International Energy Agency

IEA TECHNOLOGY ROADMAPS WORKSHOP

ESTELA

Overview of current market trends for Solar Thermal Electricity plants

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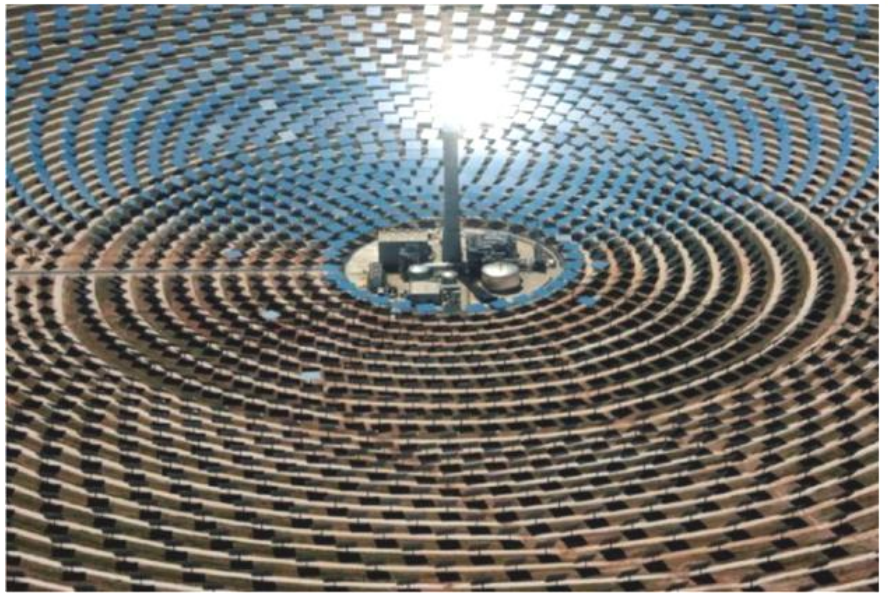
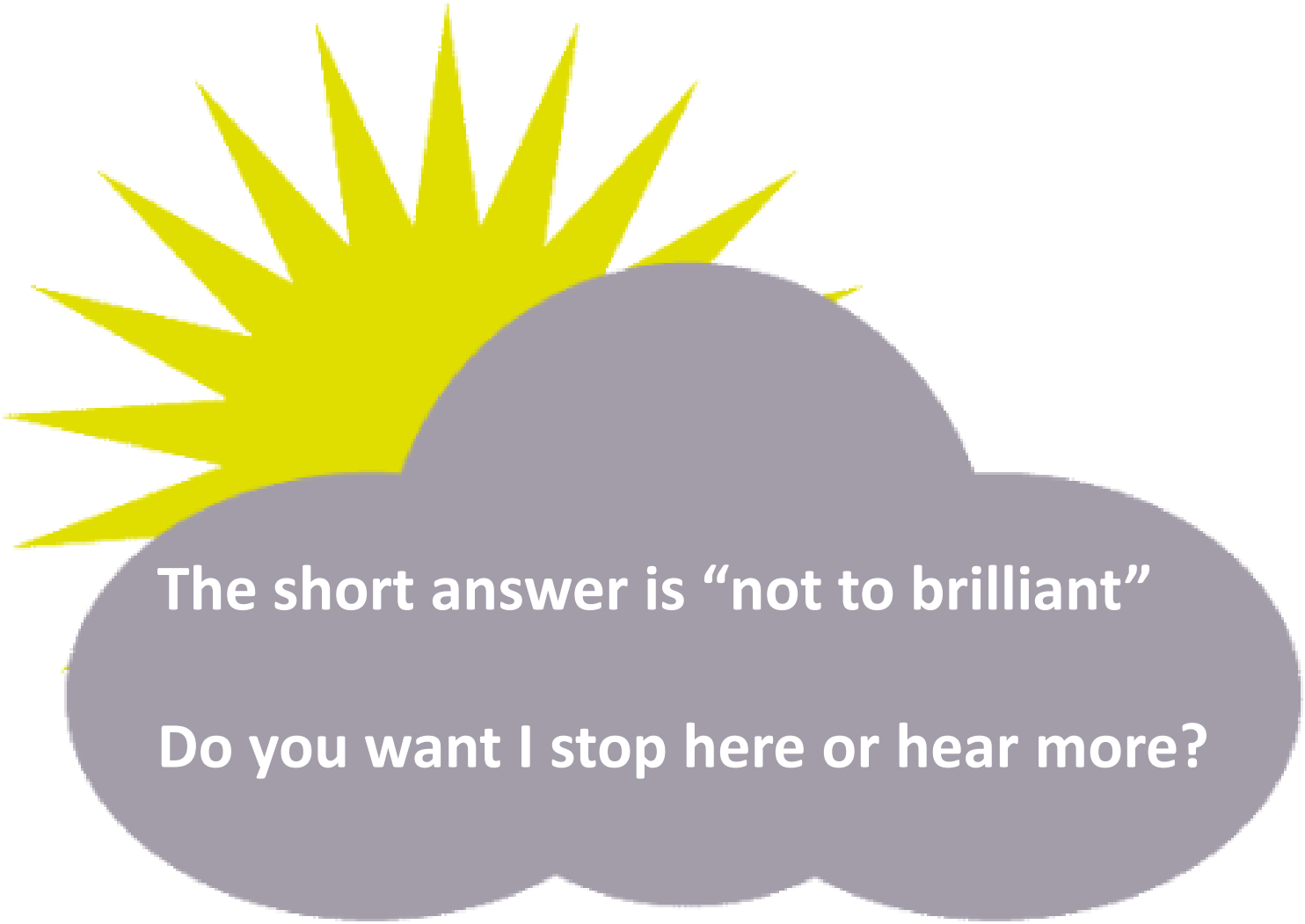


Paris , 3 February 2014

Current market trends for STE



Situation of commercial STE plant deployment

Spain

- Latest news
  Completion of the last 7 previously approved plants (350 MW) in 2013
- Total power in operation
  2304 MW (mainly PT, 40% with storage and 60% without storage)
  Proven operational experience. Positive reference for other countries
- Prospects
  No more plants envisaged in the short term
  Further deployment could be based on the Cooperation Mechanisms of the RES Directive

Rest of Europe

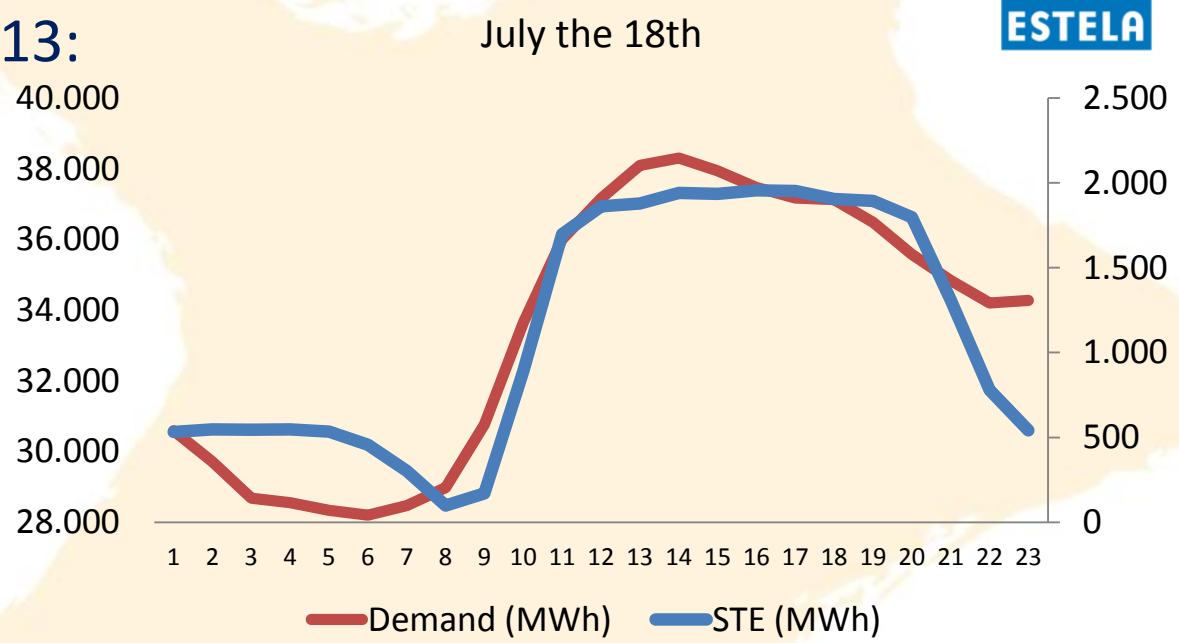
- Italy: Demo plant in Sicily (5 MW, PT). FiT system in force
  3 plans (PT) in the approval process (55 MW, 50 MW, 12 MW)
  Another few more plants (150 MW) in promotion stage
- France: 2 plants (10 MW, F each aprox.) ready to start construction
- UE level: Big frustration with the 5 NER-300 projects (Greece, Spain, Italy and Cyprus)

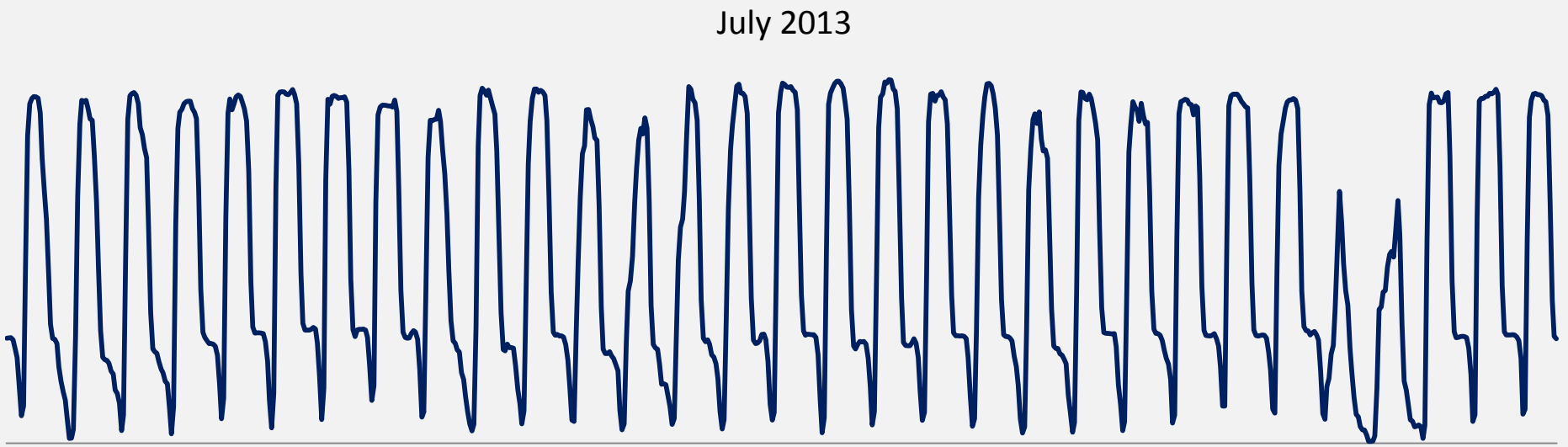
A wide variety of STE plants has been built in Spain

Operational references from the Spanish STE plants

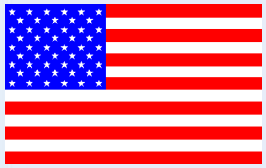
Important milestones in 2013:

- ✓ Max. contribution 7,6 % (July the 18th at 12:00)
- ✓ Max. daily contribution 4,6% (August the 11th)
- ✓ Monthly production 3,6% (776 GWh in July)





Situation of commercial STE plant deployment



USA

- Latest News
  Completion of Solana (280 MW, PT), Ivanpah (390 MW, T) and the first phase of Genesis (125 MW, PT) in 2013

- Total power in operation
  1325 MW in operation

- Plants in advanced construction stages
  Crescent Dunes (110 MW, T), Mojave (280 MW, PT) and second phase of Genesis (125 MW, PT)

There are some 20 more large projects in promotion or early development stages but only few of them have chances to be built in the next future.
Palen (2 x 250 MW, T) under environmental analysis and tribal protests,
Rice (150 MW, T) under negotiations with the utilities, …

- Prospects
  Strong competition with PV
  Future STE plants will depend on the position of the utilities regarding dispatchability. Rising of Portfolio Standards in some states will help.

Solana / Abengoa 280 MW

Ivanpah / BrightSource 390 MW

Situation of commercial STE plant deployment

MENA Region (Arab countries)

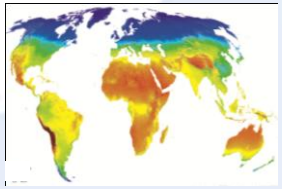
Completion of Shams 1 (100 MW, PT) in 2013
Total STE power in operation: 165 MW (considering equivalent power of the ISCCs)
Noor I (160 MW PT) is under construction in Ouarzazate (Morocco)
Noor II (200 MW PT) and Noor III (100 MW T) in the RfP phase after PQ of bidders
Al Shagaya (50 MW PT) with big storage and dry cooling recently awarded in Kuwait
Ambitious plans in Saudi Arabia two first rounds (900 and 1200 MW) and 25 GW by 2032 (White paper). STE plans announced in many other countries

South Africa

200 MW (150 PT / 50 T) under construction Rounds 1 & 2
100 MW (50 PT / 50 T) MW recently approved in round 3
ESKOM plant (100 MW) in RfP. Rounds 3.5 and 4 (300 MW) to be launched shortly
Interesting FiT approach with hourly discrimination (Time Of Day tariff +270%)
Increased interest in the dispachability features and local content of STE plants.
Clear possibilities to increase the 2020 goal from 1100 MW to 3300 MW

India

Completion of Godawari (50 MW PT) and Reliance (100 MW F)
Megha (50 MW PT) in advance construction.
The other 4 plants of the JNNSM will -most likely- not be completed (unrealistic FiT)
Two new plants (50 MW PT & 50 MW T) will be soon announced for bidder PQ



Other countries

- **China**

  Apart from some demo plants the only real project is the completed first phase (10 MW, T) of a 50 MW plant in Delingha.
  There are many projects in promotion but still uncertain FiT conditions.
  Ambitious plans for 2015 (1000 MW, unrealistic) and for 2020 (3000 MW)

- **Israel**

  2 plants (110 MW PT & T) under early construction phases. Another few hundred MW in promotion stage.

- **Australia**

  The ISCoalPlant in Kogan Creek (44 MW F) is near to completion. The Solar Dawn project (250 MW F) under the SFP didn't get the financial support and it was withdrawn.
  New expectations based on the Renewable Energy Target and the financial support of ARENA

- **Chile**

  The first plant (110 MW T / base load) has been recently awarded

- Increasing interest in other Latin American countries and African neighbors of SAR

Big differences between industrialized / developing countries which explain the current penetration of STE

❑ Industrialized countries (Where Wind and PV have been mainly deployed)

Non dispatchable RE technologies contribute to savings on fossil fuels without longer-term considerations or backup requirements. Overcapacity in the systems leads to operation restrictions for conventional plants and curtailments for RES plants.

STE will play an essential role when phasing out conventional plants

❑ Quick developing countries

Substantial additional generation (2 or 3 times over the next 10-20 years) will be required. This can't be firmly supplied by non dispatchable technologies alone and a considerable amount of backup power -combined cycles- have to be included when planning the investments.

In this context STE plants - with storage and/or hybridization - will provide major advantages , besides their macroeconomic impacts.

Therefore **STE can be considered as a competitive option today**

Barriers for quicker STE deployment

- Longer Project Development and Construction periods
- **Higher Current Investment and O&M costs**
- Delays in Technology Development feedback

WIND

330 GW

PV

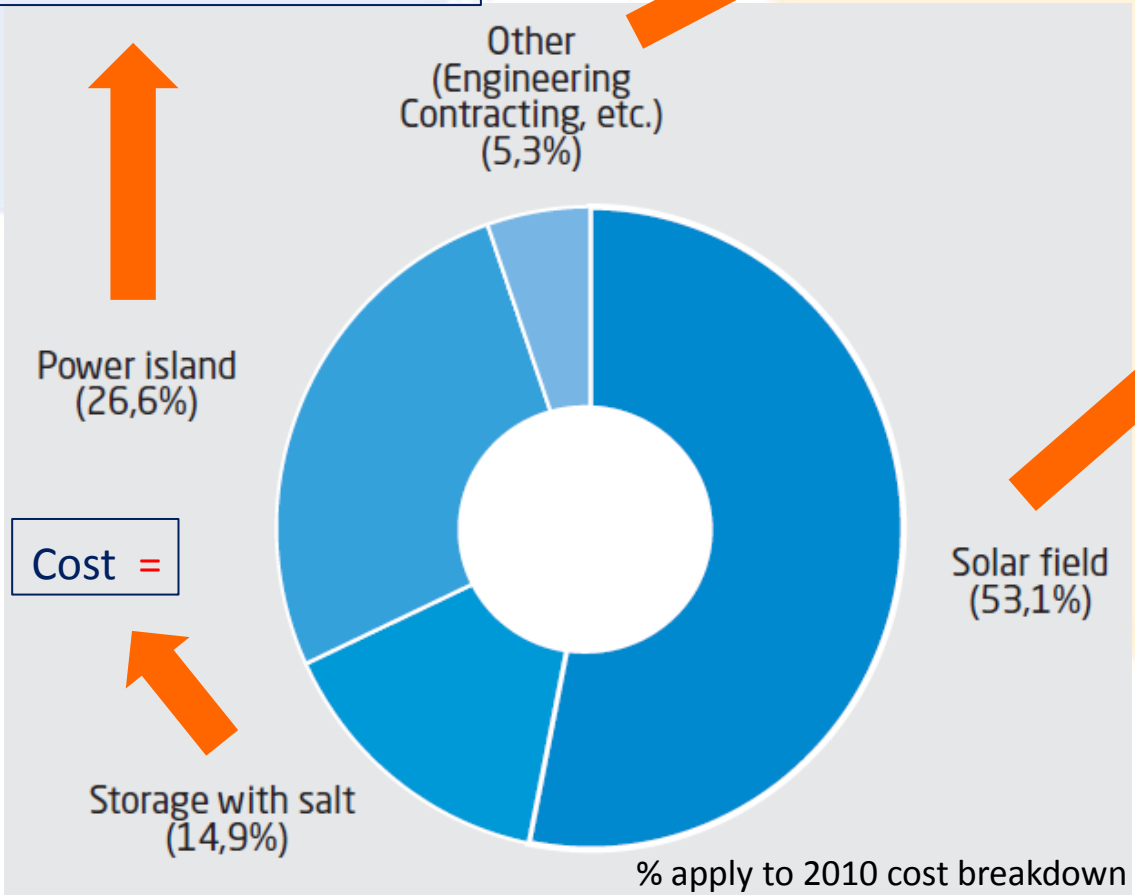
120 GW

There is an urgent need to remove blocking perceptions among Policy Makers and to show them the value proposition of STE

What has been done so far
(Stars ★ mean achievements)

Cost =
Performance increase ★

Cost reduction ★★



Cost reduction:
Structure ★★★
Tubes ★★
Mirrors ★★

Performance increase ★

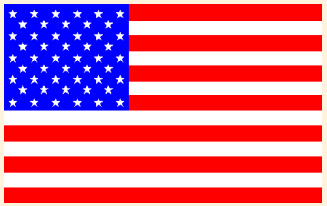
The increase of financing costs has counteracted this effort to some extend

Trying to understand cost issues. “LCOE vs PPA”

- LCOE is being used in institutional reports to show the situation of different technologies and to make comparisons among them.
  The LCOE is -by definition- the **constant** value that makes the Net Present Value of the sales of electricity equal to the NPV of all incurred costs along the life span of the plant.
- But what really matters when deciding building a STE plant is whether the PPA (or FiT) for a shorter period than the life span of the plant will provide a reasonable profit over the costs to the developer. Incomes associated to the PPA might be variable and might depend on the dispatch profile and some other factors.
- One should be careful when using LCOE for comparisons among technologies as the variety of system designs - specially for STE -, the different life span, the site dependence of costs when there are different local contents, the differences on financing costs, the impact of the breakdown between DNI/global radiation, other relevant meteorological factors, etc., makes extremely difficult to provide precise basis for comparison.
- PPA references can be tracked - although they need to be duly harmonized - in order to inform Policy Makers on the gap that need to be filled when considering launching a STE program in their countries. LCOEs must be consistent with this references incorporating the corresponding differences in the formula.

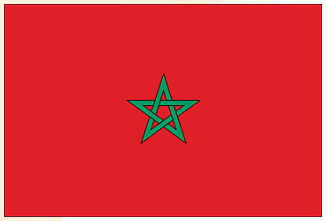
Real cost references from current projects

30 c€/kWh



13 c$/kWh

20 c$/kWh



14 c€/kWh

20 c€/kWh

21 c$/kWh

The “harmonization” model for STE costs

“Discount” factors

- Plant size
- PPA or FiT duration
- PPA escalation rate
- Grants
- Concessional loans
- Specific Financial conditions
- Loan duration
- …

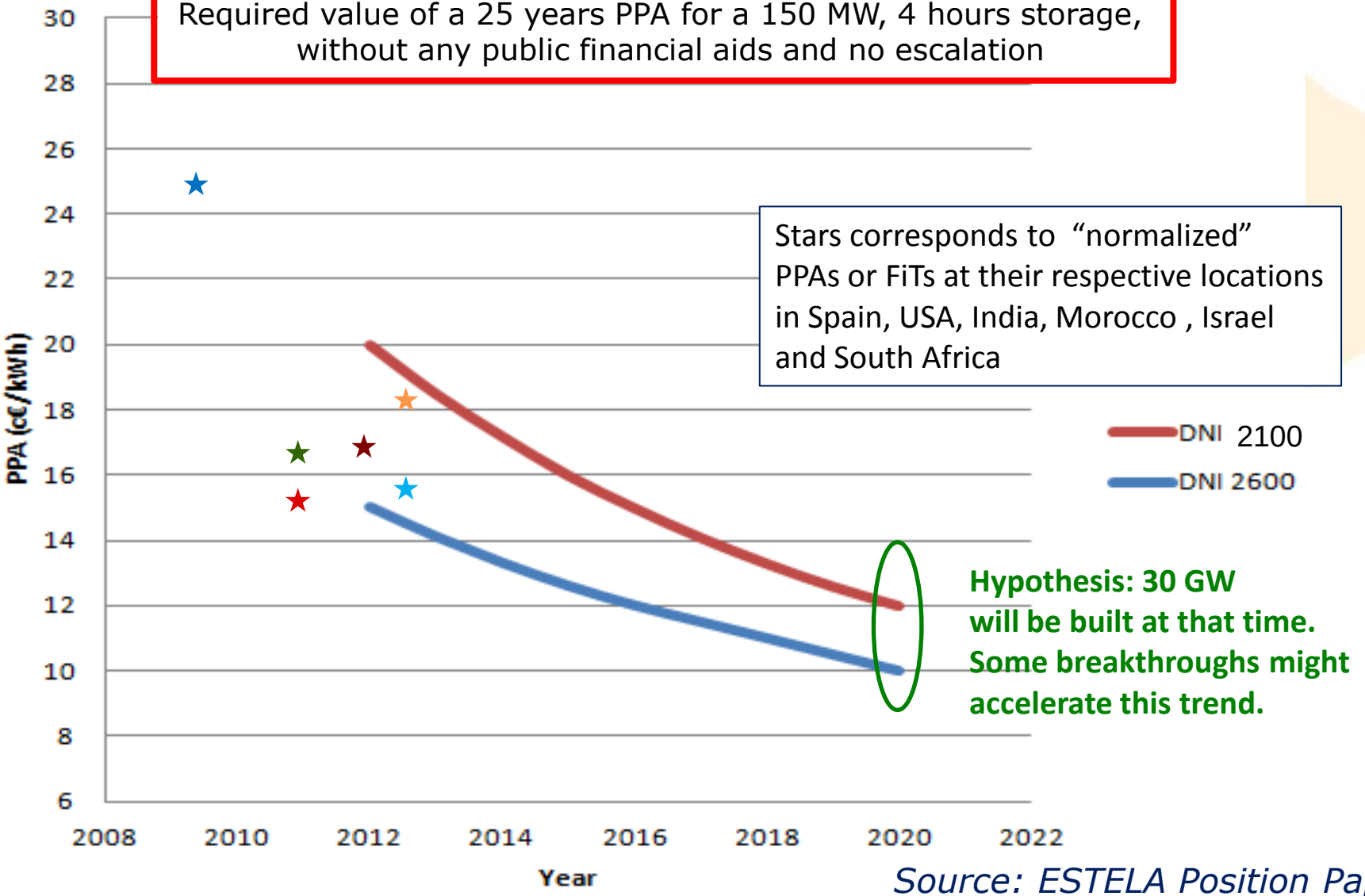
Actual PPA for a given project at a certain location under specific support circumstances

Harmonized PPA for a **typical project** at the same location **WITHOUT PUBLIC SUPPORT**

DISCLAIMER: This attempt to provide reference prices must be considered approximated. There are many default values that might be not applicable to all projects as well as some country specific requirements.

Current cost references and the view of the Industry on future cost reductions

Required value of a 25 years PPA for a 150 MW, 4 hours storage, without any public financial aids and no escalation



Stars corresponds to "normalized" PPAs or FiTs at their respective locations in Spain, USA, India, Morocco , Israel and South Africa

Hypothesis: 30 GW will be built at that time. Some breakthroughs might accelerate this trend.

Source: ESTELA Position Paper

Opportunities and value of different STE technologies

Strong PV competition

Hybridization will enhance competitiveness

Efficiency

Parab. trough
Fresnel

Compressed Air Rec. Tower

Steam Tower
Parab. trough
Fresnel

Molten salt tower
Parab. trough

Molten salt tower
Parab. trough

Integrated Solar Field

Peak Power (No storage)

Dispatchable (Medium size storage)

Base Load (Large storage)

My personal views on the trends

- The greatest push for STE will come from developing countries. Dispatchability and local content will be the main drivers for STE deployment
- Interconnections in big regions (i.e. Europe) will allow for a large RE penetration and optimum combination among RE technologies. STE will play a great role
- Decisions on new STE plants will still consider linear systems (PT & F) and molten salt towers in the medium term. In the future the tower could be the winning concept due to higher efficiency and storage matters
- Nevertheless parabolic troughs could be preferred for lower latitudes - where the “M curve” is not too strong and night temperatures are mild - due to scale advantages
- Fresnel could be preferred for direct steam generation to integrate solar fields in fossil fired thermal plants
- Optimum working fluid temperature is related to the concentration factor. This principle along with feasibility issues bring doubts in increasing the fluid temperature in linear concentrating systems
- Clever hybrid systems than just heating the working fluid must be implemented to increase STE competitiveness

Thank you for your attention

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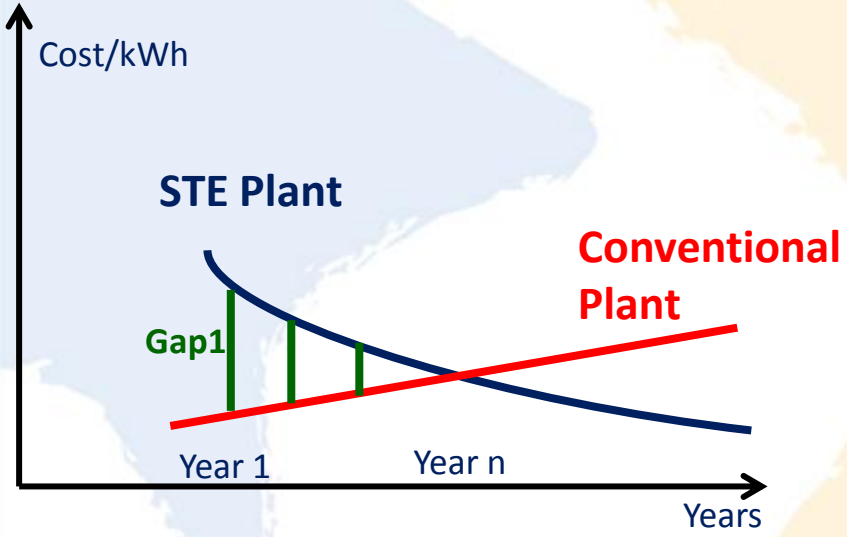
Convincing materials for Policy Makers
(Not for this audience but to share with this audience)

The tool for policy makers

"Making the business case for my country"

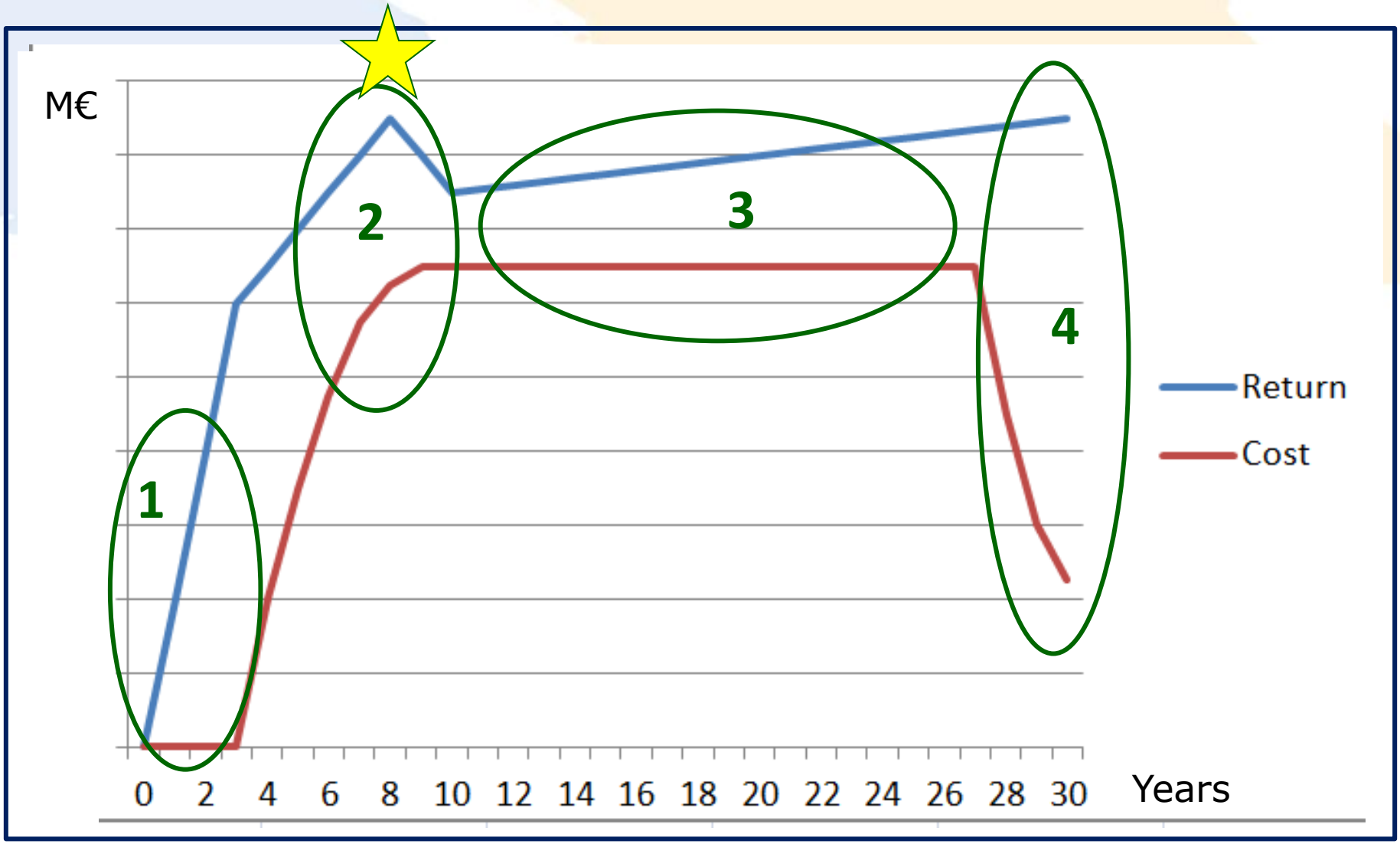


The basic questions:

- ❑ How much will a support program cost?
- ❑ How much can the economy of my country benefit from it?

		Power	Energy	Cost	Returns of all kind	Diference
Year -2		0	0	0	R1	Positive
Year -1		0	0	0	R2	Increasing
Year 1	Gap 1	P 1	E 1	G1xE1	R3	Increasing
Year 2	Gap 2	P 2	E 2	G1xE1 + G2xE2	R4	Increasing
Year 3	Gap 3	P 3	E 3	G1xE1 + G2xE2 + G3xE3	R5	Increasing
…	…	…	…	…	…	Increasing
Year n	0	Pn	En	G1xE1 + G2xE2 + G3xE3 + …Gn-1xEn-1	Rn	Increasing
Year n+1	0		En+1	idem	Rn+1	Increasing
…						Increasing
Year 25	0	P25	E25	G2xE2 + ….	R25	Golden End starts

ESTELA is proud to offer assessment to Policy Makers in order to build up their specific country cases



ESTELA is proud to offer assessment to Policy Makers in order to build up their specific country cases

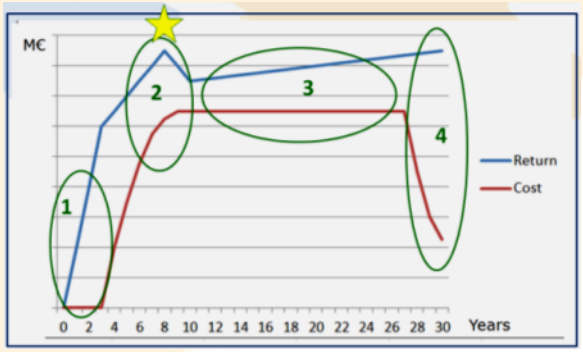
1. Start up phase

First positive impacts of the construction of the first plants and no payments

2. End of the promotion program

Until this point the returns will be continuously growing based on the construction plus the electricity generation effects while the increase of the supports for new plants will be lower

At this point commercial plants can be deployed without Further supports and the country will be prepared to get the maximum return



3. Mature phase

Two years after the stop of the promotion program -when the breakeven with the conventional energy is reached- the contribution of the construction will finish but the corresponding one to the generation will be continuously increasing while the supporting cost will remain constant

4. Golden end

After the PPA period the supports will fall down to cero in few years while the benefits from the generated electricity will be continuously growing

Solar Thermal Electricity:
The great opportunity for sunbelt countries

- **Net importers:** reduction of imports / energy independency / potential exports
- **Net exporters:** Adding value to their resources / Additional exports / preparing for the future

A usual opinion of Policy Makers:

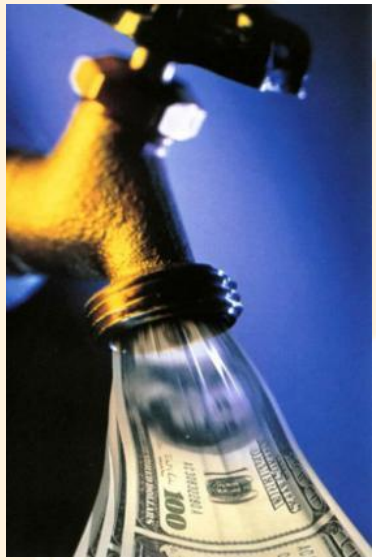
As STE will be cost competitive in some years it is advisable to wait

But this is a big mistake because:

1. **There is much more to gain than to loose for the country's economy in the first years (and beyond)**
2. **If the program is launched today the country will be prepared to provide a high percentage of local content when the technology become competitive**

Solar Thermal Electricity:
The great opportunity for sunbelt countries

Countries are loosing money every single day as long as they do not launch a specific STE support program



- ✓ Programs must be straight forward and clear
- ✓ Rules should facilitate both investors and industry commitments

The reasons for a brilliant STE future

1. **Technical**

   STE is the only dispatchable and grid-friendly renewable technology with potential enough to meet the electricity needs worldwide in order to achieve a carbon free generation system
   A wise mix with other R.E. technologies will be the right choice

2. **Local Economic Development**

   Local content of STE plants -and corresponding contribution to the GDP- will be one of the main drivers behind the supporting policies in many countries of the sun belt

3. **Affordable cost and positive macroeconomic impact**

   The cost of STE plants will show important reductions when approaching from the current 4 GW installed to the similar values of Wind (330 GW) and PV (120 GW)