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SOLIBRO INTRODUCTION

BIPV MARKET ASPECTS & CONSIDERATIONS

SOLIBRO PRODUCTS / APPLICATIONS
SOLIBRO – KEY MILESTONES

2007
New R&D Center in Uppsala

April 2008
Production start in Germany

December 2009
Production start Fab 2 (100 MW)

September 2012
Hanergy purchases Solibro

March 2014
Start of Solibro Hi-Tech GmbH
THE SOLIBRO FAMILY

Solibro Research AB
- Basic research @ small sizes
- Process development
- Scale-up feasibility
- Equipment prototyping
- Material and device characterization

Solibro Hi-Tech GmbH
- Turnkey fab provider
- CIGS Equipment manufacturing
- Process, Equipment and Module development
- Handover to mass volume production
- Support production in trouble shooting / optimization

Solibro GmbH
- Module production

R&D ➔ Turnkey provider & Industrial development ➔ Production

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CIGS Power Line

- Full service from groundbreaking to start of production and beyond
- Scalable concept (150 MW to 1.2 GW capacity)
- Realization in less than 24 months
- Lowest production costs
THIN FILM TECHNOLOGY CHAMPIONS

17.0% total area efficiency module world record!

21.1% @ 1cm² cell world record
SOLIBRO IS PART OF THE HANERGY GROUP

- Established 1994
- Chairman & Founder Li Heyun
- HQ in Beijing
- 15000 employees
- Core businesses: hydro- and windpower, PV and related products
- Hanergy Thin Film Power Group Ltd
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TURN RISK OF LOSS TO PROFIT

45 $/sqm

300 $/sqm
MARKET FORECAST IN CHINA - #1 MARKET

In next 3 years, market forecast reaches 16.5 B RMB

• Based on government plan
  Building Forecast (2016-2020)
    ✓ Public buildings
    ✓ Real estate
    ✓ C&I
    ✓ High-End residential
    ✓ New town

• High PV market share for BIPV
ADAPTION TO BIPV MARKET IS KEY TO SUCCESS

- Value chain is different and more complex, deployment is slower as a result
- The building industry is the customer!
- Good enough BIPV solutions are already in place!(?)
REGULATION & STANDARDS ASPECTS

- Environmental directives, i.e., net zero building directive, could be a strong driver for the market development.

- PV is in competition with other environmental regulation/demands, i.e., green roofs.

- BIPV specific standards and codes has to be more developed:
  - EU glass facade case; finding were its very hard to identify clear regulation or standards:
    - common Euro codes for wind load
    - glass lamination material and minimum thickness
    - tempered glass not necessary
    - maximum allowed tension in laminated float and ESG glass

- Project specific product customization demands and time schedules are in conflict with the current PV certification standards and time consumption - adoptions or work-arounds in product development necessary.
TECHNICAL FEASIBILITY CONSIDERATIONS

• **Product development considerations i.e.**
  - Safety
  - Easy electrical connectivity
  - Temperature
  - Easy replacement
  - Enough electricity generation level
  - Reasonable cost
  - Easily scalable
  - Multifunctionality
  - Appearance options (color, transparency, format)

• **New technology will give new BIPV opportunities**

• **BIPV case illustration: enough electricity generation?**
  ▶️ 36% compared to regular non-transparent PV installation

- 40% transparency PV in facade
- Overtemp coeff 0,95 (assumed)
- Color, 15% reduction (5-50%, pending color and solution)
- Vertical facade in south
- No shading

<table>
<thead>
<tr>
<th>Yield</th>
<th>East</th>
<th>South</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>57,7</td>
<td>74,5</td>
<td>57,4</td>
</tr>
</tbody>
</table>
THIN FILM AND BIPV IS A GOOD FIT

- Aesthetically pleasing already in its standard format
- Flexible / lightweight
- Appearance options: format, color, transparency
- Reduced sensitivity to shading by its monolithic interconnections
- Low temperature coefficient
- Sustainability: low energy pay back time and material consumption
- Efficiency development 1%/y and a good basis for tandem devices with efficiency levels to >30%
- Production cost can be further reduced
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### SOLIBRO SL2 UNFRAMED

IDEAL FOR INDUSTRIAL FLAT ROOF SYSTEMS & LARGE SCALE INSTALLATIONS

<table>
<thead>
<tr>
<th>Module Types</th>
<th>SL2 (unframed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Classes</td>
<td>Up to 145 Wp</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Up to 16.5%</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1190 mm x 789.5 mm x 7.3 mm (+15.5 mm junction box)</td>
</tr>
<tr>
<td>Weight</td>
<td>16.5 kg</td>
</tr>
</tbody>
</table>
SOLIBRO SL2-XL

- High power module up to 315Wp
- Reduced system costs:
  - Double power with same voltage
  - More modules per string
  - Fast installation with back-raills
  - Reduced BOS cost
- Backrails - less mechanical stress

**EFFICIENCY**  
15 % (Basic) up to 16.5 % (GEN3)

**POWER CLASS**  
285 Wp – 315Wp (-0/+5 Wp)

**DIMENSIONS**  
1190 mm x 1580 mm x 6.5 mm (1.88 m²)

**TEMPERATURE COEFFICIENT**  
-0.32 %/K

**RELATIVE EFFICIENCY**  
98% (at 200 W/m²)

**OPEN-CIRCUIT VOLTAGE**  
100V (basic) down to 60 V (GEN3)

Prototype shown at Intersolar
BIPV SL2 WATERPROOF SLIDE-IN SYSTEM

STEP 1
The metal profiles are laid out on the blank roof

STEP 2
Slide the decoupling rail and unframed modules with spacer

STEP 3
The anti slip safeguards are fixed
COLORED MODULES

SOLIBRO SL2 COLOR SERIES
- Solibro SL2 module with colorful appearance
- Several color options available
- Exceptionally well-suited for architectural applications
BAPV/BIPV MODULES

MOUNTING: MAXIMUM FREEDOM OF DESIGN
- BAPV modules can be applied in landscape and portrait format for maximum freedom of architectural design, according to regional and local restrictions.

VENTILATED FACADE SYSTEM
- Ventilated façade are a multifunctional building envelope, combining the advantages of a high aesthetic solution with thermal, waterproofing and “solar active” benefits. Several mounting system options available.

CUSTOMIZED SOLUTIONS
- Customer-tailored as flat or bent modules in all geometrical shapes
- By using colored front glass, BAPV modules can be produced in different colours, even with semi-transparency.

Gold  Turquoise  Black
Blue
Semi-transparent
ADVANCED BIPV FACADE SYSTEMS IN DEVELOPMENT

- Innovative systems for facade
- PV combinable with other facade materials (fiber cement, metal, etc.)
- Color panels can be used to create a living facade
- Integrated ventilation
- Easy and quick installation
- Watertight
HANERGY BIPV HANTILES

- In flat and curved variants
- Price about 200 $/sqm in China
- CIGS thin film PV technology
- Product released and certified in China