

THE **FICHTNER** GROUP

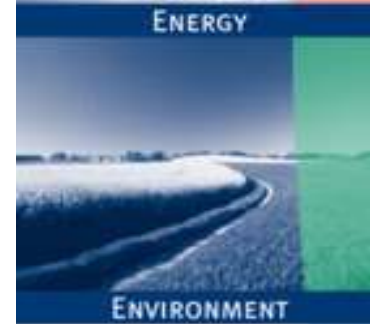
# FICCI Lessons Learned for India



CONSULTING & IT



ENERGY



ENVIRONMENT



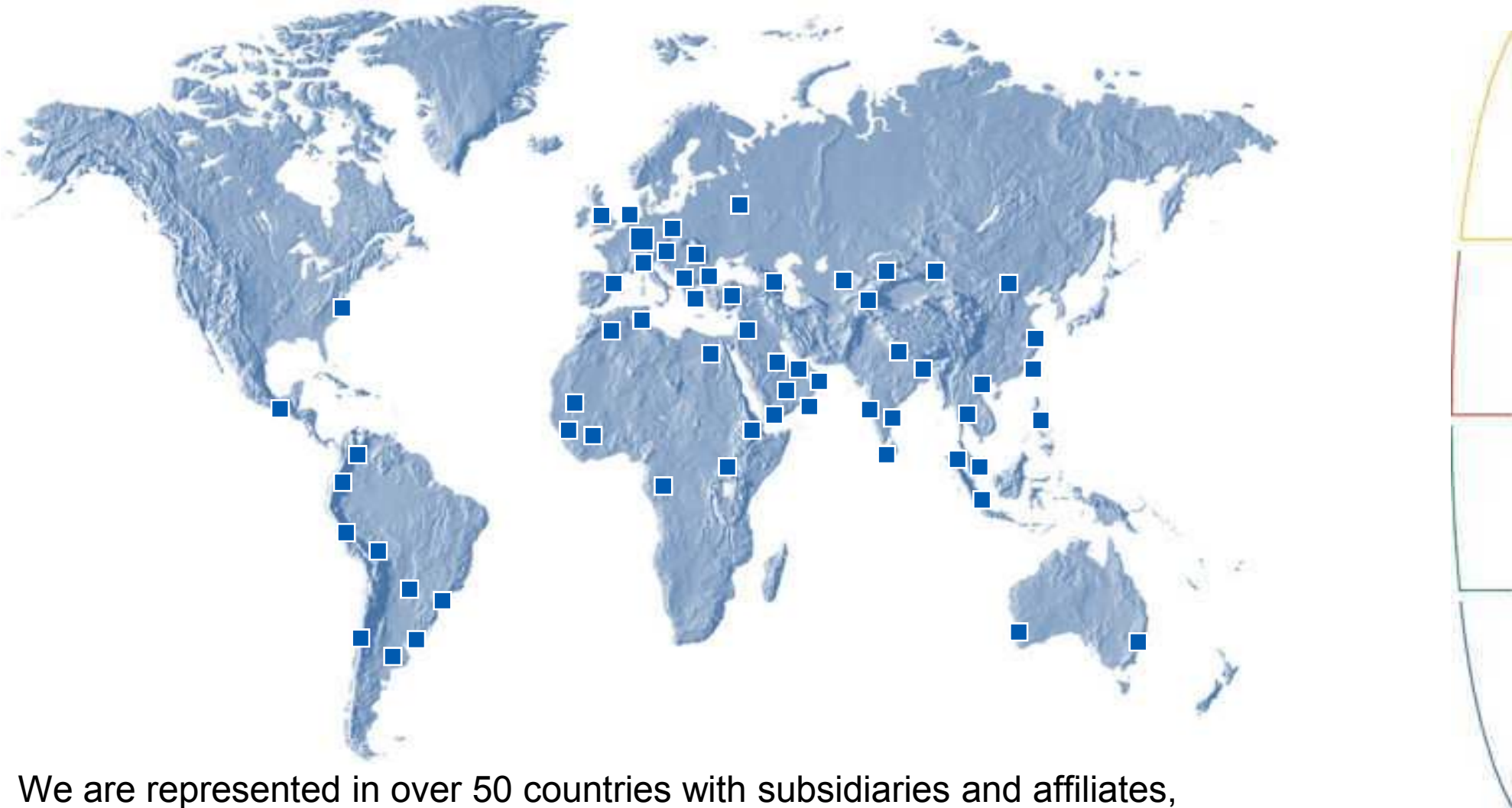
WATER & INFRASTRUCTURE

Dr. Martin Stickel

## The Fichtner Group

- Established in 1922 and family-owned ever since
- Germany's biggest independent engineering and consultancy enterprise
- More than 1800 employees worldwide – over 500 in our Home Office
- Over 500 in India (Chennai, Mumbai, Delhi)
- Project experience in 150 countries, over 1200 ongoing projects – 650 of these in our Home Office
- Total turnover of €196 million in 2009
- Capital investment volume now under planning in the home office: €60 billion – of which some €12 billion is in renewable energies

## Worldwide Presence



We are represented in over 50 countries with subsidiaries and affiliates, branches and project offices

## Fichtner's Areas of Activity

### Energy

Energy economics • power plants • renewables • district heating • energy transmission and distribution • I&C and power system technology • oil & gas • energy management • electric mobility • energy-purchasing portfolio management

### Environment

Environmental management • environmental technology • environmental information systems • waste management • soil and water protection • air pollution control • sustainable development • emissions trading

### Water & Infrastructure

Total water management • drinking water supply and sanitation • surface and engineering structures • traffic, transportation and civil engineering • mining and mineral economics • integrated infrastructure concepts •

### Consulting & IT

Studies • organization and strategy consultancy • privatizations • project management • financial modeling • infrastructure management • IT consultancy and services • geo-solutions

## Total Turnover of Fichtner Group, 2009

### By business sector

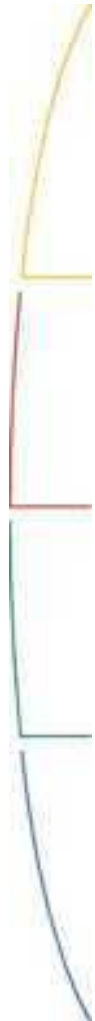


### By region



# Renewable Energy Technologies

- Photovoltaic
- Solarthermal power
- Hydropower
- Wind power
- Geothermal power
- Solid biomass
- Sewage and landfill gas
- Biogas
- Biomass to Liquid (BtL)
- Fuel Cells

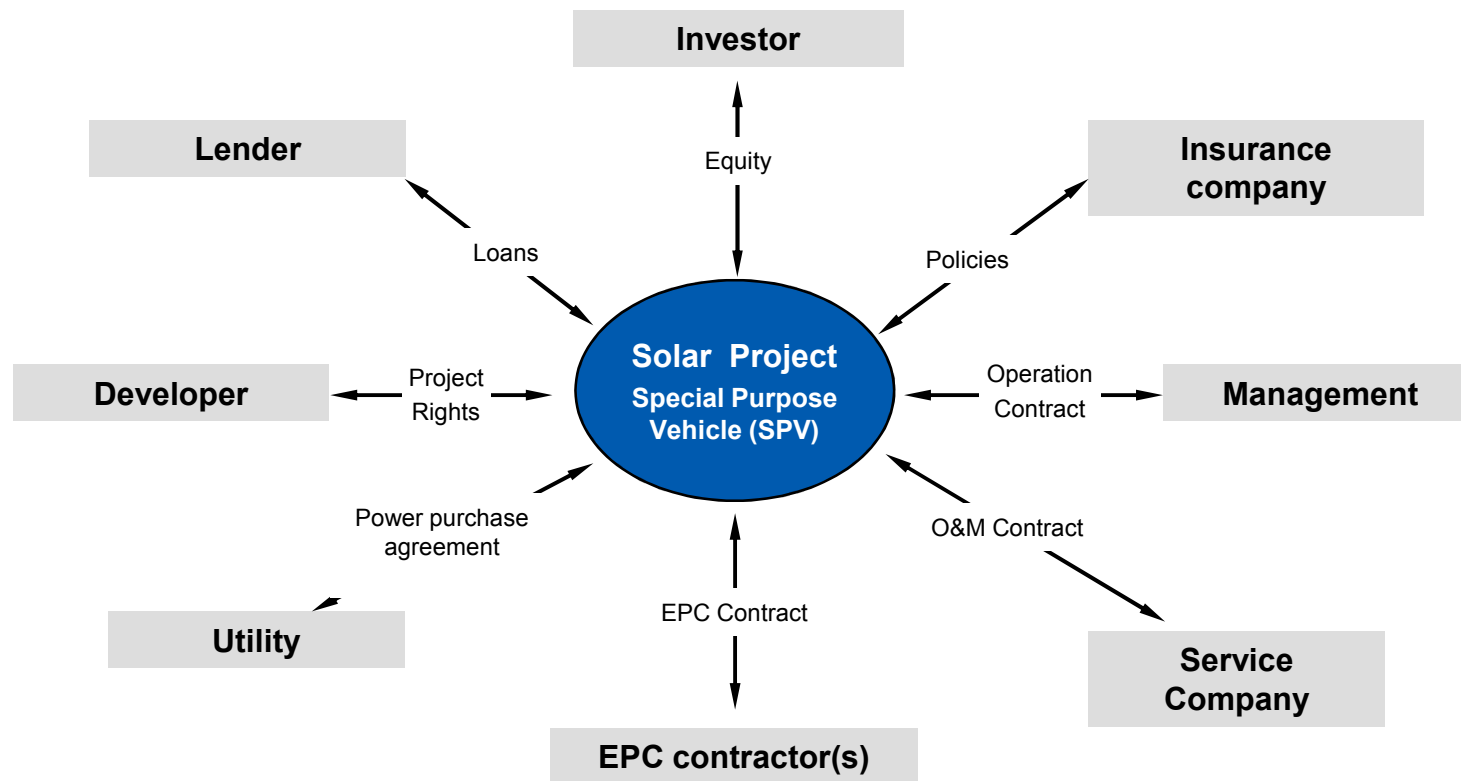


## Present PV Highlights

About 20 PV projects ongoing at present, mostly due diligence services on behalf of financing institutions and investors as well as owner's engineering services, among others:

- 3 projects in Spain
  - >10 projects and project pipelines in Italy
  - 1 project pipeline in the Czech Republic
  - 1 project in Qatar (test facility for solar equipment)
  - 4 projects in Bulgaria
  - 1 project pipeline in Canada
  - 2 projects in Peru
  - 1 project in United Kingdom
  - 1 project in Chad
  - 1 project in Ukraine
  - 1 project in Turkey
  - 1 project in Thailand
  - 1 project in India
- Technology / reliability studies on behalf of reknown and innovative PV module producers (thin film and crystalline)
  - In total above 500MW installed capacity, i.e. CAPEX >>1bn€; inter alia Europe largest PV plants (Rovigo >70WM, Montalto di Castro >80MW in total)
  - For research related fields long term colaboration with Centre for Solar Energy and Hydrogen Research (ZSW) in Stuttgart.

# PV Due Diligence Services – Typical Project Structure



## Objectives:

- Implementation of a **long life** power plants with **high energy yield** and **availability**
- **Proper and safe operation** complying with the relevant requirements
- Low cost, high **return on investment**



# Due Diligence Services in PV Projects

Preliminary  
DD

Yield  
Projection

Full Due  
Diligence

Construction  
Monitoring

Verification of  
Construction  
Completion

Prov. & final  
Acceptance

Operation  
Phase

## Phase I: Pre-Financial Close Due Diligence - I

### 1. Preliminary Due Diligence

- Suitability of the key plant components (modules, inverters)
- Rough verification of the plant key data (size of the site, installed capacity)

### 2. Yield Projection

#### Input

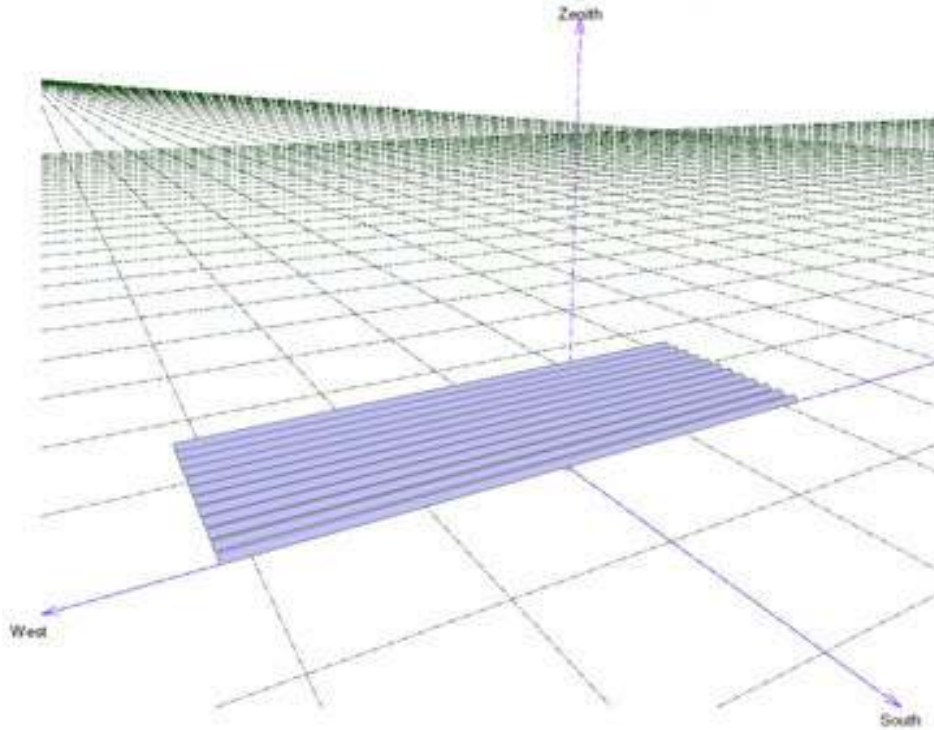
- Irradiation data to be expected on site based on the best available sources
- Site inclination
- Project design (e.g. inclination and positioning of the modules, partial shading)
- Actual characteristics of the plant key components (including temperature behavior of the modules, part load characteristics of inverters and transformers)

#### Output

- Annual electricity production (MWh/a; kWh/kWp/a)
- Probability cases (e.g. P50, P75, P90)

# PV Performance Projection - Example

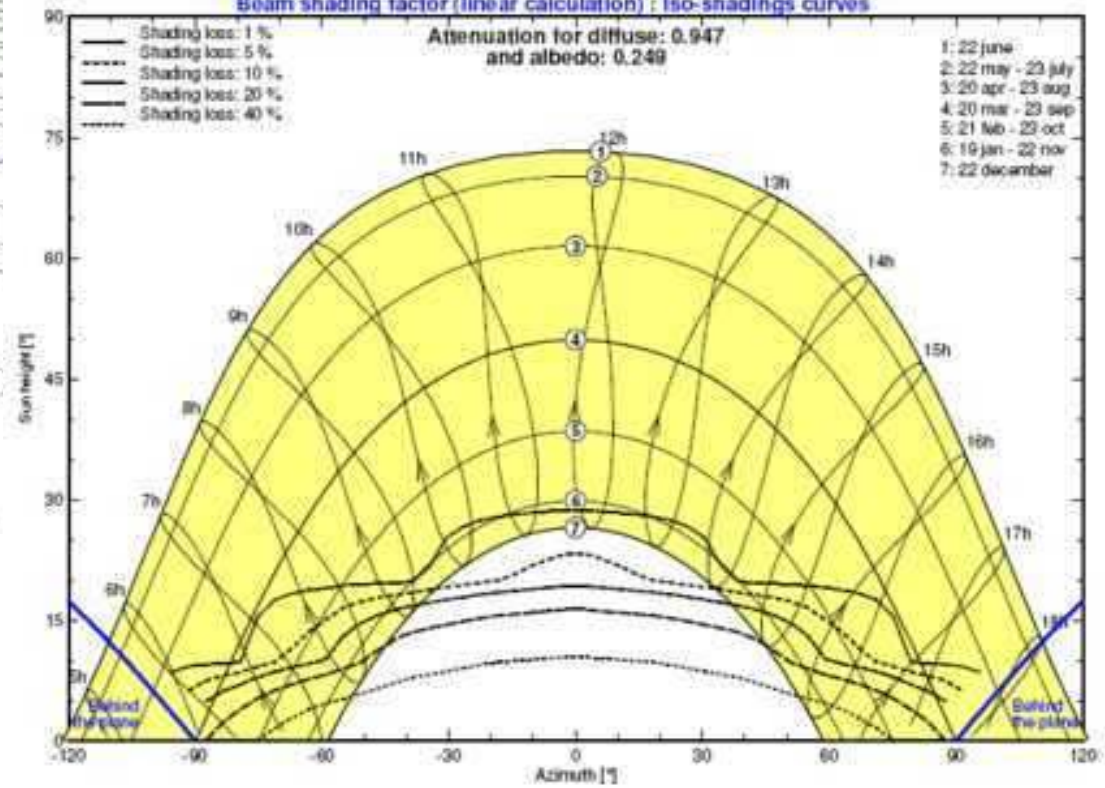
Perspective of the PV-field and surrounding shading scene



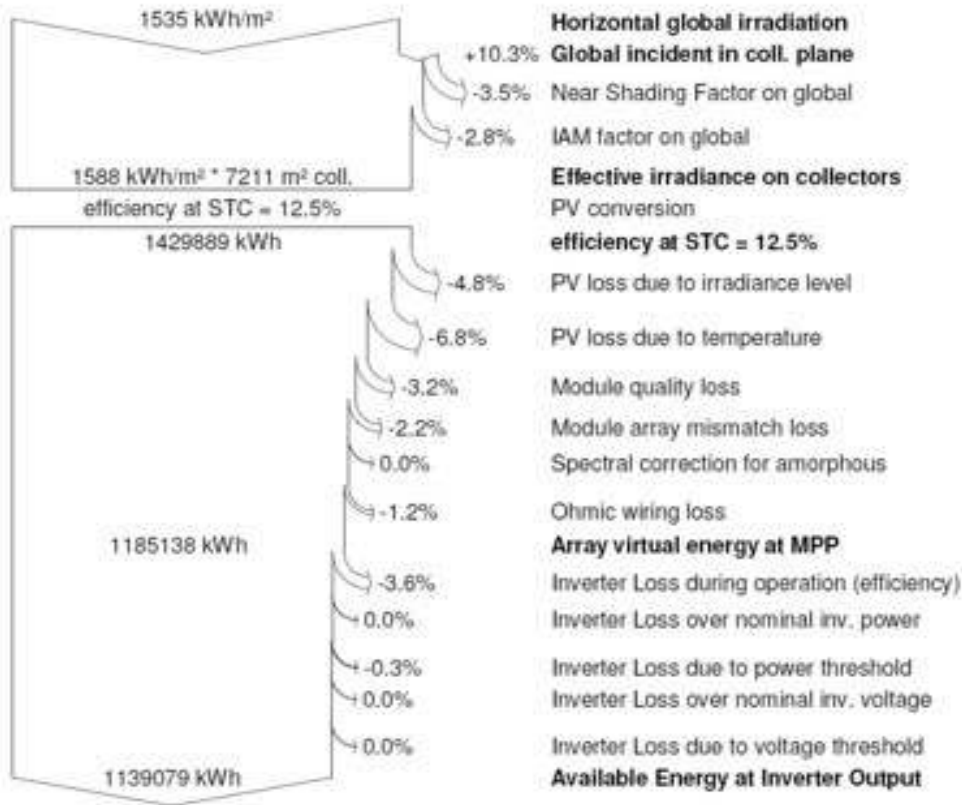
## Iso-shadings diagram

PV Apulia: DIA SPC 190 D Shading

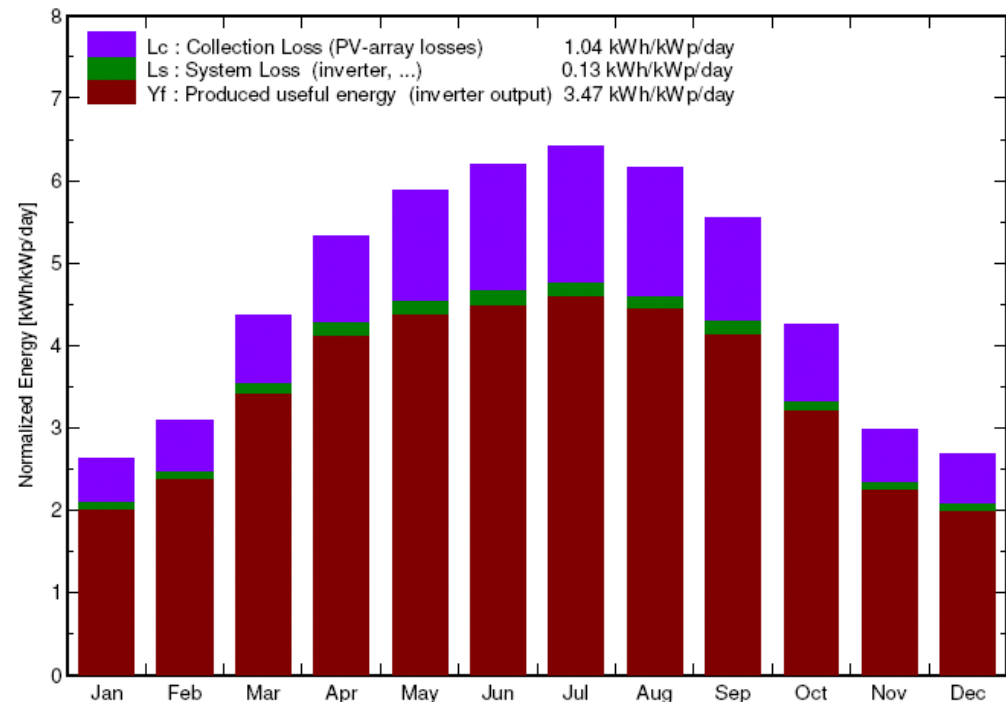
Beam shading factor (linear calculation) : Iso-shadings curves



# PV Performance Projection - Example



Normalized productions (per installed kWp): Nominal power 899 kWp



# Due Diligence Services in PV Projects

Preliminary  
DD

Yield  
Projection

Full Due  
Diligence

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Completion

Prov. & final  
Acceptance

Operation  
Phase

## Phase I: Pre-Financial Close Due Diligence - II

### 3. Full Due Diligence

- Suitability of site (site visit)
- Technical concept
  - Plant layout
  - Key components
  - Grid connection
  - Civil works / structural verification
  - Security and surveillance
- Project structure and obligations of project parties, project management
- Contracts / project agreements (EPC Contract, component supply contracts, O&M Contract)
- Adequacy of the technical warranties and verification procedures e.g.
  - Guarantees of Contracts / liquidated damages provisions
  - Performance test, availability, technical characteristics
- Project time schedule
- Permits and licenses (status, constraints, etc.)
- Technical input data for the financial model
  - CAPEX & OPEX / Capital replacement
  - Electricity yield

# Due Diligence Services in PV Projects

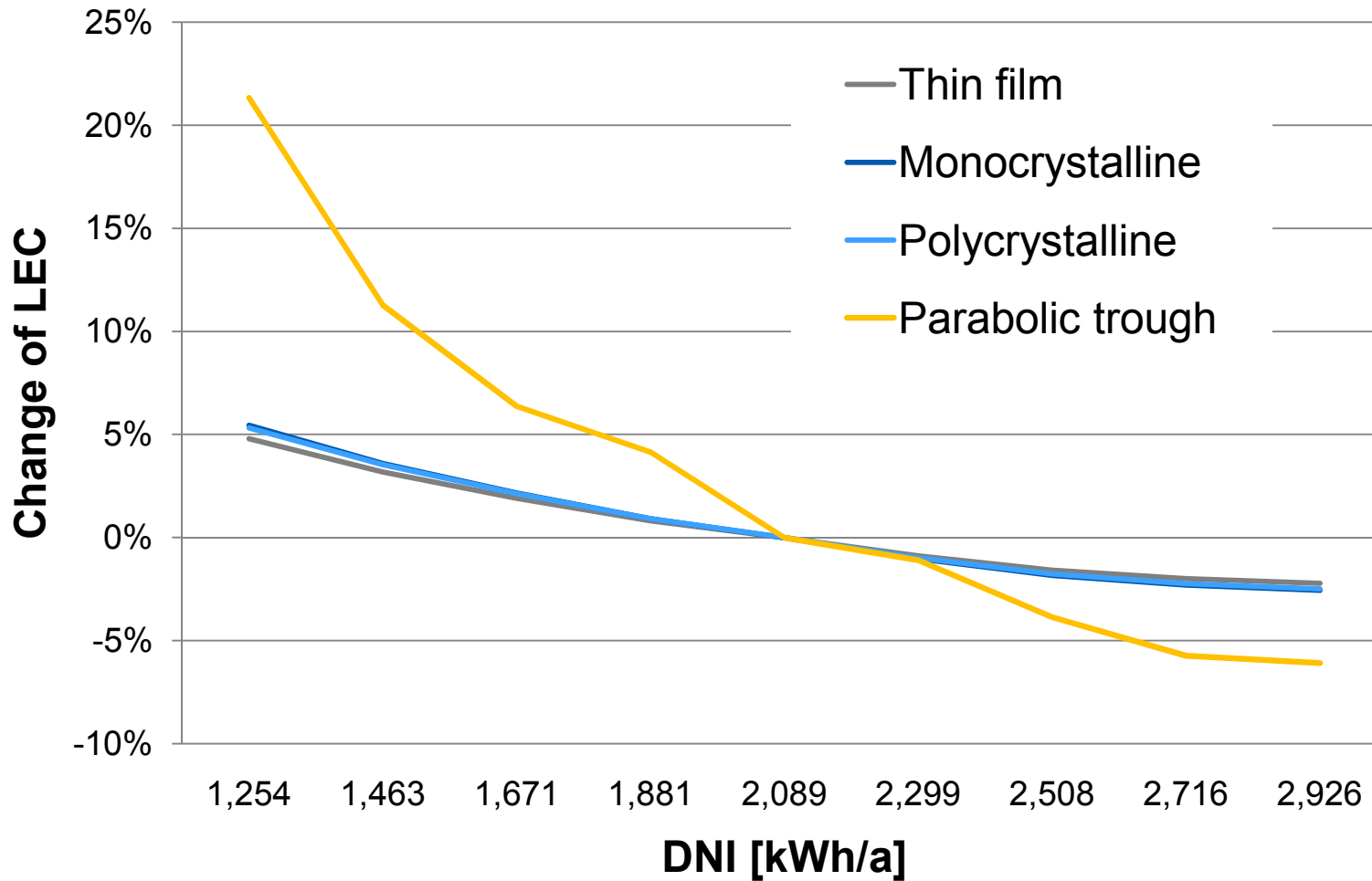
<p><b>Preliminary DD</b></p>	<p><b>Phase II: Construction Monitoring</b></p>
<p><b>Yield Projection</b></p>	<ul style="list-style-type: none"> <li>• Construction monitoring (compliance with contract / specifications)</li> <li>• Compliance with project schedule</li> <li>• Review of EPC contractor's / owner's progress report</li> <li>• Site and workshop inspections</li> <li>• Preparation of monthly or quarterly progress reports and progress certificates</li> </ul>
<p><b>Full Due Diligence</b></p>	<p><b>Phase III: Testing and completion (provisional and final acceptance)</b></p>
<p><b>Construction Monitoring</b></p>	<ul style="list-style-type: none"> <li>• Review of commissioning and of trial operation</li> <li>• Attendance and monitoring of the performance and reliability tests</li> <li>• Review of performance test results in view of liquidated damages requests</li> <li>• PV plant installation and mounting inspections</li> <li>• Certification of completion</li> </ul>
<p><b>Verification of Construction Completion</b></p>	<p><b>Phase IV: Monitoring during operation</b></p>
<p><b>Prov. &amp; final Acceptance</b></p>	<ul style="list-style-type: none"> <li>• Preparation of (semi-) annual operating status reports including             <ul style="list-style-type: none"> <li>• operating performance (availability, power performance, energy yield)</li> <li>• maintenance and extraordinary events</li> <li>• O&amp;M budget verification</li> </ul> </li> </ul>
<p><b>Operation Phase</b></p>	

# Site Assessment



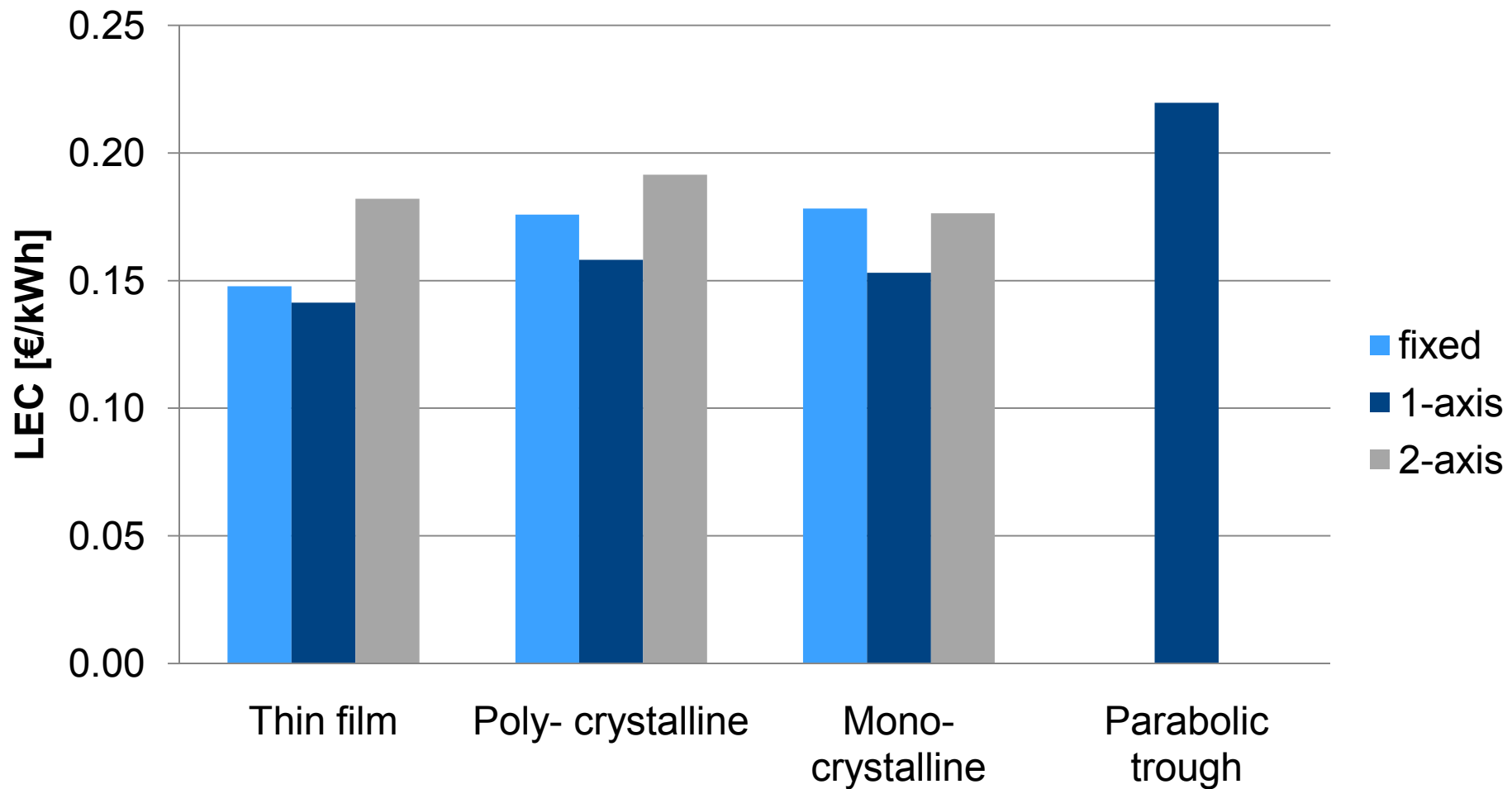
Source: Google Maps

# Sensitivity of Direct Normal Irradiation



# Assessment of Costs

Example: Johannesburg, South Africa





## Summary

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### Industry

- No „better“ technology but project specific technology selection
  - Size, topography, irradiation (global / direct), Accessibility, grid condition
  - Feed-in tariffs
  - Relevance of dispatchability / storage
- **Sound engineering and design required for each project**
- **Thorough project development and due diligence process**
  - “Bankable” EPC and O&M Contracts
    - performance and plant acceptance criteria and procedures
    - liquidated damages and incentive schemes
  - Reliable Yield Forecasts

### Framework

- Reliability of framework is key is basis for planning
- Tariffs, PPAs
- Permitting
- **Project financing conditions**

**Selected References:**

# **Photovoltaic Power Plants**



**CONSULTING & IT**



**ENERGY**



**ENVIRONMENT**



**WATER & INFRASTRUCTURE**

## Photovoltaic Power Plants (1/3)

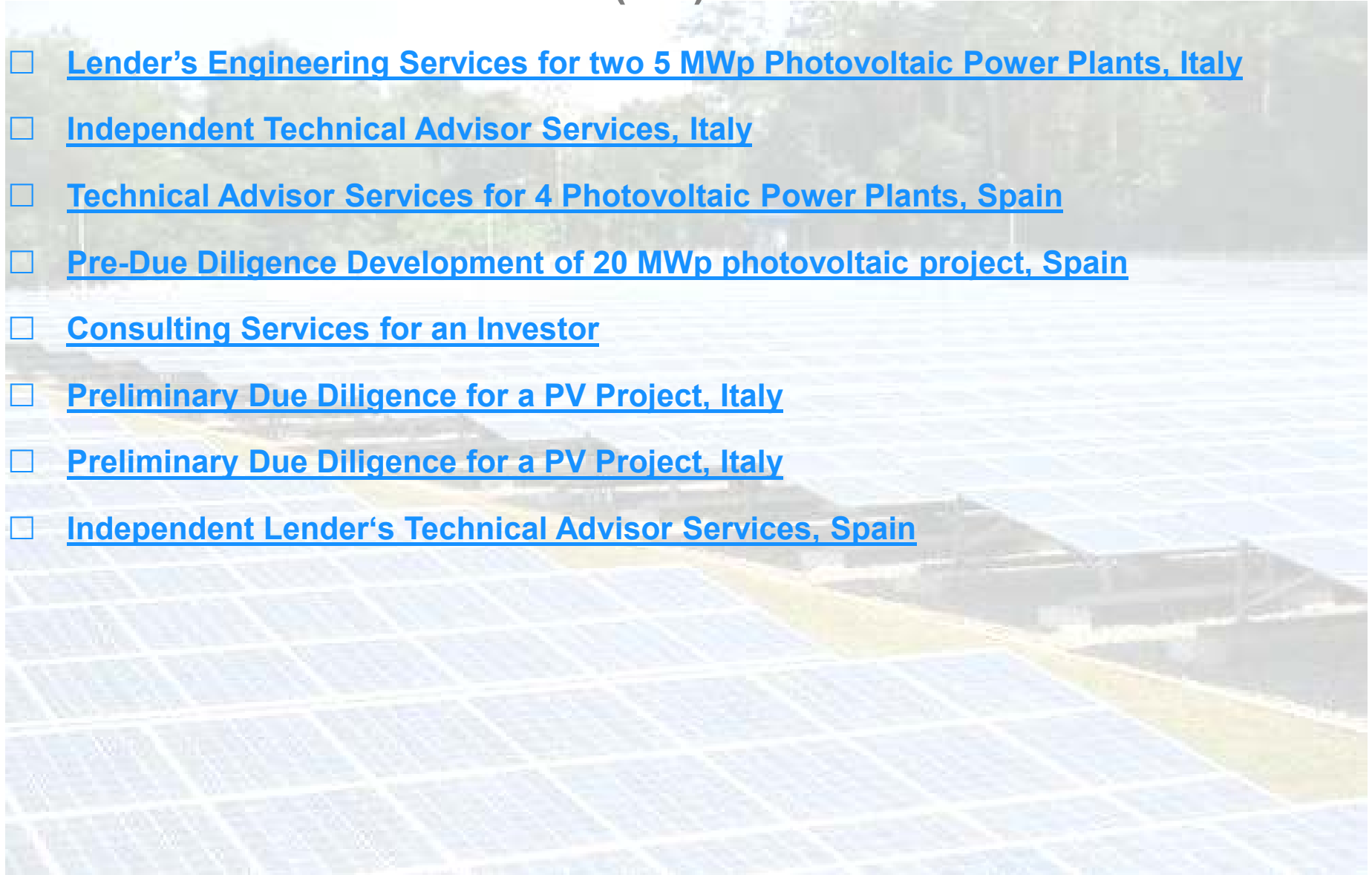
- [Expert Appraisal of PV Park Yield, Italy](#)
- [Independent Engineer for 21.8 MW PV Solar Power Plant, Srem, Bulgaria](#)
- [Independent Engineer for a 2.5 MW Solar PV Power Plant in Pchelarovo, Bulgaria](#)
- [Independent Engineer for a 3.8 MW Solar PV Power Plant in Kalipetrovo, Bulgaria](#)
- [Independent Engineer for a 3.55 MW Solar PV Power Plant in Drachevo, Bulgaria](#)
- [Technical Due Diligence for “Energy 21” Project, Czech Republic](#)
- [Technical Advisor for 5 PV Plants, Sicily, Italy](#)
- [Technical Due Diligence for a 24 MW Photovoltaic Power Plant, Italy](#)
- [Lender’s Technical Advisor Services for Montalto Solar PV Power Plant, 9 MW, Italy](#)
- [Lender’s Technical Advisor Services for Montalto Solar PV Power Plant, 53 MW, Italy](#)
- [Lender’s Technical Advisor for 4 projects in Spain](#)

## Photovoltaic Power Plants (2/3)

- [Technical Advisor for Pipeline of Photovoltaic in Apulia, Italy](#)
- [Consultancy Services for the implementation of a Solar Test Facility within the area of Qatar Science & Technology Park, Qatar](#)
- [Yield Projection for a Photovoltaic Project, Italy](#)
- [Pre-feasibility Study for Solar Photovoltaic Power in Florida, USA](#)
- [Due Diligence on behalf of Institutional Investor in the Czech Republic](#)
- [Due Diligence for a 20 MW Plant on behalf of Financing Bank, Spain](#)
- [Feasibility study for Photovoltaic Power Plants, Italy](#)
- [Technical Advisory Services for a 10 MW Photovoltaic Power Plant, Italy](#)
- [Due Diligence for a 5 MW Photovoltaic Power Project, Italy](#)
- [Pre-Feasibility Study for a Photovoltaic Power Plant, Italy](#)
- [Independent Engineering Services, Italy](#)
- [Lenders Engineering Services for a 3 MW Photovoltaic Plant, Italy](#)

## Photovoltaic Power Plants (3/3)

- [Lender's Engineering Services for two 5 MWp Photovoltaic Power Plants, Italy](#)
- [Independent Technical Advisor Services, Italy](#)
- [Technical Advisor Services for 4 Photovoltaic Power Plants, Spain](#)
- [Pre-Due Diligence Development of 20 MWp photovoltaic project, Spain](#)
- [Consulting Services for an Investor](#)
- [Preliminary Due Diligence for a PV Project, Italy](#)
- [Preliminary Due Diligence for a PV Project, Italy](#)
- [Independent Lender's Technical Advisor Services, Spain](#)

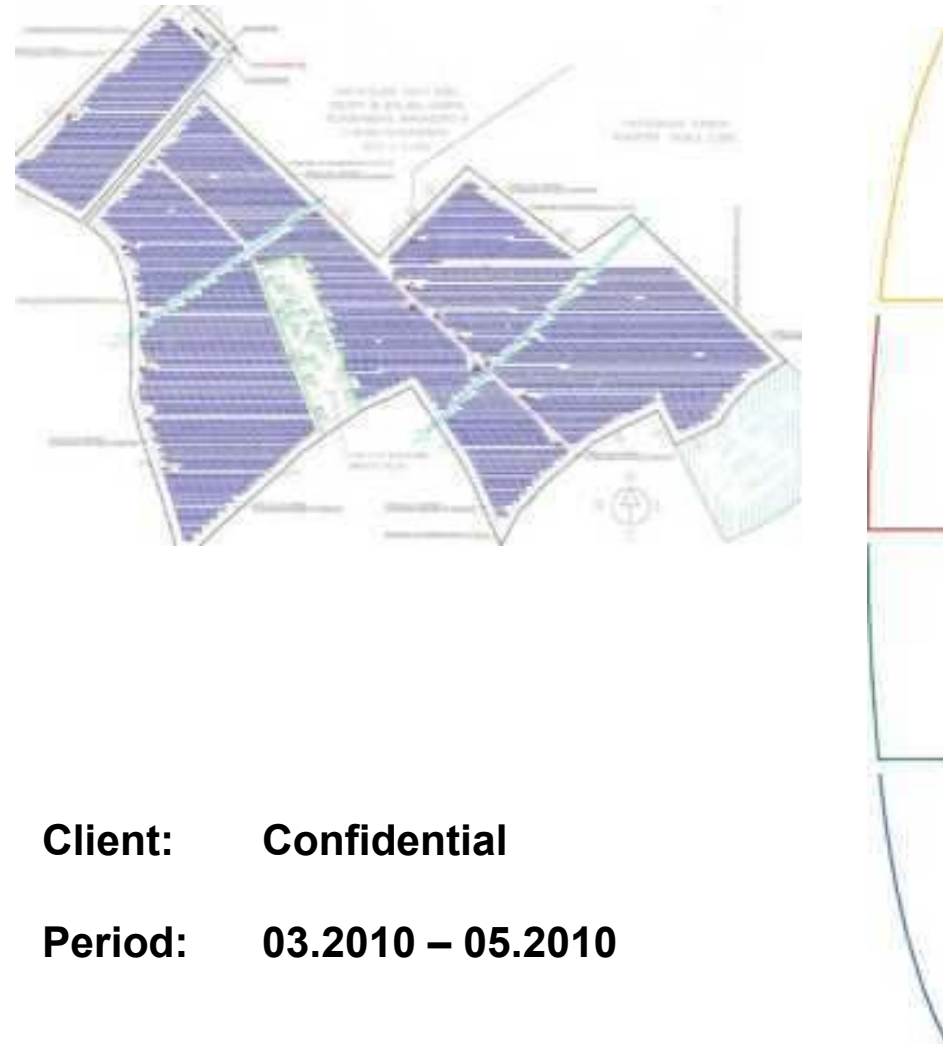


# Photovoltaic Power Plants

## Expert Appraisal of PV Park Yield, Italy

An EPC Contractor intends to build a PV Plant in Italy for which Fichtner prepares an expert appraisal of electricity yield as an input parameter to the EPC contract. In this context Fichtner:

- checked the conceptual design data
- verified the Client's assumptions for the yield simulations (meteorological data, shading)
- prepared a yield projections based on PVSYST (version 5) simulations
- including an analysis of uncertainties and the calculation of probability cases (P50, P75 P90) over different time periods.



**Client: Confidential**

**Period: 03.2010 – 05.2010**

# Photovoltaic Power Plants

## Independent Engineer for 21.8 MW PV Solar Power Plant, Srem, Bulgaria

Fichtner prepares a fully-fledged technical due diligence on behalf of the future lenders. Among others, Fichtner performed the following tasks, which are reflected in the technical due diligence report.

- A visit of the project sponsor's existing plants and monitoring center in France
- A verification of the suitability of the site and the grid connection
- Verification of the Srem plant concept and the suitability of the plant key components
- A verification of the sponsor's operation and maintenance activities
- A detailed yield projection (PVSYST v.5) simulation and comparison of the results with sponsor's own calculations, considering among others Client's on-site meteorological measurements
- The verification of the main project contracts (EPC Contract, O&M Contract, Grid Connection Agreement)
- Verification of the project time schedule



**Client:**            **Electricité de France (via Société Industrielle de l'Atlantique, Bulgaria) on behalf of IFC International Finance Corp. Washington, DC, USA  
UniCredit, Munich, Germany**

**Period:**            **03.2010 – 05.2010**

# Photovoltaic Power Plants

## Independent Engineer for a 2.5 MW Solar PV Power Plant in Pchelarovo, Bulgaria

A private developer, owner and operator of solar power plants assigned Fichtner with the independent engineering service to the project's financing bank. The related scope of work is performed in the following phases:

### 1. Irradiation yield analysis

- Estimation of irradiation and calculation of performance ratio

### 2. Project analysis

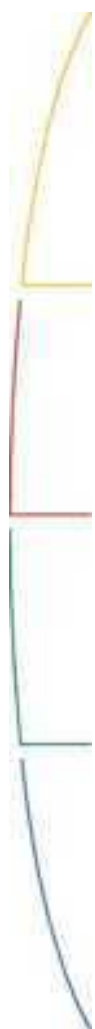
- Review of technical concept, O&M/EPC contract and of permitting situation to ascertain whether the project is "bankable"

### 3. Construction works monitoring

- Monitoring of construction works in comparison with the project schedule and of the compliance with key purchasing agreements

### 4. Operation phase monitoring

- Verification of the technical reporting (production, availability) to the lenders



**Client: Confidential**

**Period: 03.2010 – 05.2010**



# Photovoltaic Power Plants

## Independent Engineer for a 3.8 MW Solar PV Power Plant in Kalipetrovo, Bulgaria

A private developer, owner and operator of solar power plants assigned Fichtner with the independent engineering service to the project's financing bank. The related scope of work is performed in the following phases:

### 1. Irradiation yield analysis

- Estimation of irradiation and calculation of performance ratio

### 2. Project analysis

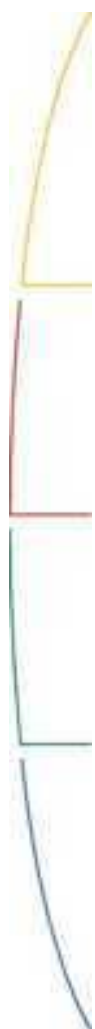
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### 4. Operation phase monitoring

- Verification of the technical reporting (production, availability) to the lenders



**Client: Confidential**

**Period: 03.2010 – 05.2010**

# Photovoltaic Power Plants

## Independent Engineer for a 3.55 MW Solar PV Power Plant in Drachevo, Bulgaria

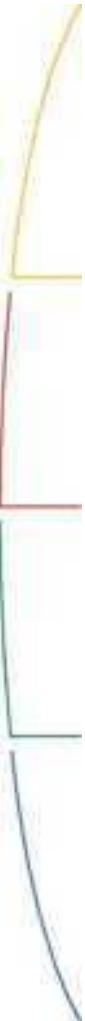
A private developer, owner and operator of solar power plants assigned Fichtner with the independent engineering service to the project's financing bank. The related scope of work is performed in the following phases:

### 1. Irradiation yield analysis

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### 2. Project analysis

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**Client: Confidential**

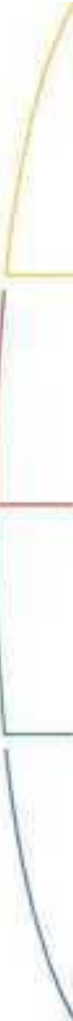
**Period: 01.2010 – 03.2010**

# Photovoltaic Power Plants

## Technical Due Diligence for “Energy 21” Project, Czech Republic

An international investor is planning to invest in the solar technology enterprise “Energy 21”. To check the chances and risks of the investment, Fichtner has been retained to conduct a technical due diligence analysis. The company possesses an inventory of 15 to 20 photovoltaic plants with a total capacity rating of around 50-60 MW. The technical review focuses on the services:

- Technical evaluation of PV module design and component selection
- Verification of planned project pipeline
- Evaluation of yield models
- Project time tables and planning
- Check of contracts: EPC, component supply and O&M
- Cost analysis
- Technical standards, environmental impact and permit procedure



**Client: Confidential**

**Period: 01.2010 – 03.2010**

# Photovoltaic Power Plants

## Technical Advisor for 5 PV Plants, Sicily, Italy

A project developer is involved firstly as equity investor and secondly as financial advisor and mandated lead arranger in a range of photovoltaic projects in Sicily of total rating around 33 MW. Fichtner undertakes a due diligence review of these as independent technical advisor. Services cover, among others, evaluation of project structure, suitability of site, energy yield assessment, technical concept evaluation, contract evaluation, adequacy of technical warranties and verification procedures, permits and licenses, project insurance, project management, and risk management with project sensitivity analysis.



**Client:** Commercial bank

**Period:** 01.2010 – 03.2011



# Photovoltaic Power Plants

Lender's Technical Advisor Services for Montalto Solar PV Power Plant, 24 MW, Italy

Following financial close and start of construction, Fichtner assists construction of the 24 MWp tranche of Montalto Solar Farm on behalf of the project developer and financing banks. Through monthly site visits and reviews of the construction site logs of the contractors, construction progress is documented. Upon ending construction, Fichtner additionally supervises the concluding functional and performance trials during commissioning, and compiles the results in a general report for the construction phase.



**Client:** SunRay Management Ltd., London, United Kingdom

**Period:** 10.2009 – 03.2010

# Photovoltaic Power Plants

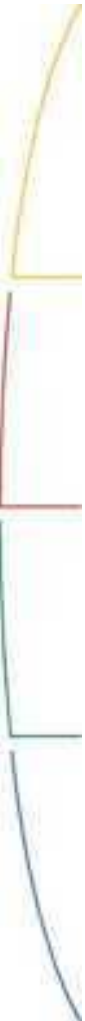
## Lender's Technical Advisor Services for Montalto Solar PV Power Plant, 9 MW, Italy

The Client is developing a 9 MW single-tracked photovoltaic solar park located at Lazio, Italy. Fichtner was appointed as Independent Lender's Technical Advisor (TA) for the services of:

- Pre-Financial Close
- Technical and environmental due diligence investigation
- Revision of technical aspects of the construction, operations and maintenance of the project including
  - Solar power production simulation
  - Review of the construction schedule and identification of possible constraints
  - Review of and comments on project budget
  - Review and provision of sensitivity analysis



**Client:** Confidential  
**Period:** 10.2009 – 07.2010

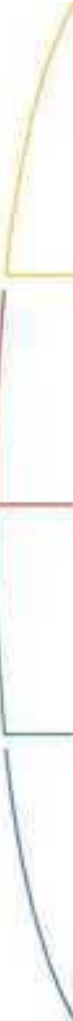
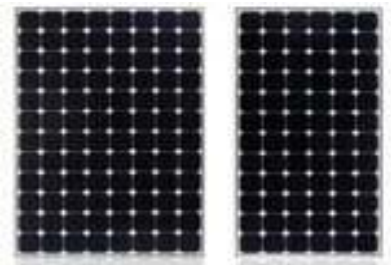


# Photovoltaic Power Plants

## Lender's Technical Advisor Services for Montalto Solar PV Power Plant, 53 MW, Italy

The Client is developing a 53 MW single-tracked photovoltaic solar park located at Lazio, Italy. Fichtner was appointed as Independent Lender's Technical Advisor (TA) for the services of:

- Pre-Financial Close
- Technical and environmental due diligence investigation
- Revision of technical aspects of the construction, operations and maintenance of the project including
  - Solar power production simulation
  - Review of the construction schedule and identification of possible constraints
  - Review of and comments on project budget
  - Review and provision of sensitivity analysis



**Client:** Confidential

**Period:** 10.2009 – 05.2010

# Photovoltaic Power Plants

## Lender's Technical Advisor for 4 projects in Spain

On behalf of the financing bank, Fichtner has been involved in the pre-financial close as well as construction phase of four photovoltaic solar power plants on Mallorca/Spain, with fix installed PV power plant with a total installed capacity of 8.3 MW.

- Pre-financial close services
  - Technical and environmental due diligence
  - Review of technical opportunities and risks
  - Investigation and description of planned operating regime and costs
- Construction monitoring on behalf of financing bank
- Verification of operational data in first years of commercial operation



**Client:** Commercial bank

**Period:** 2008 – ongoing



# Photovoltaic Power Plants

## Technical Advisor for Pipeline of Photovoltaic in Apulia, Italy

The Client is interested in the development and investment of a portfolio of PV projects with two different Project Developers at Puglia, Italy with a maximum installed capacity of around 7 MW. Fichtner was appointed as Owner's Technical Advisor (TA) for the services of:

- Technical and environmental due diligence investigation
- Site assessment for suitability for the PV plants and identification of any constraints
- Revision of technical aspects of the construction, operations and maintenance of the project including
- Solar Production Due Diligence review
- Revision of input and assumptions of the financial model
- Assist the Client in technical matters



**Client:** Confidential

**Period:** 10.2009 – 11.2009

# Photovoltaic Power Plants

Consultancy Services for the implementation of a Solar Test Facility within the area of Qatar Science & Technology Park, Qatar

Qatar Science & Technology Park (QSTP), located in Qatar Foundation's Education City. Alongside campuses of several leading universities it is planned to build within the area of the QSTP a demonstration and test facility for solar technology in Qatar. The area will have approx. 4 hectares. Green Gulf as the representative of this project engages Fichtner as the technical advisor of this project covering:

- Performance of shading analysis for several different sites within QSTP and elaboration of site assessment report
- Detail comparison of different solar technologies in photovoltaics, low temperature solar thermal sector
- Elaboration of the test facility master plan including conceptual layout, infrastructure planning, definition of media and energy supply requirements
- Development of project implementation plan



**Client: Green Gulf, Qatar**

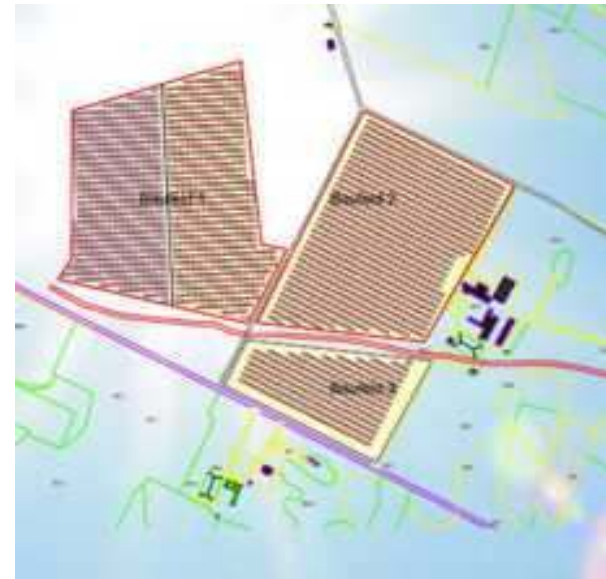
**Period: 09.2009 – 05.2010**

# Photovoltaic Power Plants

## Yield Projection for a Photovoltaic Project, Italy

In Apulia, DEE is developing the Torre Santa Susanna Photovoltaic Project. Based on the conceptual design Fichtner

- checked the conceptual design data
- verified the Client's assumptions for the yield simulations (predominantly meteorological data)
- prepared a yield projection based on PVSYST (version 5) simulations
- including an analysis of uncertainties and the calculation of probability cases (P50, P75, P90) over different time periods



**Client:** DEE Deutsche Erneuerbare Energien GmbH, Düsseldorf, Germany

**Period:** 09.2009 – 10.2009

# Photovoltaic Power Plants

## Pre-feasibility Study for Solar Photovoltaic Power in Florida, USA

Fichtner provided assistance in selecting the technology for generating electricity from solar energy. In this connection, various candidate locations in the State of Florida, USA, are investigated and a pre-feasibility study is prepared, which covers among others:

- Verification of site suitability
- Technological and commercial evaluation of different plant concepts, such as:
  - poly-, mono-crystalline, thin film modules
  - tracked systems vs. fix installation
- Preparation of cash-flow model and calculation of key financial parameters



**Client: Confidential**

**Period: 08.2009 – 11.2009**

# Photovoltaic Power Plants

## Due Diligence on behalf of Institutional Investor in the Czech Republic

Fichtner has been appointed to perform technical due diligence services on several existing PV power plants (350 kW – 1 MW, fix module installation) and to assess future projects of a leading Czech project developer on behalf of a potential institutional investor. The services include:

- Assessment of plant concepts
- Site visits and assessment of plant realization
- Verification of yield projections and performance of PVSYS simulations
- Elaboration of recommendations for improvements for future plants
- Verification of insurance policies



**Client:** Confidential

**Period:** since 03.2009

# Photovoltaic Power Plants

## Due Diligence for a 20 MW Plant on behalf of Financing Bank, Spain

Fichtner has been appointed to conduct technical due diligence investigations for a 20 MW photovoltaic power plant (dual-axis tracking) project in Spain.

The following services are carried out:

- Assessment of plant concept
- Verification of permitting situation
- Verification of yield projections
- Site visit and verification of plant realization
- Assessment of mover structure
- Verification of O&M concept and costs
- Verification of insurance risk coverage
- Verification of security and surveillance concept



**Client:** Confidential

**Period:** since 02.2009

# Photovoltaic Power Plants

## Feasibility study for Photovoltaic Power Plants, Italy

Fichtner was appointed to conduct initial technical and financial due diligence investigations as well as a prefeasibility study for PV-projects in Southern Italy.

The provided services included:

- Assessment of potential project sites regarding technical suitability for a PV power plant
- Comparison of PV technologies and sensitivity study of the electricity production costs
- Preparation of a summary of administrative framework and required formal steps for receiving the construction and operation permits and licenses in Italy
- Preparation of a flexible financial model



**Client:** Confidential

**Period:** 06.2008 – 09.2008

## Photovoltaic Power Plant

### Technical Advisory Services for a 10 MW Photovoltaic Power Plant, Italy

The Customer, a private investor, is in process to acquire the property of two sets of PV Plants each composed of 1 MWp units. The current developer will be appointed as EPC contractor as well as O&M contractor to build and operate the plants. The Customer, in agreement with the MLA, appointed Fichtner as Technical Advisor for all project phases:

- Pre-financial closing
- Construction
- Operation



**Client:** Confidential

**Period:** since 04.2008



## Photovoltaic Power Plant

### Due Diligence for a 5 MW Photovoltaic Power Project, Italy

The client, an Investment Fund, is willing to acquire PV Projects in the southern part of Italy. The Projects are realized by the Developer who will remain involved in the Project as EPC Contractor.

Fichtner has been appointed to perform a full Due Diligence of the Project to assess the technical, contractual and authorizing aspects prior to the completion of the transaction.



**Client:** Confidential

**Period:** since 04.2008

# Photovoltaic Power Plant

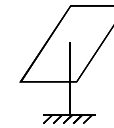
## Pre-Feasibility Study for a Photovoltaic Power Plant, Italy

The Customer owns two pieces of land located in an industrial area for a total available surface of 100 hectares.

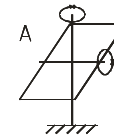
Fichtner has been appointed to perform a pre-feasibility study for a PV project focusing on the plant concept, the pre-selection of the most suitable technologies and configurations, the plant layout, the production estimate, the authorization processes and the preliminary business model.

### Tracking modes

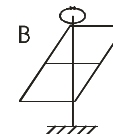
Fixed orientation



Biaxial tracking



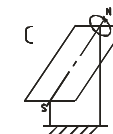
Single axis tracking



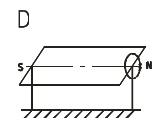
- vertical -



Photon 7/2004



- tilted -



- horizontal -

**Client:** Confidential

**Period:** since 04.2008

# Photovoltaic Power Plant

Independent Engineering Services, Italy

The client intends to act as major equity investor for photovoltaic projects in Italy and in other European Countries and is in the process of defining the term sheets for EPC and O&M framework agreements with international suppliers.

Fichtner has been appointed with the following services:

- Provision of technical and contractual support in the finalization of a framework agreement



**Client:** Confidential

**Period:** since 01.2008

## Photovoltaic Power Plant

### Lenders Engineering Services for a 3 MW Photovoltaic Plant, Italy

The client, the Italian subsidiary of an international bank, is going to finance on a non recourse basis a PV plant currently being developed by a private investor. Fichtner was awarded with the following services:

- pre-financial closing technical advisor services
- technical and contractual due diligence including an independent production estimate
- monitoring of the construction and the first two years of operation



**Client:** Confidential

**Period:** since 01.2008

## Photovoltaic Plant

### Lender's Engineering Services for two 5 MWp Photovoltaic Power Plants, Italy

The Client, the Italian subsidiary of an International Bank, is going to finance on a non recourse basis a PV plant currently being developed by a private investor.

Fichtner was awarded to perform the following technical advisory services:

- pre-financial close support
- technical and contractual Due Diligence, including an independent production forecast
- monitoring of the construction as well as of the first year of operation.



**Client:** Confidential

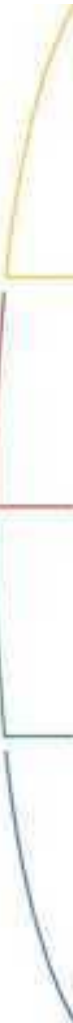
**Period:** since 01.2008

# Photovoltaic Power Plant

Independent Technical Advisor  
Services, Italy

## Assessment of the PV modules supplier and EPC contractor

An international bank is expected to act as major equity investor in two photovoltaic project portfolios (respective total output 40 and 20 MWp) currently under development in Southern Italy. In view of the full technical and environmental due diligence of the 40 MWp project to be undertaken at a later stage, Fichtner was awarded to independently assess the bankability of the proposed PV technology, panel suppliers and EPC contractor.



**Client:** Confidential

**Period:** 12.2007

# Photovoltaic Power Plant

## Technical Advisor Services for 4 Photovoltaic Power Plants, Spain

Deutsche Bank AG is planning the erection of four photovoltaic power plants at four different sites in Spain. Fichtner's pre-financial close Lender's Engineering services for the financing bank include:

- technical and environmental due diligence
- review of the technical concept and risks
- review of the plant project costs with a special focus on O&M costs



**Client:** Deutsche Bank AG,  
Frankfurt, Germany

**Period:** 08.2007 – 11.2007

# Photovoltaic Power Plant

## Pre-Due Diligence Development of 20 MWp photovoltaic project, Spain

An international bank is interested in purchasing a 20 MWp photovoltaic project in Spain. To ensure an appropriate degree of security for this purchase, an analysis with calculation of figures is necessary with respect to:

- check of location in view of the plant's technical requirements
- check of technical concept for feasibility, compliance with state of the art and reasonableness of requirements
- check of grid infeed conditions
- evaluation of project risks under the aspects of location, technical concept and procurement, as well as the significance of the recent royal decree 661/2007



**Client:** Confidential

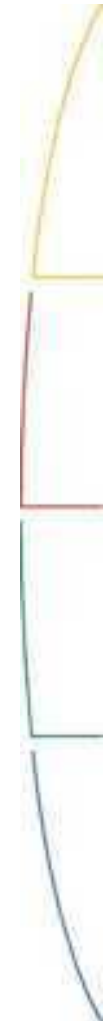
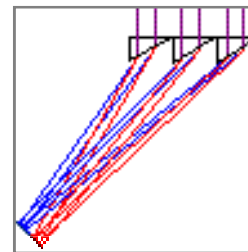
**Period:** 08.2007 – 09.2007



# Photovoltaic Power Plant

## Consulting Services for an Investor

Fichtner consults an Investor with regard to the readiness for the marketing of concentrator photovoltaic technology.



**Client: Confidential**

**Period: 07.2007**

# Photovoltaic Power Plant

## Preliminary Due Diligence for a PV Project, Italy

A major Italian group operating in the energy sector is considering the acquisition of shareholding interests in a photovoltaic project being developed in a EU country. In order to assess the feasibility of the acquisition, the client has appointed Fichtner to perform a preliminary analysis of the project, including in particular the assessment of the site layout and of its expected production, of the different technology options, of CAPEX and OPEX estimates and of the potential risks.



**Client:** Confidential

**Period:** 01.2007 – 02.2007

# Photovoltaic Power Plant

## Preliminary Due Diligence for a PV Project, Italy

The project developer, Aliwin Plus S.L., based in Madrid/Spain, plans to erect a solar photovoltaic power plant in Extremadura Province, South-Western Spain. The plant will have an electrical generation capacity of 20 MW. The Lender's Engineering services for the financing Deutsche Bank AG, London, include the following for the Pre-Financial Close phase:

- technical and environmental due diligence
- solar power simulation review
- review of technical conditions and risks, including time scheduling
- check of and comment on project budget



**Client:** Aliwin Plus S.L., Spain  
on behalf of  
Deutsche Bank AG,  
London, Great Britain

**Period:** 01.2007 – 10.2007

# Photovoltaic Solar Energy

## Independent Lender's Technical Advisor Services, Spain

Erection of two Photovoltaic Power Plants on two sites in Albacete-Province in South Eastern Spain, of 15 MW and 5 MW. The lender's engineering services include the following:

### Phase I

- technical and environmental due diligence
- solar power output simulation review
- review of technical conditions and risks, including time scheduling
- check of and comments on project budget

### Phase II

- tracking and monitoring construction activities
- tracking plant commissioning
- reports on status of construction
- certification of draw downs



**Client:** Abastecimientos Energeticos SL Madrid, Spain  
on behalf of Deutsche Bank AG, London, United Kingdom

**Period:** 05.2006 – 12.2008



# Standby Slides



CONSULTING & IT



ENERGY



ENVIRONMENT



WATER & INFRASTRUCTURE

## Design Review

### 30 MW<sub>e</sub> Fresnel Solar Power Plant, Puerto Errado II, Spain

The plant will have an installed capacity of 30 MW<sub>e</sub>. A turnkey contractor has been appointed for detail engineering, procurement, construction and commissioning of the power plant. A design review is conducted for all parts of the plant in order to ensure a reliable and easily maintainable design.

Fichtner supports EBL during the design review in the following areas:

- Solar steam generation
- Water-steam cycle including steam turbine and generator
- Electrical equipment
- Instrumentation and control
- Grid connection
- Civil works.



**Client:** EBL, Liestal, Switzerland  
**Period:** 05.2010 - 12.2010  
**Project Data:** 30 MW<sub>e</sub> Fresnel trough power plant

## Feasibility Study

### Jaisalmer 50 MW<sub>e</sub> Solar Power Plant, India

In close collaboration with Fichtner India Pvt Ltd, Fichtner Germany supported the elaboration of a Feasibility study for a 50 MW<sub>e</sub> parabolic trough power plant to be located in Jaisalmer, India.

Fichtner's support included:

- Solar resource assessment
- Preliminary solar field and HTF system design, including layout
- Preliminary plant performance analysis (annual electricity production)
- Costs estimated of solar field together with the heat transfer fluid system
- Recommendations for follow-up actions



**Client:** Fichtner Consulting Engineers  
India Private Limited, India

**Period:** 04.2010 – 06.2010

**Project Data:** 50 MW<sub>e</sub> parabolic trough

# Conceptual Design, Tendering and Bid Evaluation

## 140 MW<sub>e</sub> ISCC Power Plant, Mathania, India

The project is to be implemented by an EPC Contractor who has to operate the plant for an initial five year period. The Fichtner services include:

- Prepare the conceptual design
- Validation of CO<sub>2</sub> abatement
- Request for pre-qualification
- Request for proposal
- Evaluation of EPC cum O&M bids



**Client:** KfW, Frankfurt, Germany  
**Period:** 11.1997 – 05.1998  
**Project data:** 220,000 m<sup>2</sup> parabolic collectors field  
140 MW<sub>e</sub>



# Feasibility Study

## Solar Thermal Parabolic Through Power Plant, Mathania, India

Fichtner prepared a feasibility study for the first large scale solar power plant to be erected in in the 140 MW<sub>e</sub> range:

- Assessment of local constraints and conditions
- Comparison of power plant concepts
- Optimization of solar plant and Integrated Solar Combined Cycle (ISCC)
- Drawing up heat balances
- Estimate of capital costs
- Analysis of operating economics



**Client:** Rajasthan Energy Development Agency, India

**Period:** 09.1995 – 03.1996

**Project data:** 140 MW<sub>e</sub> ISCC  
220,000 m<sup>2</sup> solar collector area

# Feasibility Study

## Solar Thermal Power Plant (SOLIN-1), India

Fichtner prepared a feasibility study for the first large scale solar power plant to be erected in India in the 30 - 80 MW<sub>e</sub> range.

This study covered

- Investigation of the Indian power scenario
- Evaluation of various potential sites
- Selection of the most suited solar energy technology
- Optimization of plant parameters
- Performance evaluation
- Investigation of potential suppliers
- Cost estimate
- Determination of ecological benefits
- Determination of organizational concepts
- Devising a strategy to introduce solar energy on a large scale into the Indian power scenario



**Client:** Ministry of Energy New Dehli, India

**Period:** 08.1989 – 11.1990

**Project Data:** 30 – 80 MW<sub>e</sub>

**Selected References:**

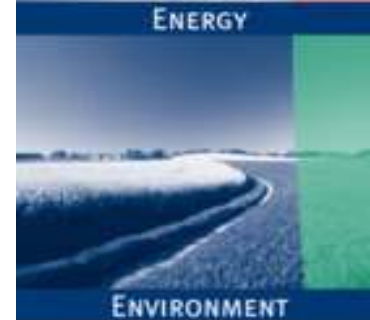
# **Solar Thermal Power Plants (India)**



**CONSULTING & IT**



**ENERGY**

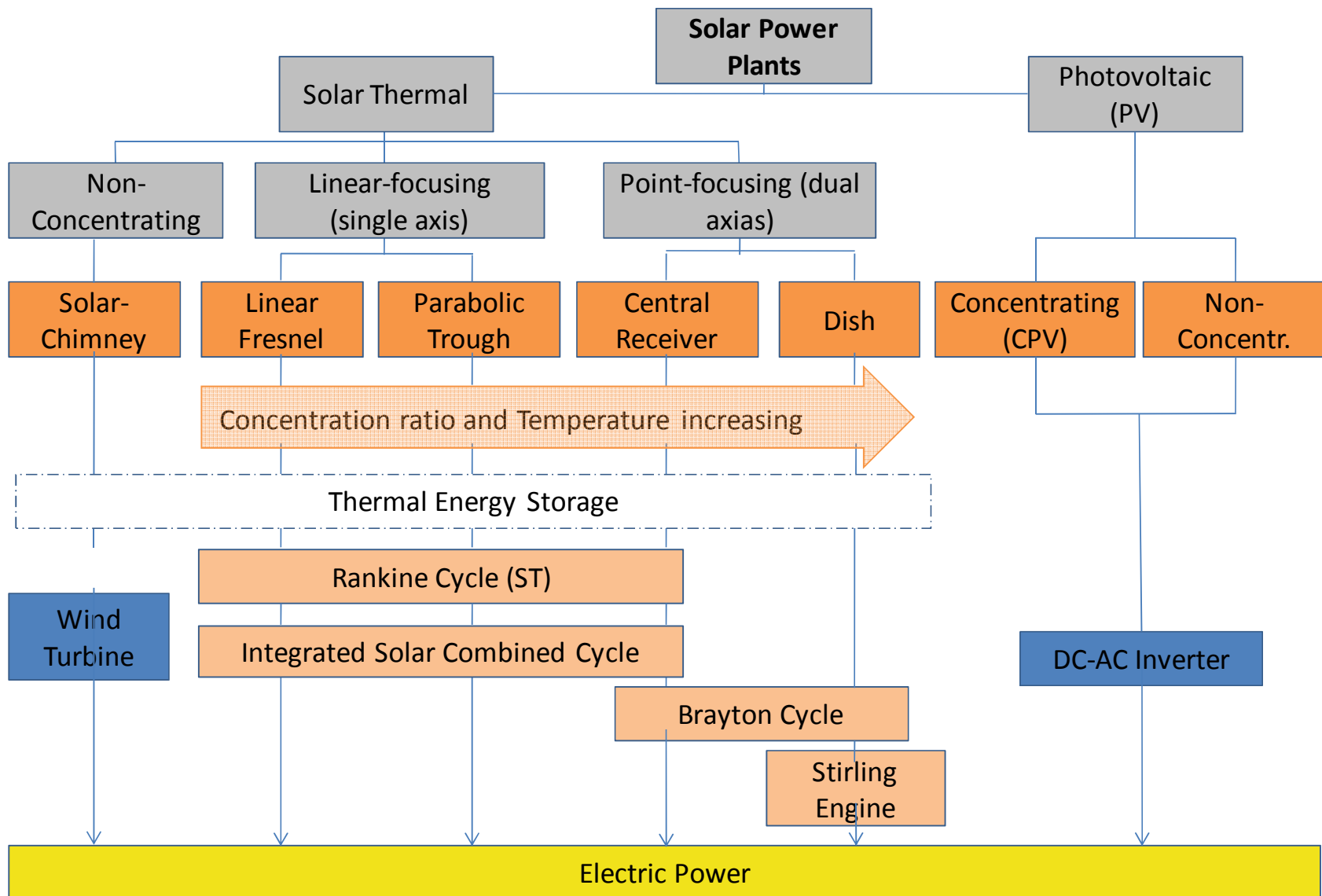


**ENVIRONMENT**

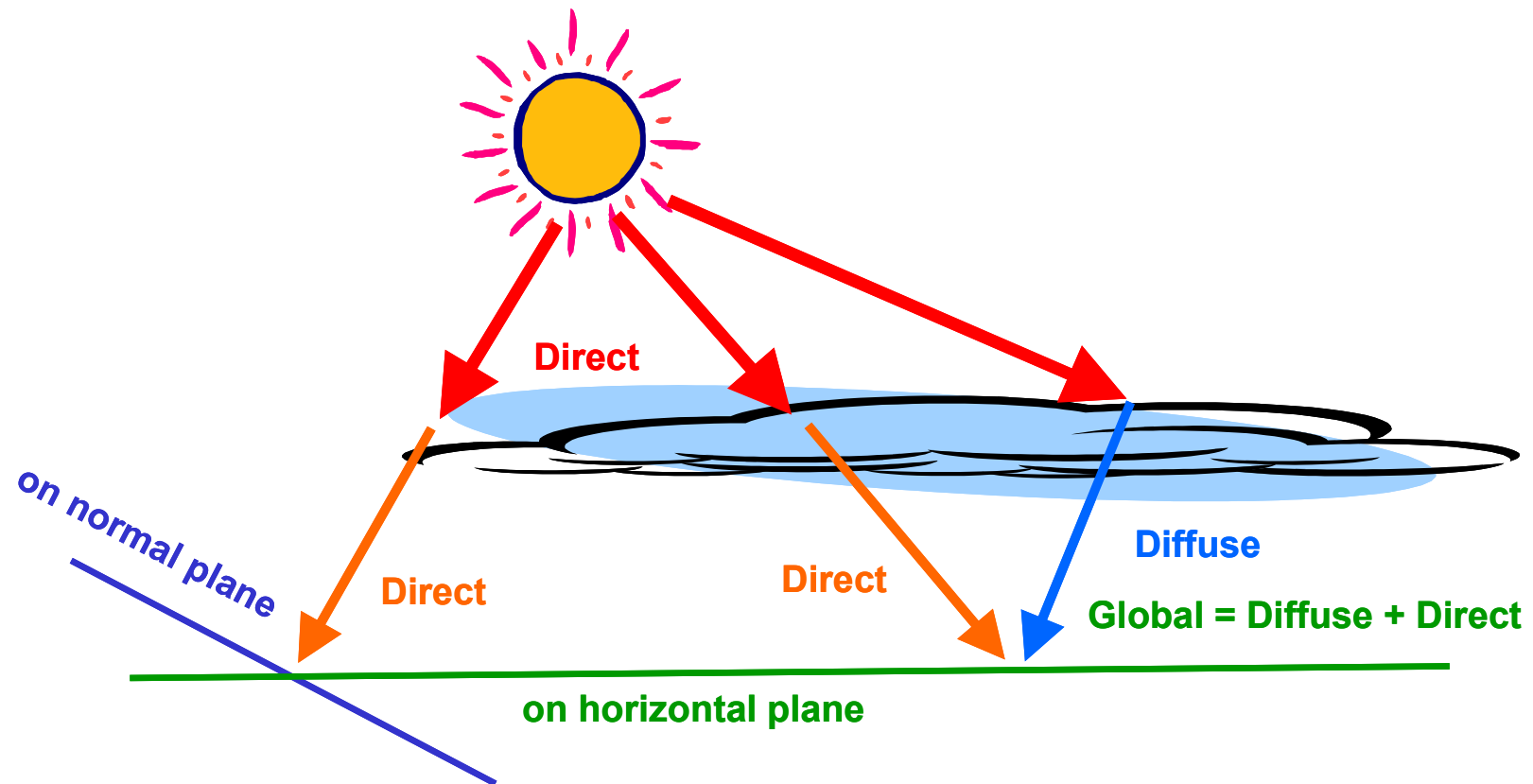


**WATER & INFRASTRUCTURE**

# Solar Technologies - Overview

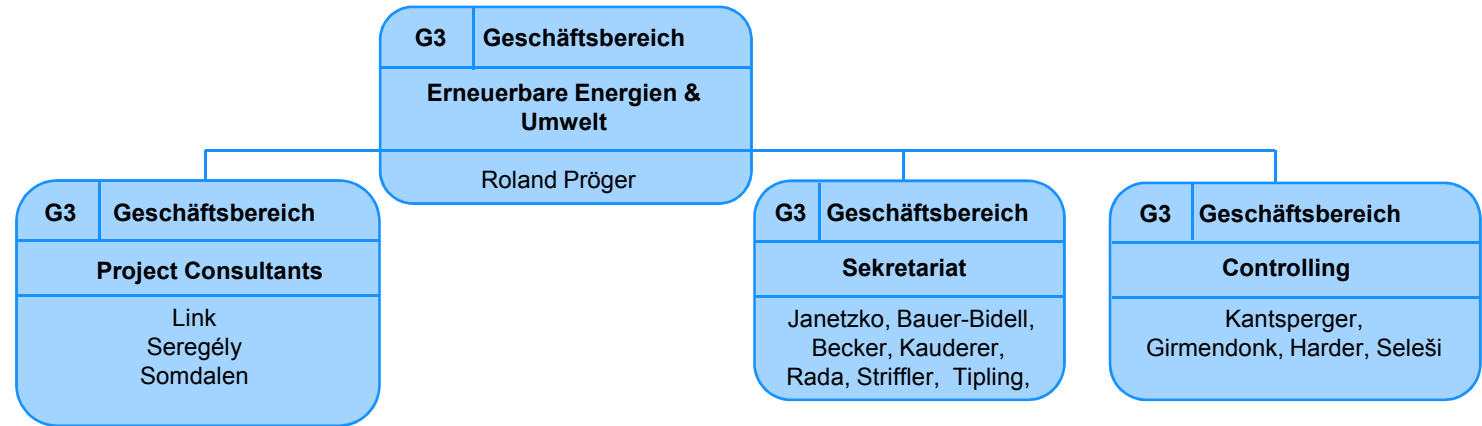


## Solar Irradiation



**Different technologies use different type of irradiation.**

# Organisation Geschäftsbereich G3



**G31 Projektbereich**

**Energiewirtschaft**  
Heinrich P.  
(Dr. Stuible)

Bohlmann  
Fey  
Finker  
Gomez Mejia  
Jahraus  
Kohberg  
Plasa  
Rehrl  
Schlegel  
Schüller  
Ulrichs  
Wülbeck

**G32 Projektbereich**

**Umwelt- und Klimaschutz**  
Turek

Basteck  
Benz  
Eckert  
Fricke  
Dr. Langniß  
Öllbrunner  
Preuß  
Stumpp  
Ullrich  
Wössner

**G33 Projektbereich**

**Wasserkraft**

Studien	Planung und Ausführung Bauteil	Planung und Ausführung Elektromechanik
<b>Dr. Palt</b> (Dr. Schäfer)	<b>Siemer</b> (Dr. Trifkovic)	<b>Hegetschweiler</b> (von Bueren)
Dr. Ayros Dr. Gurmessa Haug Heider Dr. Hildebrand Dr. Kammerer Dr. Peissner Pfizenmaier Dr. Rosier Shresta Thapa Thévenaz Vuckovic	Bölling Brüggemann Croissant Fahrenbach Dr. Hönisch Osan Schütz Stangl Tedla Fr. Vuckovic	Brunner U. Gantenbein Guimond Mancal Yungi
	<b>Büro Lima</b> Borel Heimel	

**G34 Projektbereich**

**Ökonomie**  
Linder  
(Dr. Hönig)

Ökonomie	Project Assessment
<b>Linder</b> Becker Dr. Belova Clausen Dr. Horn Horstmann Dr. Hönig Johnson Dr. Korn Mahler Dr. Pintz Rischawy Dr. Unger	Dr. Butler
	<b>Abfallwirtschaft</b> <b>Bickel</b> Mettler Österle Dr. Obid Vancini Fuchs

**G35 Projektbereich**

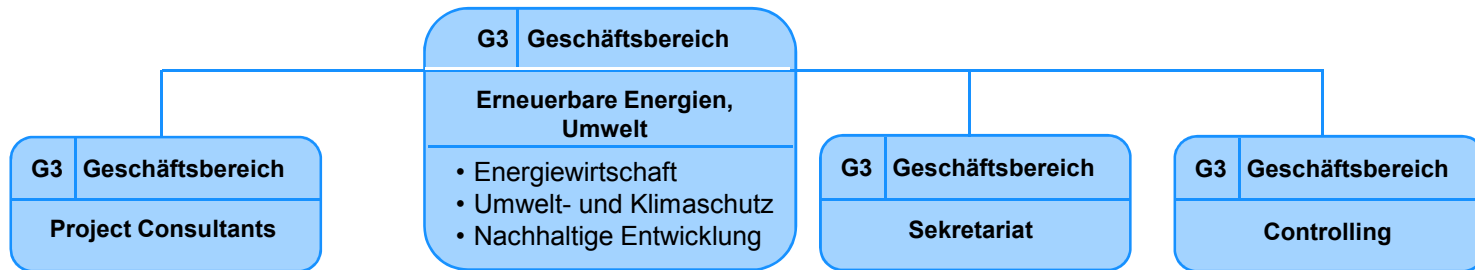
**Photovoltaik / Solar Technologies**  
Dr. Stickel

Baumgartner  
Capdevila  
Becerra Cruz  
Gudat  
John  
Kuhn  
Lecoufle  
Lemaitre  
Meyer, T.

Fichtner MEI Oil & Gas GmbH

Fichtner Carbon Management GmbH

# Organisation Geschäftsbereich G3



**G31 Projektbereich**

**Energiewirtschaft**

- Energiesysteme
- Energiemärkte
- Förderung, Regulierung
- Integrierte Infrastrukturkonzept
- Biomasse
- Geothermie
- Photovoltaik
- Solarthermie
- Windkraft

**G32 Projektbereich**

**Umwelt- und Klimaschutz**

- Genehmigungsmanagement
- Umweltmanagement
- Umweltverträglichkeitsstudien
- Emissionshandel, CDM, JI
- CO<sub>2</sub>-Speicherung
- Standorte, Trassen
- Immissionsberechnungen
- Raumplanung
- Geoinformatik

**G33 Projektbereich**

**Wasserkraft**

- Studien
- Laufwasserkraftwerke
- Speicherkraftwerke
- Pumpspeicherkraftwerke
- Hochdruckanlagen
- Rehabilitation, Modernisierung
- Dämme, Talsperren

**G34 Projektbereich**

**Ökonomie**

- Ökonomie
- Tarife, Preismodelle
- Restrukturierung/ Unbundling
- Institutional Strengthening
- Financial Modelling
- Privatisierung, PPP
- Abfallwirtschaft
- Kommunalwirtschaft
- Projektsteuerung
- Risk Management
- Projekt- und Unternehmensbewertung, Due Diligence
- M&A

**G35 Projektbereich**

**Photovoltaik / Solar Technologies**

- Photovoltaik-Anlagen
- PV-Zellen und PV-Modul Technologien (kristallin, Dünnschicht)
- Freiflächen- / Aufdach- / Gebäudeintegrierte Anlagen
- Niedertemperatur Solarthermie (Solares Heizen und Kühlen)
- Due Diligence
- Anlagenspezifikation / -ausschreibung
- Anlagenplanung
- Ertragsprognosen
- Anlagenabnahme (inkl. Kennlinienmessung / Verifizierung Anlagenperformance)
- Projektmanagement
- Studien

Fichtner MEI Oil & Gas GmbH

Fichtner Carbon Management GmbH

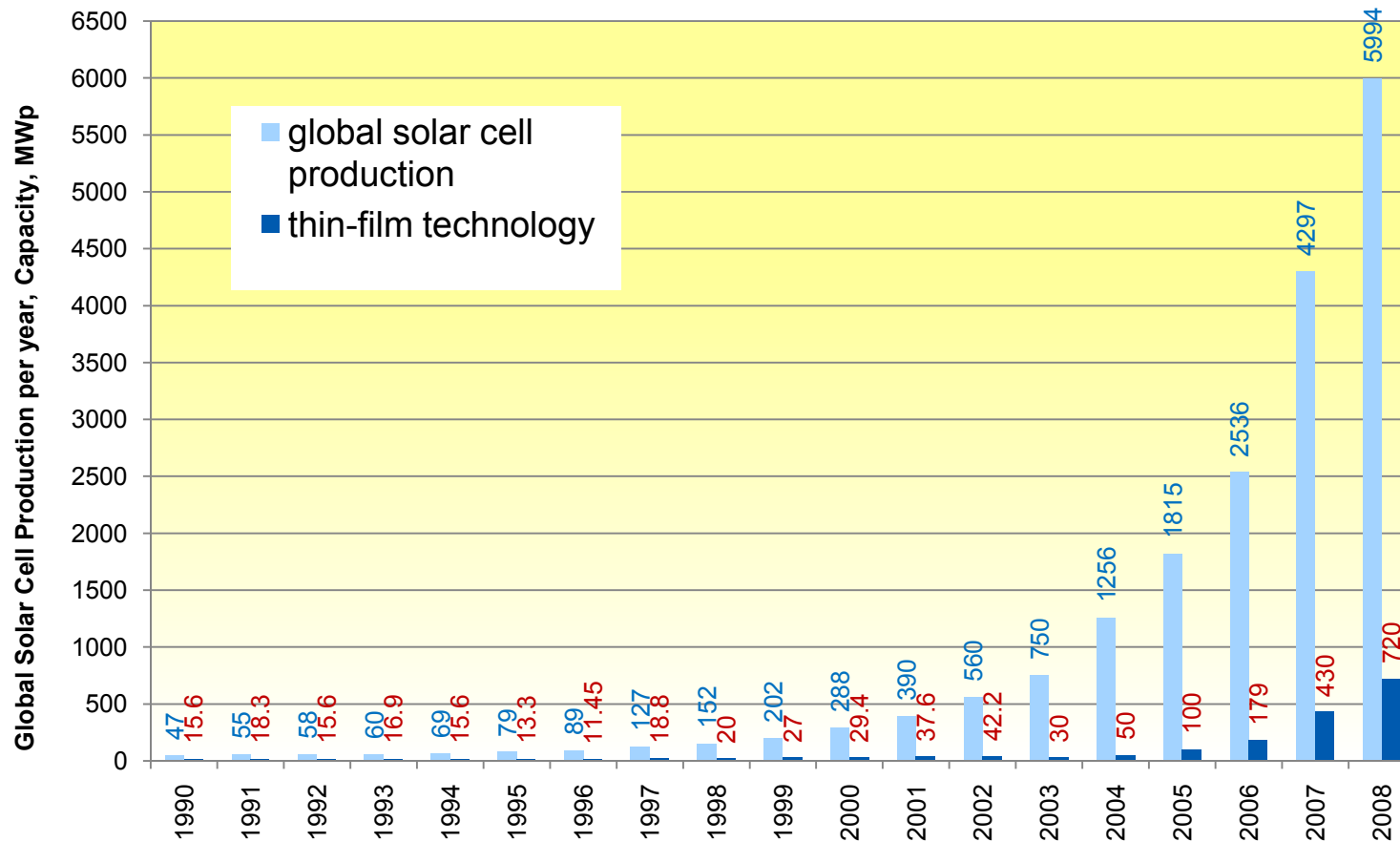
## Photovoltaic Power - Module Types

- **Mono-crystalline silicon:** Most efficient technology (efficiencies of around 18% (commercial) to 28% (research))
- **Multi-crystalline silicon:** Cheaper than mono-crystalline silicon but also less efficient. Research cells approach 24% efficiency, and commercial modules approach around 16% efficiency.
- **Thin film:**
  - Cheaper than crystalline silicon but less efficient.
  - Various materials (amorphous silicon, Cadmium Telluride, Copper Indium Diselluride (CIS))

Selection of the technology depending on: site, irradiation, temperature, costs vs. efficiency etc.



# PV: Crystalline vs. Thin-film Production Capacity

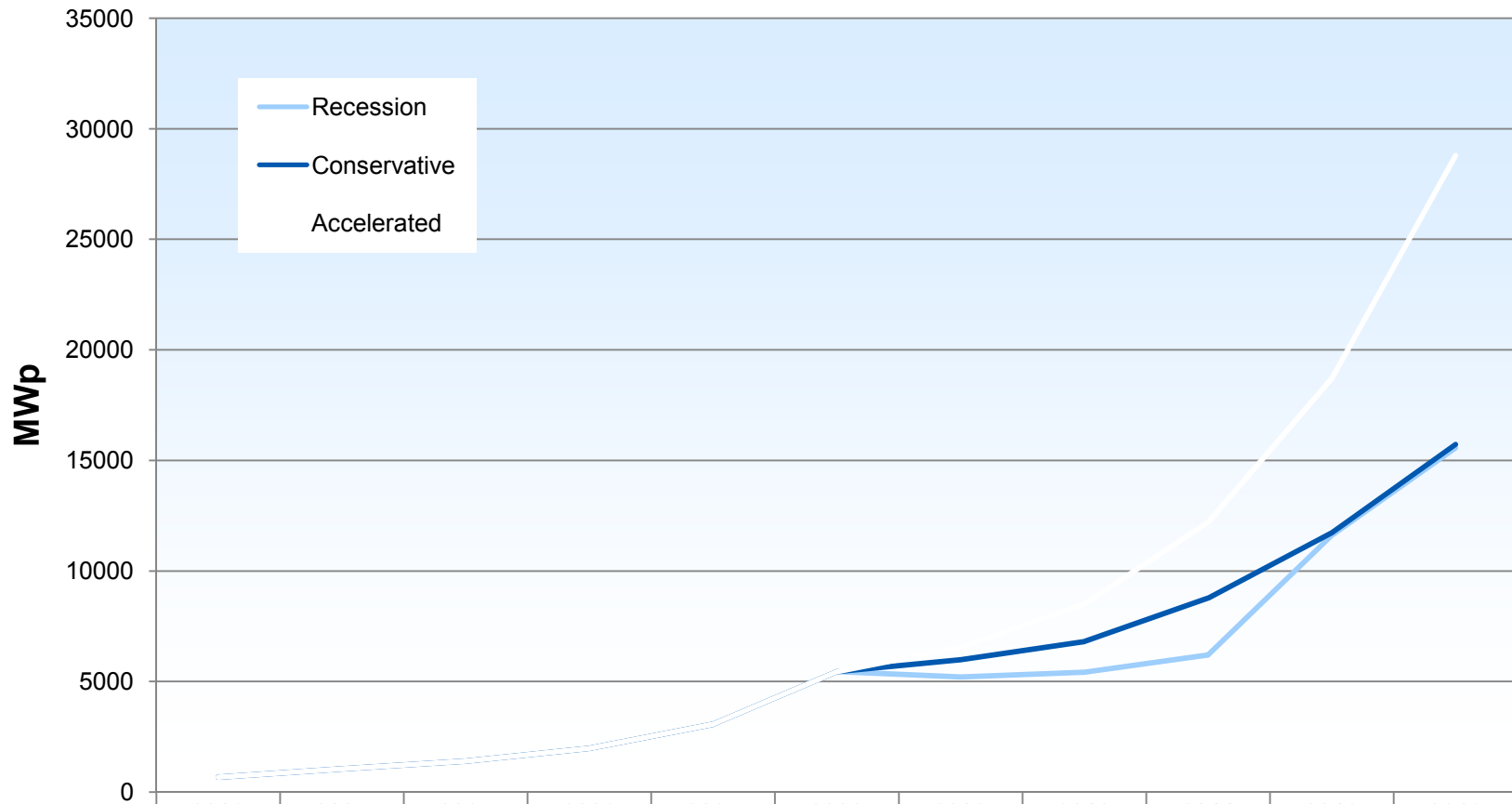


Source: ZSW Centre for Solar Energy and Hydrogen Research Baden-Württemberg

Data: Global Solar Cell Production:  
 1983-2000: Räumer, PSE  
 2001-2002: Strategies Unlimited (PV Systems Inc.)  
 2003-2007: Photon 3/2008  
 2008: EuPD Research, 2009

Data: Thin-Film Technologie:  
 1990-2002: DLR, 2005  
 2003-2005: EPIA  
 2006-2007: Navgant Consultant Inc.  
 2008: EuPD Research, 2009

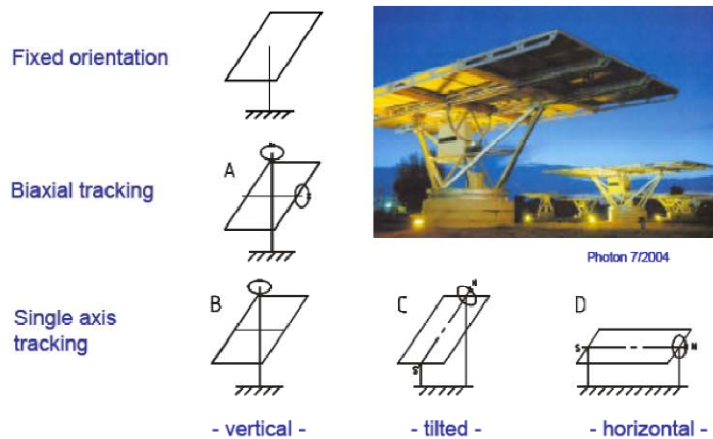
# PV: Projection of Module Production Capacity



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
— Recession	675.3	1049.8	1407.7	1984.6	3073	5455.8	5214.1	5425.4	6207.7	11611	15569.5
— Conservative	675.3	1049.8	1407.7	1984.6	3073	5455.8	5990.2	6808.1	8770.3	11731.9	15732.7
— Accelerated	675.3	1049.8	1407.7	1984.6	3073	5455.8	6555.2	8507.2	12202.2	18718.2	28795.6

Source: Paula Mints, Navigant Consulting, Inc., 2009

# Photovoltaic Power - Module Tracking



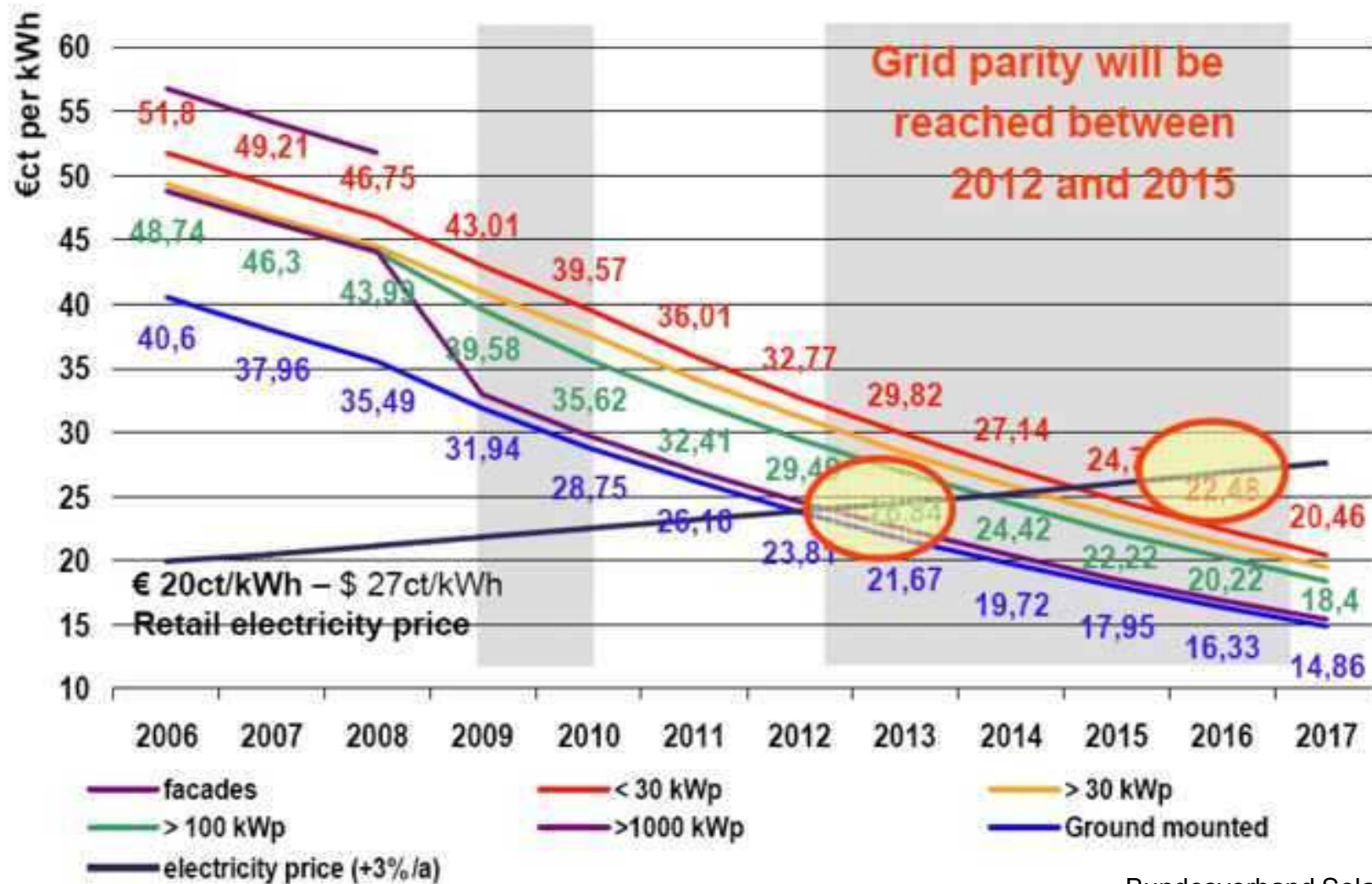
Photon 7/2004



	Mean annual radiation gain in Central Europe	Mean annual radiation gain in Southern Europe
Fix, optimum tilt angle	0%	0%
Horizontal N-S axis	11.5%	17.4%
30° tilt axis	22.9%	29.8%
Vertical axis, module tilt 50°	23.1%	29.6%
Biaxial tracking	27.2%	34%

# PV „Grid Parity“ in Germany

Based on degression rates decided on June 6th, 2008



# Site impressions

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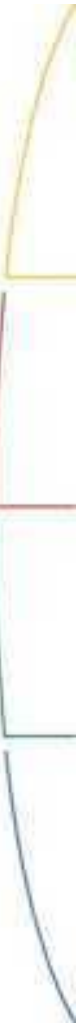














For further information, please contact

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Photovoltaic / Solar Technologies

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**Fichtner GmbH & Co. KG**

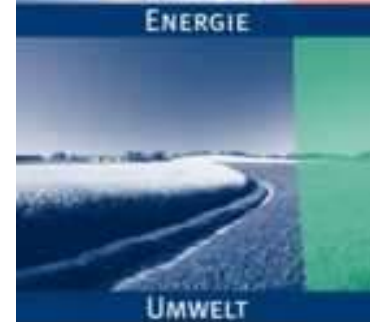
[www.fichtner.de](http://www.fichtner.de)



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