



Artes Applications Workshop

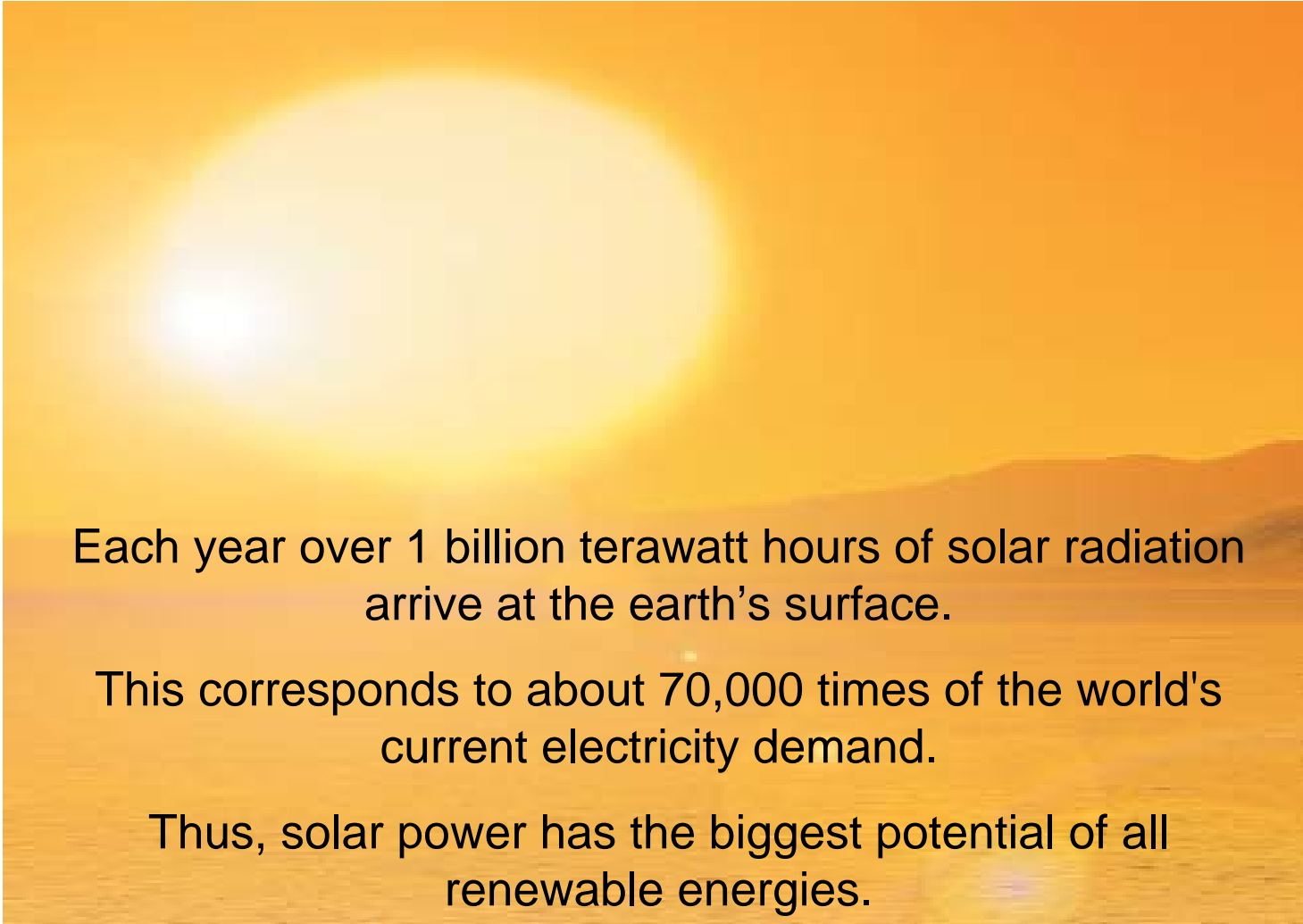
CSP FoSyS Project Presentation

Nordwijk, 05-06 April 2011

Birk Kraas



Solar Power is inexhaustible...

A large, bright sun in a clear orange sky over a landscape. The sun is the central focus, with a soft glow around it. The background shows a hazy horizon line over a body of water or a flat landscape.

Each year over 1 billion terawatt hours of solar radiation arrive at the earth's surface.

This corresponds to about 70,000 times of the world's current electricity demand.

Thus, solar power has the biggest potential of all renewable energies.

We`re developing the Future

Solar Millennium AG

- ... is a **successful pioneer** with a **long track-record** thanks to the **early entry into the market** (1998)
- ... developed the **first parabolic trough power plants in Europe**
- ... pursues projects **globally** with an overall capacity of **more than 2,000 MW**
- ... has an **experienced management** and **invests in R&D** with the aim of **achieving and securing sustainable technology leadership**



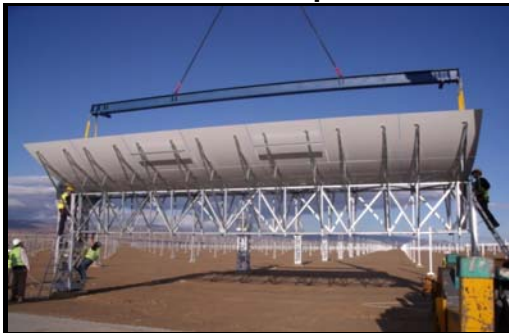
Parabolic Trough Power Plants

- **Proven Technology:** Commercial operation of parabolic trough plants in California for approx. 25 years.
- **Flexible in terms of implementation:** Hybrid power plants combine solar energy with other forms of power generation, i.e. natural gas or biogas
- **Efficient and cost-effective**
- **Possibility of storing heat energy and co-firing:** Power generation is possible on demand; thermal storage and natural gas co-firing allow power generation independently from actual solar irradiation
- **Grid stable power production:** Use of steam turbine allows predictable production and participation on grid stabilization processes



Andasol 3 – Factsheet

- Location: Aldeire, La Calahorra, Andalusia (Spain)
- Capacity: 50 MW, 8h thermal storage
- Collector type: SKAL-ET
- Solar field size: 497,000 m²
- Start of construction: Q3 2009
- Start of operation: Q3 2011



- *Last project of the Andasol complex (Andasol 1-3)*
- *100% Solar Millennium AG development*
- *Currently final construction works: Power Block / end of commissioning*

CSP FoSyS – Project

Concentrating Solar Power Forecasting System for Spain

Solar Millennium AG

together with

DLR (German Aerospace Center)

and sponsored by

ESA

started a research project for investigation and implementation of a **high accuracy, reliable and flexible** system for the programming of CSP power plant production.



Background of CSP - FoSyS

- Andasol 3 is supposed to start operation end of September 2011
- Irrespective of the selection of the fixed or the premium tariff, CSP Plants have to deliver “programming” (= forecast) of power production
- Inaccurate programming will result in penalty payments
- Beside solar energy there are different factors influencing the production of a CSP Plant (Wind, Plant availability, Operation & Maintenance strategy)
- Solar energy is quite variable in space and in time
- Solar energy can be stored as heat. Usually the stored energy needs to be used until the next morning.
- **Forecasting system is of high interest for**
 - **minimizing penalty payments arising from false programming**
 - **optimizing operation of power plant to increase energy yield and achieve best energy prices**

State of the art and technology gaps

Currently available:

- Forecasting of clouds, wind, temperature
- Forecasting of Global Radiation
- Rather low accuracy and low temporal resolution (max 1 h)

Forecasting system to be developed:

- Forecast of Direct Normal Irradiation
- High accuracy, high temporal resolution (5-15 min)
- Integration of Satellite data
- Considering local (site-specific) weather prediction
- In combination with Power Plant Model
- Taking into account Plant Operation & Maintenance Strategy

CSP-FoSYS Project Phases

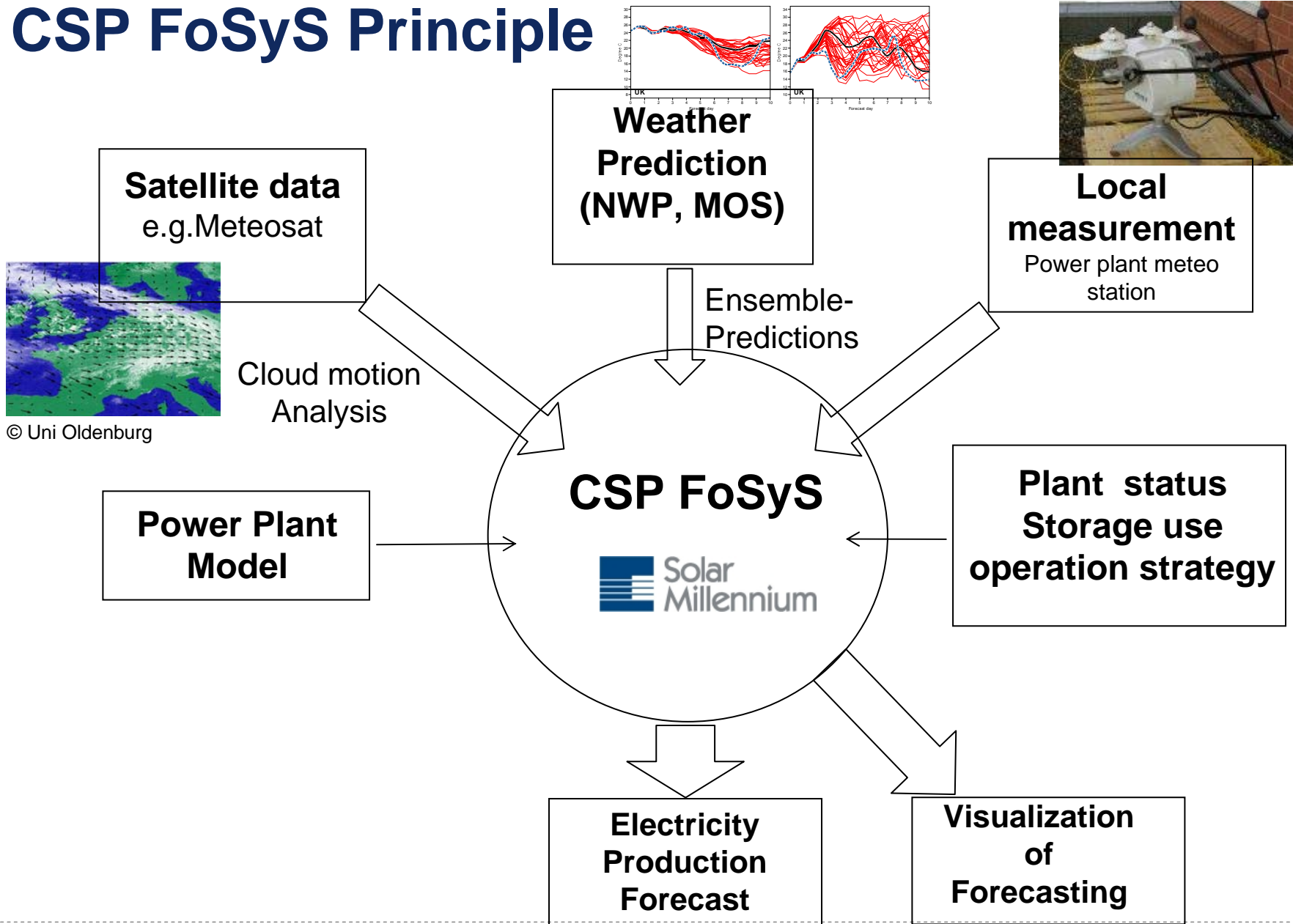
Phase 1 (completed)

- Initiation of the CSP-FoSYS Project inside the ESA IAP Program as **Pre-Feasibility Study** (FoSyS Phase 1)
- January 2009 - July 2009

Phase 2

- Follow up of the CSP-FoSYS Project inside the ESA IAP Program
- Completion of a **Feasibility Study** (FoSyS Phase 2) including a Prototype Software for the prediction of CSP Power Production of Andasol 3
- May 2010 - September 2011

CSP FoSyS Principle

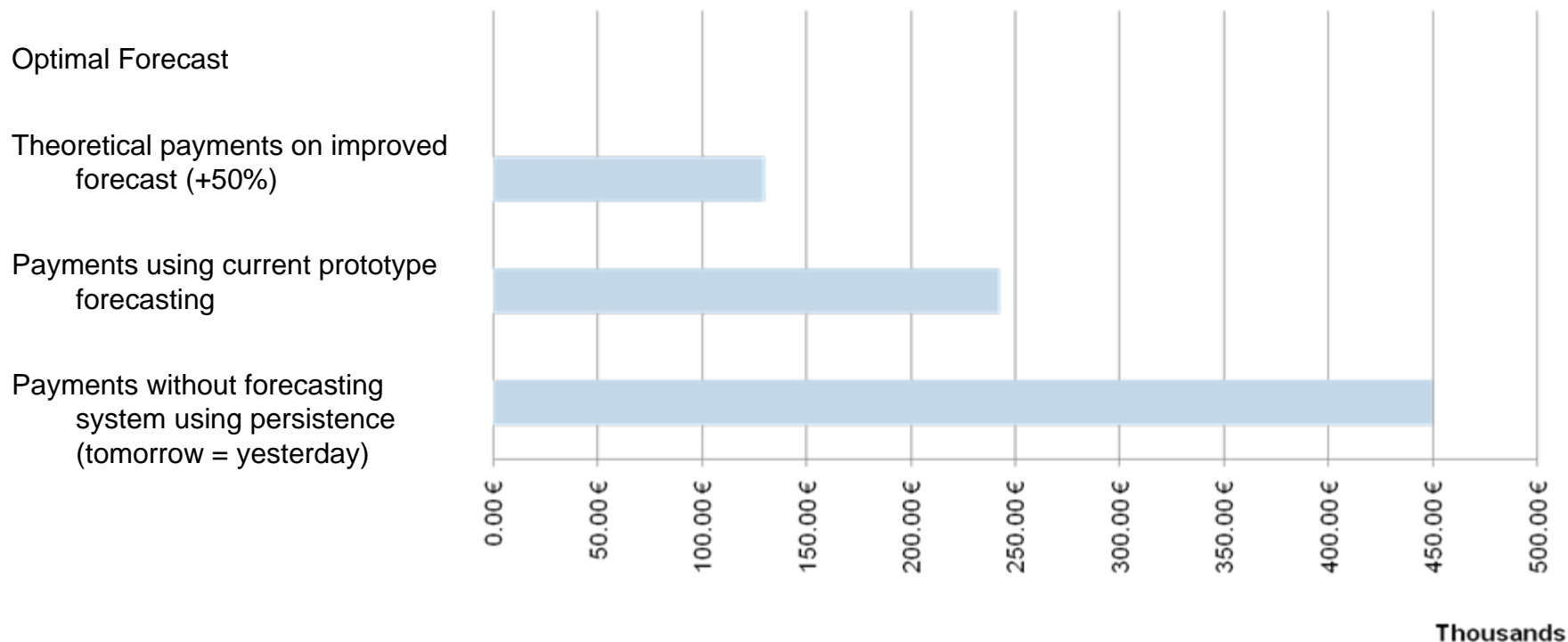


Added value of CSP - FoSyS

- DNI forecast included, merging/selection from different forecasts
- Highest available accuracy
- Integration of Power Plant Performance Model
 - Consideration of actual plant status (solar field, storage, turbine)
 - Consideration of plant operation strategy
 - Visualization of weather and production forecast allows interpretation and control by operator
- Automatic generation of output files for electricity market/transmission system operator
- Integration of high accuracy short-term satellite-based forecasts allows plant operation optimizations
- Improved maintenance planning depending on weather situation

Revenues for market participation

Deviation Payments 2007 in Thousand €



Additional advantages

Assets of forecast system in plant operation

- Improvement of plant operation
 - Turbine start and preheat
 - Stabilization of solar field outlet temperature
 - Use of storage
- Planning of maintenance on cloudy days
 - Clear sky day has revenues up to 150,000 €

Assets of status on grid access (“prueba de gestionabilidad”)

- Participation on grid stabilization processes like
 - Control of reactive power – revenues 480-500 k€ per year

Contact

**Contact Person and
Project Responsible:**

Dipl.-Ing. Birk Kraas

Address:

Solar Millennium AG

Nägelsbachstr. 33

91052 Erlangen

Tel.: +49/9131/9409-0

Fax.: +49/9131/9409-111

E-Mail: kraas@SolarMillennium.de

www.SolarMillennium.de

Disclaimer:

The present presentation does not constitute a legally binding offer of participation or for the purchase of shares in the company. It is not to be viewed by the recipient as constituting the subject matter of a contract or as a contractual basis for investment. Only inquiries and assessments carried out by the recipient on his/her own account can form a basis for investment in the company.

The presentation has been compiled solely on the basis of the company's business model and range of services, as well as on market and competitive environment research based on sources available publicly. No guarantee or warranty is provided for the accuracy, precision and completeness or for the interpretation of the data and the commentary, nor is any other form of liability for the content of this presentation acknowledged.

Budgeting is based on management assumptions and projections and reflects the market development and market opportunity perspectives at the time of compilation. The nature of the dynamic market environment is such that it is subject to constant changes and can therefore influence this budgeting content. No guarantee is provided for the budgeting feasibility.