WORLD BANK GROUP
Energy & Extractives

MENA CSP KIP

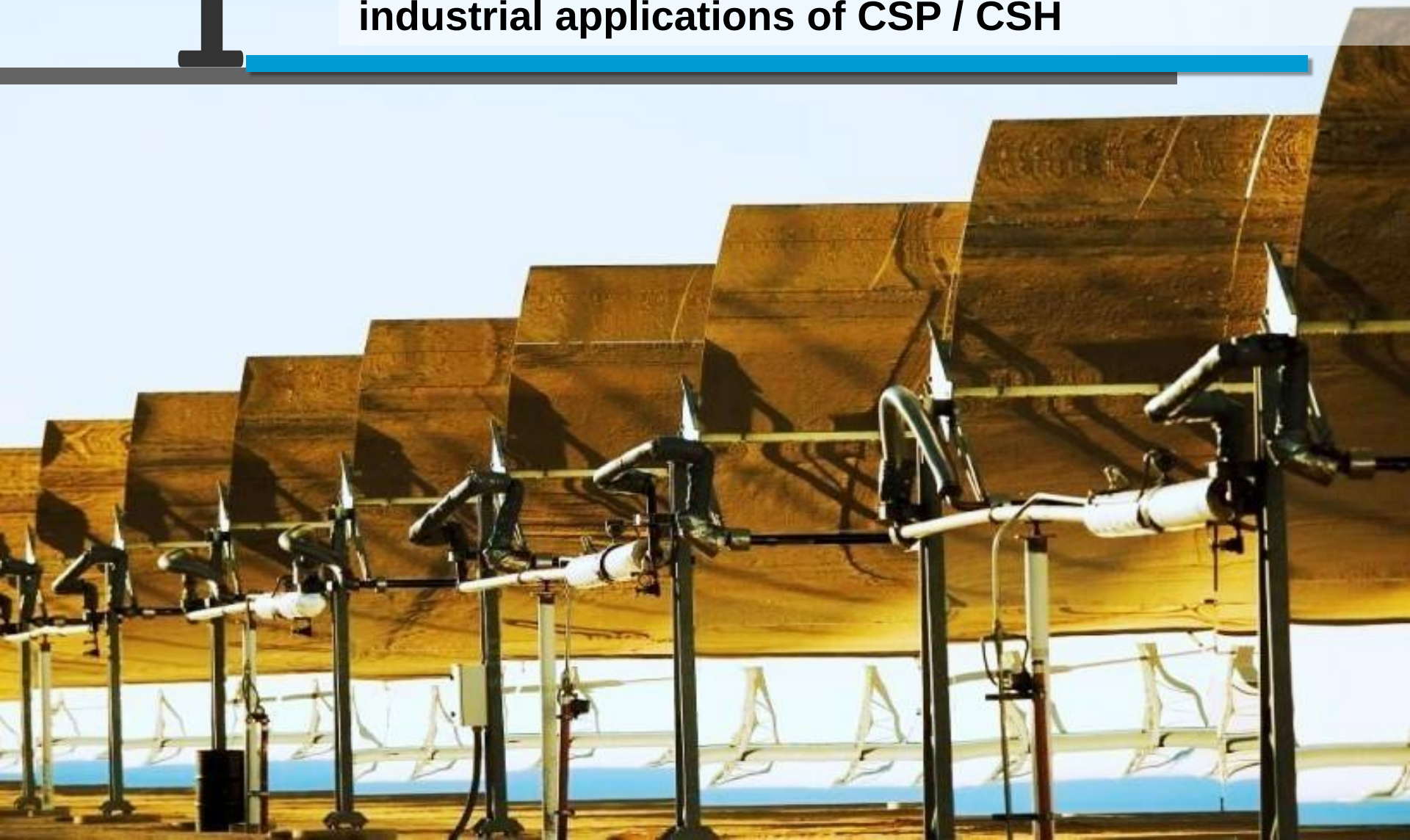
Webinar: Solar Heat for Industry in Morocco and Tunisia

The potential of CSH in Morocco

3rd of December 2019

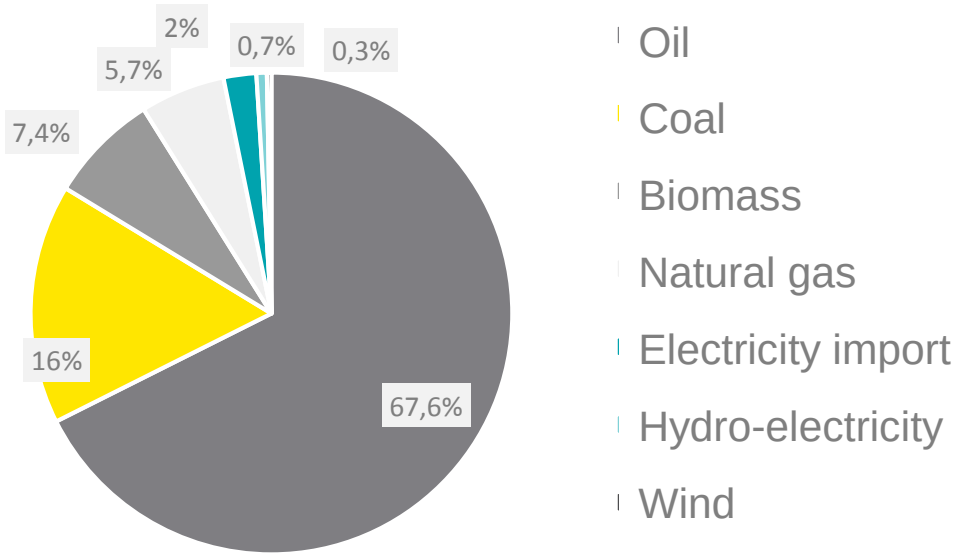
CLUSTER SOLAIRE

1 Presentation of opportunities in Morocco for industrial applications of CSP / CSH



The Moroccan energy situation

- Morocco's energy situation is pushing for **a diversification of energy sources**:
  - A sharp rise in energy consumption;
  - An energy mix that is predominantly fossil;
  - Energy dependence on oil and gas imports.

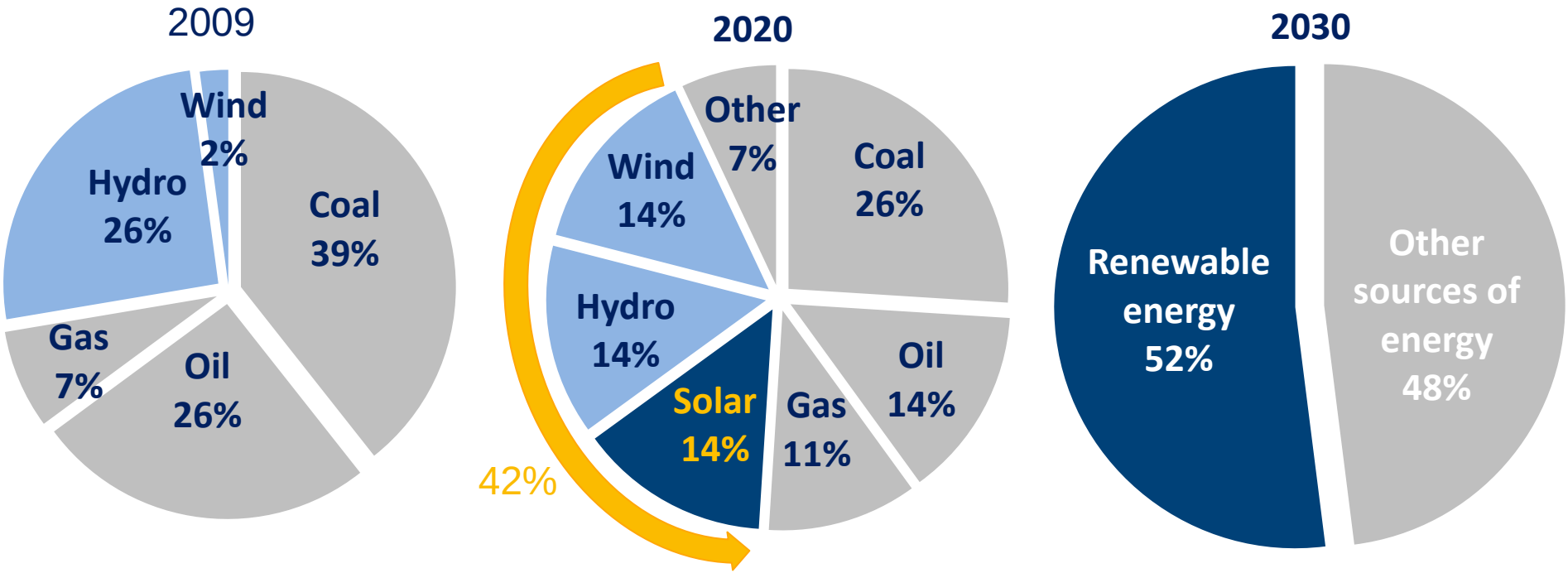


Distribution of primary energy sources in Morocco in 2012

(Source : IEA, 2014 – EY work)

- **Ambitious objectives** set in 2009:
  - Reduce its energy dependence on imports from 95% to 85% by 2020;
  - Reduce energy consumption by 15% by 2030;
  - Achieve 52% of renewable power installed by 2030;
  - **Produce 14% of its electricity needs via solar energy.**

A clear and ambitious renewable energy strategy



An open solar program has all the technologies with a key role for the CSP providing dispatchable green electricity meeting the needs of the national operator (evening tip)

Integrated project development

ELECTRICITY PRODUCTION	INDUSTRIAL INTEGRATION	LOCAL DEVELOPMENT	TRAINING AND R&D
Min 52% capacity installed by 2030	For a competitive local industry	For inclusive development	For the mastery of technologies and qualified HR

Aimed at creating an ecosystem contributing to the socio-economic development of the country by combining technologies to provide the best answers to identified needs optimizing the cost of KwH and maximizing synergies

Comparison of different technologies

- **Three of the most relevant technologies have been selected by KIP for small capacity projects (power less than 3 MW installed capacity and less than 5000 m2).**

Parabolic trough

- ✓ Mature technology
- ✓ modular
- ✓ Low demand for materials

Fresnel reflectors

- ✓ Mature technology
- ✓ modular
- ✓ Better land use factor
- ✓ Using the shadow

Dish design

- ✓ Very modular
- ✓ More adaptable to different types of terrain (relief)

Several processes have been identified as particularly relevant

- Several processes particularly suitable for the installation of a CSP / CSH system for the production and supply of heat (for the usual operating temperature range)
- **Each process remains specific and requires precise dimensioning of the heat requirement.**

Industry	Procédé	Température range (°C)
Food	Drying	30 – 90
	Washing	60 – 90
	pasteurization	60 – 80
	Ebullition	95 – 105
	Sterilization	110 – 120
	Heat treatment	40 – 60
Paper	Heating and drying	60 – 80
	Feeding water for heaters	60 – 90
	whitening	130 – 150
Surface treatment of metals	Treatment, electroplating	30 – 80
Building bricks	Hardening	60 – 140
Textile	Whitening	60 – 100
	Dyieng	70 – 90
	Drying, degreasing	100 – 130
	Fixing	160 – 180
	Pressing	80 – 100
Chemical industry	Soap	200 – 260
	Synthetic rubber	150 – 200
	Process heating	120 – 180
	Pre-heating water	60 – 90
Plastic industry	Preparation	120 – 140
	Distillation	140 – 150
	Separation	200 – 220
	Extension	140 – 160
	Drying	180 – 200
Co-products of flour	Sterilization	60 – 90
All sectors	Pre-heating of boilers	30 – 100
	Heating	30 – 80

Examples of processes used in certain sectors and usual temperature ranges (Source : EY)

Example of projects

COPAG (50 kW) - Taroudannt

- Integrated installation on the roof
- Power of 50 KW thermal to produce 112 MWh / year
- Partial heating of cleaning solutions for part of the dairy
- Savings of 10 873 m3 of gas per year
- Project financed by MASEN and GIZ

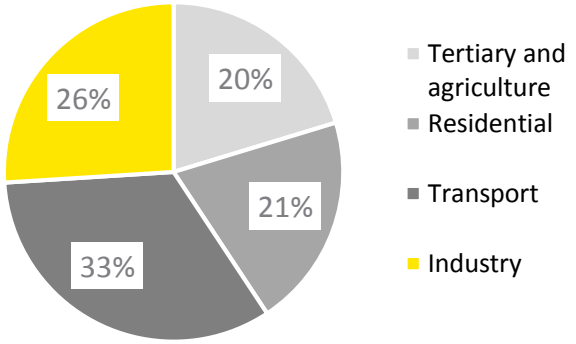
Ciments du Maroc (3,9 MW) – Ait Baha

- Pilot project with innovative technology of cyclindro-parabolic mirrors and organic Rankine cycle.
- Installed power of 3.9 MWth to produce 1 GWh / year.
- Additional production of electricity using an organic fluid.

Carte des projets identifiés utilisant le CSP de petite capacité au Maroc (Source : EY)

What about the Moroccan industry?

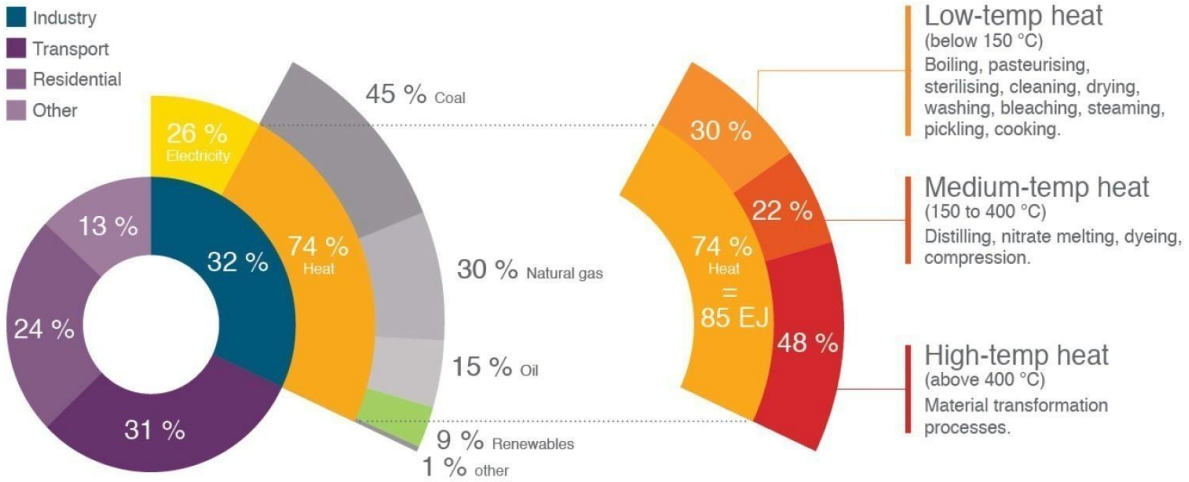
- The industrial sector is **a major consumer of the country's energy** (about 27% of the total consumption of the country),
- With a **wide variety of processes** requiring heat, cold and electricity.



Breakdown of energy demand by sector in Morocco

(Source IEA – EY)

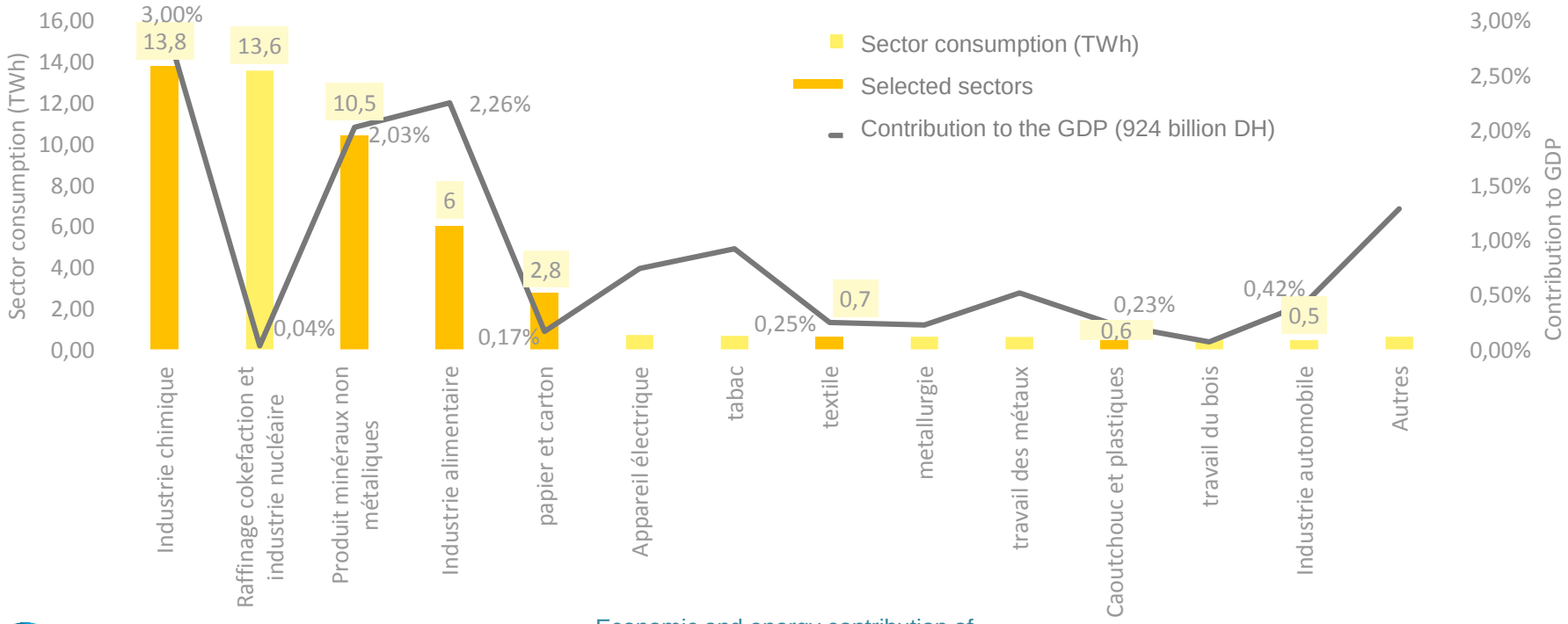
- Today, process heat accounts for **75% of the industry's energy consumption worldwide**.
- Industry requirements for very diverse heat temperatures therefore very relevant for the CSP / CSH



Decomposition of heat and temperature requirements of the industry (source : Solar Payback – IRENA, 2017)

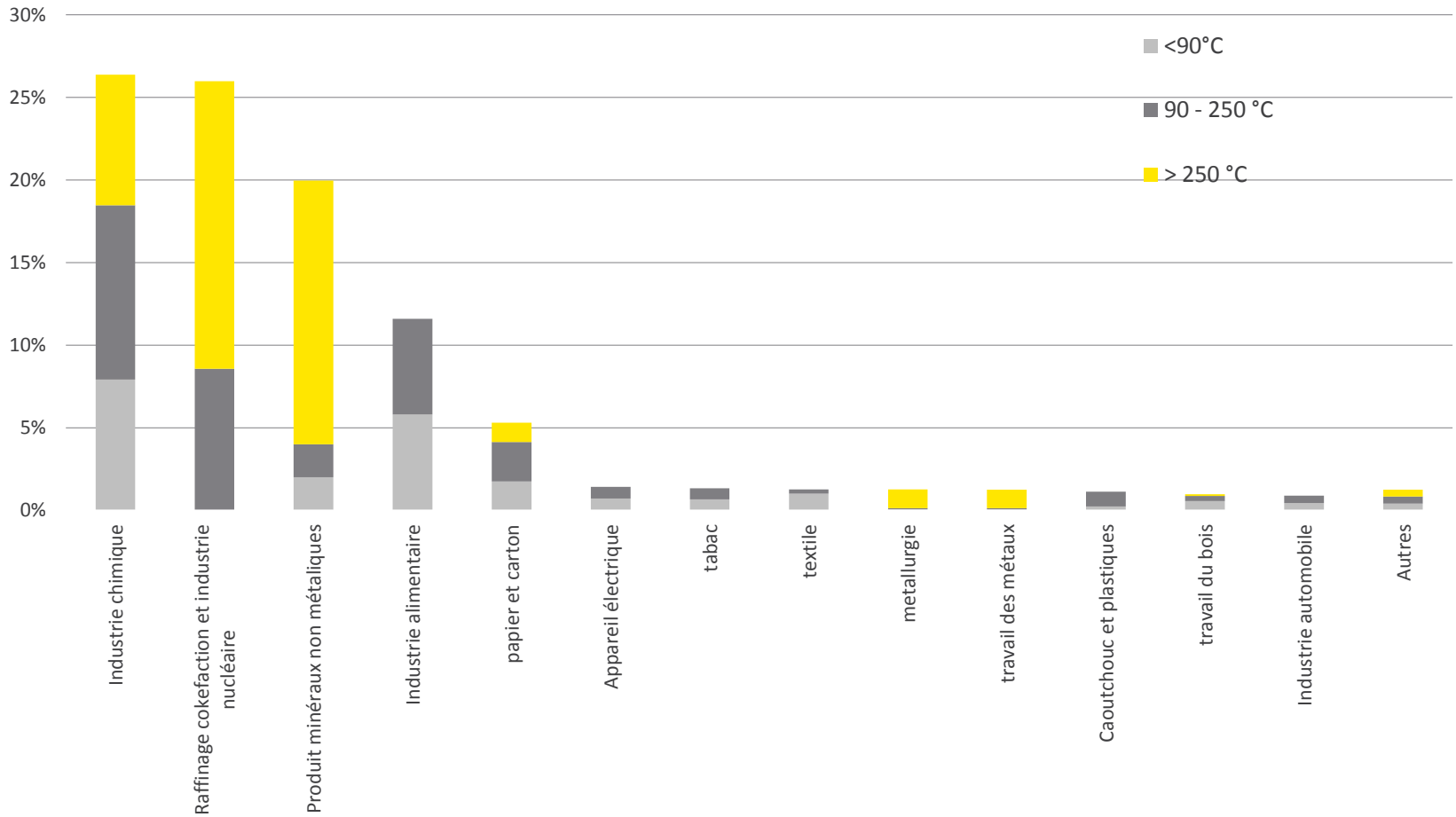
Analysis of relevant sectors in the Moroccan industry

- Five relevant industrial sectors (the chemical industry, the non-metallic mineral products industry, the food industry, the textile industry and the rubber and plastics industry) were selected according to two criteria:
  - The importance of the sector in Moroccan industry (contribution to GDP and final energy consumption of the country);
  - The adequacy in terms of temperature between the needs of the processes and the production capacities of the CSP technologies.

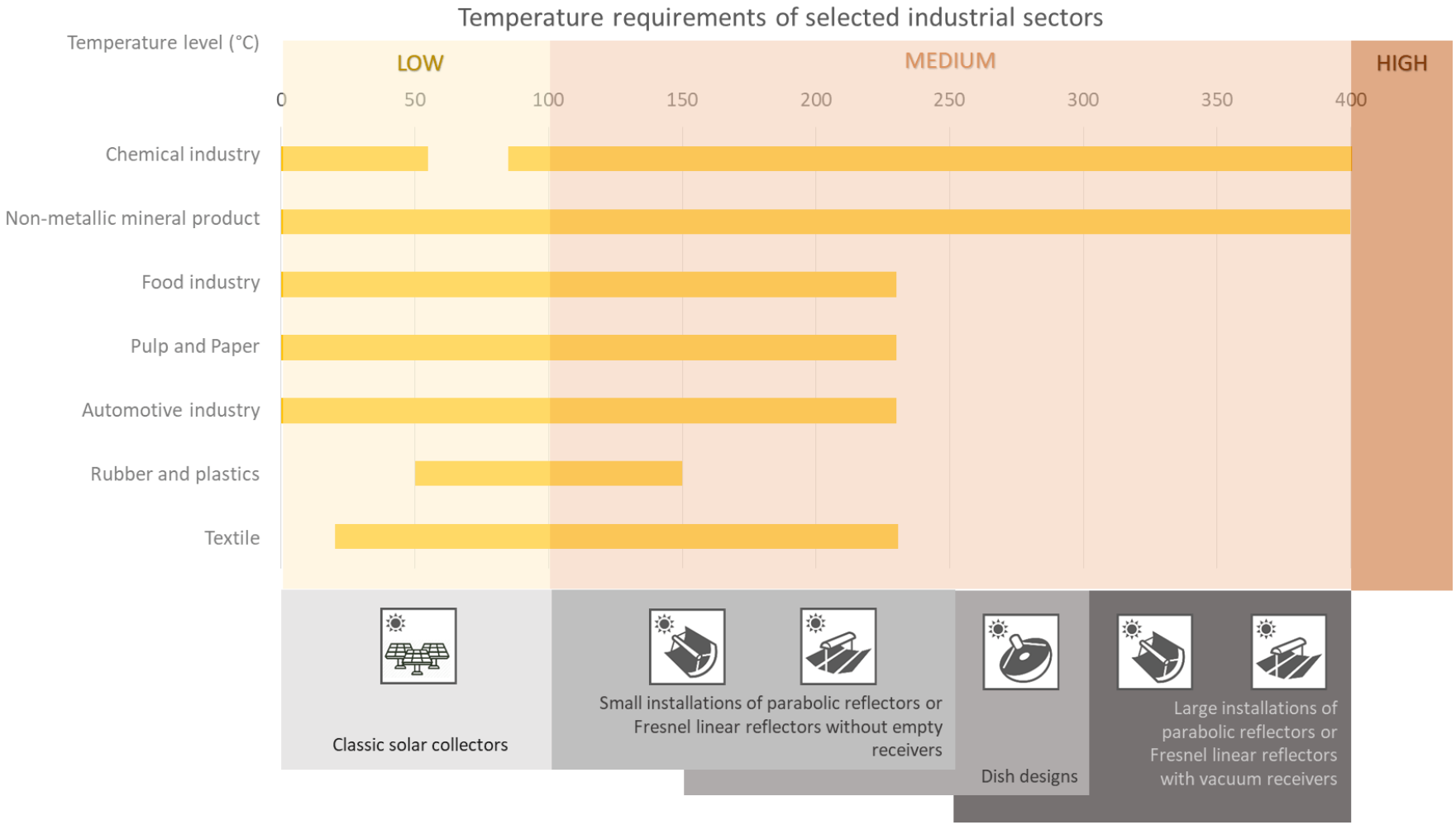


Economic and energy contribution of the various Moroccan industrial sectors (Source : EY)

The analysis takes also into account the needs of each sectors



The potential of the selected sectors and the suitable

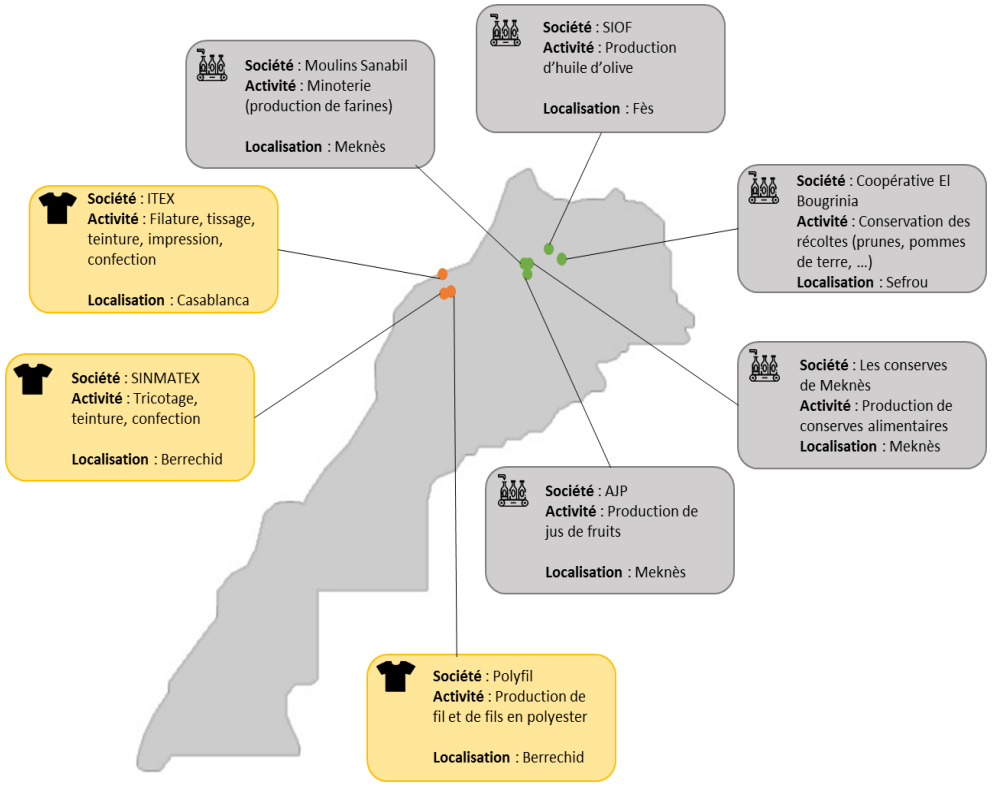


Concluding diagram on the temperature requirements of selected industrial sectors and adapted CSP technologies (Source : EY)

Interviews were carried out to confirm the results of the analysis

- Interviews were carried out to confirm the results of the bibliographic analysis and gather qualitative information about the specific situation in Morocco.
  - Interviews with project developers
  - Local interviews with Moroccan industrials to identify levers and barriers

Company	Country	Technology	Example of project
Rackam	Canada	Parabolic trough	COPAG in Taroudant (Morocco)
Alsolen	Morocco	Fresnel	-
Industrial Solar	Germany	Fresnel	RAM Pharma project in Jordan
Aalborg CSP	Denmark	Parabolic trough	Urban heating project in Denmark
Alto Solution	Morocco / France	Parabolic trough	COPAG in Taroudant (Morocco)



Interviews were carried out to confirm the results of the analysis

- Several barriers have been identified through the interviews:
  - Low knowledge of the technology;
  - No local offer for the installation of this type of system;
  - Return on investment too long;
  - binding regulatory framework;
  - Low qualification of facility staff to manage these facilities;
  - Investment cost too high;
  - Technical constraints of integration in the processes.

- However, two main levers have thus been identified thanks to the interviews:
  - Financial assistance in the form of grants to reduce the cost of the initial investment for companies and thus reduce the time of return on investment. In addition, it is possible to imagine more innovative support mechanisms that take into account the carbon economy, for example.
  - The implementation of pilot projects serving as benchmarks to show companies the functioning of the HSC and the technical viability of the different solutions.

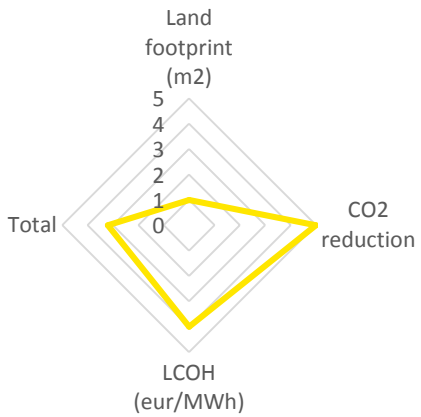
Comparative analysis of the different technologies

- A methodology has been developed for this study in order to compare different technologies that can be used to produced heat and/or electricity on an industrial site. The methodology was based on 3 main criteria:
  - Land footprint
  - CO2 reduction
  - Levelized Cost Of Heat

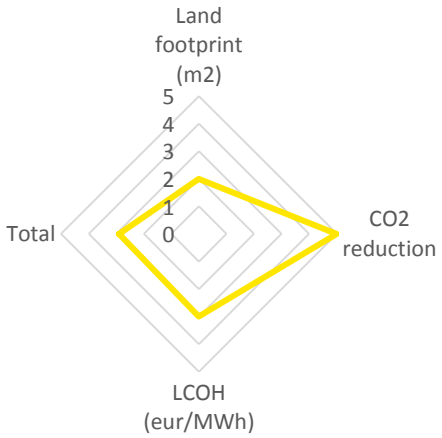
	Parabolic trough	Fresnel	Fuel	Gas	Biomass
Land footprint (m2)	7 028	6 781	200	200	200
CO2 reduction (average between fuel oil, gas and biomass)	1 146	1 146	0	0	0
LCOH (eur/MWh)	32	54	81	74	14

Notation	Parabolic trough	Fresnel	Fuel	Gas	Biomass	Weight
Land footprint (m2)	1	2	5	5	5	30%
CO2 reduction	5	5	1	1	2	10%
LCOH (eur/MWh)	4	3	1	2	5	60%
Total	**3,2**	**2,9**	**2,2**	**2,8**	**4,7**	**1**

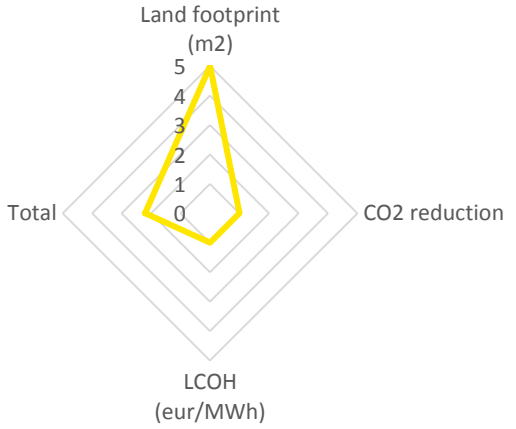
Comparative analysis of the different technologies



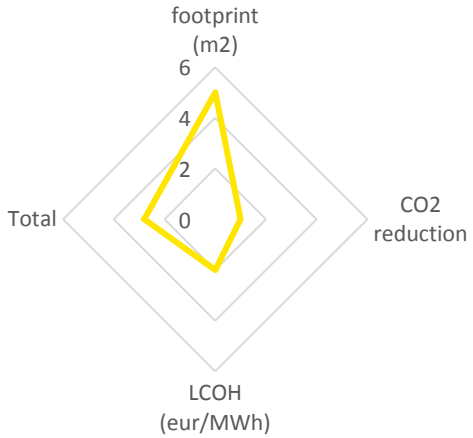
Parabolic trough



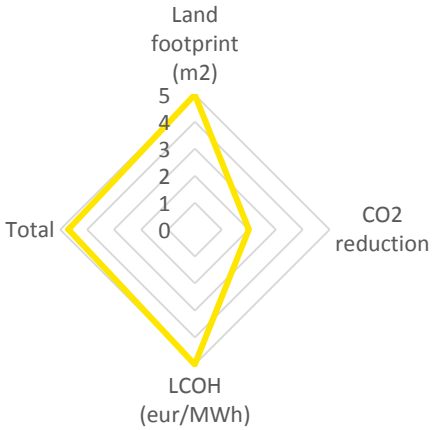
Fresnel



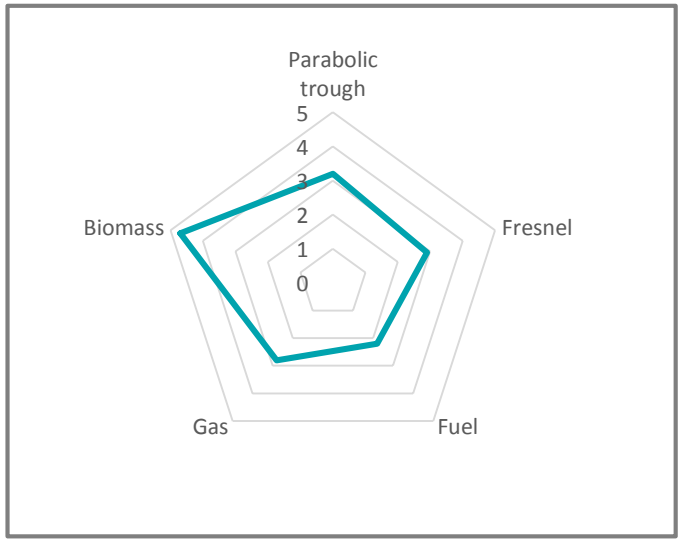
Fuel



Gas



Biomass



Estimated potential market and economic and environmental benefits

Potential market		
Total consumption of industries with potential	35 000 000,00	MWh/year
Maximum solar share	5 250 000,00	MWh/year
High potential industry 10% (Textile and Agro)	689 468	MWh/year
Medium potential industry 5% (chemical and non-metallic minerals)	1 213 035	MWh/year
Low Potential Industry 2% (Rubber & Plastics, Automotive, Paper)	76 600	MWh/year
Total potential consumption	1 979 103	MWh/year
Surface equivalent of collectors	1 706 532	m2
Equivalent in total power of the installations	1 057	MWt
number of installations (medium power hypothesis of 1MWt)	1 057	
Total investment (hypothesis only of the parabolic trough)	687 732 338	euros
Economical benefits		
Maximum local share (50% according for GIZ)	343 866 169	euros
Maximum local share (between 20 and 30% according for DLR)	171 933 085	euros
Average local share	257 899 627	euros
Number of direct and indirect jobs (according to the ration by power of the afdb)	13 737	job
Number of direct and indirect jobs (according to the investment ration of the afdb)	7 737	job
Average number of jobs	10 737	job
Environmental benefits		
CO2 avoided on the basis of the energy mix of Moroccan industry	515 142	t of CO2
share of the emission of the Moroccan industry	4,5%	
if it is an alternative to fuel and gas	557 375	t of CO2
share of the emission of the Moroccan industry	4,9%	
if it is an alternative to gas	405 716	t of CO2
share of the emission of the Moroccan industry	3,5%	
if it is an alternative to fuel	562 065	t of CO2
share of the emission of the Moroccan industry	4,9%	

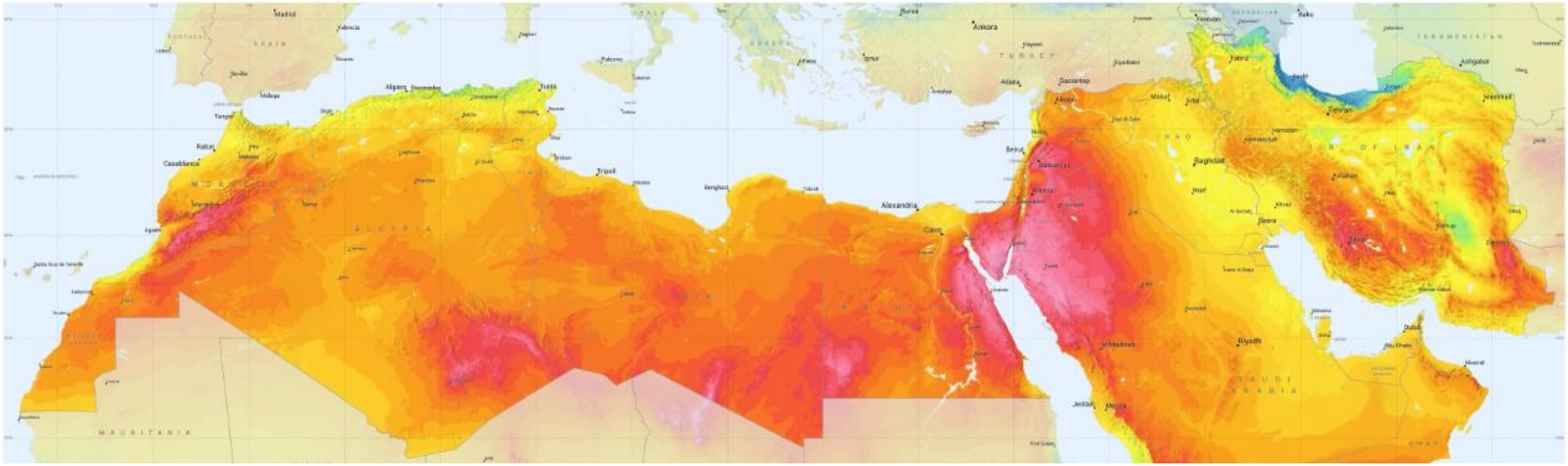
Geography is also an important criteria fro project profitability

Criteria	Agadir	Casablanca	Ouarzazate
DNI (KWh/m2/year)	1950	1850	2450
Variation compared to Ouarzazate	20%	24%	0%
LCOH (eur/MWh)	**40**	**43**	**32**
Variation compared to Ouarzazate	26%	32%	0%

SOLAR RESOURCE MAP

DIRECT NORMAL IRRADIATION

MIDDLE EAST AND NORTH AFRICA



CSP / CSH opportunities in the Moroccan industry

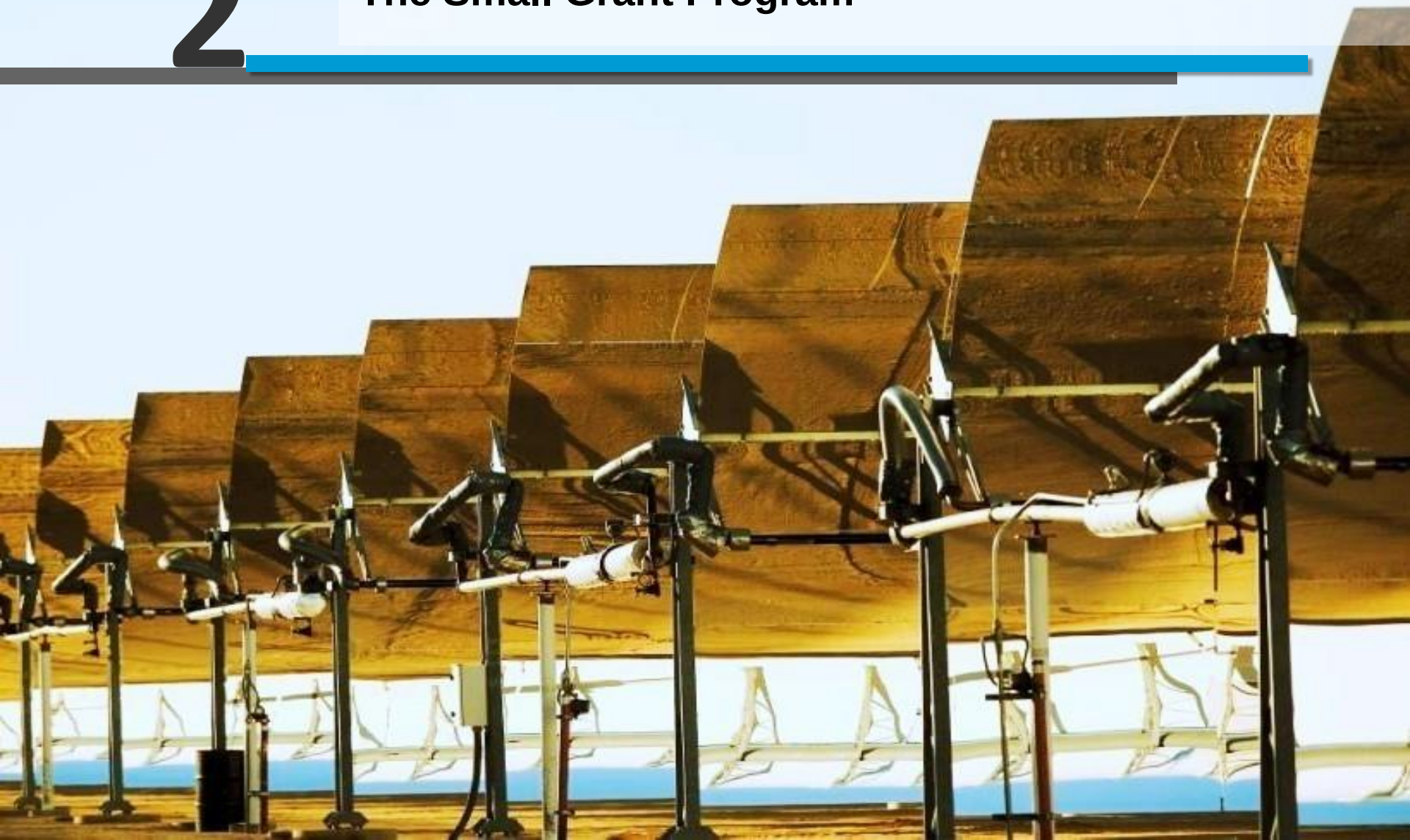
A final analysis has been carried out on the extra-financial competiveness of CSH

Categories	Criteria	CSH/CSP	Gas	Fuel oil	CSH/CSP	Gas	Fuel oil
Technical performance and safety	Energy efficiency	3	2	2	Comp	High comp	Not comp
	Reliability / Autonomy (regularity, need for extra work, maintenance, etc.)	1	3	2			
	Easy installation / integration / use	1	3	3			
	Lifetime	3	2	1			
	Safety risk (explosion, intoxication, legionella, road safety, etc.)	3	2	1			
	FINAL GRADE	**11**	**12**	**9**			
Attractiveness of the market	Extra-financial business benefits (guarantee, payment terms, etc.)	3	2	1	Comp	High comp	Not comp
	Marketing (national programs, advertising, promotional offers, etc.)	2	2	2			
	Regulatory constraints	2	2	1			
	Current level of development / Structuring of the distribution chain (sales, installation, after-sales)	1	3	2			
	FINAL GRADE	**8**	**9**	**6**			
Sustainability	Image (modernity, aesthetics)	3	2	1	High comp	Not comp	Not comp
	Environmental impact (GHG, pollution, nuisances, landscape integration, etc.)	3	1	2			
	Economic and social impact (economic development, employment, export, etc.)	3	2	2			
	Contribution to energy independence	3	1	2			
	FINAL GRADE	**12**	**6**	**7**			

All these analysis show that there is real potential for small scale CSH/CSP in the Moroccan industry. Today the technology is mature and competitive (biomass is still more competitive but and must overcome some barriers to being fully developed: financial profitability is still a little low for an industrial actor to accept to invest in a new and unknown technology.

In fact, the cultural aspect is very important in Morocco and companies are reluctant to bet on an technology they do not know. Trust is a major barrier to the development of CSP/CSH.

2 The Small Grant Program



Who is the SGP for?

Beneficiaries of SGP projects

- Moroccan industrial enterprises
- Moroccan tertiary enterprises

Desiring to have a small capacity CSP / CSH installation to meet its energy needs (heat or electricity).

Partner actors

- Moroccan Studies Offices
- Developers / suppliers technologies CSP / CSH

Capable of supporting beneficiaries of project projects in the implementation of their project

Criteria for eligibility of the project leader

► Type d'entreprise	Industrial or tertiary sector company in partnership with a developer
► Statut légal	Company legally registered in Morocco with at least 51% of its capital held in Morocco
► Regulatory conformity	Compliance with the provisions in force relating to the fiscal and administrative aspects of businesses
► Independence	Guaranteed to have no direct relationship with the entity in charge of selecting SGP applications

For which types of project?

Type of SGP Beneficiary Projects

- Industrial demonstration
- Thermal or electrical application
- Small capacity

Any CSP / CSH technology

Project Eligibility Criteria

► Type of project and technology	Industrial demonstration of application of the CSP / CSH for industrial or tertiary uses
► Capacity of the installation	Less than 400 kWth
► Investment cost	Total estimated investment cost of less than 500 kUSD or approximately 4700 kMAD

2 Following the study, a Small Grant Program has been developed. One project is currently being partially financed by this program.

- For different technical and economical reasons, one project has been to the end of the process and is currently being partially financed by the World Bank.

Developer	Final user	Technology (developer)	Sector	Process	Capacity
Industrial Solar	ITEX	Fresnel (Industrial Solar)	Textile	Thermal oil heating for processes	445 kWth
Industrial Solar	SINMATEX	Fresnel (Industrial Solar)	Textile	Thermal oil heating for processes	445 kWth
Rabat University	Bituma	Parabolic Trough	Industrial (production of bitumen)	Heating of the bitumen storage tank	20 kWth
Moroccan Solar	Interedec	SunOyster	Tertiary (Hotel)	Heating and cooling of villas in a luxury hotel	48 kWth
Moroccan Solar	Starnor	SunOyster	Tertiary (shopping center)	Public bath heating in a shopping center	37,5 kWth 25 kWelec
Moroccan Solar	Différence & Répétition	SunOyster	Tertiary (Hotel)	Heating and cooling of an hotel	83 kWth 55 kWelec
Green Energy Transition	Cotite Nord	Parabolic Trough (Absolicon)	Textile	Auxiliary heating at the boiler (technical study to be done)	??

THE WORLD BANK

ata renewables

CASTALIA Strategic advisors

EY Building a better working world

Fraunhofer ISE

Fraunhofer ISI