A LOW COST BIPV APPROACH FOR MASS MARKET

Valérick CASSAGNE – TOTAL - New Energies
PV MARKET PERIODS AND EVOLUTION

World PV Market

- Green, humanist, exploratory era: CAGR: +26%/year
- Financial opportunistic era: CAGR: +45%/year
- Energy era: CAGR: +15-25%/year

From 50's space application

World yearly market (MWP)

1,000,000

100,000

10,000

1,000

100

10

1

PHOTOVOLTAIC IN/ON BUILDINGS

Agriculture

Residential collective

Warehouse

Public building

Residential individual

Commercial

Industry

Offices

Sources: Sunpower, Tenesol

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BIPV DEFINITION

- **BAPV**: Building Added PhotoVoltaic → over imposed

- **BIPV**: Building Integrated PhotoVoltaic → 2 functions:
  - energy generation + construction functionality

PV integrated in the construction project

**BIP²V**: Building Integrated Project PhotoVoltaic
BIP2V – COUNTER EXAMPLE

Green Office Rueil (France)
Bouygues Immobilier
office building, 6 floors, 52 kWh/m²
2000m² floors, 600 kWp PV + cogen
104% consumption covered
PROJECT INTEGRATION

- Project management
- Design
- Construction

- Costs
- Performances

BIP²V is economically motivated

LCOE: Levelized Cost of Electricity
PERFORMANCES
### ROOF POTENTIAL VS. ACTIVITY CONSUMPTION

#### Consumption kWh/m²/yr

<table>
<thead>
<tr>
<th>Activity</th>
<th>Consumption kWh/m²/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Center</td>
<td>3000-7000</td>
</tr>
<tr>
<td>Industry</td>
<td>100-1000</td>
</tr>
<tr>
<td>Supermarket</td>
<td>400-800</td>
</tr>
<tr>
<td>Cold Warehouse</td>
<td>200-400</td>
</tr>
<tr>
<td>Office*</td>
<td>60-300</td>
</tr>
<tr>
<td>Hospital*</td>
<td>80-100</td>
</tr>
<tr>
<td>Residential*</td>
<td>30-100</td>
</tr>
<tr>
<td>School *</td>
<td>25-35</td>
</tr>
<tr>
<td>Sport hall</td>
<td>15-35</td>
</tr>
<tr>
<td>Farm</td>
<td>1-100</td>
</tr>
<tr>
<td>Warehouse</td>
<td>3-30</td>
</tr>
<tr>
<td>* multi-floors</td>
<td></td>
</tr>
</tbody>
</table>

#### PV production kWh/m²/yr

<table>
<thead>
<tr>
<th>Country</th>
<th>PV production kWh/m²/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>100-230</td>
</tr>
<tr>
<td>France</td>
<td>130-315</td>
</tr>
<tr>
<td>Italy - Spain</td>
<td>160-360</td>
</tr>
</tbody>
</table>

* Sources: Total, Ademe
Energy Efficiency

Service station in Nigeria

74 kWp PV + 383 kWh battery

-20% CAPEX

65 kWp PV + 266 kWh battery

Source: Total, Sunhive
ORIENTATION

European location

Roof first
PROJECT INTEGRATION

Costs savings

● Co-engineering
  - Performances optimization
  - Sizing optimization
  - Standard elements
  - Simplified installation design

● Co-construction
  - Material functionality saving
  - Construction sharing
SIZING PV OPTIMIZATION

● Sizing criteria
  - Surface
  - Power
  - Costs
  - Architecture
  - Communication
  - Regulation
  - Economy

Customer objectives
  • Internal Return Rate (IRR)
  • Net Present Value (NPV)
  • Payback time (PBT)
  • …
SELFCONSUMPTION SCHEME

Ex: Commercial Germany

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ECONOMY VS SIZE

Examples:
- commercial building 1 floor 3000 m² 600 kWh/m²
- office building 6 floors x 500 m² 100 kWh/m²

Based in Munich Germany

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EX: PV TERTIARY BUILDING

PV module efficiency: 20%

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Green Office Rueil (France)
Bouygues Immobilier
office building, 6 floors, 22 kWh/m²
35 000m² floors, 2700 m² PV
100% consumption covered
Orientation

Not equipment shadow

Roof first

Optimized sizing

Dedicated roof surface

Energy efficiency

Easy cabling

Structure adaptation

Standard PV modules

Construction coordination

Construction equipment sharing

Integrated financing
CONCLUSION

BIP²V

● Strong integration of PV in the building project: design, construction
● Performances: energy generation
● Costs
  - Co-design: sizing, performances, easy installation
  - Co-construction: coordination, costs sharing
  - Finances

IRR > 10%
PBT < 10 years
NPV₀ ~4000€/m²
Consume coverage > 25%
BACK-UP
IN A NUTSHELL

- **Revenue**: 189.5 B€
- **Net income**: 10.7 B€
- **Organic investment**: 21.3 B€
- **R&D**: 7.1 B$ over 4 years
- **Operating in 130 countries**
- **98 800 employees**
- **5th ranked international oil and gas company**
- **Active in photovoltaics since 1983**

- **Revenue**: 2.5 B$
- **Net income**: 41.7 M€
- **1 GW/yr capacity**
- **5 000 employees**
- **22.8% modules efficiency**
Optimization

Economics

**Incomes**
- Feed-in-Tariff
- Self-consumption/net metering: savings
- Tax credit
- Tax delays

**Expenses**
- Initial investment: PV system (modules, BOS, installation, engineering, administration and margins)
- Replacement of inverters
- Maintenance cost
- Taxes
- Inflation
- Interest on loans or negative treasury
ROOF UTILISATION

Energy need cover - Comparaison nb of levels
Building. 30 000m² 65 kWh/m²/yr Paris area. Roof coverage 80% PV

- Module multi-Si Std 15%
- Module HJ Si 18%
- Module adv. Si 21%

Roof: efficient, available …. But may be not enough
ROOF UTILISATION

Energy need coverage - Roof coverage ratio
Building. 30 000m² R+6 65 kWhpe/m²/yr Paris area

Yearly energy need covering (%)

Other surfaces: facade, sun shade, shades

Overlap

+1 m = +6% surf.

Module multi Std 15%
Module HJ Si 18%
Module adv. Si 21%

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