Central vs. String Inverters: Myth & Reality

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Act today for a tomorrow without the mistakes of yesterday.
A clean future for us and all who follow.
POWER HOUR

NEXT GENERATION UTILITY SOLUTIONS
YOUR SPEAKERS
FOR TODAY

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A focused leader in inverter technology

1997 - Founded by Professor Cao
2006 - Expanded to the Global Market
2011 - Listed on SZSE
2015 - No.1 of Global Market Share
2018 - India Factory in Operation
2019 - Hit 100GW Installation
Committed to providing world-leading clean power solutions

- PV Inverters
- ESS
- Floating PV Systems
- Project Development
- Power Electronics
- Wind Energy Converters
Core technology is the permanent power of Sungrow.

$90 M
Invested in R&D in 2019

40%+
Proportion of technical R&D personnel

2000+
Patent applications accumulated
The world’s largest inverter factory

50 GW / Year
Global Production Capacity

China Factory
47 GW / Year
ESS 6 GW / 6GWh

India Factory
3 GW / Year
An extensive footprint across the globe

- **60+ Countries**
- **50+ Service Outlets**
- **20+ International Subsidiaries**

**AMERICAS**
- 3 Service offices
- 11 Local warehouses

**EUROPE**
- 6 Service offices
- 16 Local warehouses

**MIDDLE EAST**
- 1 Service office
- 1 Local warehouses

**SOUTHERN AFRICA**
- 1 Service office
- 1 Local warehouses

**APAC**
- 7 Service offices
- 10 Local warehouses

**Factors for Success**
- Local knowledge of specific electricity systems
- Experienced service and support teams
- Strategic partnerships with local businesses
- Strong commitment to customer satisfaction
UK Office – Milton Keynes

UK Office
Sales
Presales Technical
Logistics & Administration
Service & Service Partners
Service Warehousing

Focus on utility scale EPC’s & Investors
Global project reach
Added value service for you

- Technical callcentre
- O&M
- Field Service
- Repair Centre
- CRM Warranty Management
- Project Management
- Training Academy
Central vs String Inverters: Myth & Reality
The $1mil question

Are strings or centrals a better option, overall, for my project?
The $1mil question

Let’s explore!
What is the industry doing

- Both technologies are relevant in the global PV arena

- Both concepts have a strong following in the developer/EPC community

- Both financial models equally viable, not necessarily for the same projects though

Source: IHS Markit
Head-to-head: centrals vs strings

CASE STUDY 1
- **Size:** 50MWac @40°C
- **Location:** United Kingdom
- **Mounting type:** Fixed mount
  - **Terrain:** Flat
- **DC/AC ratio:** 150%
- **Inverter model:** SG3125HV-30 (central)

CASE STUDY 2
- **Size:** 10MWac @45°C
- **Location:** Spain
- **Mounting type:** Single-axis tracker
  - **Terrain:** Fairly hilly
- **DC/AC ratio:** 110%
- **Inverter model:** SG250HX (string)
Analysis assumptions

- The project lifetime is 20 years.
- No repowering is considered in either case study. All inverters covered by a warranty extension from Y6 to Y20.
- Annual module degradation rate taken as 0.5% / year.
- The analysis ignores time-value-of-money effects.
- Simple relative-performance metric:

\[
TPI = \text{Technology Performance Index} = \frac{\Delta \text{CAPEX} + \Delta \text{REVENUE}_{\text{YEAR1-20}} + \Delta \text{OPEX}_{\text{YEAR1-20}}}{M \text{W}_{\text{AC}}}
\]
# Case Study 1: CAPEX

## CENTRALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.25MVA stations</td>
<td>7 units</td>
</tr>
<tr>
<td>3.15MVA stations</td>
<td>1 unit</td>
</tr>
<tr>
<td>24-input combiners</td>
<td>246 units</td>
</tr>
<tr>
<td>300mm² 1-core AL/XLPE/AWA/PVC cable</td>
<td>93,480m</td>
</tr>
</tbody>
</table>

## STRINGS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG250HX inverter</td>
<td>223 units</td>
</tr>
<tr>
<td>6.3MVA TX station</td>
<td>8 units</td>
</tr>
<tr>
<td>240mm² 3-core + 120mm² 1-core AL/XLPE/SWA/PVC cable (TN earthing)</td>
<td>42,370m</td>
</tr>
</tbody>
</table>

\[ \Delta \text{CAPEX} = €305,140 \]

Total  
€2,522,988 +  €2,828,128  
=  €5,351,116

\[ \Delta \text{CAPEX} = €305,140 \]

Total  
€5,351,116  
€5,351,116  

**UK 50MW**
### Case Study 1: \( \text{REVENUE}_{\text{YEAR1-20}} \)

<table>
<thead>
<tr>
<th>CENTRALS</th>
<th>STRINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWhs</td>
<td>MWhs</td>
</tr>
<tr>
<td>Y1-Y20 Yield</td>
<td>1,474,071</td>
</tr>
<tr>
<td></td>
<td>Y1-Y20 Yield</td>
</tr>
</tbody>
</table>

\[ \Delta \text{REVENUE}_{\text{YEAR1-20}} = \text{REVENUE}_{\text{Y1-20} \ @ \ €60/MWh} - €230,580 \]

\[ \text{REVENUE}_{\text{Y1-20} \ @ \ €60/MWh} = €88,444,260 \]

\[ \text{REVENUE}_{\text{Y1-20} \ @ \ €60/MWh} = €88,674,840 \]

Notes:
1. Cable loss profiles: 1.5% DC / 0.1% AC (centrals)
   0.6% DC / 1.1% AC (strings)
2. Mismatch loss profiles: 0.6% (centrals)
   0.4% (strings)
Case Study 1: OPEX$_{\text{YEAR1-20}}$

### CENTRALS

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive</td>
<td>135,046</td>
</tr>
<tr>
<td>Corrective</td>
<td>369,167</td>
</tr>
</tbody>
</table>

### STRINGS

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive</td>
<td>168,807</td>
</tr>
<tr>
<td>Corrective</td>
<td>595,721</td>
</tr>
</tbody>
</table>

\[
\Delta \text{OPEX}_{\text{YEAR1-20}} = \text{€ 260,315}
\]

Total € 504,213 + Total € 764,528

**Notes:**

1. OPEX covers warranty extensions up to Y20 and labour cost for all inverter maintenance works.
2. All O&M work is subcontracted to 3rd parties (no in-house personnel available).
3. A 2-man crew assumed for all works, except for centrals’ corrective maintenance (1-man crew).
4. Corrective maintenance is carried out on an annual basis for both centrals and strings.
## Case Study 2: CAPEX

### CENTRALS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.25MVA stations</td>
<td>1 units</td>
</tr>
<tr>
<td>3.15MVA stations</td>
<td>1 units</td>
</tr>
<tr>
<td>24-input combiners</td>
<td>35 units</td>
</tr>
<tr>
<td>300mm² 1-core AL/XLPE/AWA/PVC cable</td>
<td>9,100m</td>
</tr>
</tbody>
</table>

### STRINGS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG250HX inverter</td>
<td>48 units</td>
</tr>
<tr>
<td>6.3MVA TX station</td>
<td>2 units</td>
</tr>
<tr>
<td>240mm² 3-core AL/XLPE/SWA/PVC cable</td>
<td>6,240m</td>
</tr>
</tbody>
</table>

**ΔCAPEX = € 133,478**

Total SPAIN 10MW:
- **€ 452,210**
- **€ 585,688**
## Case Study 2: REVENUE$_{YEAR1-20}$

### CENTRALS

<table>
<thead>
<tr>
<th></th>
<th>MWhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1-Y20 Yield</td>
<td>455,065</td>
</tr>
</tbody>
</table>

### STRINGS

<table>
<thead>
<tr>
<th></th>
<th>MWhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1-Y20 Yield</td>
<td>460,293</td>
</tr>
</tbody>
</table>

**REVENUE$_{Y1-20}$ @ €60/MWh**

**€ 27,303,900**

**ΔREVENUE$_{YEAR1-20}$ =**

**€ -313,680**

**REVENUE$_{Y1-20}$ @ €60/MWh**

**€ 27,617,580**

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**Notes:**

1. Cable loss profiles: 1.37% DC / 0.1% AC (centrals)
   
   0.38% DC / 0.76% AC (strings)

2. Mismatch loss profiles: 1.0% (centrals)
   
   0.4% (strings)
## Case Study 2: OPEX_{YEAR1-20}

### CENTRALS

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive</td>
<td>33,761</td>
</tr>
<tr>
<td>Corrective</td>
<td>76,861</td>
</tr>
</tbody>
</table>

**Total**  
€ 110,622

### STRINGS

<table>
<thead>
<tr>
<th>Maintenance type</th>
<th>Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive</td>
<td>0</td>
</tr>
<tr>
<td>Corrective</td>
<td>114,506</td>
</tr>
</tbody>
</table>

**Total**  
€ 114,506

**ΔOPEX_{YEAR1-20} =**  
€ 3,884

### Notes:

1. OPEX covers warranty extensions up to Y20 and labour cost for all centrals’ maintenance works.
2. Central’s O&M work is subcontracted to 3d parties. Strings’ O&M handled by in-house personnel (zero labour).
3. A 2-man crew assumed for all works, except for centrals’ corrective maintenance (1-man crew).
4. Corrective maintenance is carried out on an annual basis for both centrals and strings.
Head-to-head: outcome

**Case study: 1**  
UK 50MW

- Centrals’ TPI = € 6,697 / MW\(_{AC}\)
- Strings’ TPI = - € 6,697 / MW\(_{AC}\)

**Case study: 2**  
Spain 10MW

- Strings’ TPI = € 17,631 / MW\(_{AC}\)
- Centrals’ TPI = - € 17,631 / MW\(_{AC}\)

i.e. the savings’ potential of both technologies can be positive, and hence make more financial sense over their counterpart, **under specific circumstances**.
Conclusions

Technology decision strongly dependent on factors such as:

- Business strategy & key project drivers (min CAPEX, max PR etc.)
- In-house expertise and supply-chain optimisation (EPC / owner)
- Geography & solar resource
- O&M arrangements

Though the cut-off is far from clear, there is strong evidence that centrals’ financial advantage scales with project size, a trend that has not been reversed in the last 10-15 years.

A one-size-fits-all approach seems to lead to sub-optimal decisions. Thorough investigation of all options is advised at all times.
SG3215HV-MV

Complete medium voltage solution for a 400 MW solar PV installation

Meets electricity needs of 150,000 residents

Completion date
January 2019

Capacity
400 MWp
Large solar plant in Egypt

The solar park produces
1.8 GWh of electricity
annually

Completion date
March 2018

Capacity
150 MWp
SG125HV

Inverter **status** accessible from **iSolarCloud app**

Provides energy for **2,100 homes**

Completion date **2018**

Capacity **10 MWp**
SG60KTL

Supplying the **growing demand** for clean energy

Completion date
**2018**

Capacity
**7.5 MWp**
Sungrow string & central portfolio

Utility
- SG6250 / 6800HV-MV
- SG250HX

C&I
- SG110CX
- SG33/40/50CX

Residential
- 2kW~20kW PV Inverters
- SH5.0/6.0/8.0/10R T Hybrid Inverters
- SBP4K8 Battery

Monitoring
- iSolarCloud
- APP
- Logger1000
CLEAN POWER FOR ALL

www.sungrowpower.com