



**INSEL<sup>®</sup>**

Integrated Simulation Environment Language

# Simulation of Renewable Energy Systems



**doppelintegral**

Integral Planning & Software Technology

# doppelintegral :: Energy between Sun and Earth

## Integral planning and software solutions

Our company doppelintegral GmbH develops concepts for energy efficient buildings and renewable power supply. We offer simulation services in all areas of renewable energy systems.

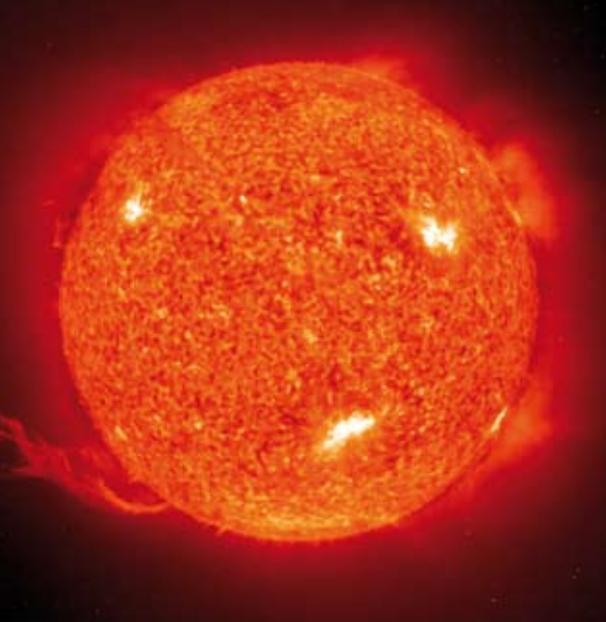
Our software solutions are used for the planning and yield prediction of photovoltaic power plants, solar heating and cooling systems and other renewable technologies. The energetic performance can be simulated, monitored and visualized within the same software environment. Online data access allows fast analysis and fault detection of building and energy plant performance.

## Our product :: INSEL

doppelintegral develops and markets the Integrated Simulation Environment Language INSEL. The software system has been developed and continuously improved during the last 20 years.

Flexible models are available for renewable energy plants, meteorological data calculations and building supply systems and can be easily extended by the user.





Credit: NASA/Solar Data Analysis Center

## Software development

doppelintegral develops customer designed software solutions. The fast design of complex software solutions is possible by using our extensive simulation libraries. High precision of results in all models is a special feature of our development work. User friendly interfaces are designed according to the customers needs.

Continuous development of the software takes place following the demand of our industry customers. Solutions are offered for renewable energy component optimization, energy concepts or special questions such as the physics of vapour transport in polymer foils for photovoltaic modules.

Our customers can profit from a company being continuously involved and engaged in applied sciences research projects.

## Training

doppelintegral offers software training for INSEL newcomers. Small groups are tutored by experienced INSEL users.

A one day course already gives a good overview of all the software features and enables planners to work with INSEL on complex problems.

- ❖ Long term experience in energy system simulation
- ❖ INSEL as a modular software environment can be used in engineering practice, but also for research and development
- ❖ Customer service and training courses are on offer from doppelintegral
- ❖ Innovative research results are continuously integrated in the software system



Credit: NASA/Visible Earth

## INSEL :: Simulation of energy systems

# INSEL®

Integrated Simulation  
Environment Language

### INSEL features

INSEL is a general-purpose graphical modelling language, which can solve any problem of computer simulation.

INSEL is mainly used to plan, monitor, and visualize energy systems.

INSEL provides state-of-the-art functions for the simulation of meteorological data, electrical and thermal energy components. Simulation models like grid-connected PV generators can be created from existing blocks in a graphic editor with a few mouse clicks.

INSEL comes with data bases for photovoltaic modules, inverters, thermal collectors and meteorological parameters. Even more, INSEL offers a programming interface for the extension of the block library.

### INSEL users

INSEL is used for simulation tasks in companies, research institutes, schools and universities.

Planners use INSEL for the design of complex energy systems. Engineers use INSEL for services like visualization and Internet monitoring. Operators use INSEL for monitoring and fast fault detection of their systems. Investors use INSEL for highly precise yield prognoses and economic calculations of photovoltaic systems, wind parks etc.

Renowned research institutes around the globe use INSEL for research, development and teaching of renewable energy systems. Class room licences for 20 students offer an excellent training package. Customers come from all continents and several hundred licences are currently in use.

Researchers appreciate INSEL in their scientific work for exact algorithms and free programming of own component models. Students get fundamental insights e.g. into the principal functioning of solar cells with their forward and backward characteristics, temperature and irradiance effects.



## Simulation :: Closer to reality

### Meteorological time series

Hourly irradiance, temperature, humidity and wind speed data can be generated from monthly mean values for any given location and orientation. All algorithms have been thoroughly tested and produce very reliable input data to any renewable energy system simulation.

### Solar heating and cooling

Solar thermal systems with storage tanks, controllers, heat and cold distribution systems and thermal chillers can be simulated with INSEL. The contribution of solar heating and cooling plants to the supply of a building or a district heating and cooling network can be accurately determined.

### Photovoltaic power plant yield prognosis

Highly accurate prediction of photovoltaic power plant performance is a special feature of the INSEL software. The current-voltage characteristics of the photovoltaic generator can be calculated with a special algorithm using the manufacturer data sheet information. Alternatively curve fitting algorithms are available, if measured IV curves are given.

Photovoltaic systems can be simulated with fixed orientation, one or two axis tracking systems or in special backtracking modes. The power reduction caused by shading is precisely simulated for building integrated photovoltaics or tracking systems.



### Data bases

INSEL contains up-to-date data bases for meteorology and solar energy use. Weather data for 2000 locations worldwide are available and new locations can be added by the user.

The photovoltaic data base provides current-voltage characteristic parameters of several thousand modules from the market.

All market available inverters can be simulated via coefficients in the inverter data base. For solar thermal applications data bases for collectors and storage tanks are available. Parameter sets for solar thermal cooling machines are also included.



### Solar Decathlon

International student teams competed in the Solar Decathlon to design, construct and build the house of the future – a fully energy autonomous residential building, which was exhibited in front of the Washington White House in October 2007. The German team won the first prize with an energy concept that was developed and thoroughly tested with INSEL software. It includes building integrated thin film photovoltaics with a battery system to drive all household appliances and an electric car. Thermal energy is provided by a small heat pump and vacuum tube collectors, for air conditioning evaporative cooling is used.



Credit: Kaye Evans-Lutterodt/Solar Decathlon



### Photovoltaic production

A simulation tool has been developed by doppelintegral to follow the complete production chain of the **BP Solar** photovoltaic manufacturing plant. The model assesses the economics and energy performance of each production step.

Modifications of the optical performance of the PV module glazing, the antireflective coating, the absorption properties can be simulated just as well as the cell interconnections, cabling losses and other electrical properties. The tool gives the manufacturer direct feed back on any optimization measures.



### Monitoring and visualization

doppelintegral developed a complete visualization, monitoring and alarm system for the photovoltaic generator at the Berlin Main Station of the **Deutsche Bahn**. The performance of the roof integrated photovoltaic modules and each of the 119 inverters is continuously checked. The software tool automatically accesses the SMA data loggers every minute and compares performance with the design values.



### Tracking systems

Special INSEL simulation models have been developed for **Conergy** to predict power plant performance with different tracking mechanisms. Mutual shading of tilted module rows with or without backtracking can be calculated. Energy yield prognoses for several MW tracking plants in Asia have been done by doppelintegral.

### Customer software

**Bayer Material Science** needed simulation models to evaluate the water vapour transport in foil materials of photovoltaic modules. Diffusion transport for different material characteristics and temperature dependent condensation is calculated to analyse long term performance under outdoor conditions. Bayer Material Science now uses doppelintegral software to improve their foil production process.

### User friendly interfaces

The software PACdimension has been created for installers of photovoltaic systems, who want to use inverters from the **Oelmaier** company. It can be downloaded for free from the manufacturer's website. It has an intuitive user interface, but uses highly precise simulation models from the INSEL calculation engine. For a given peak power or roof surface area, the simulation tool automatically suggests the best inverter options and calculates the return of investment.



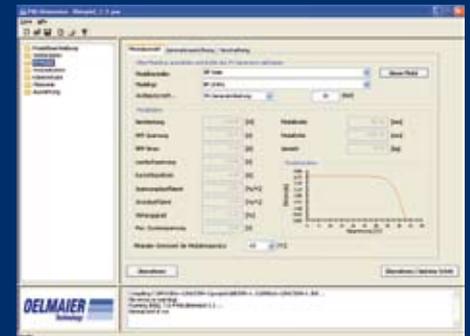
### Solar cooling simulation

Solar thermal cooling systems can be simulated with INSEL to optimize the energetic performance of such innovative systems. Tools were provided to the Austrian research institute **Arsenal** to support architects and planners in the engineering of desiccant cooling systems.



### Market studies

The economics and energy performance of solar thermal cooling plants is of special interest to solar collector manufacturers. Potential studies have been done for **Schott, General Electric, and COLT**, for instance, to support the market entry. Design rules for different building types have been developed by doppelintegral to calculate performance and costs of solar powered absorption, adsorption and desiccant cooling systems.



### Customer libraries

The INSEL software offers complete flexibility for integration into other simulation environments. A library with the best meteorological algorithms has been implemented into the well known software tools T\*SOL and PV\*SOL.

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