CSP and PV - friend or foe?

Kuwait

December 2018

Frank Wouters
Structure

1. Introduction to CSP
2. Storage
3. Market
4. System Value
5. Recent Developments
Introduction to CSP
What is Concentrating Solar Power?

Source: DLR
What is Concentrating Solar Power?
Ancillary Services by CSP

Like any other steam-electric power plant, CSP can provide ancillary services:

- **Frequency** control: Primary (0s – 30 s), secondary (30 s – 15 min) and tertiary control (>15 min)
- CSP Plants can provide **secondary and tertiary reserve**, up and down. Offering one or the other – or both – will depend on the market conditions and specific regulations.
- **Reactive power** compensation: As any other large synchronous generator CSP plants can easily and efficiently provide reactive power to the system.
- **Spinning reserve**: as opposite to other renewable fluent generation technologies, the operation of CSP plants don’t require spinning reserve provisions in the system.
Concentrating Solar Irradiation

Source: Volker Quaschning
CSP with Thermal Energy Storage

Source: PSA
Storage
Value of CSP with Storage

- **Storage provides**
  - **higher value** because power production can match utility needs
  - **lower costs** because storage is cheaper than incremental turbine costs

Source: NREL
Storage technologies

- Batteries
- Flywheel
- Super capacitors
- Molten Salt
- Pumped Hydro
Cost of CSP vs. PV with Batteries with 6hr Storage

Source: NREL
CSP and PV, friend or foe?

PV plant without storage

100 MWe solar plants

Solar tower plant with large storage

Similar invest in grid infrastructure

100 MVA substations

100 MVA transmission lines

175.2 GWh/a

Load center

613.2 GWh/a

Much higher annual energy transfer

Source: Fraunhofer ISE

A project funded by the European Union
Market
Concentrating Solar Power Plants

CSP PROJECTS WORLDWIDE
4

System Value
Analysis of Operational and Capacity Value of CSP in California
Operational and Capacity Value

- **Operational value** represents the avoided costs of conventional generation and includes fuel costs, start-up costs, variable operation and maintenance costs, and emission costs.

- **Capacity value** reflects the ability of PV or CSP-TES to avoid the cost of building new conventional thermal generators in systems that need capacity in response to growing energy demand or plant retirements.
CSP integrated with thermal energy storage maintains high capacity value with increasing RE penetration, while capacity value of PV collapses.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Capacity Credit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSP-TES (with &gt; 3 Hrs Storage)</td>
<td>PV</td>
</tr>
<tr>
<td>33% RPS Scenario</td>
<td>92.2%</td>
</tr>
<tr>
<td>40% RPS Scenario</td>
<td>96.6%</td>
</tr>
</tbody>
</table>

NREL 2014

Mills and Wiser 2012
Relative value of CSP is **5ct per kWh greater** than PV in the 33% scenario and about 6ct per kWh greater in the 40% scenario.
Cost vs Value?!  

Source: Fraunhofer ISE, 2016

<table>
<thead>
<tr>
<th></th>
<th>CCGT 30$</th>
<th>Diesel/oil 30$</th>
<th>Diesel/oil 40$</th>
<th>Nuclear</th>
<th>CSP 8h</th>
<th>PV 1800</th>
<th>Wind 2500</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX $/kW</td>
<td>1000</td>
<td>150</td>
<td>150</td>
<td>6000</td>
<td>4500</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>Interest %</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Var. OPEX $/kWh</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0</td>
<td>0.015</td>
</tr>
<tr>
<td>Fixed OPEX $/kW</td>
<td>22</td>
<td>30</td>
<td>30</td>
<td>200</td>
<td>30</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Output kWh/a</td>
<td>7000</td>
<td>7000</td>
<td>7000</td>
<td>7500</td>
<td>4200</td>
<td>1800</td>
<td>2500</td>
</tr>
<tr>
<td>Fuel prices $/kWh</td>
<td>0.03</td>
<td>0.03</td>
<td>0.04</td>
<td>0.005</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>eff %</td>
<td>55%</td>
<td>35%</td>
<td>35%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Degradation %</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.1%</td>
<td>0.4%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
Recent Developments

A project funded by the European Union
Maktoum Solar Park Park Dubai

Largest single solar site in the world: projected to be 5 GW by 2030

- Phase I: solar PV  13 MW
- Phase II: solar PV  200 MW
- Phase III: solar PV  800 MW
- Phase IV: CSP     700 MW
Maktoum Solar Park Dubai, Phase IV

Largest CSP project in the world

- 700MW CSP, 15 hours storage
- $3.9 billion investment
- Central Tower 100 MW
- Parabolic Troughs 3x200 MW
- Auxiliary solar PV 4x33 MW
- Tariff 7.3 ct/kWh
- PPA 35 years
- Dispatch: between 4pm and 10am
Hybrid PV-CSP dispatch profile

- PV
- CSP
- Combined

A project funded by the European Union
CSP and PV, friend or foe?

Source: Fraunhofer ISE

788.4 GW/a

A project funded by the European Union

Source: Fraunhofer ISE
Thank you!