre de Miguel Sesmero does not have sufficient infrastructure to supply the demand.

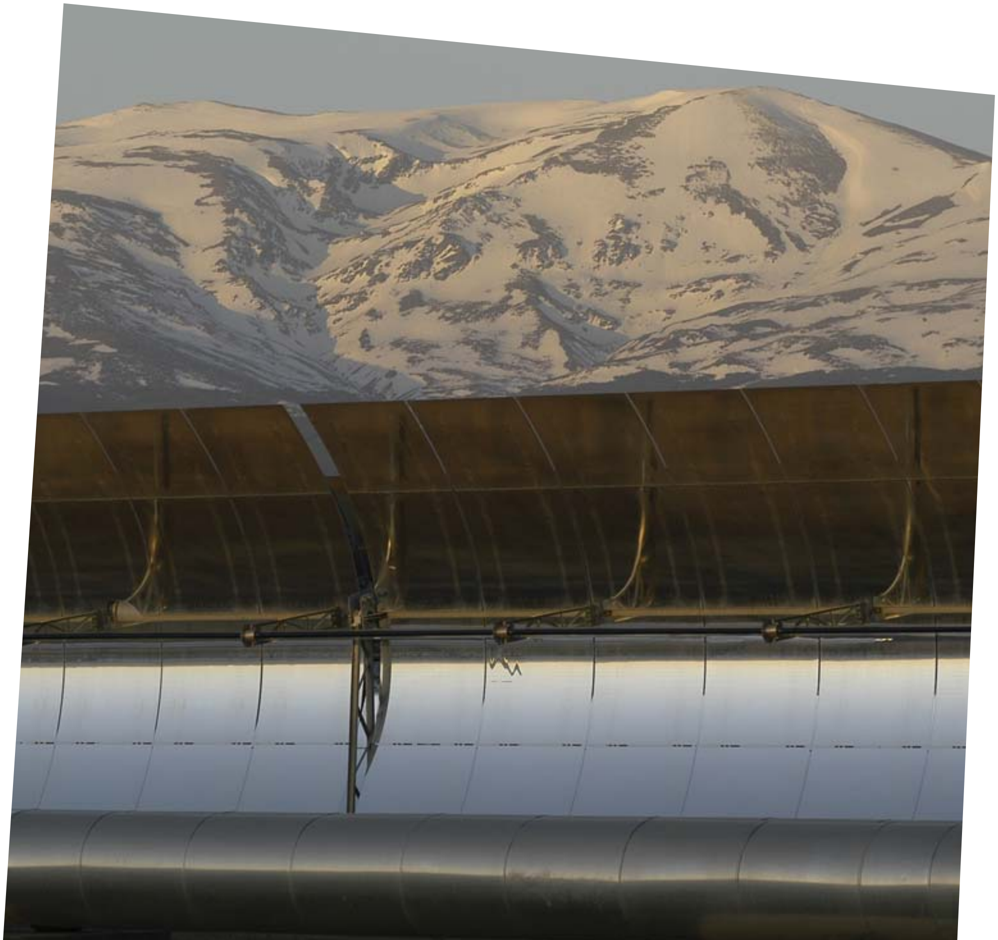
Operation of the plants has also had a very positive repercussion on the town from taxes on construction and development fees, rents, and the need to hire workers for operation and maintenance.

The increase in budgetary resources has improved the welfare of the population. Specifically, it has enabled the Town Council to build an industrial park and a residence for dependent people, as well as take a series of environmental actions:

- Photovoltaic solar facility
- Renovation of public lighting with a more efficient system

In environmental terms, the construction of the plants has made use of an old dehesa, on land located outside of town, and therefore, has not had any negative impact on the surroundings. The water is taken from a reservoir that is not used for irrigation, avoiding competition for use of this resource. At present, an aqueduct from the Guadiana River is under construction to ensure the water supply to all three plants and reduce risks that could be brought about by a year with low rainfall.

Environmental impact and reduction of energy dependence



5

5.1. Methodology and calculation of energy replaced

Electricity generation from fossil fuels, combined-cycles with natural gas or carbon and fuel power plants, do not internalize a series of costs known as externalities. Externalities (negative in this case) are costs incurred by a part or all of society which are not absorbed by those who produce them.

In this sense, conventional energy sources produce CO_2 and other greenhouse gas emissions that contribute to global warming and other gases hazardous to health. The replacement of these sources by renewable energies favors compliance with the European Union and Spanish targets for reducing these emissions and saving emission rights for CO_2 avoided.

Dependence on energy resources located outside of the national territory also involves transfers of large amounts of money overseas which is an important risk to the economy as a whole. Spain is especially vulnerable in terms of its energy dependency, since it has almost no conventional resources to supply it.

It should also be noted that the prices of fossil fuels are much more volatile than the cost of generating electricity in the long term. Furthermore, while in the coming years the first will undergo an upward trend due to the increase in demand and shortage of the resource, renewable energies will show a significant downward trend in the cost of generation derived from learning accumulated during the years in which the technologies are developed. In the case of STE, the reduction in the investment has already been 19% in plants without storage and 17.4% with storage (see Section 2.3).

In this sense, for the purpose of quantitatively evaluating the positive effects of the penetration of STE into the national power system, the following methodology was developed:

- **The conventional power replaced was quantified:** The volume of natural gas, coal and fuel oil avoided by the use of STE was assigned by working under the assumption that power produced by STE replaces fossil fuels in the proportion of each fuel in the fossil generation mix in Spain.
- **CO_2 emissions avoided are estimated** using the ratios of mean emissions per technology replaced, the tons of CO_2 that would have been emitted into the atmosphere without STE, and the economic savings in CO_2 rights using the average price of CO_2 emissions rights.
- **Imports of fossil fuels avoided are evaluated** in terms of tons of oil equivalent. The savings in this item is found by assigning a monetary value to each fuel (according to international prices).

According to information published by the National Energy Commission, in 2010 691.5 GWh were produced by solar thermal power plants[12], rising sharply over 2008 and 2009, when only 15.4 and 103.1 GWh were produced, respectively. **If the STE penetration targets set by the 2011-2020 Renewable Energy Plan are met, production will increase to 8 287 GWh in 2015 and 14 379 GWh in 2020, respectively.**

12. It should be noted that not all the installed power was in operation all year long.

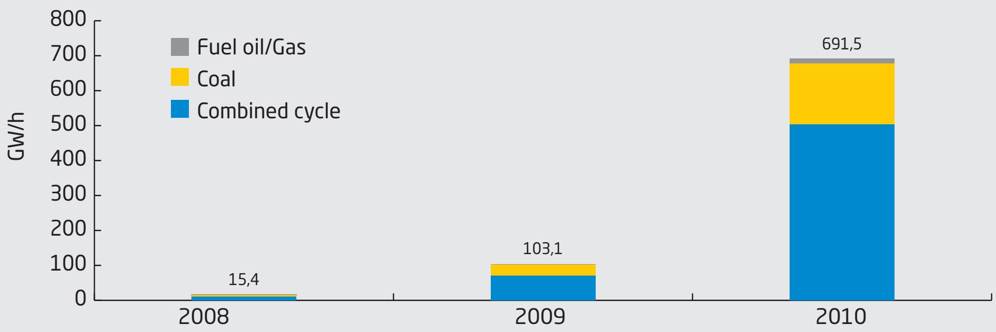


Figure 52.
Energy replaced by STE production.

5.2. Environmental impact

According to the results found, STE had the following environmental impact:

- **The emission of 361 262 tons of CO_2 into the atmosphere was avoided in 2010,** and the cumulative total for the 2008-2010 period was about 426 492 tons of CO_2. The economic impact of this was that in 2010, about 5.2 million € in emissions rights were saved.

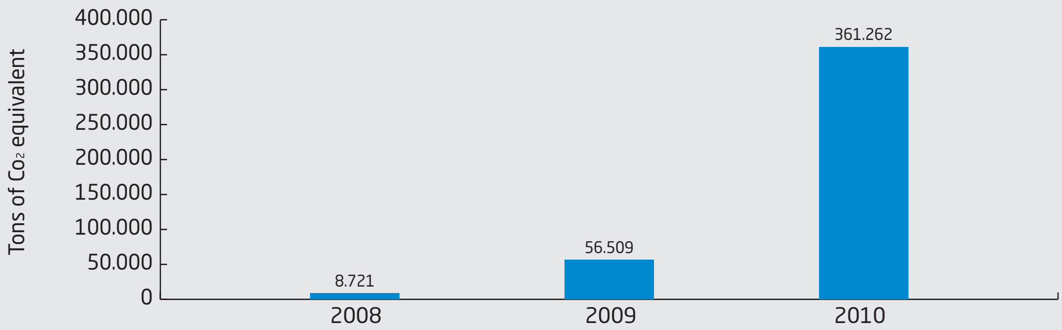


Figure 53.
CO_2 emissions avoided in 2008-2010.

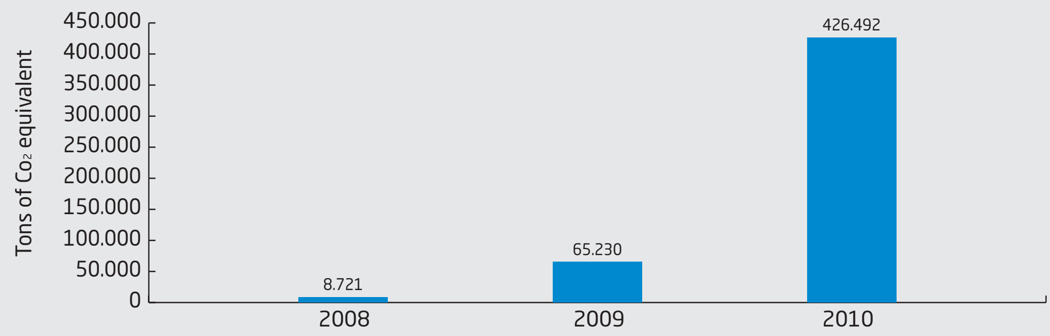
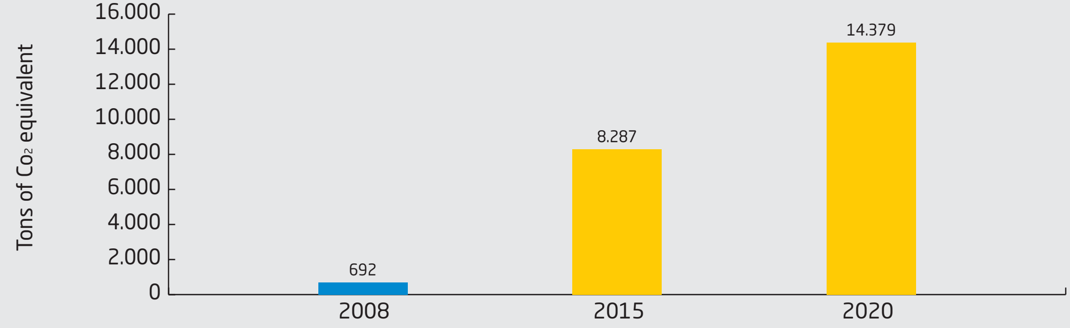


Figure 54.
CO_2 emissions avoided in 2008-2010 (cumulative).

• If the targets set in the 2011-2020 PER draft are met, **the power produced by STE plants will have avoided approximately 3.1 million tons of CO_2 in 2010 and over 5.3 million tons in 2020.**

Figure 55.
Forecast CO_2 emissions avoided and cumulative in 2015 and 2020.



5.3. Reduction of energy dependence

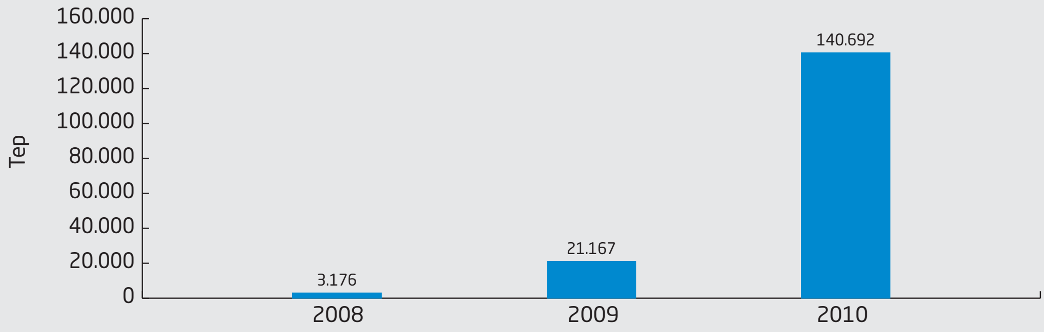
The use of renewable energies in power production contributes significantly to reducing fossil fuel imports.

- In 2010, **the production of STE in Spain avoided the import of around 140 692 tons oil equivalent.**

  According to the prices of fossil fuels, **STE saved over 23.9 million € in imported fossil fuels in 2010[13].**

- In 2015 and 2020, STE is forecasted to replace the import of a total of around 1.6 and 2.7 million toe, respectively.

Figure 56.
Imported fossil fuels replaced in 2008-2010.



13. Prices of fossil fuels: Natural gas 5.23 €/MMBtu, Coal 70.13 €/tn, Fuel oil 60.19 €/barrel.

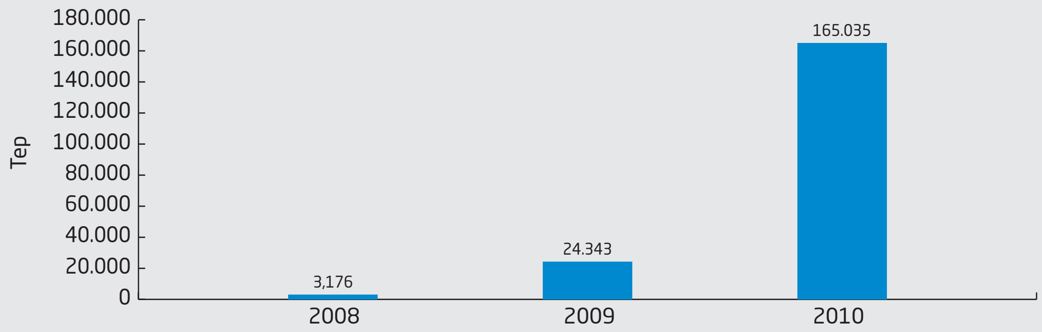


Figure 57.
Fossil fuels replaced in 2008-2010 (cumulative).

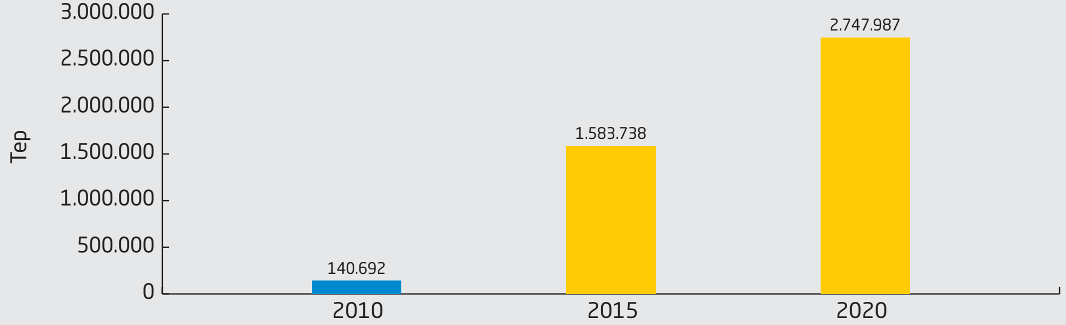
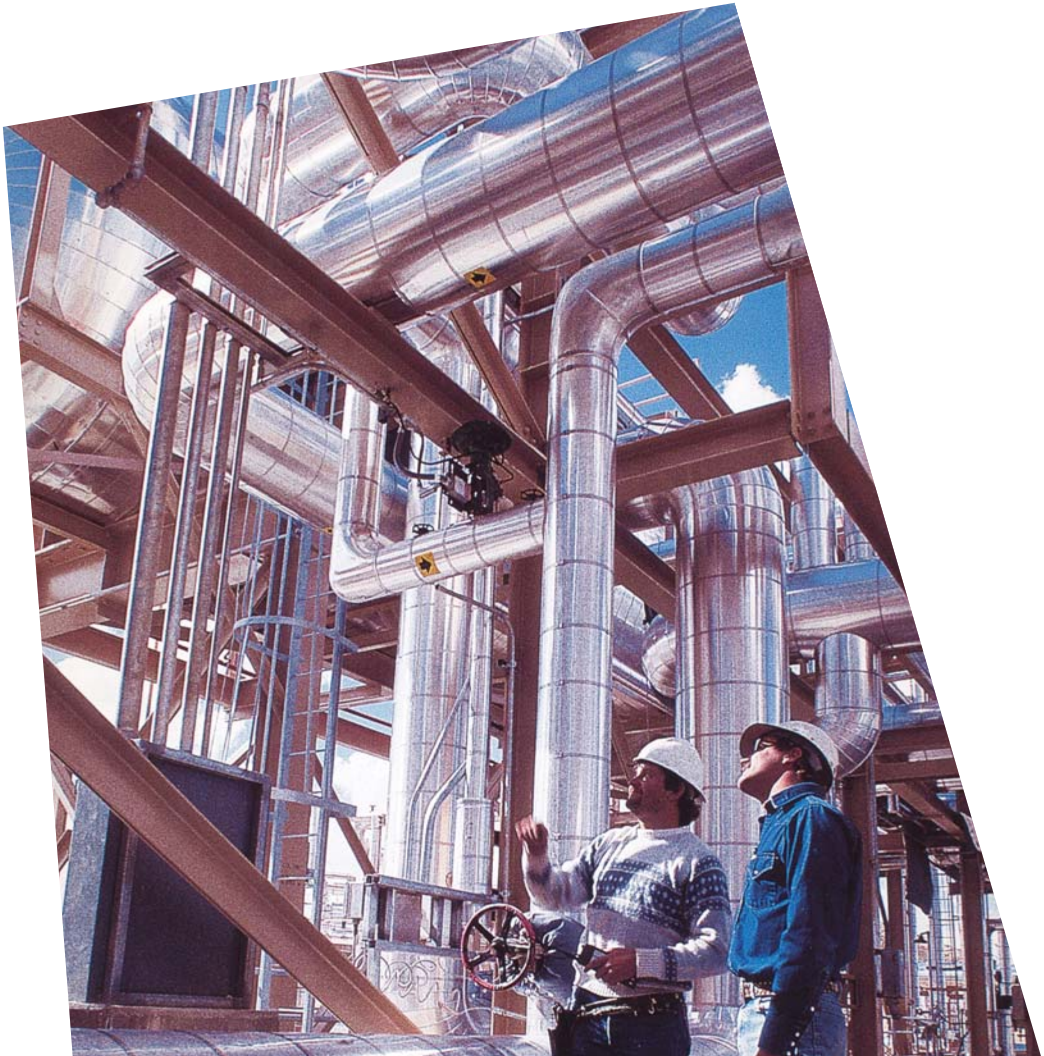


Figure 58.
Forecast imported fossil fuels replaced (2015 and 2020).

Conclusions



6

The study of the macroeconomic impact of the Solar Thermal Electric Industry in Spain demonstrates that the birth of this industry has given an important boost to the country's economy in terms of contribution to the GDP and employment, mostly in the last three years. The positive effects which have caused most interest in this technology are especially visible in industries hard hit by the economic crisis, such as the construction or manufacture of equipment, as well as the significant positive impact on many towns and districts not previously favored by industrial development. Evidence of all these statements is, for example, a 0.16% contribution to the Spanish GDP over 1 600 million €, or the creation of over 23,800 jobs in three years.

Spain leads in the installation of power plants within this technology and has companies able to supply products and services in practically the whole value chain. This is especially important considering the expectations for growth of this technology worldwide in the short and mid-term. In this sense, Spanish contractors and builders, already have an important role as exporters of the technology through direct investment. This role could be lost if the effort in Spanish territory does not continue ensuring the competitive advantage of being in the technological vanguard.

Due to its particular characteristics, Solar Thermal Electricity has a series of advantages over other renewable technologies; the most important being its dispatchability for generating on System Operator demand, due to its capacity for storage and hybridization. This characteristic becomes essential for future scenarios of CO_2-free power generation.

The use of a renewable resource as abundant as the Sun in Spain, also means important savings for the country by replacing imported fossil fuels, and alleviating the risks derived from this situation, and favoring the development of domestic industry.

The development of renewable energies in Spain in general, and of Solar Thermal Electricity in particular, contributes and will continue to contribute significantly to the decrease in CO_2 emissions and compliance with Spain's environmental targets.

Although it is true that the investment per MW for this type of plant is higher **than some other technologies, the cost of the new plants would today be significantly lower than those entered in the Pre-allocation Register, and a still larger reduction is expected in the future** as advances are made in the learning curve, and research on new types of plants, materials, equipment and processes continues. Spain can take on a very relevant role in this sense, having a RD&I infrastructure in the vanguard and highly qualified professionals.

In the next few years, technological development will depend on the results produced by these advances, and also on the economic signals received by the contractors of these facilities.

Thus it is fundamental that the rates frameworks defined for the future building of plants, starting in 2014, provide incentive for the investments necessary to meet the power targets set in the 2011-2020 PER draft.

If the positive impacts derived from the activities in the industry - such as contribution to the GDP 1 650 million €, generation of 23 844 jobs, Social Security contributions of 270 million €, corporate taxes of 66 million €, and personal income tax of 71 million €, savings in emissions rights of 5 million €, replacement of 24 million € worth of imported fossil fuels, and ranking of

Spanish companies in the international market - **were placed on a scale with premium feed-in tariffs,** which in 2010 were 185 million €, **it would be demonstrated that the incentive policies provided for this technology was an efficient economic and technological decision for Spain.**

Table of Figures

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