WEBINAR

An inverter’s role in delivering high availability and low LCOE for a new era of utility-scale solar

MARCO TROVA
SENIOR GLOBAL PRODUCT MANAGER, STRING UTILITY SOLUTIONS
FIMER

MAREN SCHMIDT DE ANGELIS
MANAGING DIRECTOR, UTILITY LINE OF BUSINESS
FIMER

LIAM STOKER
EDITOR IN CHIEF
SOLAR MEDIA

MODERATED BY
A New Era
Our vision is to shape a new and powerful energy model that uses the power of the sun to drive progress and prosperity for a cleaner and sustainable world.

We do it in a sustainable, innovative and dynamic way, through a complete portfolio of photovoltaic solutions for energy conversion and storage, and e-mobility solutions for electric vehicles.
RESPONSIBILITY

Every day we strive to offer our customers reliable and highly technological solutions and to build a world where energy is used in a sustainable manner for future generations.
We never stop. We are a company that has growth in its DNA, able to evolve and improve, perfecting our know-how and our expertise. This is reflected in the passion we put into our work, into the solutions we create and into the technologies we design every day.
PROFESSIONALISM

We are close to our customers in all challenges with expertise, to ensure the quality and distinctive excellence of our solutions.
We are quick to interpret changes and fast at adapting to market developments. We are able to constantly improve and work hard to be number one when it counts, where it counts.
ETHICAL SOURCING
Sustainability goes beyond carbon footprint and emissions, it begins with base raw materials.

We’re sourcing raw materials in accordance with international standards and practices, as well as introducing some of our own standards to secure a supply chain free from corruption of people or planet.
Over 90% of our business is solar.

Operating in over 100 countries, we are close to our customers, taking care of understanding and of satisfying their needs.

Direct presence: over 20 countries in 5 continents
Geographic distribution: over 100 countries
Employees: over 1100
Global repair centers: 12 in 5 continents
Production sites: 3
Research centers: 3

Continuous growth since 1942
Active in more than 100 markets
Providing complete solutions for the solar market, we address the challenge of energy transition. Today, inverter development and manufacturing is our main vocation, and we can provide support to customers all over the world and at every stage of a solar project.

12+ GW Capacity/year (String Inverter, Central Inv, Storage PCS)

55+ GW Installed base

5 Continents
The drivers

Thanks to innovative power electronics the large string inverters are reaching the economical benefits of central inverters.

Reduced project development time and cost requires flexible solution with multiple MPPT and wider voltage range.

Higher risk and cost associated to components or functional parts obsolescence is a long-term threat to system owners.

FIMER’s objectives

Address the central inverter market with a fully scalable solution for the remaining 39% still using central inverter.

Focus utility developments and operations on a modular power building block, reducing time-to-market and management costs.

Unmatched flexibility and scalability: adapt to systems of any kind and any size.

Drastically reduce downtime costs – System availability 99.9%
FIMER MODULAR CONVERSION SOLUTIONS to support 100% of Utility Inverter Market Demand

Modular Inverter Concept

Centralized System Layout

Decentralized System Layout

FIMER answer to a clear market need
NEW PVS-350 and NEW PVS-260/300-MVMCS

Designed for 100% of Utility-Scale applications; satisfying the needs for both centralized and decentralized applications.
NEW PVS-350 solution for Decentralized Architecture
Modules cells Size trend

- 2008: 156 mm
- 2015: 158 mm
- 2019: 161 mm
- 2025: 182 mm
- 2025+: 210 mm
PV modules Power trend

Power more than double in the last 10 years


290 305 320 325 330 340 350 360 385 400 445 500 600+

156 mm 158 mm 161 mm 166 mm 182 mm 210 mm
PV modules Power trend

System Benefits

- Per Module unit power increase
- Power per string increase
- Reduced number of installed modules per MW
- Reduced number of string and cables per MW
- Reduced steel/aluminium per MW
- Logistics cost decrease
- Tracker and installation cost decrease
- eBOS decrease
- Total Saving

→ up to 0.09 €c/Wp
→ 0.35 ÷ 0.66 €c/Wp
→ 0.1 ÷ 0.15 €c/Wp
→ 0.5 ÷ 0.9 €c/Wp
String Inverter Power trend

Thanks to innovative power electronics String inverter power trend follow the rush of the modules

Fully exploit the latest innovations in power switch technology.
String Inverter Power trend

PVS-350: why 350kW?
The rationale

15 years inverter technology trends

- Power rating: 35 X
- Power/Weight Ratio: 12 X
- Power/Volume Ratio: 7 X


Power trend

String Inverter

- YIELD
- CAPEX
- LOGISTIC

>3kW/kg

0.27kW/kg

FIMER

21 October 2021
PVS-350: why 350kW?
The rationale

**YIELD**
Optimal balance of the DC and AC cable losses to preserve the maximum Yield and reduce CAPEX

**CAPEX**
Maximum exploitation of the electrical BoS to minimize the cost per W of the system

**LOGISTIC**
Keep the form factor to be able to ship in a standard pallet to minimize the Logistic cost

350kW
253A
800Vac

EU pallet
String Inverter Power trend

PVS-350: 350kW – 3 Technical Innovations enabling the record-high power capacity

- **Availability of new High Current/Low Losses Power IGBT modules**
  - Optimization of the 3-level topology

- **Efficient cooling system**
  - +30% cooling efficiency with skived heatsing technology
  - Thermal loads moved outside of the IP66 enclosure

- **Ultra-high efficiency through advanced IGBT modulation techniques**
  - -30% switching losses
  - Discontinuous Modulation (DPWM)
# PVS-350
## Multi-MPPT Inverter for Decentralized Systems

<table>
<thead>
<tr>
<th>PVS-350</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AC Power</strong></td>
<td></td>
</tr>
<tr>
<td>350kW @30°C</td>
<td>333kW @40°C</td>
</tr>
<tr>
<td><strong>MPPT # / Ratings</strong></td>
<td>12 / 45A Impp, 60A Isc</td>
</tr>
<tr>
<td><strong>DC Voltage</strong></td>
<td>500 – 1500 Vdc</td>
</tr>
<tr>
<td>Max Input Voltage</td>
<td>1500Vdc</td>
</tr>
<tr>
<td><strong>AC Voltage</strong></td>
<td>800 V</td>
</tr>
</tbody>
</table>

- **Wireless** access to the **embedded Web User Interface**
- **Easy commissioning** capability
- **Remote** firmware upgrade
- **String diagnosis** through online IV curve analysis
- **Fuse-free design**
- **Arc Fault Detection** device included (also in IEC version)
PVS-350
Multi-MPPT Inverter for Decentralized Systems

- The most powerful string inverter in Utility
- The highest Power to Weight Ratio in the category (> 3kW/kg)
- Compatibility with ULTRA-high power modules with a single model
- String diagnosis through online IV curve analysis
- DC Series Arc Fault Circuit Interrupter
## PVS-350

**Main Benefits Vs Existing Multi MPPT Platform**

**Optimal balance of the DC and AC cable losses to preserve the maximum Yield and reduce CAPEX**

### 100MW Project

<table>
<thead>
<tr>
<th></th>
<th>FIMER PVS-350</th>
<th>FIMER PVS-175</th>
</tr>
</thead>
<tbody>
<tr>
<td>N° of inverter</td>
<td>286</td>
<td>540</td>
</tr>
<tr>
<td>Inverter x MV station</td>
<td>22 (7.7MVA)</td>
<td>36 (6.66MVA)</td>
</tr>
</tbody>
</table>

**Benefits**

- **-47% Inverter**
- **-2% AC cables**
- **-5% AC trenches**

> - 0.01 €/W
PVS-350
Main Benefits Vs Existing Multi MPPT Platform

Maximum exploitation of the electrical BoS to minimize the cost per W of the system

From 6.66MVA Block to 7.7MVA block

<table>
<thead>
<tr>
<th>Benefit</th>
<th>13.3% MV Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter x MV station</td>
<td>22 (7.7MVA)</td>
</tr>
<tr>
<td>N° of station</td>
<td>13</td>
</tr>
<tr>
<td>Benefit</td>
<td>-13.3% MV Station</td>
</tr>
<tr>
<td>CAPEX</td>
<td>&gt; - 0.26 €c/W</td>
</tr>
</tbody>
</table>

100MW Project

FIMER

FIMER

PVS-350

FIMER

PVS-175

Inverter x MV station | 22 (7.7MVA) | 36 (6.66MVA) |
N° of station | 13 | 15 |
Benefit | -13.3% MV Station |

> - 0.26 €c/W
PVS-350
Main Benefits Vs Existing Multi MPPT Platform

- Power-to-Weight Ratio: 3027 W/kg
- Power density: 835 W/dm³
- Inverter Box is compatible with standard EU pallet to optimize the shipment cost

Thanks to its weight and dimensions, PVS-350 represents the higher power density inverter on the market!

<table>
<thead>
<tr>
<th></th>
<th>FIMER PVS-350</th>
<th>FIMER PVS-175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (WxHxD) [mm]</td>
<td>1100x740x490</td>
<td>1100x890x360</td>
</tr>
<tr>
<td>AC Power Max/Nominal [kW]</td>
<td>350/333</td>
<td>185/175</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PVS-350</th>
<th>PVS-175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum 2 Layers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Layers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FIMER PVS-350</th>
<th>FIMER PVS-175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nº of Layers</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Inverters x Container</td>
<td>69</td>
<td>54</td>
</tr>
<tr>
<td>Power x Container</td>
<td>24.15MVA</td>
<td>9.99MVA</td>
</tr>
<tr>
<td>Benefit</td>
<td>+140%</td>
<td></td>
</tr>
</tbody>
</table>

- 0.02 €/W

LOGISTIC
Keep the form factor to be able to ship in a standard pallet to minimize the Logistic cost
# PVS-350

Main Benefits Vs Existing Multi MPPT Platform

<table>
<thead>
<tr>
<th>MAIN BENEFITS</th>
<th>&gt;&gt; KEY ADVANTAGES &lt;&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistic &amp; Installation</td>
<td>-30% overall costs</td>
</tr>
<tr>
<td></td>
<td>thanks to the record-high capacity and power-to-weight ratio. Saving may exceed (0.03 , \text{€c/watt})</td>
</tr>
<tr>
<td>AC eBOS</td>
<td>Up to 15% higher AC capacity for the MV station</td>
</tr>
<tr>
<td></td>
<td>means less stations per MWac installed power. In a 100MW system the saving may exceed (0.26 , \text{€c/watt})</td>
</tr>
<tr>
<td>182/210mm Ready</td>
<td>Optimized for the latest Ultra-High Power modules</td>
</tr>
<tr>
<td></td>
<td>enabling additional cost savings compared to 166mm modules on Trackers, eBOS, and Logistics up to (0.5 - 0.9 , \text{€c/W})</td>
</tr>
<tr>
<td>Total savings</td>
<td>0.8 to 1.2 €c/W lower than other solutions</td>
</tr>
<tr>
<td></td>
<td>saving on a 50/100MW plant, depending:</td>
</tr>
<tr>
<td></td>
<td>• the PV module technology and</td>
</tr>
<tr>
<td></td>
<td>• thanks to the FIMER’s new Multi-MPPT solution that is the enabler to be able to use this modules</td>
</tr>
</tbody>
</table>
NEW PVS-260/300-MVMCS solution for centralized architecture
PVS-260/300-MVMCS
Modular Solution for Centralized Systems

- The most powerful single stage modular inverter in Utility
- Replace any conventional central inverter solution in the same footprint
- Reduced O&M costs, compared to a central inverter solution
- Minimum system downtime, availability > 99.9%
- 100% scalable to all power sizes needed
PVS-260/300-MVMCS
100% scalable to all power sizes needed

Highest modularity, perfect fit with any DC/AC ratio

Solution based on:

- PVS-260: 262.5kW – 600V, or
- PVS-300: 300kW – 690V

Up to 24 inverter on the same Skid:

- PVS-260: 6300 kVA
- PVS-300: 7200 kVA

- 100% fully integrated solution
- True plug & play solution
- Fully controlled the supply chain.
PVS-260/300-MVMCS
Main Benefits Vs Conventional Central solution

OPEX
Replace on fail concept and swappable power blocks reduce the number of spare parts and the O&M activity on site

<table>
<thead>
<tr>
<th>Conventional Central</th>
<th>Modular Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>Labour</td>
</tr>
<tr>
<td>1,5€/kW/Yr</td>
<td>0,826€/kW/Yr</td>
</tr>
</tbody>
</table>

Typical O&M activity cost

<table>
<thead>
<tr>
<th>100MW Project</th>
<th>Central Inverter</th>
<th>Modular Inverter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter Spare</td>
<td>Fuses</td>
<td>Typically 1% of total units installed available onsite</td>
</tr>
<tr>
<td></td>
<td>Fan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modules</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.....</td>
<td></td>
</tr>
<tr>
<td>Inverter repair &amp; replacement</td>
<td>Manufacturer expertise or specialized trained technician</td>
<td>Customer technician</td>
</tr>
</tbody>
</table>

Provide more than 1.3 €c/Watt saving in 25Yrs(*)

(*) Initial 5 years are covered by the standard warranty
Main Benefits Vs Conventional Central solution

AVAILABILITY

The embedded fault tolerance is the key to maximize the system availability

- Low sensitivity to a Single fault
  → System availability > 99.9%

- Easy and fast replacement
  → Module weight ≤100kg, easy to manage even from Customer personnel
    (No need Manufacturer’s technicians)

**Monolithic Central**

<table>
<thead>
<tr>
<th>Inverter 1</th>
<th>Inverter 2</th>
</tr>
</thead>
</table>

- 2/2

**Modular Inverter**

<table>
<thead>
<tr>
<th>Inverter 1</th>
<th>Inverter 2</th>
<th>Inverter 3</th>
<th>Inverter 4</th>
<th>Inverter 5</th>
<th>Inverter 6</th>
<th>Inverter 7</th>
<th>Inverter 8</th>
<th>Inverter 9</th>
<th>Inverter 10</th>
<th>Inverter 11</th>
<th>Inverter 12</th>
<th>Inverter 13</th>
<th>Inverter 14</th>
<th>Inverter 15</th>
<th>Inverter 16</th>
<th>Inverter 17</th>
<th>Inverter 18</th>
<th>Inverter 19</th>
<th>Inverter 20</th>
<th>Inverter 21</th>
<th>Inverter 22</th>
<th>Inverter 23</th>
<th>Inverter 24</th>
</tr>
</thead>
</table>

- 24/24

- Single fault

- 1/2

**Capacity loss until repair/replace**

- 50%

- 4%
PVS-260/300-MVMCS
Main Benefits Vs Conventional Central solution

**AVAILABILITY**

The embedded fault tolerance is the key to maximize the system availability

- Up to 24 Independent MPPTs **to preserve the Yield in case of single fault**
- Complete segregation of each single unit, each inverter feeder is protected with a dedicated fuse switch disconnector in order **to safely operate on each single unit while not penalizing the Energy production**

<table>
<thead>
<tr>
<th></th>
<th>Central Inverter</th>
<th>Modular Inverter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Availability</strong></td>
<td>Maximum 99.5%</td>
<td>&gt; 99.9%</td>
</tr>
<tr>
<td><strong>99.9% compared to 99.5% maximum from central solutions, thanks to the inherent fault tolerance, reduced MTTR and labor cost guaranteed by modular conversion</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PVS-260/300-MVMCS
Main Benefits Vs Conventional Central solution

PWR Density
Replace any conventional central inverter solution in the same footprint
Based on 24 x 260/300 kVA ultra-high power density swappable power modules

Monolithic Central Inverter solution footprint

Modular String Inverters

<table>
<thead>
<tr>
<th>MODULAR CENTRAL INVERTERS – POWER RATINGS / 600Vac &amp; 690Vac</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVS-260-MVMCS</td>
</tr>
<tr>
<td>PVS-300-MVMCS</td>
</tr>
<tr>
<td>MONOLITHIC CENTRAL</td>
</tr>
</tbody>
</table>

21 October 2021
PVS-260/300-MVMCS
Main Benefits Vs Conventional Central solution

Lower LCOE is the result of the equation of the Centralized architecture and modular core

\[
\text{LCOE} = \frac{\text{CAPEX} + \text{OPEX}}{\text{YIELD}}
\]

- \( \text{OPEX}_S = 0.55 \times \text{OPEX}_C \)
- \( \text{YIELD}_S = 1.004 \times \text{YIELD}_C \)

\[
\text{LCOE}_S = \frac{0.985}{0.975} \times \text{LCOE}_C
\]

It is possible to reduce LCOE by -1.5% ÷ -2.5% compared with conventional solution
## PVS-260/300-MVMCS
Main Benefits Vs Conventional Central solution

<table>
<thead>
<tr>
<th>MAIN BENEFITS</th>
<th>KEY ADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O&amp;M</strong></td>
<td>-1.3 €c/Watt</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>+ 0.4%</td>
</tr>
<tr>
<td><strong>PWR Density</strong></td>
<td>=</td>
</tr>
<tr>
<td><strong>LCOE</strong></td>
<td>-1.5% ÷ -2.5%</td>
</tr>
</tbody>
</table>

Typical saving over 25 years, thanks to the granularity of power conversion accomplished with smaller and swappable power blocks

99.9% compared to 99.5% maximum from central solutions, thanks to the inherent fault tolerance, reduced MTTR and labor cost guaranteed by modular conversion

The AC capacity of a fully equipped plug & play 40 feet Medium Voltage Compact Skid can reach 7200kVA, same as the largest conventional central solutions

Depending on site-specific conditions the LCOE of a 50/100MW plant designed with FIMER’s new modular solution is 1.5% to 2.5% lower than conventional solutions

*FIMER*
Thank you

FIMER S.p.A.
Via J. F. Kennedy
26 20871 Vimercate (MB) Italy

Phone: +39 039 98 981
Fax: +39 039 60 79 334

info@fimer.com
fimer.com