# STORAGE MIX TO ENHANCE RENEWABLE PENETRATION

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January 2018

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# Moroccan renewable potential and electricity demand

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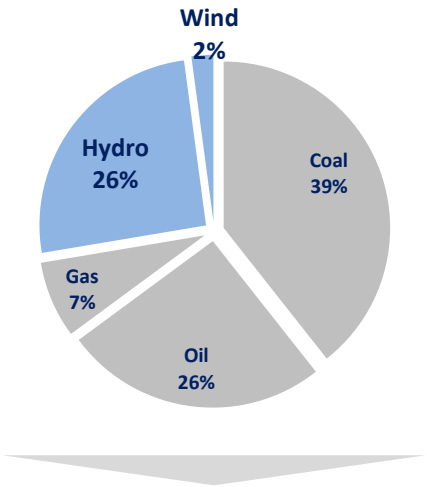
# RENEWABLE ENERGIES, AT THE HEART OF MOROCCO'S ENERGY STRATEGY

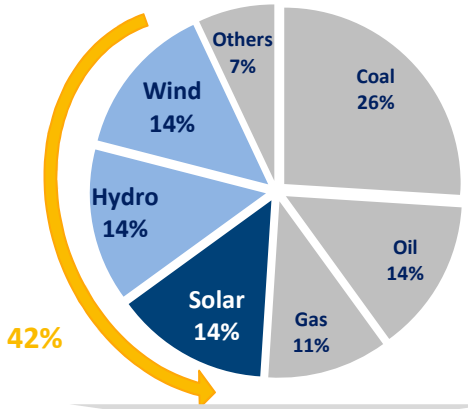
**Strong will of increasing renewable energy share within the national mix by 2020 and 2030, through a roadmap of deployment based on an optimal technological mix**

## 2009




**Renewable energy represented 28% of installed capacity**

## 2020



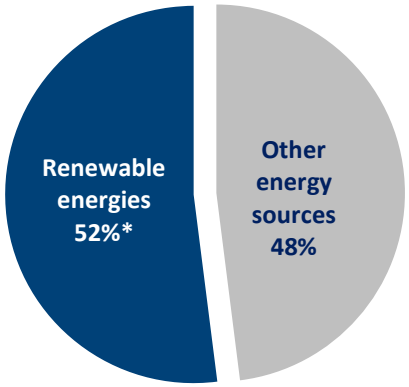

**Renewable energy will represent 42% of installed capacity**

*Morocco launched the NOOR Plan (the Moroccan solar plan), to be implemented by masen*

NOOR

***Development of a minimum of 2 000 MW by 2020***

## 2030




**Renewable energy will represent 52% of installed capacity**

***Masen will implement a minimum of 6 000 MW of renewable energy by 2030***

Conventional energy

Renewable energy

Projects developed/to be developed by masen

# RENEWABLE ENERGY IN MOROCCO : ABLE TO RESPOND WHOLE DEMAND

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## High renewable potential covering al regions

**Hydraulic :**

Potentiel in 6 regions even 2 regions Fès-Meknès and Béni Mellal-Khénifra concentrate main potential

**CSP :**

Best potential concentrated in the 4 eastern regions (saharien side of the Atlas)

**Wind onshore :**

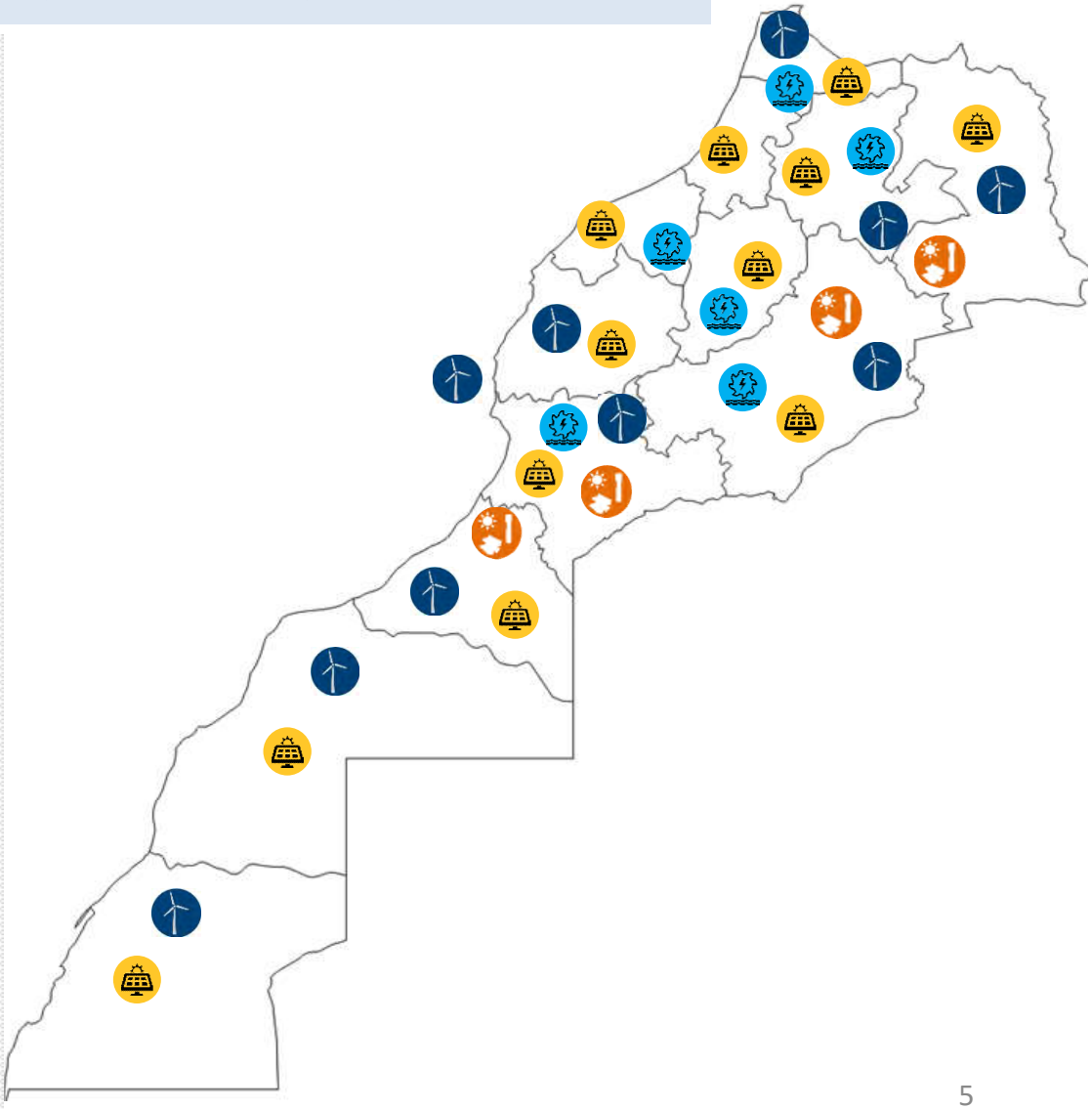
9/12 regions have wind potential , the 2 southern regions Laayoune-Boujdour-Sakia El Hamra and Oued-Eddahab have the best potential

**PV :**

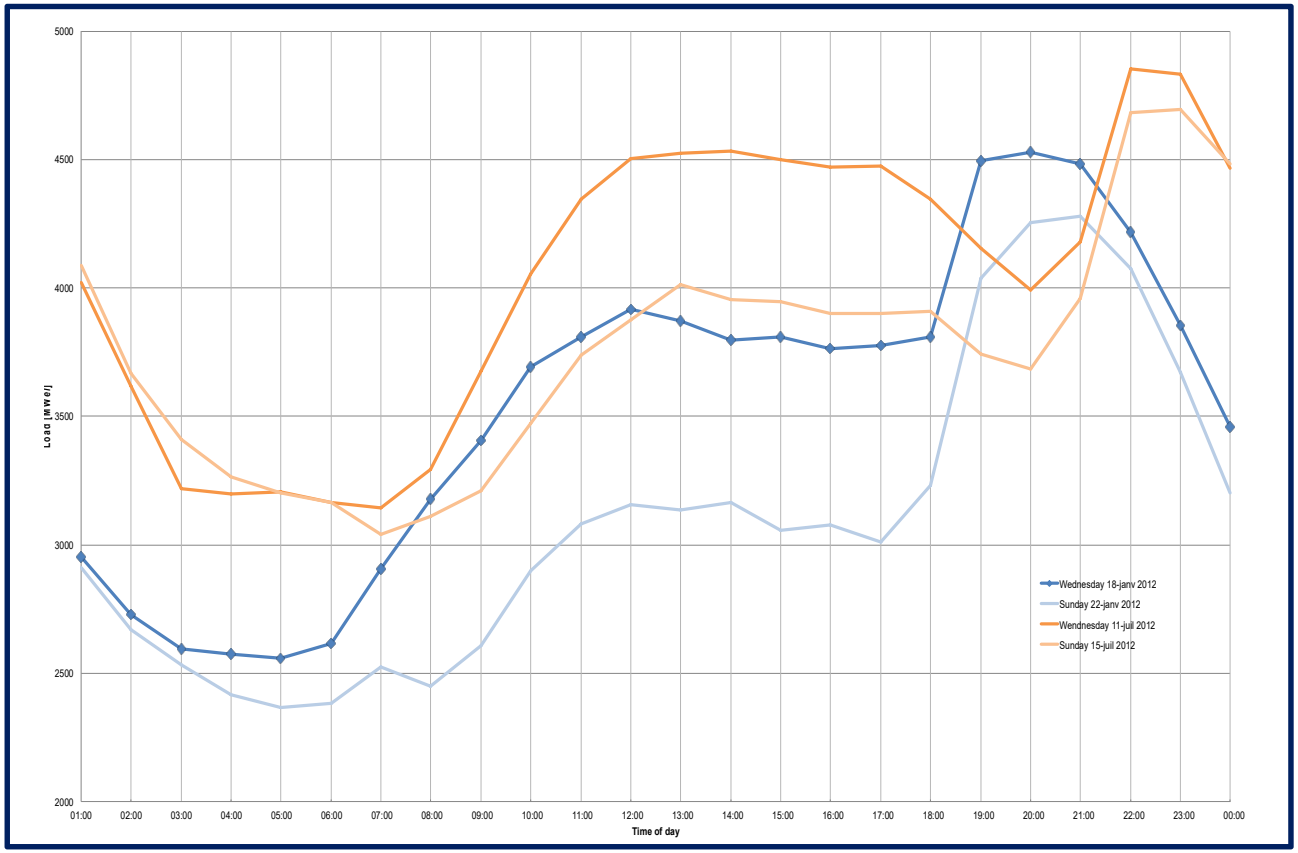
High potentiel all arround the kingdom

**Wind offshore:**

Promising potential of floating wind on atlantic coast between Essaouira and Agadir

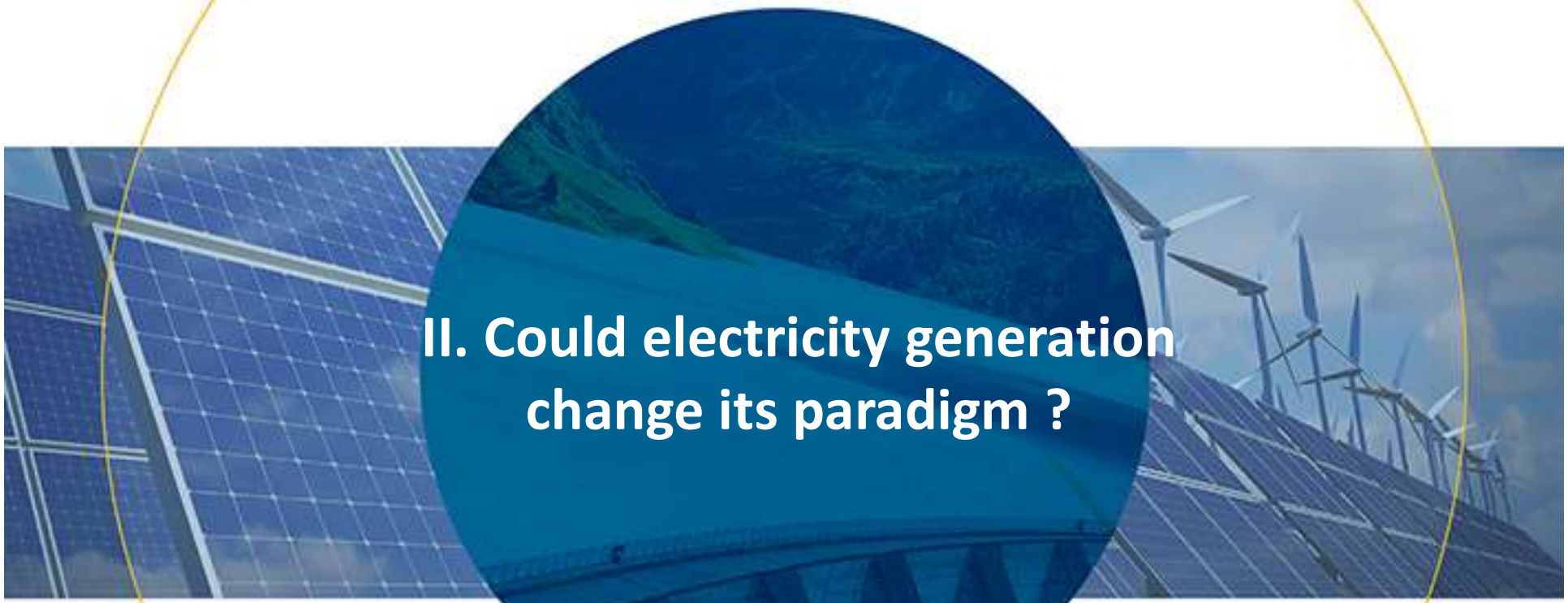


# MOROCCAN ELECTRICITY DEMAND




**Moroccan Load curve**

**Need storage to meet the Moroccan electricity demand especially peak demand**



# II. Could electricity generation change its paradigm ?

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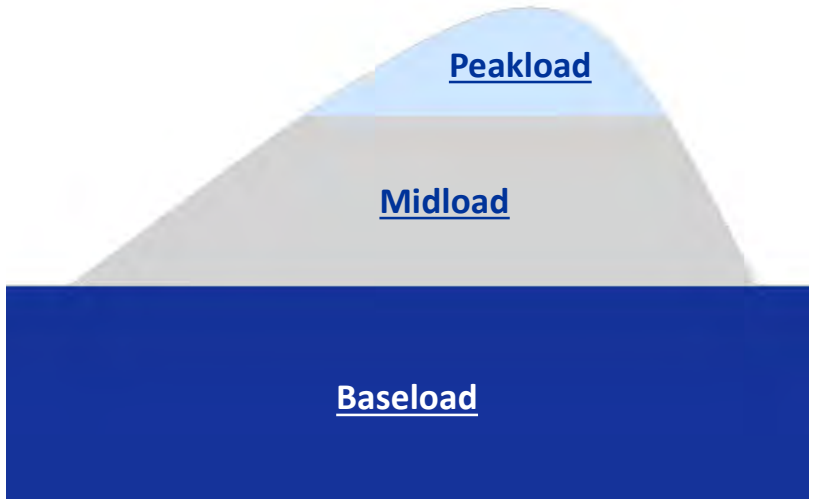
# One century of conservatism : Could electricity generation change the paradigm ?

## Conventional electrical generation:

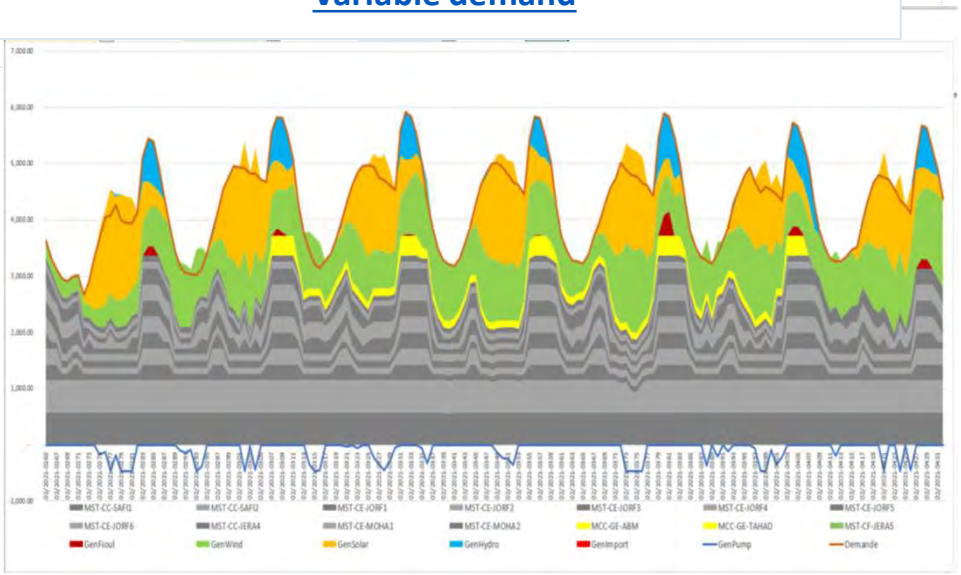



A single model for all electrical systems

Controlled generation

Vs

Variable demand



Renewable intremitent generation is being forced in such system

>> It seems to be a great mistake <<

# III. Renewable mix to maximise renewable into grid

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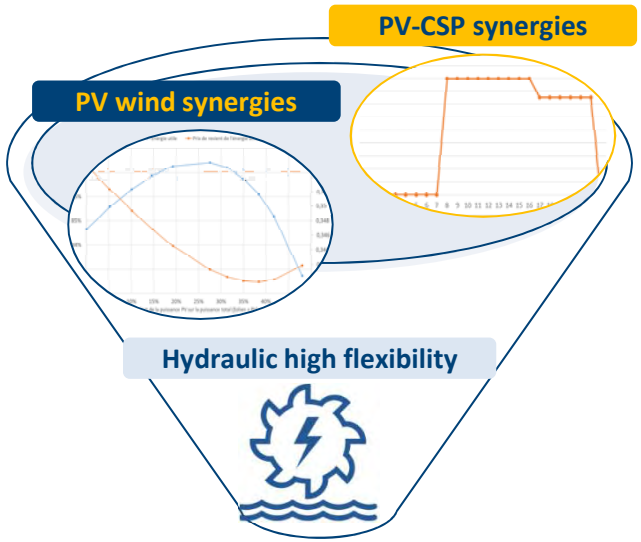
# III. Renewable mix to maximise renewable into grid

**Mix ENR**

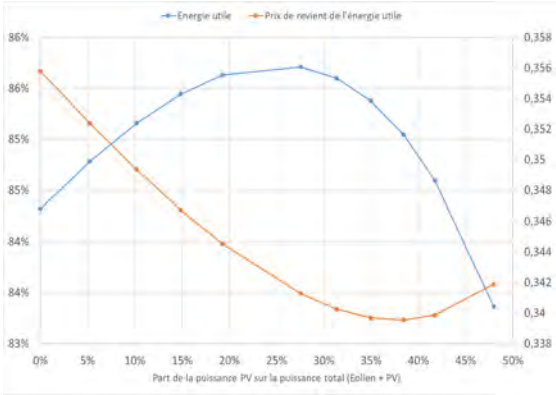



**Sites synergies**

**Technology synergies**

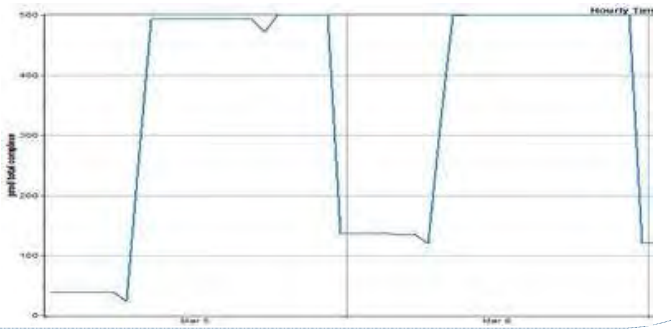
**PV-Wind**

*Maximising useful energy*

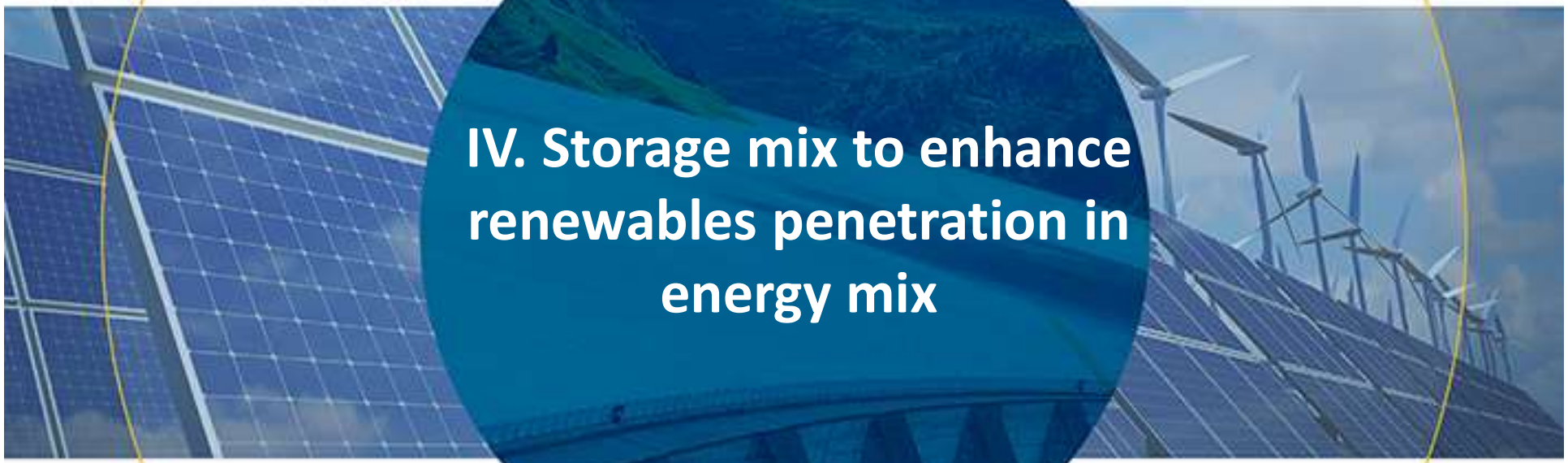



**PV-CSP with hydro-pumped**

*Baseload competitive with coal*



**Mix renewable technologies to maximise useful energy**



# IV. Storage mix to enhance renewables penetration in energy mix

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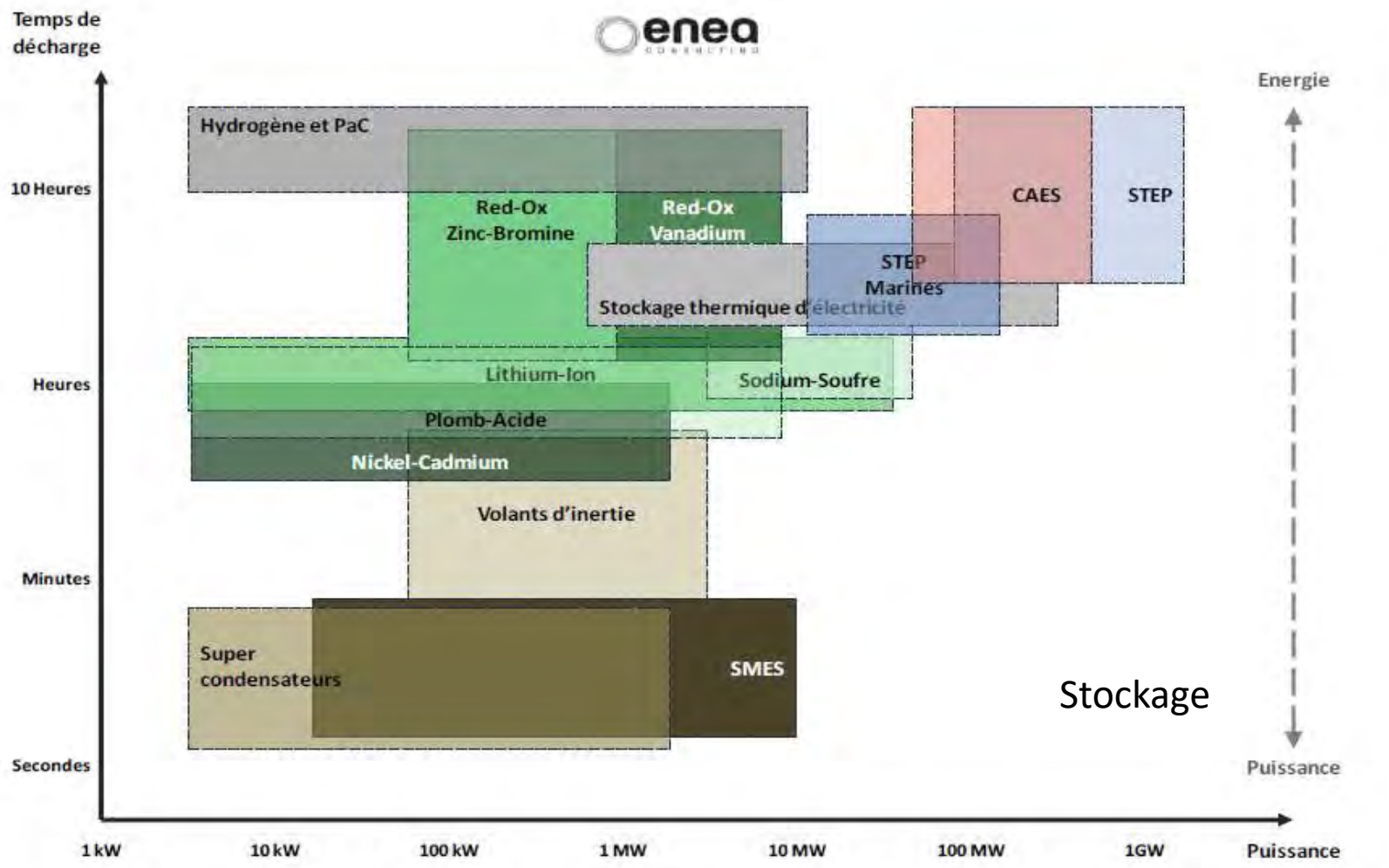
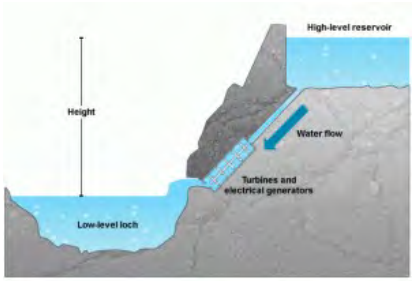
# Storage mix to enhance renewable penetration into energy mix (role of battery, hydro pumped and thermal storage)



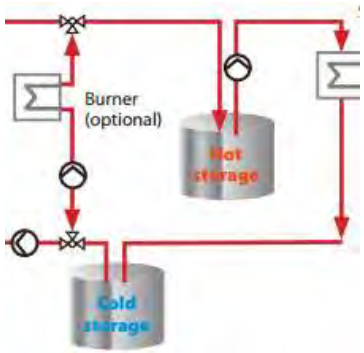
# Storage mix to enhance renewable penetration into energy mix (role of battery, hydro pumped and thermal storage)

## Hydro pumped storage




+ Mature energy storage
+ Hours
+ Lowest cost
+ Linked to potentiel site

## Thermal storage

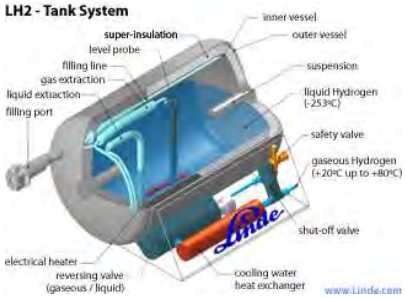



+ Limited maturity energy storage
+ Long time (many hours)
+ Used onsite

## Batteries

+ Limited maturity in utility scale
+ Capacity storage
+ installation everywhere
+ High cost decreasing fast

## Hydrogen




+ Limited maturity
+ High potentiel
+ High potentiel (power to X)
- High cost

**A mix taking into account each need is necessary**

# V. Midelt Project: a case of solar power plant with thermal storage competitive with coal

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# Feasibility Study Approach

**1 Solar technologies analysis**

**Mature technologies retained :**

- CSP : **Parabolic trough (HTF) Tower (MS) with storage**
  **DS Tower, DS Fresnel: (Operating during day)***
- PV :**mc-si, c-si, thin film, CPV**

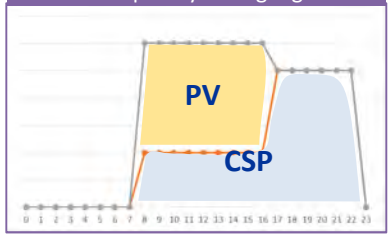
**2 CSP/CSP Hybrid solutions analysis**

**The hybrid CSP/CSP solutions not retained**

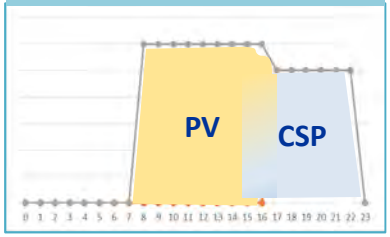
- Weak potential of cost reduction.
- High technical risks due to the combination

**3 PV/CSP Hybrid solutions analysis**

CSP operated partially during day & completely during night




CSP operated mainly during night




**The hybrid PV/CSP solution retained :**

- Interesting potential of cost reduction.
- No additional risk.

# Feasibility Study Approach

1

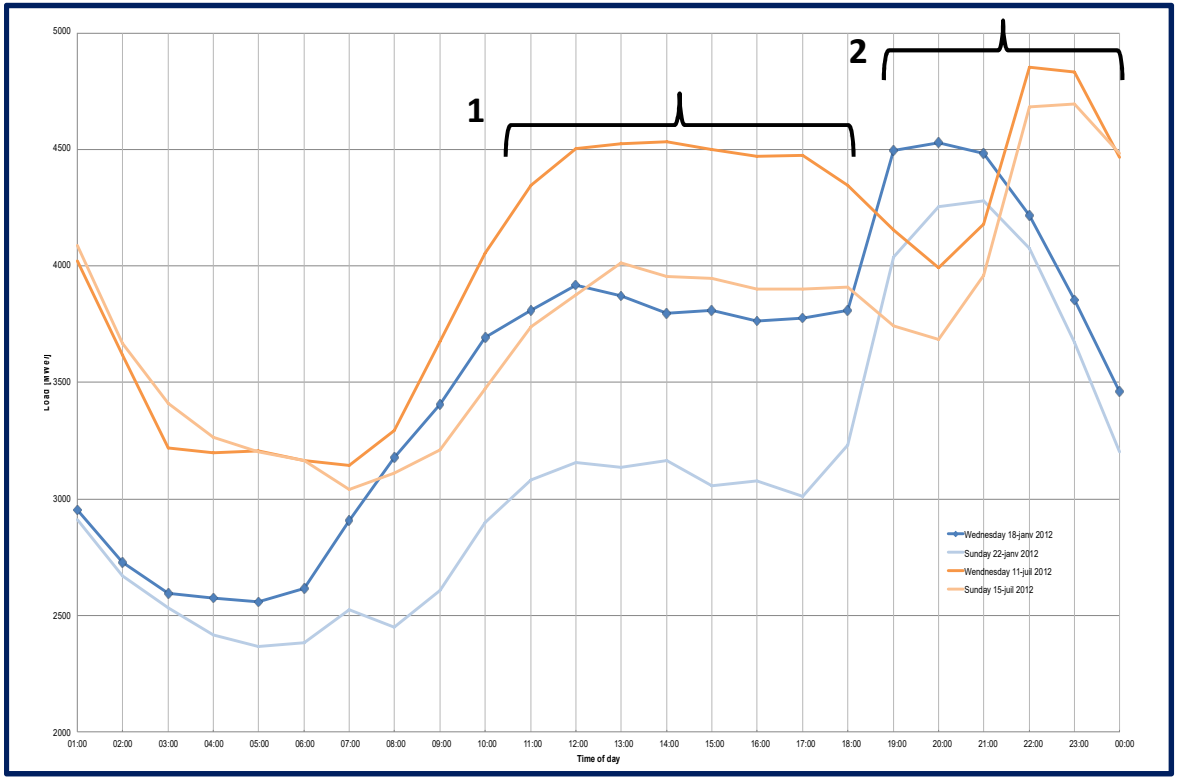
Meet the midday peak load during summer using the PV technology (low LCOE).

+

2

Meet the evening Peak load using CSP technology thanks to thermal storage.

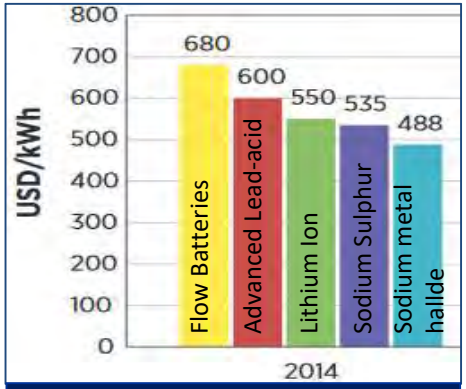
PV could be used with heaters if feasible.



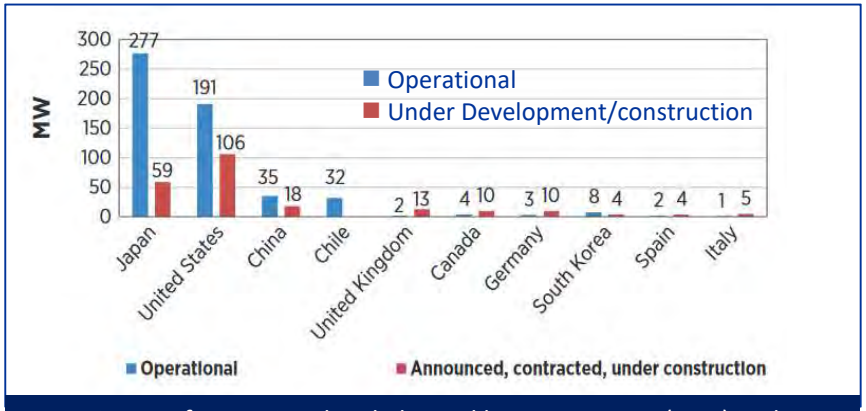

**Moroccan Load curve**

**A hybrid PV/CSP solution should meet the Moroccan energy demand while reducing the LCOE**

# Analysis for PV with Storage Batteries solution




Price of batteries for utility scale applications for 2014*




Estimate of operational and planned battery storage (MW) in the power sector by country *

**Different application of Batteries**

**Energy Batteries**

for production during the peak hours

- High price
- Reduced lifetime
- Limited track record
- Could be more attractive for other market ( Electric vehicles)

**Capacity Batteries**

for grid frequency stability support

- Developed by some countries (Japan, USA… ) in the grid as support solution
- ONEE did not specify any requirement for the $NOOR_M$ regarding the PV intermittence.
- If added, batteries could ameliorate the capacity during peak hours.

A maximum of 1 min allowed ramp-up (capacity variation) during day could be required

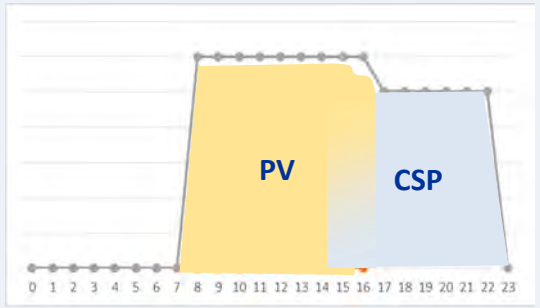
To be proposed to ONEE and adopted if needed

It will increase the CAPE by ~ 1.1% (based on 20MWh battery)

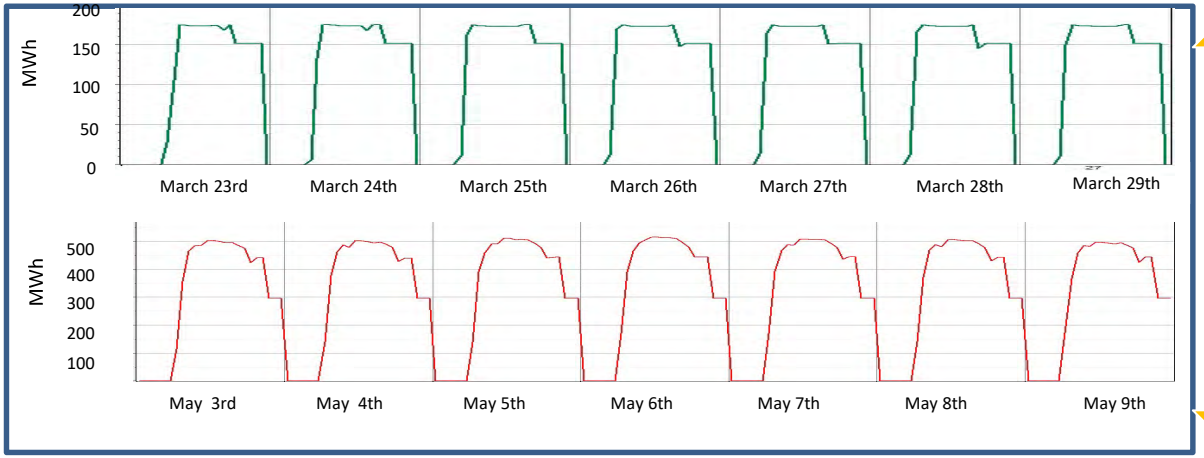
(*) Source :IRENA_BATTERY STORAGE FOR RENEWABLES: MARKET STATUS AND TECHNOLOGY OUTLOOK ( January 2015)

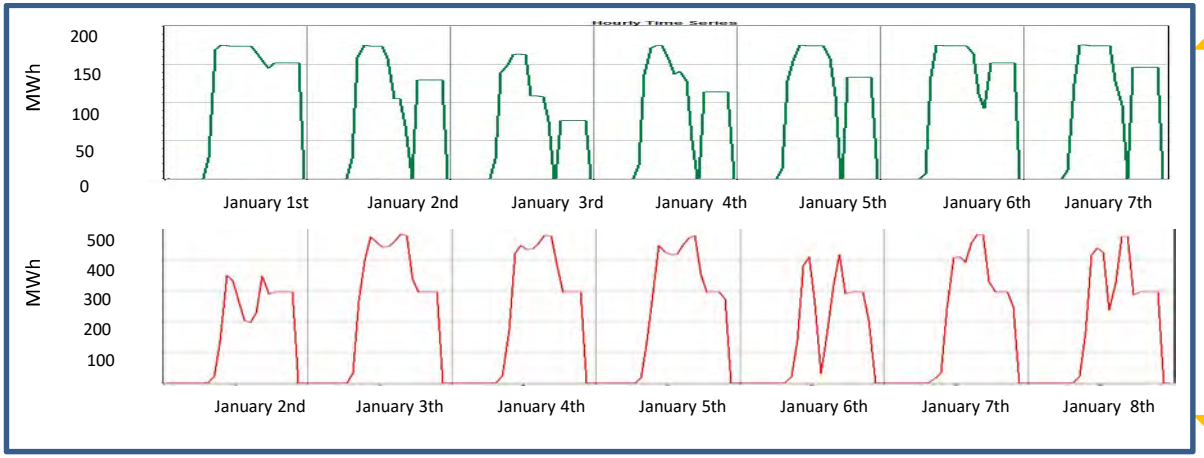
# Load curve of one Hybrid PV/CSP studied solution in Midelt VS NOOR Ouarzazate

**CSP operated mainly during peak hours**




This solution applied to Midelt site provides the following:




**Midelt load curve could be comparable with Ouarzazate Load curve**

Production of a typical hybrid power plant (Tower 150MW_7h and PV 262 $MW_{DC}$1 axis)

NOORo Total production (**Devlopper performance model for $NOOR_o$ I, II and III and simulation results for $NOOR_o$ IV**

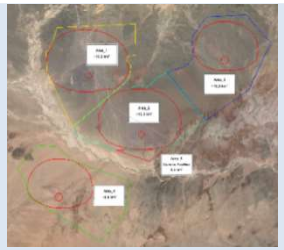
# TECHNICAL CONFIGURATION

## Objective

- **To produce Electricity during day using PV and/ or CSP (**During the day, electricity may be produced exclusively from PV**).**
- **To secure 5 hours peak production (CSP with storage).**

## Allotment

**First phase: 2 Hybrid power plants**



## Requirements

### Installed Capacity

- CSP gross capacity between **150MW and 190MW** per plant.
- DC/AC ratio shall be optimized by the Bidder to provide firm and linear curve during the day
  - ↳ The installed **$PV_{DC}$ capacity to be optimized** by the Bidder.

### Net Capacity (at ONEE busbar)

- At the Delivery Point, the net measured capacity during day could exceed the net measured capacity during night **by 20%.**
  - ↳The maximum net measured capacity during the day will be between **180MW and 228MW.**

### Storage

- **Minimum 5h of storage** to cover peak hours from CSP.
- Requirement **to maximize and to prioritize the storage from CSP before the peak hours.**

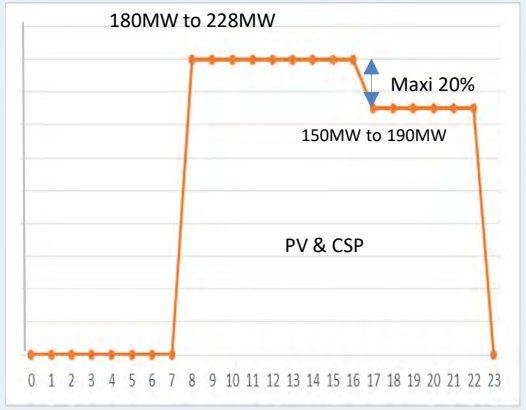
### Ramp-up

- After startup and before shutdown , the **maximum allowed ramp up is ±10%** ( of the maximum AC capacity during 1 min)
- Possibility to use batteries for ramping support.

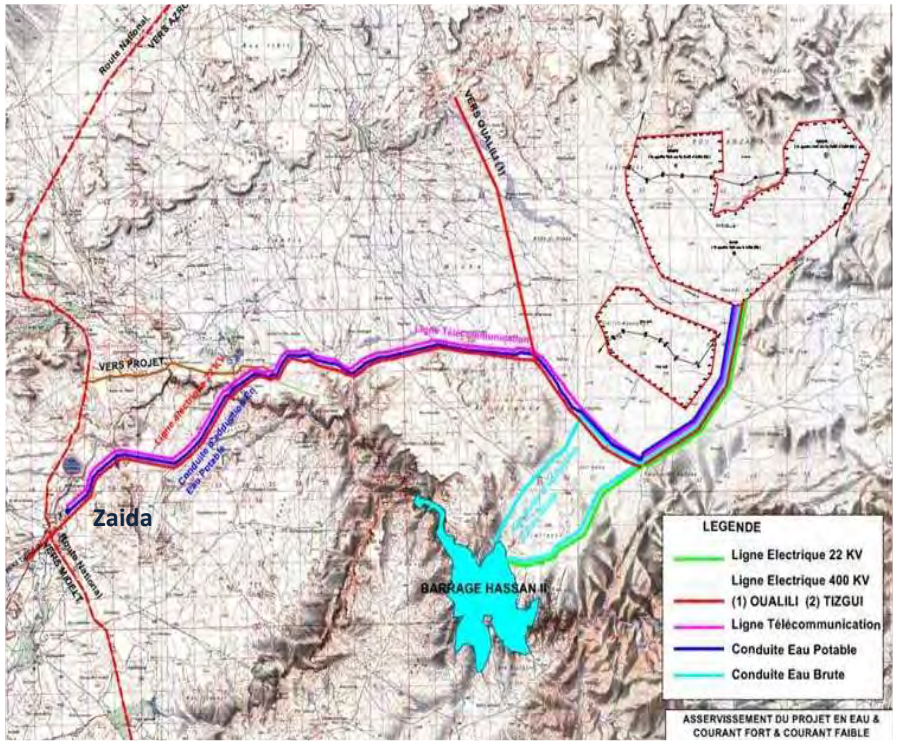
### Technologies

- CSP: **Tower or PT**
- PV : All mature technologies: **mc-si, c-si, thin film, CPV**

## Typical Load curve
(when the irradiation will be sufficient)



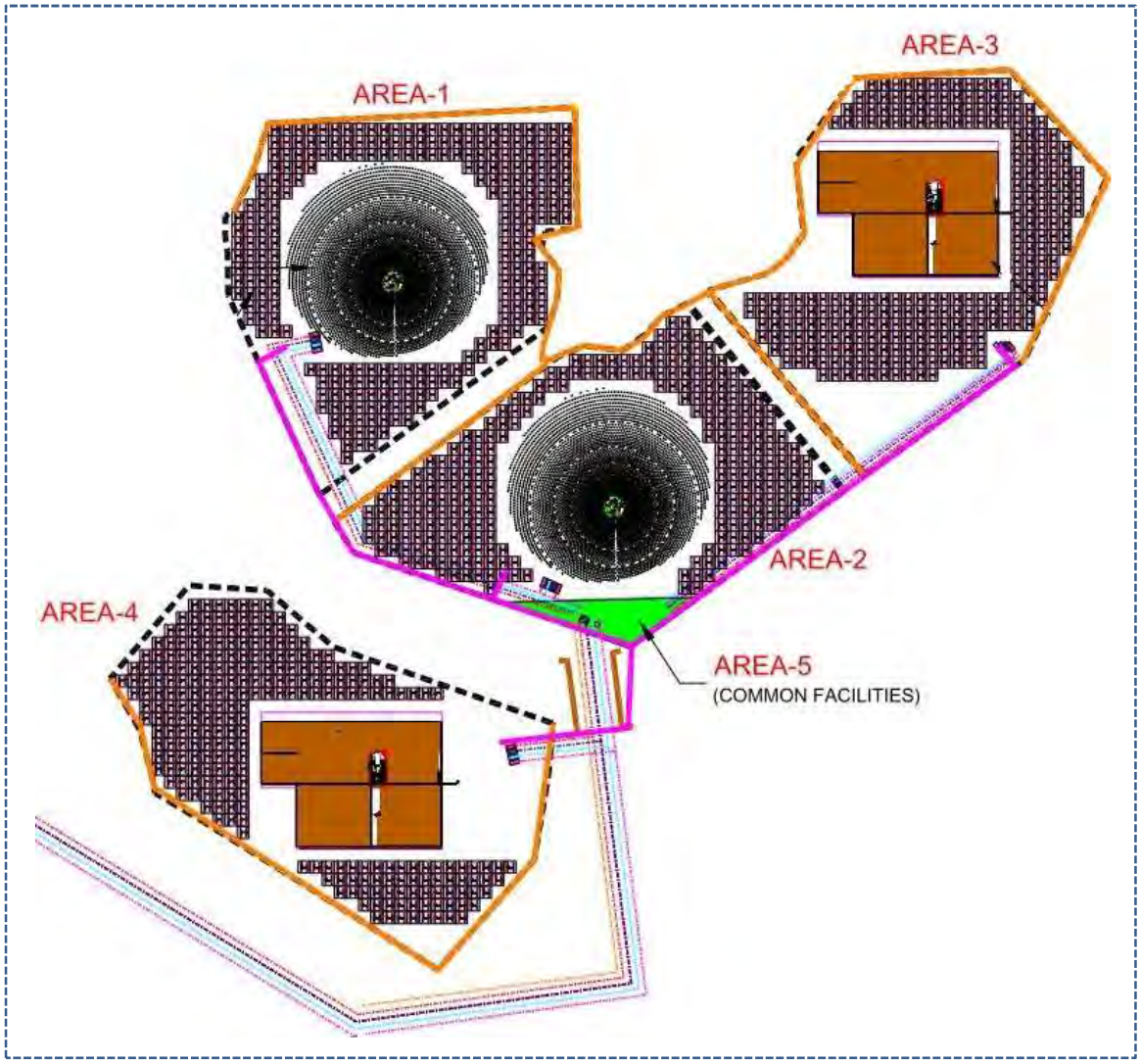
# COMMON INFRASTRUCTURES AND CORRIDORS




Those proposed corridors may be changed according to the detailed feasibility study of each infrastructure

| | Details |
|---|---|
| **Land** | *4118 Ha* |
| **Drainage system with erosion protection** | *≈8 km* |
| **Security system** | *≈30 km* |
| **Firefighting protection system** | -- |
| **Common Roads** | *≈ 30 km* |
| **Common Water system** | *≈ 14 km* |
| **Electricity** | ▪*225KV substation*<br>▪*400 kV power line operating at 225 kV* |
| **Telecommunication System** | -- |
| **Complex Administration Building** | -- |

# NOOR Midelt: Site Layout




**Midelt site areas :**

- 1st parcel: ≈ 3153ha
- 2nd parcel: ≈ 990 ha

**Expected allotment:**

- 4 Hybrid power plant areas
- 1 common facilities area


# QUESTIONS