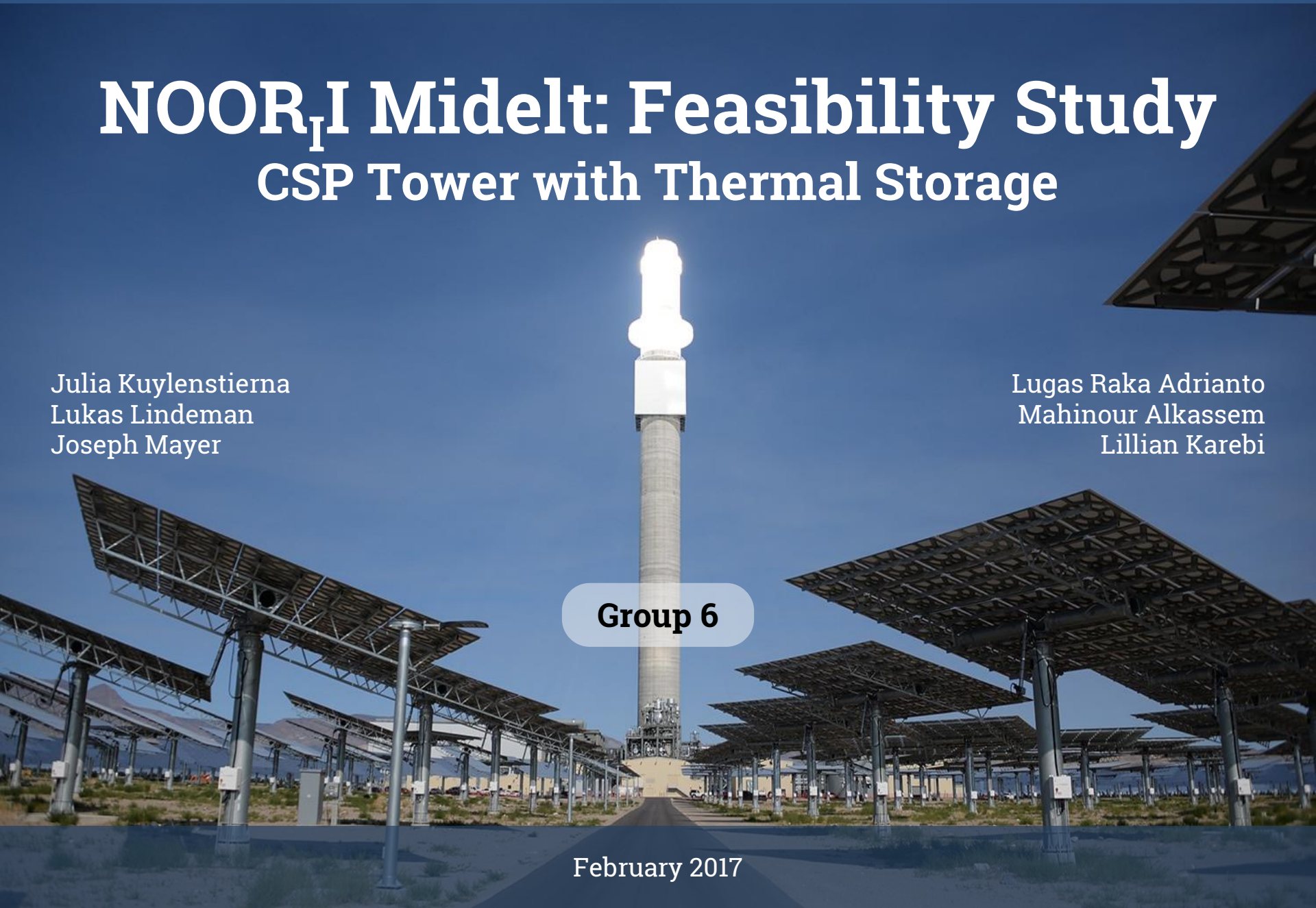
MJ2412 Advanced Renewable Energy

$NOOR_I$ Midelt: Feasibility Study

CSP Tower with Thermal Storage



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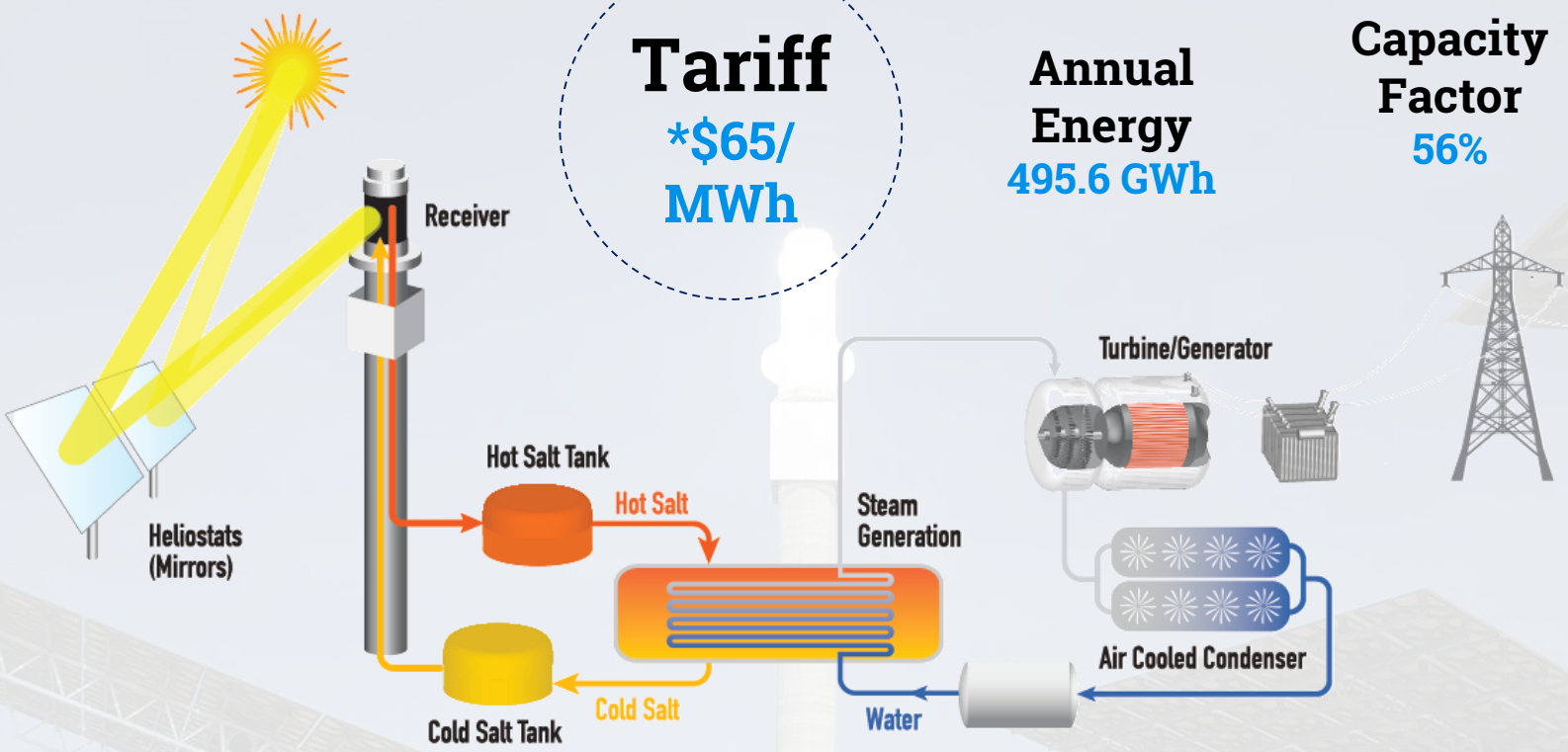
February 2017

Concentrated Solar Power in Midelt

Tariff
*$65/ MWh

Annual Energy
495.6 GWh

Capacity Factor
56%



N. Heliostats 18,125 **Mirror Area** 2,175,000 m^2 **10h energy storage, 3870 MWh capacity**

Quick Facts

- Location : Midelt, Morocco
- Technology : CSP Tower with TES 10 hours (2-tanks)
- Electricity : 100 MWe normal (150 MWe at peak hour)
- LCOE : $141 USD/ MWh

Price multiplier= 4x normal

Design Considerations (I)

❑ **3 Main Steps**: Power Block, Solar Field, and Thermal Storage

- Determining Power Block Configuration from electricity output (150 MWe)

- Siemens SST-700 is chosen due to suitable power capacity & high efficiency

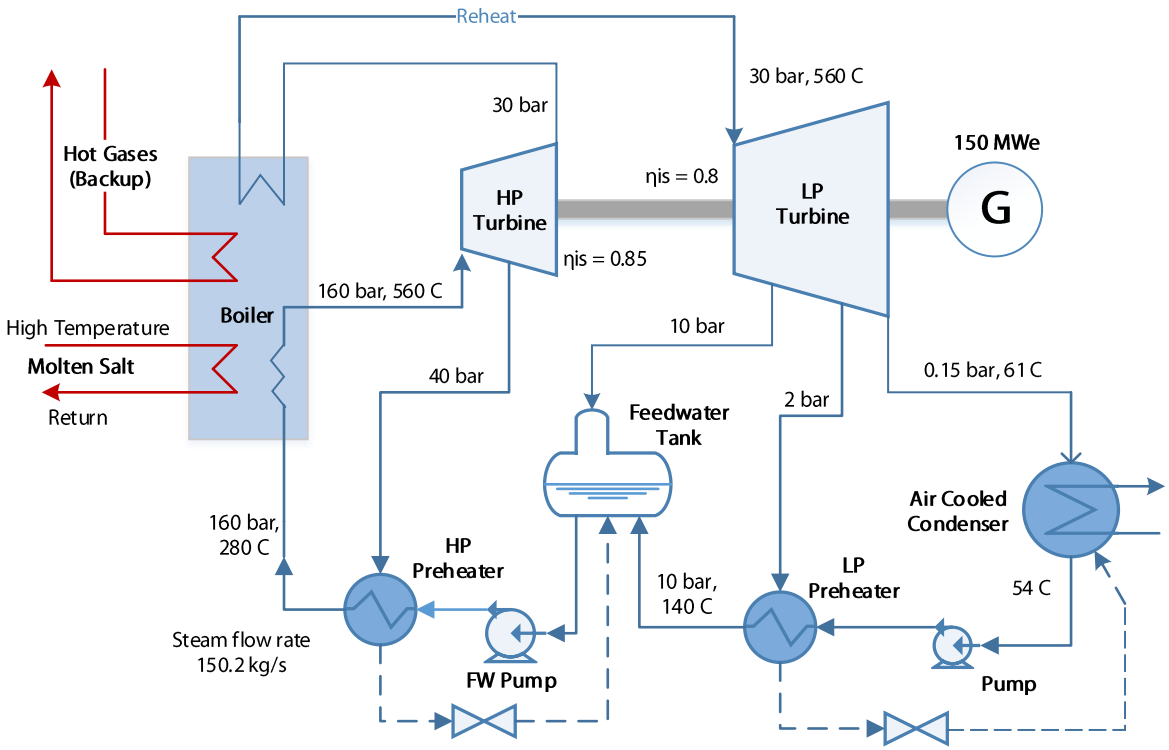
- Steam condition (P = 160 bar, 160 °C)
- Electricity: 150 MWe
- Thermal efficiency: 33.7%

Q input PB

Thermal losses (radiation, convection, etc.)

Q_{SF} = **520 MWth**

Reheat with 2-pressure levels Rankine cycle



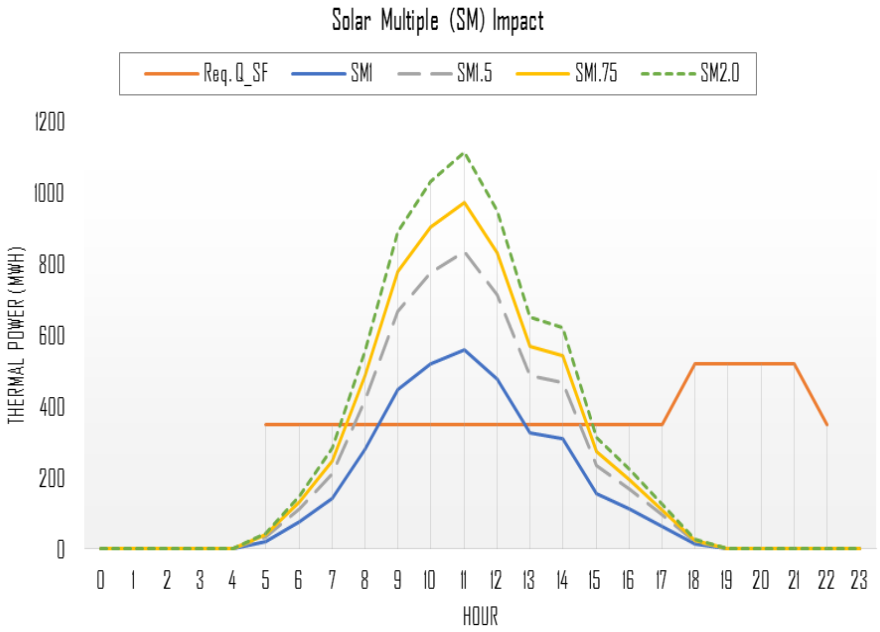
Design Considerations (II)

- Solar field thermal power is simulated based on SoDa hourly data

  - Discretization method of 144 Cells (MATLAB™)

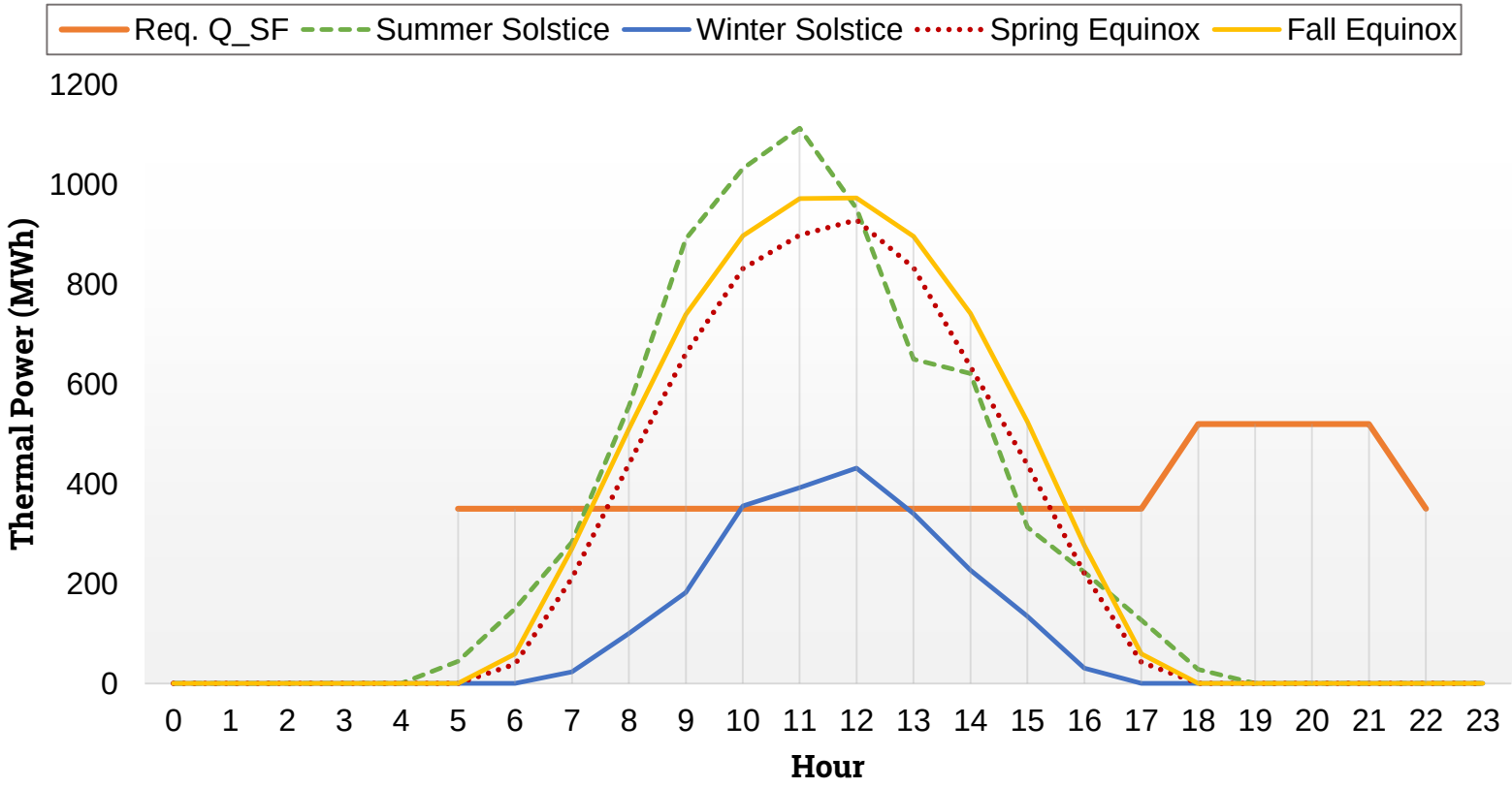
- Summer solstice (21st June) as design reference date
- Solar Multiple = 2

  - If $Q_{SF} > Q_{req\ SF}$, energy is stored to molten salt tank



Day of the year	Sun rise to Sun Set	Charging / Direct feeding hours	Normal operation hours
Summer Solstice (21st of June) Reference day	13 hours from 5-18	6 hours from 8-14	7 hours from 5-8, 14-17 & 21-22
Winter Solstice (21st of December)	9 hours from 7-16	-	-
Fall Equinox (22nd of September)	11 hours from 6-17	7 hours from 8-15	6 hours from 5-8, 15-17 & 21-22
Spring Equinox (20th of March)	11 hours from 6-17	7 hours from 8-15	3 hours from 15-17 & 21-22

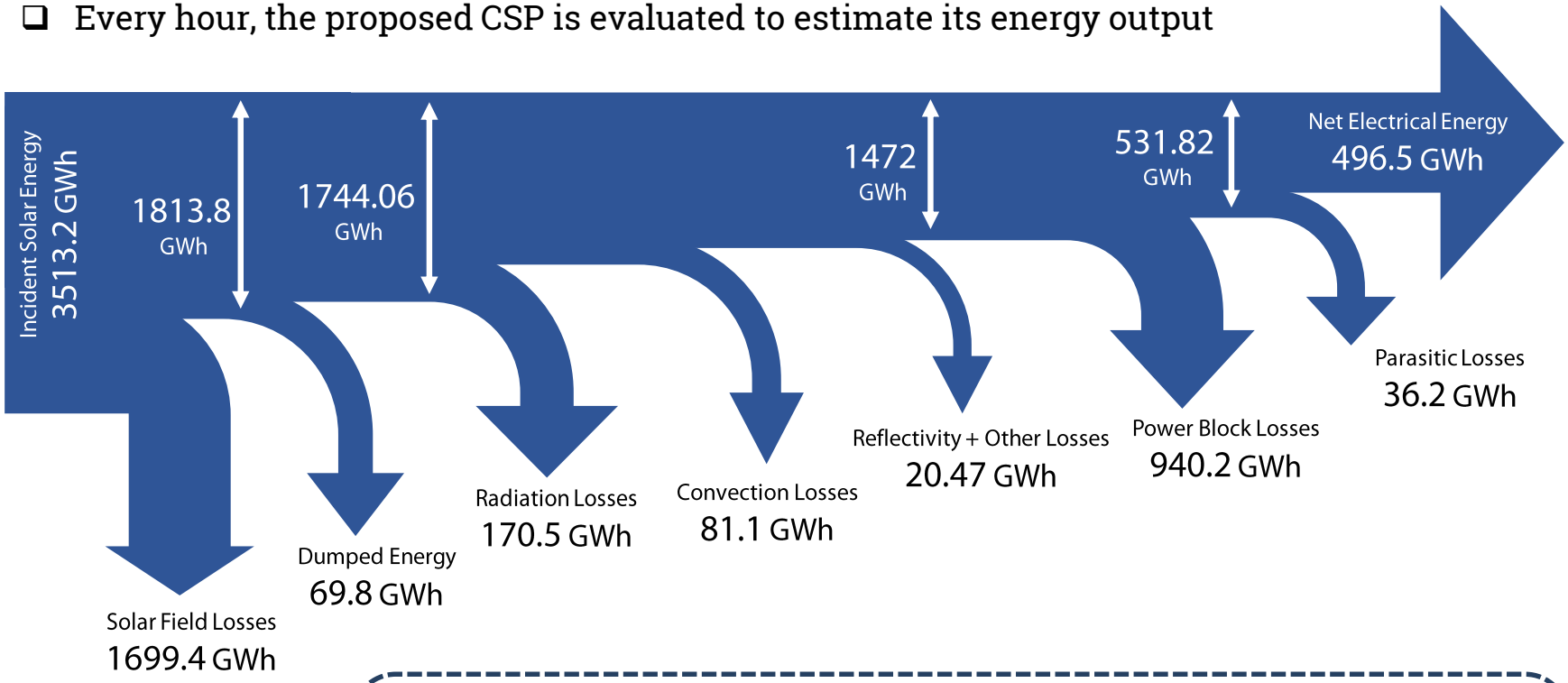
CSP Performance on Different Days



- Total Operating hours : 4434 hours
- Operating hours directly from receiver : 2755 hours
- Operating hours from storage : 1679 hours
- Technology : CSP Tower with TES 10 hours
- Capacity factor : 56%

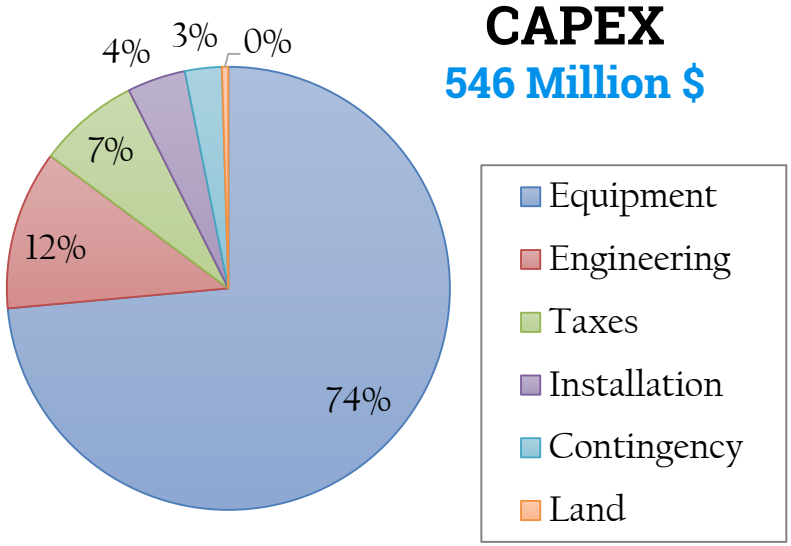
Annual Performance of CSP

- Every hour, the proposed CSP is evaluated to estimate its energy output



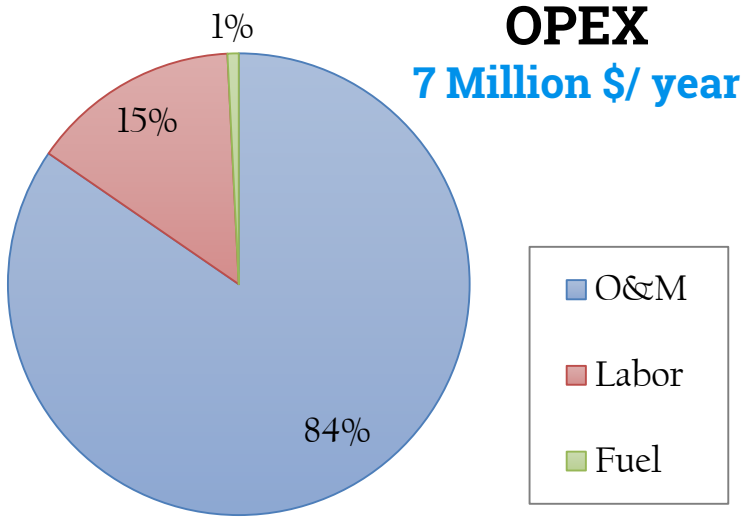
- Solar to electricity ratio : **15%**
- Solar thermal receiver efficiency : **85%**
- Total Operating hours : **4434**

Cost of Building and Operating CSP Plant



CAPEX

546 Million $

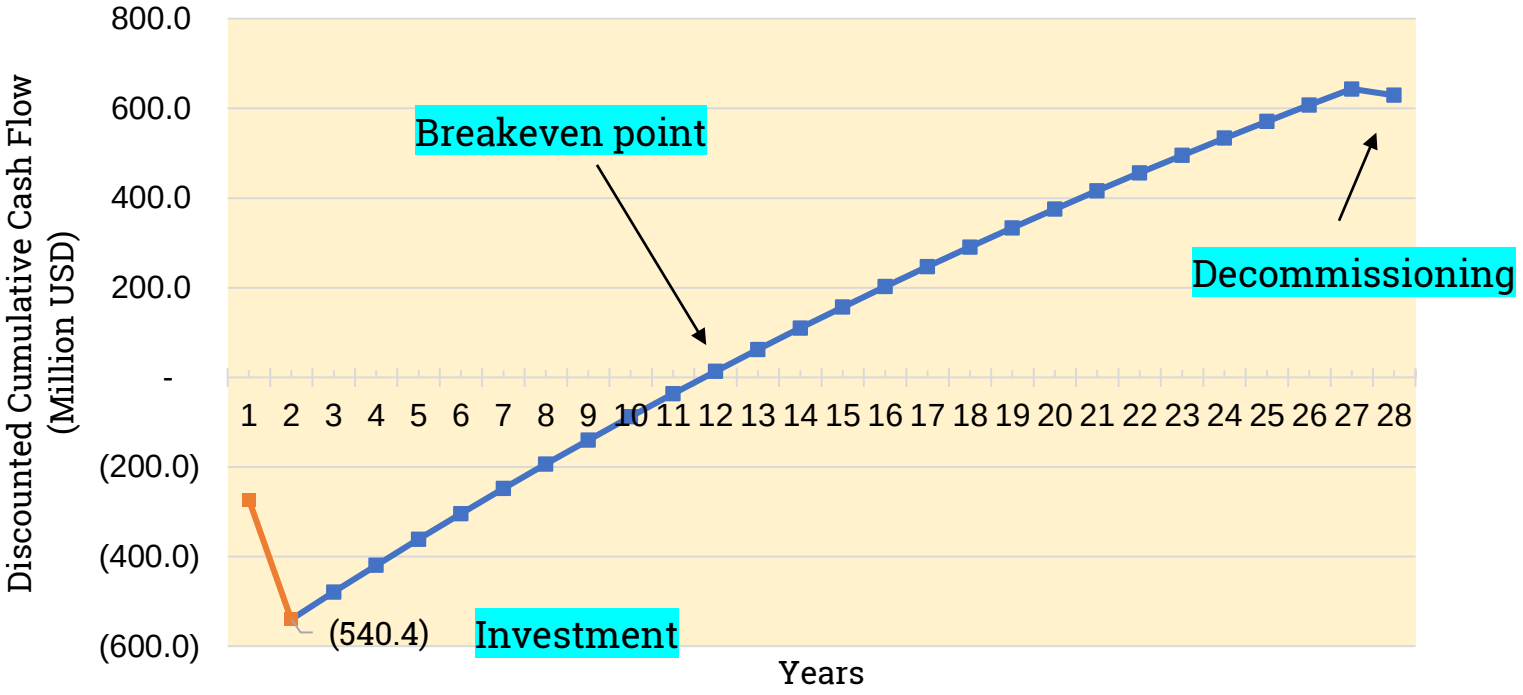


OPEX

7 Million $/ year

	Calculations	Value
CAPEX	$C_{inv} = C_{eqp} + C_{inst} + C_{eng} + C_{cont} + C_{land} + C_{tax}$	$546.4 Million
OPEX	$C_{OPEX} = C_{O\&M} + C_{fuel} + C_{labor}$	$6.99 Million
LCOE	$LCOE = \frac{\alpha \cdot C_{inv} + C_{fuel} + C_{O\&M} + \beta \cdot C_{dec}}{E_{net}}$	140.48 $/MWh
IRR	Data provided	10 %
Base Tariff ($/MWh)		65
Payback Period		10 years

CSP Plant Economic Projection



Economic Parameter

- 2.25% Interest rate
- 25 years operating lifetime

NPV
630
Million $

PBP
10
years

Conclusions

Proposed CSP project in Midelt is **feasible** and **profitable** based on the findings below.

- Plant Configuration & Annual Yield
- Transients
- Capacity Factor
- Economics (CAPEX, OPEX, PBP)
- Proposed Tariff (X)
- Environmental & Socio-economic Impacts


Solar Power, Day & Night.
Reliable power. Minimum emissions.
Thank you
UPCOMING
Q&A