Transformative Solutions at Scale

Utility scale climate change mitigation with baseload renewables and by opening new energy corridors.

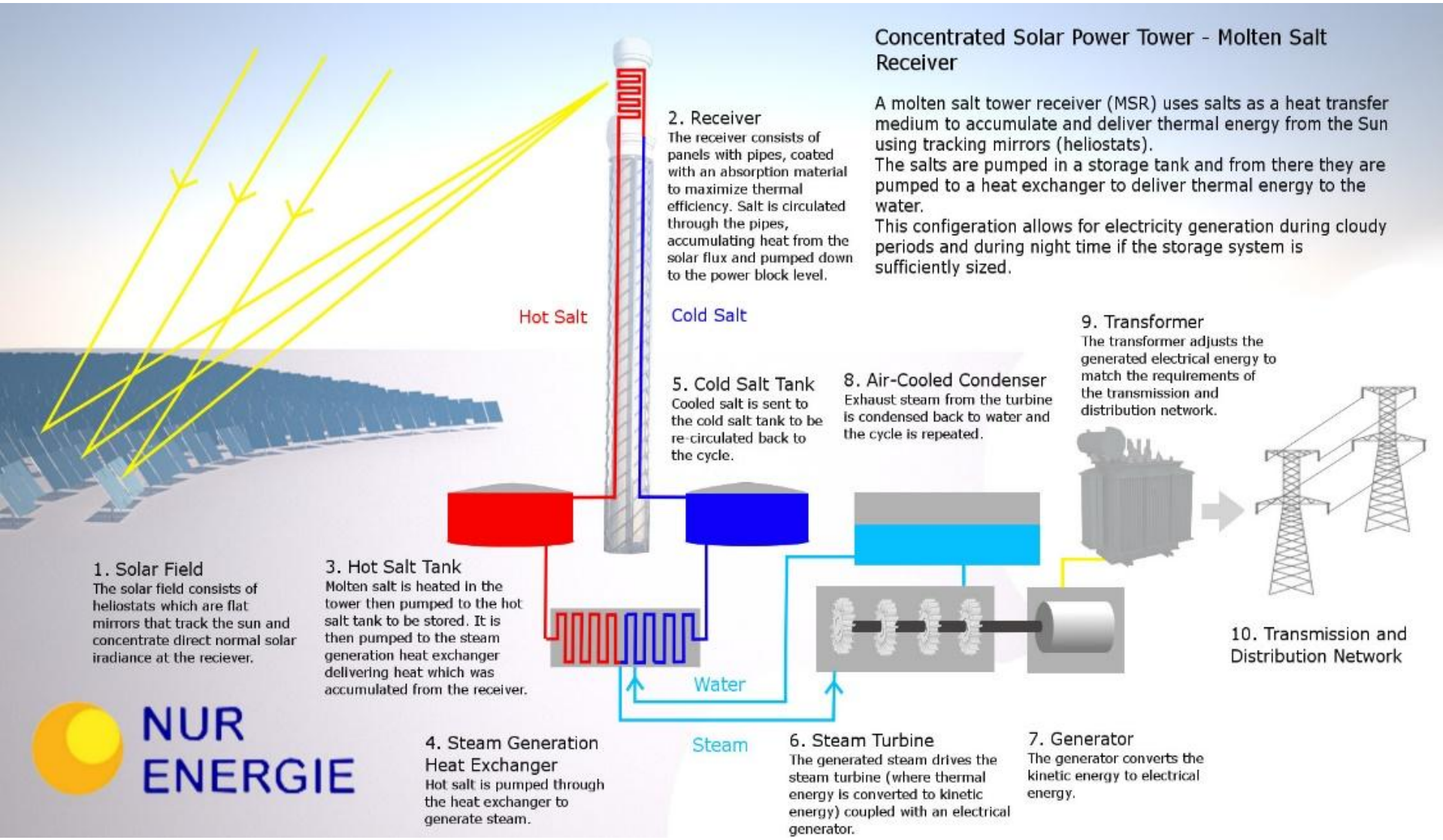
Kevin Sara, CEO Nur Energie Ltd

Sustainable Energy for All Forum, New York (June 2014)

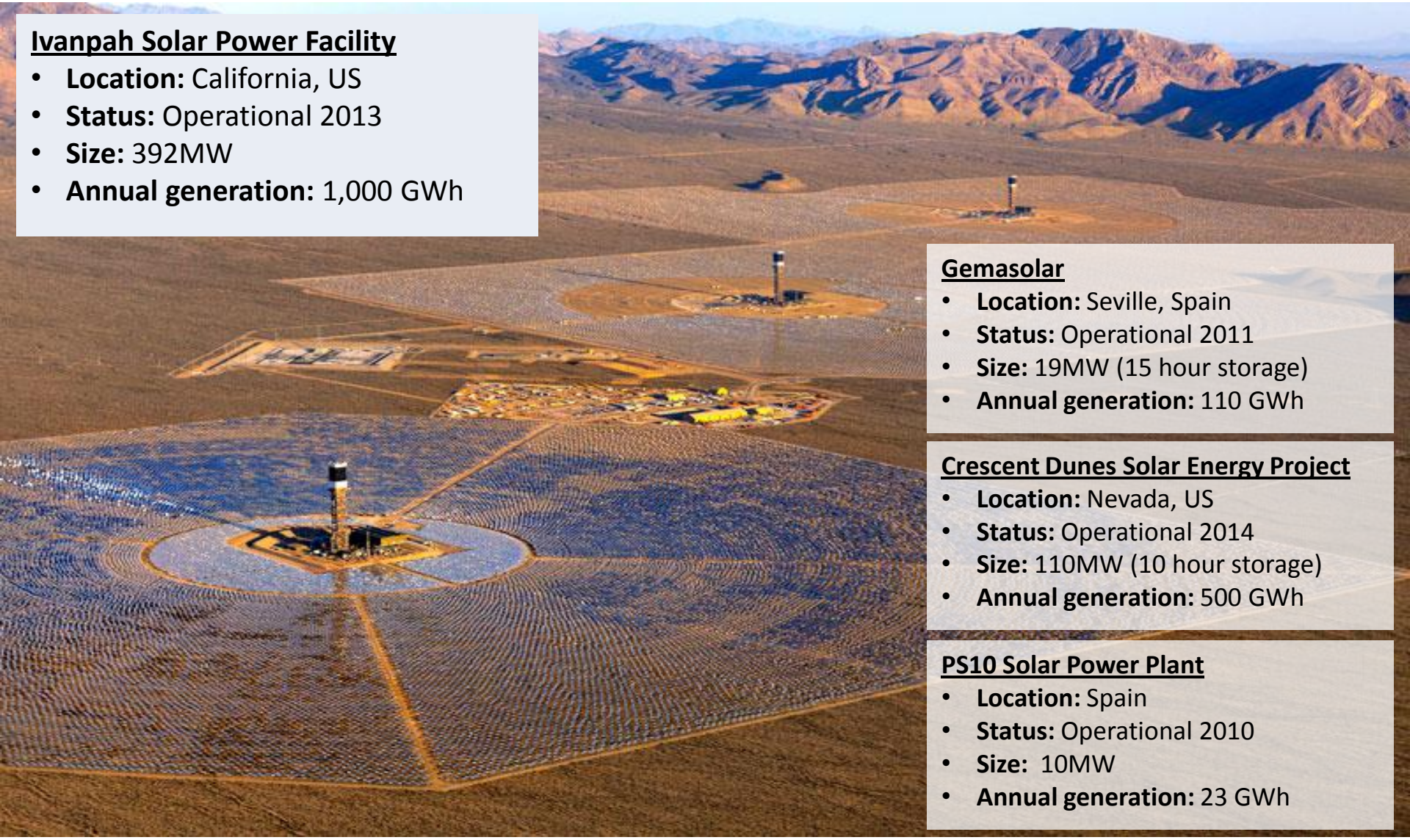
The elephant in the room is the intermittency of renewables

- **Electricity storage is still very expensive, and this will eventually limit or slow down the penetration of renewables.**
- **Geothermal and to some extent hydro and marine renewables are the only "base-load" non-intermittent renewables. But this resources are limited and sometimes difficult to harness.**
- **Concentrated Solar Power (CSP) with thermal storage is one of the few examples of a scalable, distributed base-load renewable.**
  - CSP installations are increasing and costs are dropping rapidly.
  - Technology is most suited to sun belt countries, but can be exported to centres of demand
  - CSP is being scaled up (400MW Ivanpah plant) and scaled down (5MW plant in China)

How does CSP with storage work?



Selection of Operational CSP Projects



Ivanpah Solar Power Facility

- **Location:** California, US
- **Status:** Operational 2013
- **Size:** 392MW
- **Annual generation:** 1,000 GWh

Gemasolar

- **Location:** Seville, Spain
- **Status:** Operational 2011
- **Size:** 19MW (15 hour storage)
- **Annual generation:** 110 GWh

Crescent Dunes Solar Energy Project

- **Location:** Nevada, US
- **Status:** Operational 2014
- **Size:** 110MW (10 hour storage)
- **Annual generation:** 500 GWh

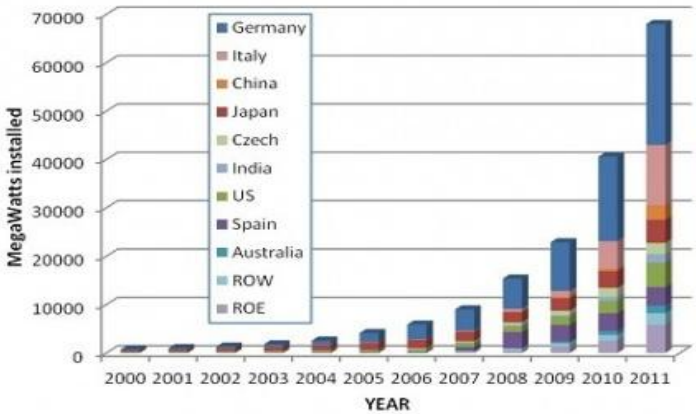
PS10 Solar Power Plant

- **Location:** Spain
- **Status:** Operational 2010
- **Size:** 10MW
- **Annual generation:** 23 GWh

Solar Energy Installations over the last decade

PV is booming…

- PV installations surpassing 100GW.
- Can still grow substantially in many regions
- Why?
  - Feed-in-tariffs & incentives
  - Cheaper than conventional electricity cost in some markets



Global PV cumulative installation (MW)

Wholesale electricity prices in Germany, 16.06.13 (source EEX.de)

…but not without consequences

On the 16th of June 2013, wholesale electricity prices in Germany plummeted to -140$/MWh due to overproduction of PV and wind energy.

Large PV (and wind) percentage in the energy mix of a country leads to grid stability problems with large "hidden" costs, such as emergency shut-downs of conventional power plants

PV cannot bring the energy revolution that the Earth needs due to its inherent limitations – intermittency and lack of dispatchability

The real cost of PV

PV is cheap…

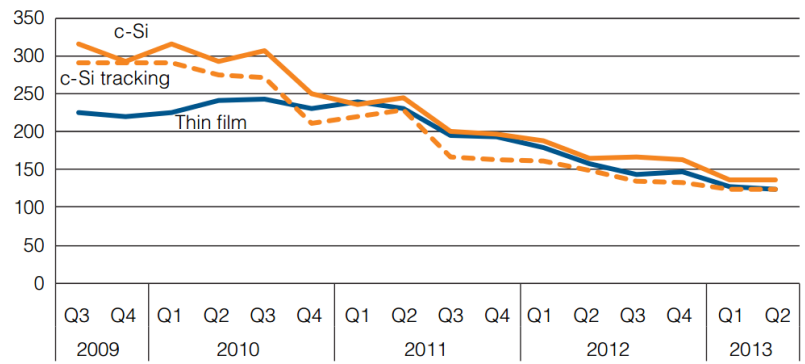
Installed PV is at c. 1.4$/W and the generates electricity at a cost of c. 140$/MWh

…but adding dispatchability is expensive

The cost of adding a storage system to PV can push the system's cost to 9.5€/W

Levelised cost of PV electricity over time, developed market average (USD/MWh)

Source: Bloomberg New Energy Finance



Cost of PV system (without batteries)

6MW of PV @ 1.4$/W
8 M$

Large grid interconnected battery (Sodium Nickel/lead acid/lithium ion)
3MW / 15MWh battery
20 M$

3MW system with 5 hours of storage for 28 M$

9.5$/W or 478$/MWh

Dispatchable Solar Energy

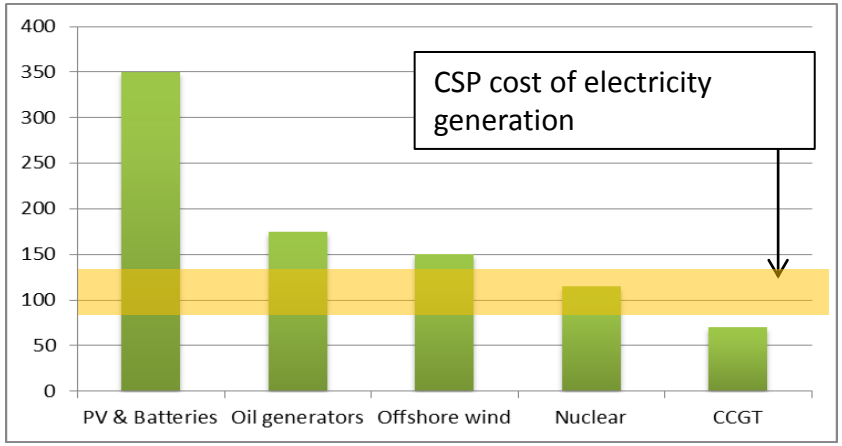
Is CSP the solution?

- Dispatchable and can operate as base load or semi-base load power
- Does not suffer from saturation problems that PV faces

New generation CSP plants delivering lower costs and longer storage.

- Morocco tendered CSP with a PPA of 190$/MWh
- 140$/MWh and below is in sight

Gemasolar: Tower CSP with 15 hours of storage



CSP vs. the alternatives

Yes, and it is one of the cheapest alternatives

CSP in the sunbelt countries is cheaper than

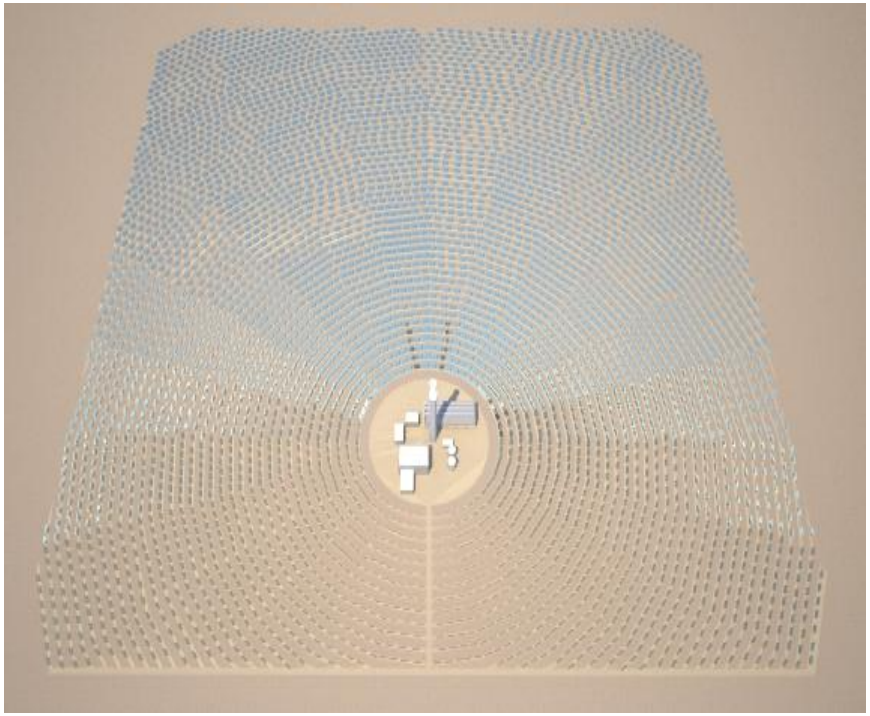
- PV with batteries
- Conventional oil fired generators
- Offshore wind
- New generation nuclear power

Implementing the Energy Revolution

Two Opportunities for CSP in the Sun Belt region

1. Scaling CSP down in size for distributed and off-grid applications; and

2. Scaling CSP up for export opportunities and industrial development opportunity.

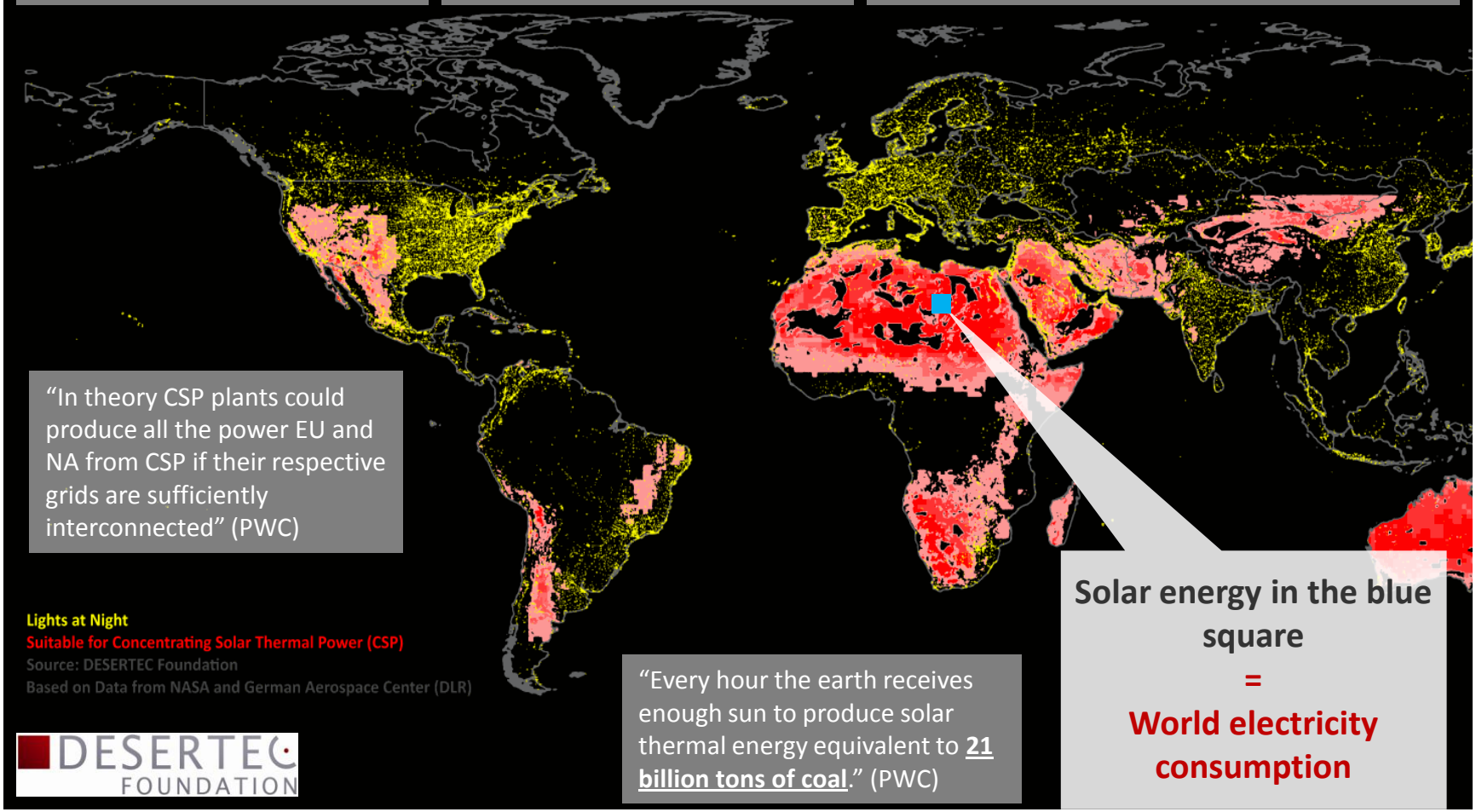


Sunbelt areas (red) and high demand areas (yellow)

"CSP plants could provide about half of the region's electrical production, from a total capacity of **390GW**" (DLR)

"Global CSP capacity be in the region of **1,500GW** and with large storage systems yearly output could exceed 7,800TWh "(ESTEA)

"CSP predicted to produce 2,200TWh annually by 2050 from **630GW** of local capacities (not including export) and up to 5% of the annual global electricity production" (IEA).



"In theory CSP plants could produce all the power EU and NA from CSP if their respective grids are sufficiently interconnected" (PWC)

"Every hour the earth receives enough sun to produce solar thermal energy equivalent to **21 billion tons of coal**." (PWC)

Solar energy in the blue square

=

World electricity consumption

1. Small Scale CSP

Countries across the sub belt region face huge energy infrastructure challenges..

- Small scale CSP (5-10MW) with storage provides a real solution
- Weak and sparse electrical transmission network
- African businesses experience annually 56 days of power outages resulting in losses of sales between 5% to 20%
- High cost of generation as oil is the dominant form of electricity generation in many countries
- Very high rates of growth of electricity demand – new capacity is urgently needed
- Similar issues in India and other sun belt countries
- Distributed generation, no need for expensive grid upgrades
- **CSP supports sustainable development through local integration, manufacturing and technology innovation – unlike extraction of fossil fuels**

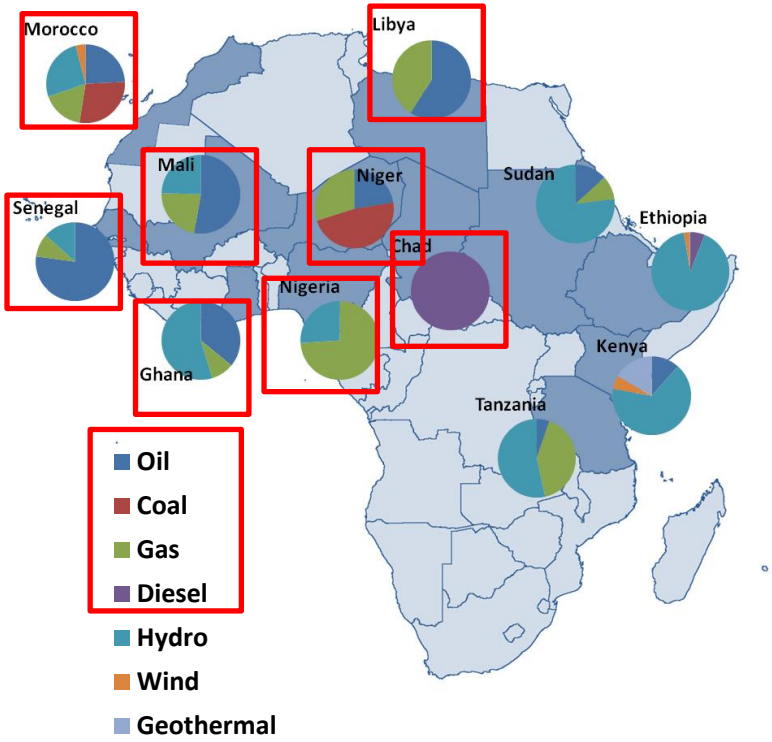
A 5MW CSP in China

Example of Small Scale CSP – Sub Saharan Africa

Much of Sub Saharan Africa has no or bad access to electricity

- Growing demand and need to plan future energy security
- Lack of energy infrastructure for large generation
- Lack of electrical connection to rural settlements creates opportunities to deploy smaller off grid solar solutions.
- Rural off grid settlements use kerosene as an energy sources which produces harmful pollutants and contribute to global warming.
- High government subsidies for fossil fuel generation
- Average effective tariff in Sub- Sahara is 350% higher than other parts of the world

Electricity generation sources in a selection of African countries



Why is small scale CSP the answer?

- High DNI makes CSP cost effective
- CSP with storage can be integrated in grids easily as predictable supply.
- CSP technology is already lower than grid parity in many markets
- CSP requires significant local content and generates employment

2. Large Scale Solar Export

Import of utility scale solar energy with storage is technologically feasible and financially attractive

- Generates ‘predictable’ supply of power.
- Baseload renewable power can be sold locally and/or exported
- Potential for up to 10GW to be imported into Europe via Italy.
- This power can be transported to Europe's industrial heartlands and cities using the existing grid with minimal upgrades.
- Can be replicated elsewhere across the globe where demand is adjacent to high solar resource

Example of Solar Export - TuNur Project

TuNur is an integrated solar export project consisting of a 2.25GW solar plant with storage in Southern Tunisia and a 2GW submarine cable from Tunisia to Italy.

CSP Power Plant in Tunisia

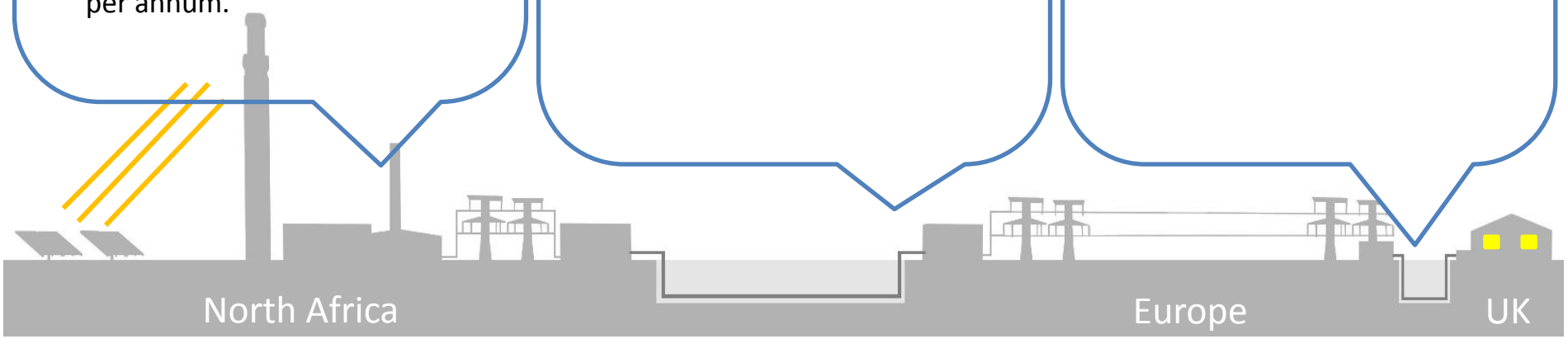
- 10,000 ha site in Tunisia.
- 18 x 125MW CSP Towers with 10 hours storage (molten salt)
- DNI 2,500kWh/m2
- New renewable energy law before Parliament in Tunisia with section on renewable energy exports
- TuNur will generate more than 9,000GWh of 100% renewable power and dispatchable power per annum.

Transmission to Europe

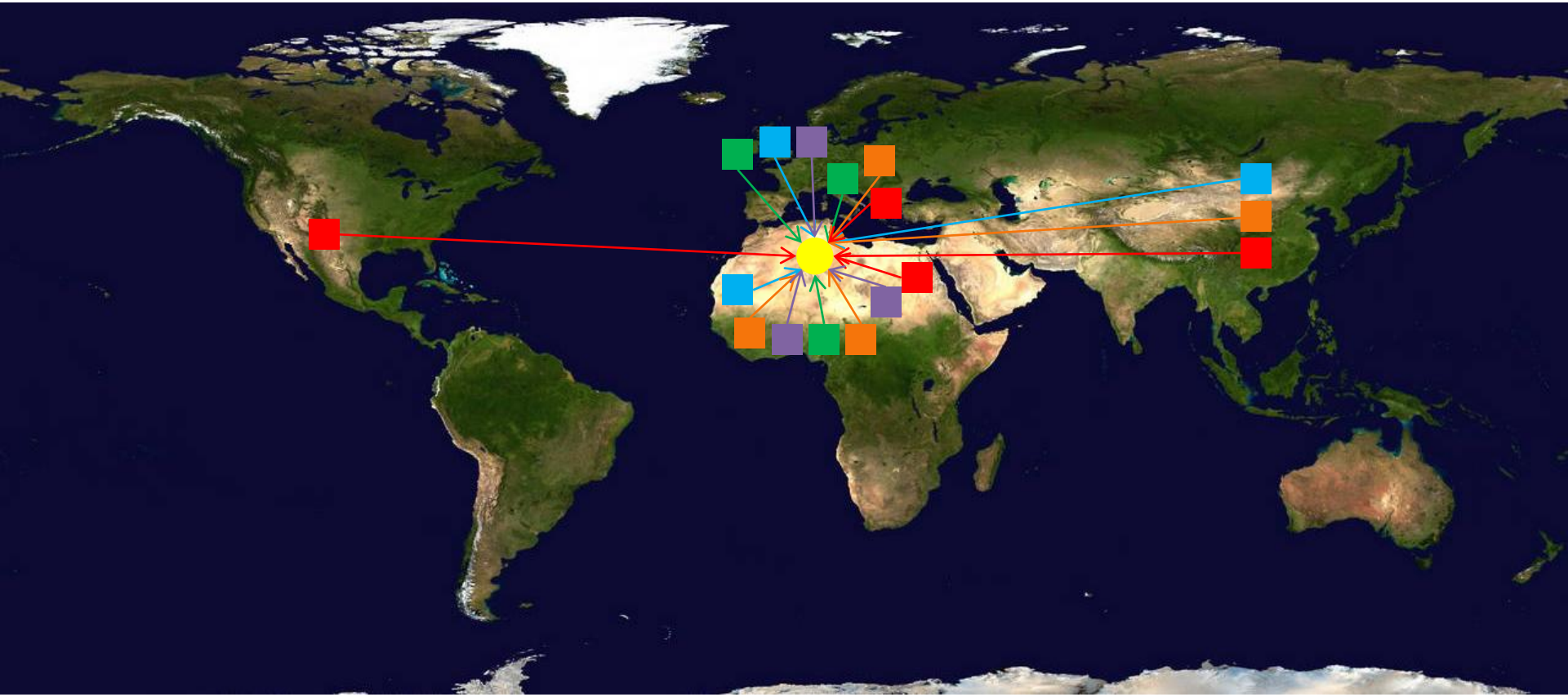
- Dedicated High Voltage DC cable
- 600Km over land and 600Km sub sea
- c.5% losses per 1,000Km
- 2 GW grid connection secured on one of strongest nodes in Italian network
- Once landed in Italy power can be transported to all other European countries

Off-take in Europe

- Energy to circa 2.5 million European homes by 2018
- Syndicate of customers including the UK, Switzerland and Germany.
- Indicative PPA offer from a major UK Utility for 25% of the power (500MW).



A truly multi national project



Technology	Investors	Engineering	Components	Customers
Africa China Europe US	Tunisia Rest of Africa China Europe	UK Italy Tunisia	Tunisia Rest of Africa Europe China	Tunisia Rest of Africa Europe

Project Sponsors

NUR ENERGIE

TOP OILFIELD SERVICES

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TUNUR
تونور

Armonia

AFRICA 50
FINANCING AFRICA'S INFRASTRUCTURE
POUR LES INFRASTRUCTURES EN AFRIQUE

BANQUE AFRICAINE DE DEVELOPPEMENT
AFRICAN DEVELOPMENT BANK

AFRICAN DEVELOPMENT FUND
FONDS AFRICAIN DE DEVELOPPEMENT

AfDB - Africa50

<u>The African Development Bank will be a co-developer of TuNur project through a new financing vehicle the Africa50 Fund.</u>

The Africa 50 Fund :

- ✓ Aims at mobilizing private financing to accelerate the speed of infrastructure delivery in Africa
- ✓ Two Business Segment: Project Development and Project Finance
- ✓ A $3bn total target capitalization to finance over $50bn worth transformational infrastructure projects including TuNur

TUNUR تونور

AFRICA50

Africa50 – A Transformational Solution for Infrastructure Development

Highlights for Tunur

The Financing Gap in African Infrastructure

It is well documented that Africa's infrastructure financing needs are estimated at an annual USD 100 billion or 10% of its GDP, a level that cannot be met by national Government budgets and is failing to be met by the current combination of DFIs and small-scale private financing. Actual annual investments are roughly at USD 50 billion, meaning that Africa suffers from a yearly 50 billion USD deficit in infrastructure financing. That means that for every dollar invested in African infrastructure, Africa needs another dollar only to match its needs.

The current lack of infrastructure and the subsequent costs of access to power, transportation, water and communications transmissions are some of the greatest barriers to Africa's economic transformation. Infrastructure is the channel through which economies breathe and Africa's lungs are not keeping up with its pace.

CSP Benefits for Africa

Benefit	Description
Job Creation	• For a 2GW project 1500 direct jobs will be created and a further 20,000 jobs can be created indirectly across the whole supply chain • Specialist skilled work - Using local partners and management for project development as well as local engineering firms for geo technical and socio impact assessments and feasibility assessment of site etc
New industry	• Industrial Development • For example Tunur - circa 825,000 heliostats (flat plate mirrors on steel pylons with motors) for the 2GW project can be manufactured locally
Regional Energy Security	• Energy Supply and security • Regional Economic integration as supply chains extend to Algeria, Egypt, Morocco and South Africa
Export Capabilities	• Establishment of critical mass of CSP technology and industry for Africa. Three clusters: Morocco, Tunisia and South Africa • Eventual reinforcement of African grid and enabler of energy exports

Conclusion

CSP Technology is proven and ready to implement AT SCALE today through:

1. Sustainable development of small scale CSP with storage in emerging economies by introducing off-grid distributed generation on a large scale and at a competitive cost; and

2. The development of large scale decarbonisation of electricity grids in mature economies through export projects.

What do we need to do to make this transformation happen?

- Financial and political support from multi lateral and international institutions for the development and financing of projects.

- Governments to open the market and support CSP with storage from local generation and exports/imports through appropriate legislation and electricity tariffs.

- Nur Energie is seeking local partners across the sun belt in areas of high solar radiation for local implementation of small and large scale projects.

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