HYBRID SYSTEMS

Solar Energy: A cost advantage for the off-grid mining industry
Juwi at a glance

- Company Structure
- Vision
- Figures and Locations
- Wind and Solar Energy

Hybrid Systems

- PV systems for industrial applications
- PV Diesel Hybrid Systems
- Sandfire Project, Australia
WE MAKE IT HAPPEN
juwi at a Glance

Organisation
- Founded in 1996 by Fred Jung (ju) and Matthias Willenbacher (wi), pioneers for renewable energies with agricultural roots
- juwi AG, not listed on the stock exchange
- 50.1% MVV Energie AG
  - 49.9% Frema GmbH & Co. KG

Total capacity
Around 3,200 megawatt (approx. 2,350 systems)

Annual energy output
Approx. 6.0 billion kilowatt-hours, corresponds to the annual power demand of around 1.7 million households

Investment volume (since 1996)
> 6.0 billion Euro

Employees & turnover
- Approx. 1,000 employees (worldwide)
- > 700 million Euro in 2013
WE MAKE IT HAPPEN

Our Vision

Our Vision
100% Renewable Energies

Projects
- Wind Energy
- Solar Energy
- on-grid / off-grid

Operations
- Technical & Commercial Operations & Maintenance

Our Impetus
Passionately work together to implement renewable energies economically and reliably.
FIGURES AND LOCATIONS

Offices worldwide

**EMEA**
Czech Republic, Germany, Great Britain, Greece, Italy, South Africa, Spain, Turkey, United Arab Emirates

**Americas**
Chile, USA/Canada

**APAC**
India, Japan, Singapore, Philippines, Thailand

**Australia**
OUR PASSION
Our Business Activities
OUR PASSION
We Construct Your Solar or Wind Power Plant

Wind Energy
- more than 840 wind turbines (at more than 100 locations)
- more than 1.800 MW of installed capacity
- total investment: approx. € 2,4 billion
- annual energy production: approx. 4,6 billion kWh

Solar Energy
- more than 1.500 PV installations
- more than 1.400 MW of installed capacity
- total investment: approx. € 3,7 billion
- annual energy production: approx. 1,4 billion kWh

Plouguin wind farm, Bretagne
PV-free-field installation Drama, Greece
Hybrid Systems

Industrial application with scalable approach

- Diesel Generator System
- Solar Plant
- Consumers
- Battery System
- Mini Grid
Hybrid Systems

Why Hybrid Power is economically interesting?

Benefits
- Cost: PV cheaper than diesel generation
- Diesel exposure: reduce impact of diesel price rises
- Carbon emissions: significant reduction
- Technology: simplifying solar/diesel integration
- Public image: enhanced profile

Renewable Energy Trend
- PV and Battery prices decreased > 50% in the last years
- PV and Battery prices keep decreasing

Fossil Fuel Trend
- Diesel & Gas: increasing with higher volatility

PV vs Diesel Cost

BSW off-grid power Forum · Intersolar 2015
# Hybrid Systems

## Comparison of Solar Penetration

<table>
<thead>
<tr>
<th>Low Penetration Applications</th>
<th>High Penetration Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Penetration</td>
<td>Up to 200%</td>
</tr>
<tr>
<td>Solar Fraction</td>
<td>Up to 100%</td>
</tr>
<tr>
<td>Fuel Savings</td>
<td>&gt;50%</td>
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<tr>
<td>CAPEX</td>
<td>high</td>
</tr>
<tr>
<td>Grid support</td>
<td>high</td>
</tr>
</tbody>
</table>

- Generator leading system
- Simple control mechanism
- No BESS necessary
- Brownfield

- Battery or generator leading system
- Complex control mechanism
- BESS necessary
- Diesel off-mode possible

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<tr>
<td>low</td>
<td>&lt;25%</td>
<td>low</td>
<td>&lt;25%</td>
<td>60%</td>
</tr>
<tr>
<td>high</td>
<td>&gt;50%</td>
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- Power ratio $P_{py}/P_{gen}$

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Sandfire Project, Australia
Current Situation

Degrussa Mine:
- **Mining**: Gold and copper
- **Location**: Doolgunna Region, North-Western Australia
- **Customer**: Sandfire Resources NL
- **Distance**: ~1000 km to Perth

Power Supply:
- **Diesel Power Station**: ~ 20MW
- **Operator**: 3rd party power station owner
- **Average load**: ~ 11MW
- **Average consumption**: ~ 100GWh p.a.
Sandfire Project, Australia
System Design

Hybrid Power Plant:
- **PV-Modules**: 10,565 MWp
- **Tracking**: East-West tracking
- **PV-Inverter**: 10 MW
- **Storage**: 4 MW / 1,8 MWh (6 MW peak)
- **Operator**: juwi Australia

Storage tasks:
- Provide spinning reserve to switch of gen-sets
- Control ramp rate → PV smoothing
- Additional spinning reserve at night
- Provide frequency support and power factor >0,8
- Grid forming if diesel-off mode (during low load days)
Sandfire Project, Australia
Simulation Results

**Simulations:**
- Energy study: full year on minute basis with Homer Pro 3.2 and PV Hyb 2.2
- Grid stability with PowerFactory
- Storage Lifetime Simulation from manufacturer

**Results:**
- **Electricity from PV:** 21.1 GWh
- **Curtailment:** ~ 5 %
- **Diesel Savings:** 6 million litres (~ 25% of total consumption)
- **CO₂ Savings:** 12,938 tonnes
Sandfire Project, Australia
Summary and Outlook

Hybrid Power Plant
- Worldwide biggest combination of an off-grid, high capacity PV system integrated with a diesel power station
- 10.6 MWp PV + 6 MW Storage
- Reducing running Diesel capacity to minimum
- Diesel-off mode during low-load days
- Timeline: project start in mid 2015
  commissioning in early 2016

Main benefits:
- Reduced operation costs (~ 25% diesel savings)
- Possibility of running solar pure mode
Thanks For Your Attention.

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juwi PV Hyb 2.2:

- Input of Load and Solar data (1min – 1h)
- Simulation of Fuel Save, Off-Grid, Own-consumption and Storage Applications
- Detailed financial analysis including sensitivity analysis
- Comparison of different system sizes to choose optimal system
- Export plots showing overview of several days or details of specific periods
- Export function of generated data for further analysis or processing