Polysun Inside: A Universal Platform for Commercial Software and Research Applications

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Abstract

The simulation tool Polysun has been extended with a software interface that allows other software to connect to the Polysun simulation kernel. As a result, on one hand, commercial software can extend its functionality and offer complex solar thermal simulation to new application areas and to a new range of users. On the other hand, the innovative software interface allows for a broad range of research applications, some of which are presented in this paper. Recently, the new software interface has also been prepared for the usage in the highly customizable Polysun Online web service applications.

It has long been recognized that it is a challenge to bring both solar energy into architectural design and in particular to enhance solar design in the early planning stage. With Polysun Inside now integrated into Lesosai, DDS-CAD, BKI Energieplaner, plan4solar and other tools [1-6], solar energy calculations are only a mouse-click away for the architect and the engineer. Simulation is combined with advanced generation of list-of-parts and state-of-the-art optimization features. Setup wizards and pre-defined solar systems make solar energy simulations easy to use for architects and engineers. This paper discusses the choice of configuration setups and default values of solar energy systems and presents how statistical analysis methodology is chosen to extract robust and representative parameter and system sets. The Polysun platform allows the flexibility needed for research applications (e.g. with a command line access through MATLAB) as well as the simplicity and high usability requirement needed to serve for a broad public with Polysun Online web browser based user interface.

In order to illustrate implications in the field of research, results are presented on advanced automatic optimization strategies making use of Polysun Inside as a forward solver and applying a Particle Swarm Optimization (PSO) algorithm for optimal sizing of system sizing components [7].

1. Polysun Service Delivery Platform

The Polysun product family includes several different versions and interfaces to one single simulation kernel. The different applications serve several purposes and have different target users, which is described in the following.

1.1. Overview

Polysun is a well established simulation tool present in the market already for many years [8]. It has for many years been developed at the Solar Energy Institute SPF at the Technical University of Rapperswil HSR in Switzerland. With the step from Polysun 3.3 to Polysun 4.0 the complete

software has been fundamentally restructured allowing for the first time that users design their own systems. The Spin-Off company Vela Solaris has taken over the Polysun development and forcefully advances usability and versatility. Considerable effort is continuously spent on the database maintenance and on extending the system templates to cover a large portion of the commercially available renewable energy systems. Furthermore, Vela Solaris offers professional support, service and training.

With Polysun 5.0 (spring 2009), the Polysun functionality has been extended to cover heat pump [9], geo-thermal [10], photovoltaics [11], PVT [12] and solar cooling [13], and many more feature improvements have been (e.g. wizard) have been presented in subsequent software releases. In parallel to the further development of the standalone version of Polysun, other ways of accessing the Polysun kernel and the Polysun component database have been established. The Polysun Inside interface has been presented in summer 2009 and several partner tools make use of this software interface in the mean time (see section 3.2 below).

In the same way, a scripting language access has been established, which targets research applications [7] that often involve automation of input generation and output processing in repeated simulation runs. Recently, as a third application using the Polysun Inside interface, full access to the Polysun simulation kernel is offered for online access as a web service [14].

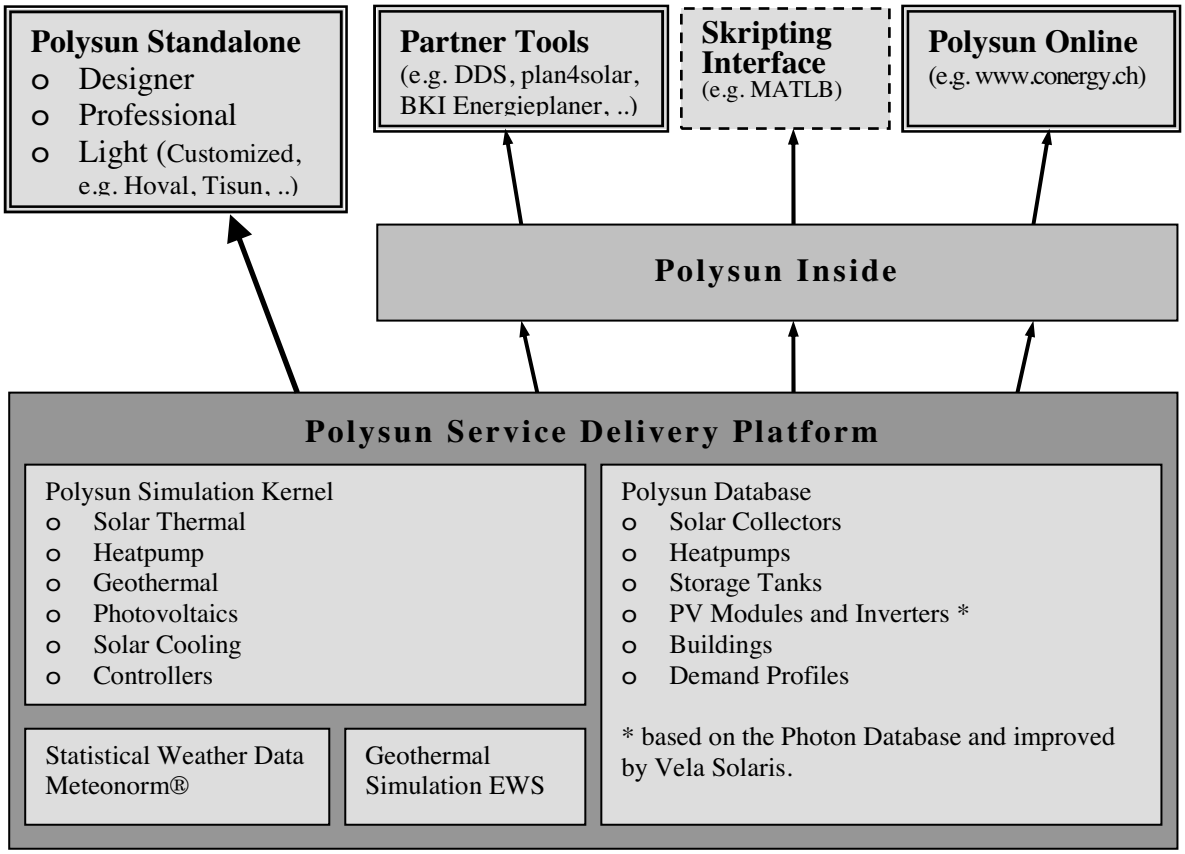

Figure 1: *Polysun overview. The Polysun software code has been structured in a way that functionality and database is maintained in a service delivery platform that serves different front ends.*

1.2 Advantages

The main advantage of making one simulation kernel available for several different applications is that reliability and stability of the numerical model and the database increases. Validation of the simulation model is done for all applications at once. Simulation results are identical for Polysun Standalone, for all partner tools as well as for Polysun Online. Recognition by funding agencies is obtained easily if the same software kernel and the same input data are used as in the standard Polysun.

Another key advantage can be seen when observing how the different applications are used in combination with each other: a house owner consults Polysun Online on the internet, passes the results further to the Architect who uses BKI Energieplaner and works together with planners that use the standalone version of Polysun for the heating system and another partner tool for the building shell.

Furthermore, if new technologies (e.g. Solar Cooling, PVT or Power-Heat-Cogeneration) or improved numerics (e.g. faster evaluation of the time-stepping scheme) are implemented, they can easily be made available for all applications.

1.3 Technical Realization

The numerical algorithm solves the energy balance and the mass balance equations for each component in the system [14]. While heat transfer involves the solution of a first order differential equation, the fluid transport between the components is solved with an explicit plug-flow technique. Pressure drop inside the fluid loops is solved in much detail but without increasing the complexity for the use. The models also cover stratification tanks [15] and modern boilers [16].

The Polysun Kernel is written in the Java programming language. This choice allows high-end software development and supports the portability to other operating systems (release of the Mac version in 2010). Software packages such as the weather generator Meteonorm [17] and the geothermal simulation package EWS [18] are integrated on a source-code level which is beneficial from a point of view of testing and execution performance.

Furthermore, Vela Solaris maintains the master copy of the component database, which is updated several times a year. On the user's computer, the database is extended with user-defined entries. Automated testing and quality control cover both the software function as well as the template and component database.

2. Polysun Standalone

The simulation software Polysun offers a broad range of functionality required for the analysis and design of domestic energy systems ranging from solar thermal to heat pump and PV systems. The combination of all these renewable energy systems in one tool allows for addressing today's market needs and to quickly cover new fields like PVT collectors [12], Solar Cooling [13] or the combination of solar thermal and heat pump [7]. Polysun Designer offers full flexibility in system design by its unique graphical editing capability and user-friendly features (see Figures 2 and 3).

In the Polysun catalogues, a broad range of components is stored with all characteristic data necessary for the hydronic and thermal analysis of heating systems and the analysis and design of PV applications. Polysun is shipped with a large number of system templates with well-established

heating and PV concepts and it calculates all relevant system parameters related to heating and electricity production. It also comprises the calculations for amortization and the data required for subsidy applications. The target users of the stand-alone version of Polysun are the installers and planners.

Polysun is commercially available in different User Levels (Light – Professional – Designer) and Industry Solutions (Solarthermal – Heatpump – Photovoltaics – Solar Cooling) and its combinations. Furthermore, Polysun is shipped with a broad range of templates, which are the basis of every simulation on the user level Professional and are typically the starting point for new schemes that are developed by the user on the user level Designer.

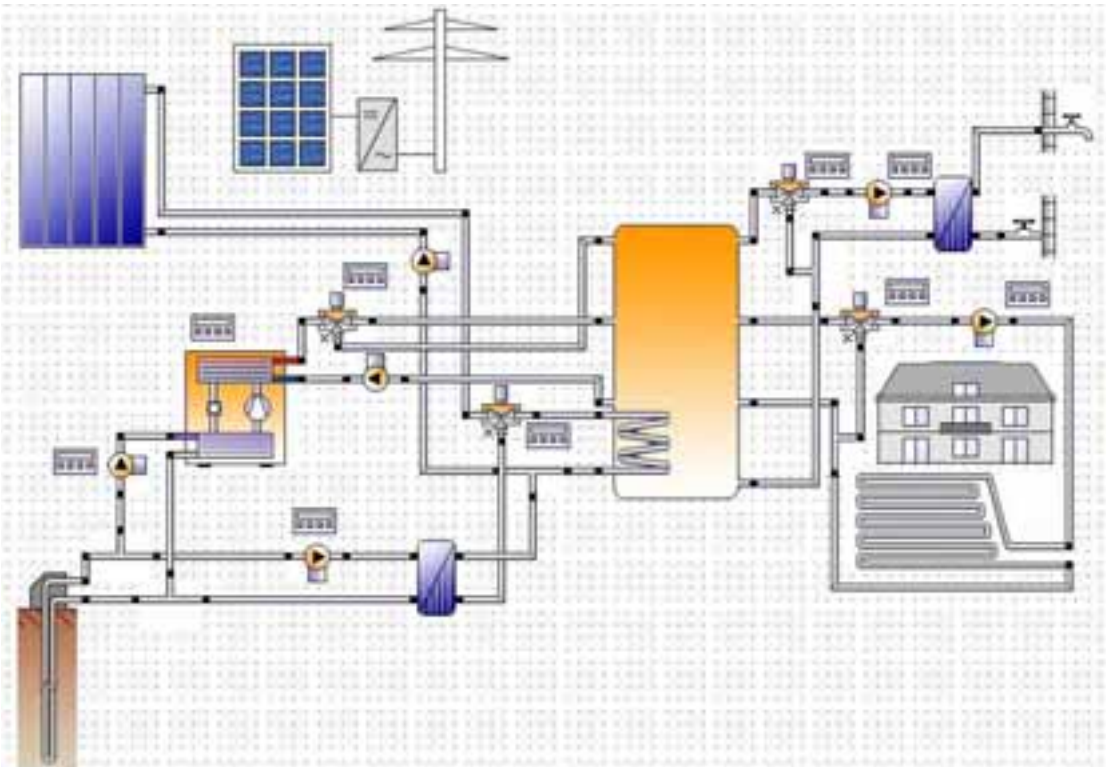

Figure 2: *Polysun planning tool including solar thermal, geothermal/heatpump, and photovoltaics in one tool. Furthermore, all details of the heating system, such as radiators/floor heating, controllers and pumps are modelled with their physical behaviour.*

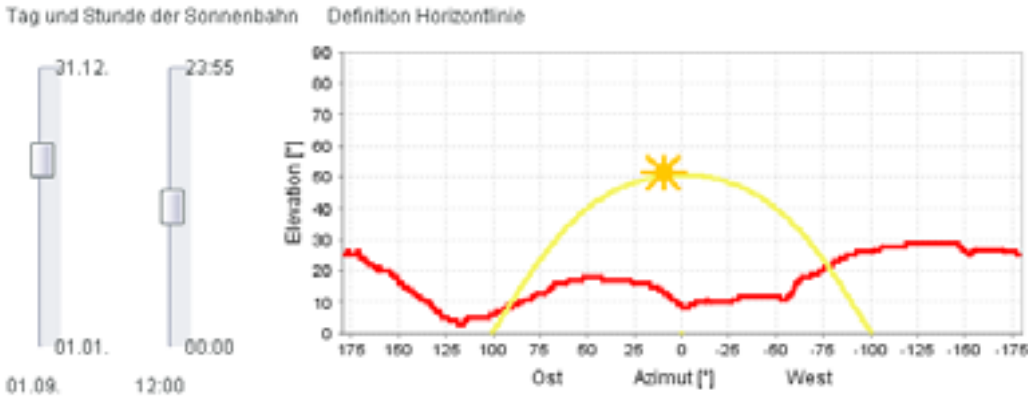

Figure 3: *The Polysun Horizon feature offers a easy-to-use yet powerful consideration of shadowing. In the simple Polysun user interface it can be evaluated how much lower the system yield is because of a specific shading object (easily entered manually) or because of the far horizon (obtained from an internet request).*

3. Polysun Inside

Vela Solaris now offers a new software interface to Polysun which allows other software to connect to the Polysun simulation kernel. In cooperation with Vela Solaris, it is now possible to include the Polysun functionality in other software and therefore to bring solar simulation into new application areas.

3.1 Methodology

With the Polysun Inside interface, a C-style API is offered to the Polysun simulation kernel. The interface has been designed in a way that makes it easy to use Polysun Inside from other programming languages like C, C++, Delphi, etc. The basic concept is to offer a light API interface with a limited number of functions. The data exchange is done through the platform independent XML format, as for example for the choice of the simulation systems, for passing system parameters, catalog data, location coordinates as wells as for retrieving the simulation results. The XML data structure is scalable, offering a simple access for the basic requests and becoming more complex for comprehensive data exchange with the calling tool. A showcase workflow is presented in Figure 3.

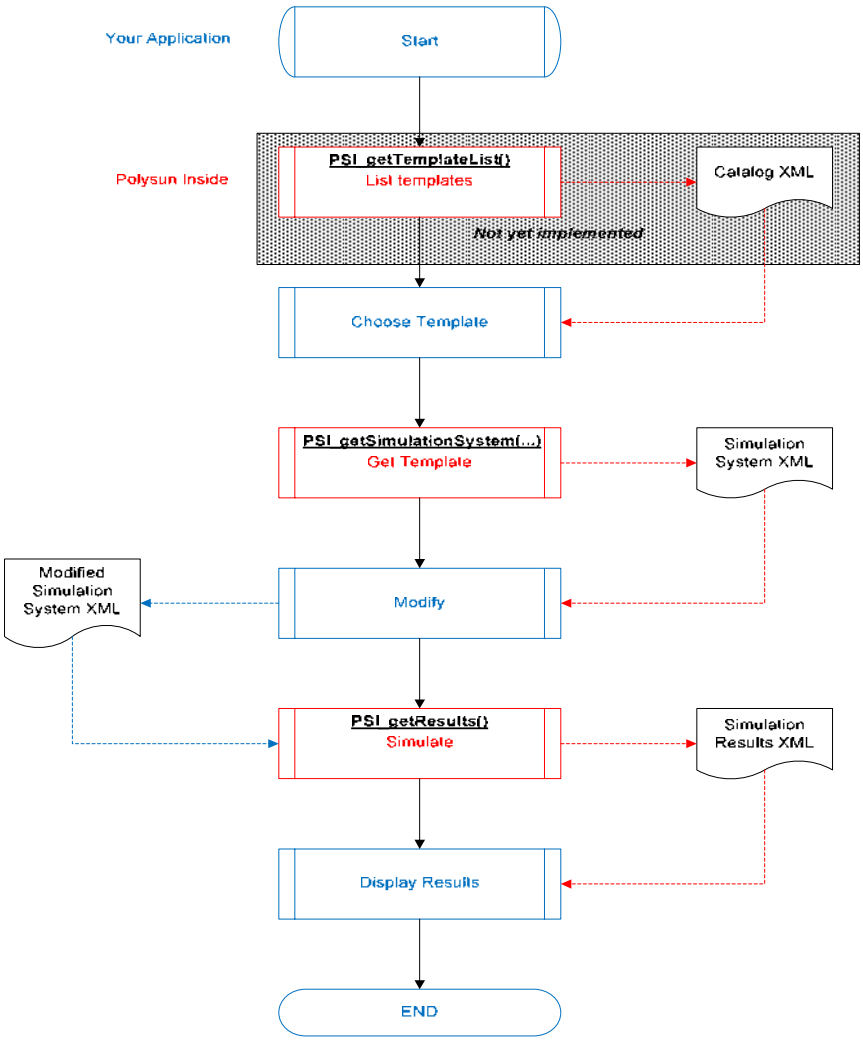

Figure 4: *Flow diagram of a Polysun Inside function call and data exchange. More details are described in the Polysun Inside developer's guide*

3.2 Commercial Software Applications that rely on Polysun Inside

The Polysun Inside user interface is already intensively used by several different tools from different application areas. The today's official Polysun Inside partners are

- **DDS-CAD**, offering a full featured 3D computer aided design software and the Polysun PV features since early 2010 as well as the Polysun solarthermal features in the near future [3]
- **Plan4solar** from the Austrian company Gascad, offering a powerful sales support tool which includes the generation of parts and 3D visualization capabilities [4]
- **BKI Energieplaner**, with PV and solar thermal capabilities to support the German EnEV, regulatory and funding requirements [5]
- **Lesosai** from the company e4tech, supporting the regulatory Standards of Switzerland, Luxemburg, Italy and France [6]

More collaborations for additional customer segments are about to be published in the near future.

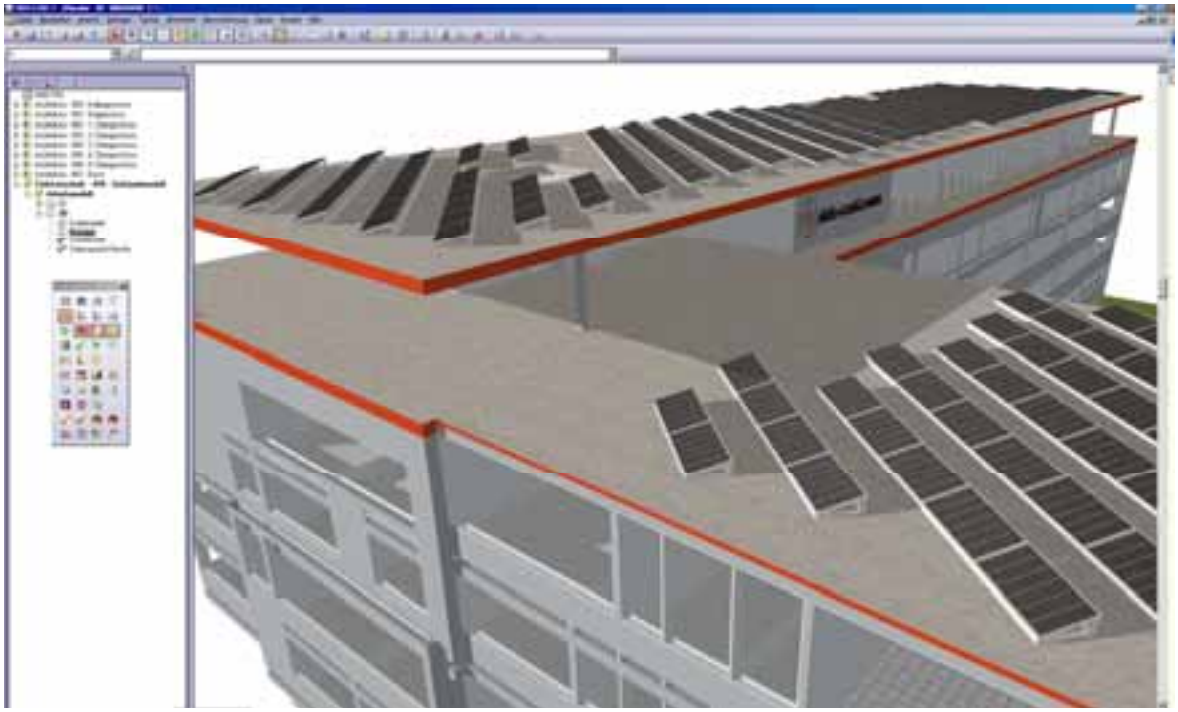

Figure 5: *DDS-CAD PV Polysun Inside as an example for the powerful combination of free 3D construction in combination with the Polysun renewable energy calculation.*

3.3 Research Applications

First applications of Polysun as a simulation tool in the field of research and testing have been done in conjunction with the system testing at the solar technology institute SPF, where Polysun has been applied along with the more comprehensive yet more complex tool TRNSYS.

Since the introduction of the new Polysun Inside interface, more rigorous applications are possible in several research fields. Polysun Inside allows to access the simulation kernel and the component database through a scripting interface and therefore allows to explore new methodologies for system investigation and optimization. Standard research tools like Matlab or Genopt can be used

to control the Polysun simulations and to generate multi-dimensional output data.

It is a particular advantage to have the full plug-flow system analysis of the Polysun simulation kernel available as a forward solver and run it repeatedly. In consequence, parametric analysis can be done for the entire system rather than for isolated components. Research results have been presented for finding the optimal sizing of the main components of a solar thermal system by applying a Particle Swarm Optimization (PSO) algorithm [7]. It has been shown therein how a sensitivity analysis can be performed with the use of the Polysun Inside scripting interface. Investigation of the relative influence of each parameter support the development of robust heating systems and the derivation of optimal control strategies. Accurate sizing of the energy components is demonstrated to be an important step in order to minimize losses while maximizing economic viability.

4. Polysun Online

As a third application area, the new Polysun Inside software interface gives access to the Polysun simulation kernel for web applications.

In contrast to other, simplified solar calculators that can be found on the internet, Polysun Online carries out fully featured simulations of solar thermal and PV systems without additional numerical approximations. Comprehensive professional renewable energy simulations become available for a broad range of users. Also non-specialists are able to accurately evaluate the potential of renewable energy sources and to calculate pay-back times.

The main advantage is a commercial benefit for the producers or system providers of solar energy systems: with the integration of Polysun Online in their company's website, they enable their customers to enter all data required to order a solar energy system. Customer requests are therefore on a high level and typically include a Polysun report in the first contact with the system provider. As a result, the workload for consulting is reduced and throughput can be increased.

The basis for Polysun Online are the system templates that are generally available in Polysun, in particular the company templates.

5. Conclusion

We have demonstrated the versatility and high potential of the Polysun Inside platform, which makes the simulation kernel of the well-established Polysun simulation software available to other software tools. In consequence, the simulation capability for renewable energy systems is made available to a broader range of people other than the typical users of the standalone version of Polysun. On the one hand, other commercial software providers make it available to their existing customers. Secondly, researchers have a new way to access the Polysun kernel in a command-line or scripting approach. Lastly, Polysun Online is also based on the Polysun Inside Interface, which offers accurate simulation results within a few mouse clicks through an internet browser .

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