

SIMPLORER's Alternative Power Library (APL)

Alternative Power Simulation Workshop,
Washington, D.C., Oct. 14 2003

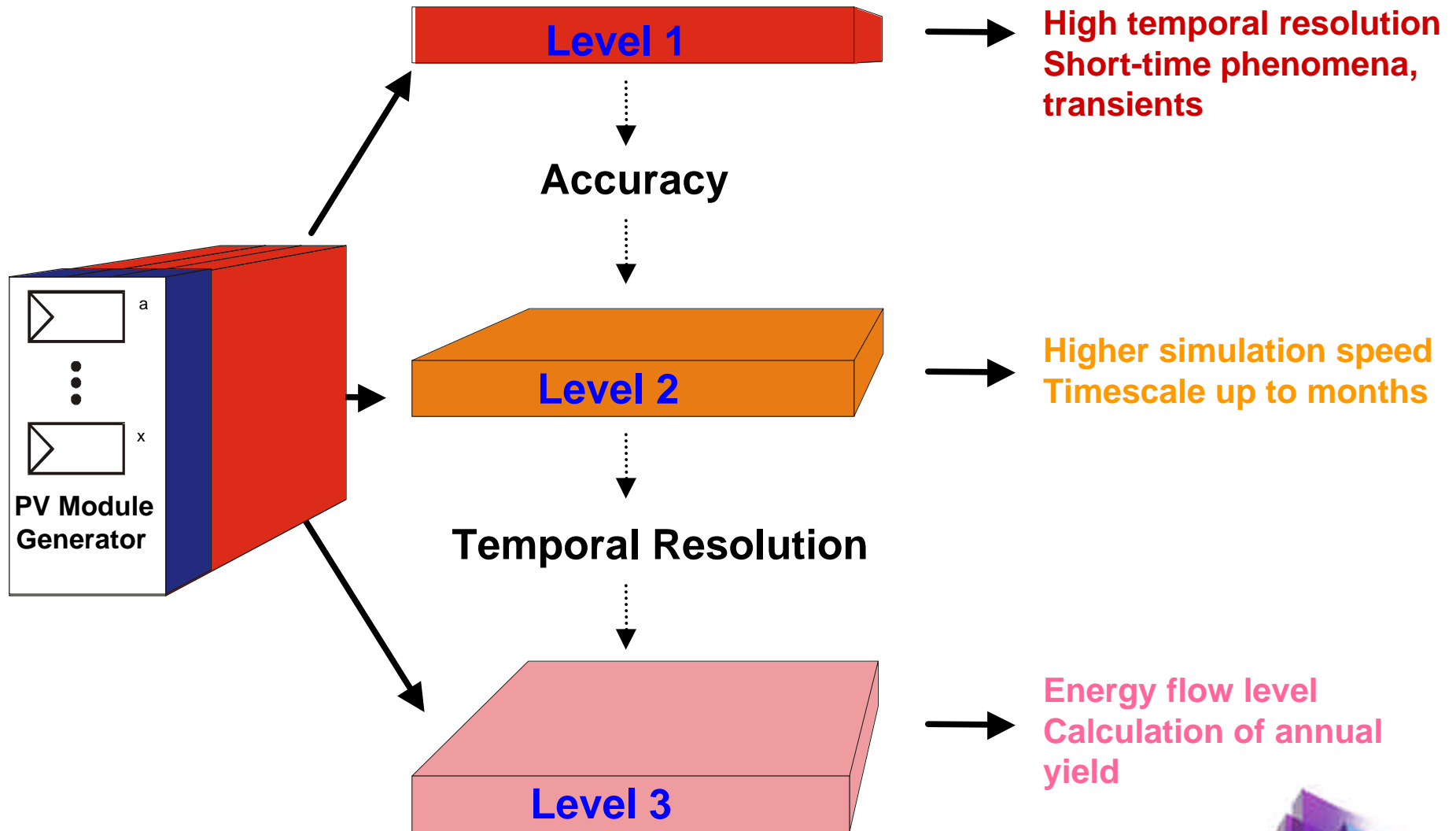


Design Challenges in the field of Alternative Power Systems

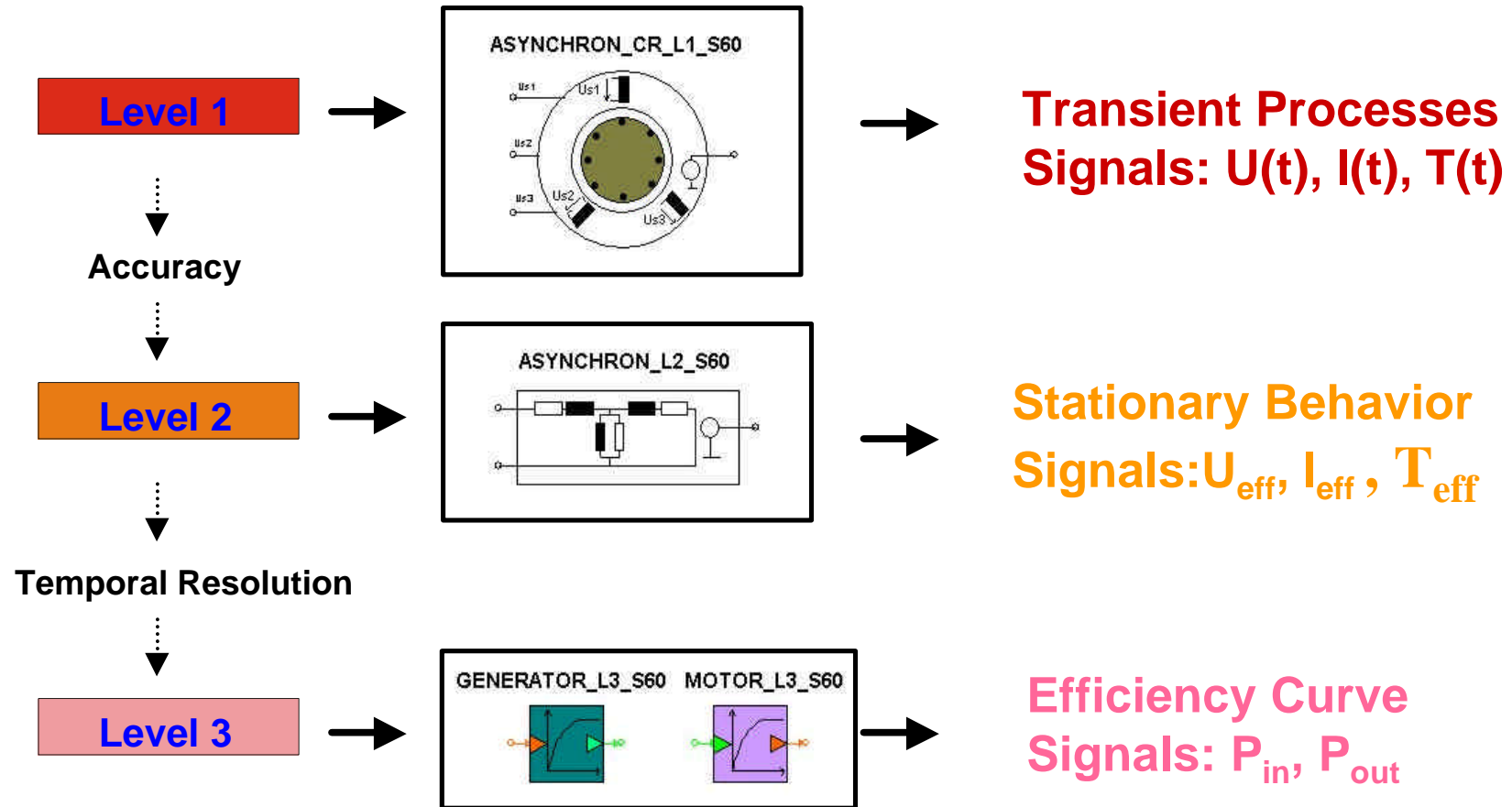
- ▶ Inverter Design $\mu\text{sec} \dots \text{sec}$
- ▶ Grid connection $\mu\text{sec} \dots \text{msec}$
- ▶ Power quality $\mu\text{sec} \dots \text{msec}$
- ▶ Control design $\mu\text{sec} \dots \text{sec}$
- ▶ Safety systems (anti-islanding,...) $\mu\text{sec} \dots \text{msec}$
- ▶ Energy balancing / battery charging $\text{sec} \dots \text{yrs}$
- ▶ Yield calculation $\text{mon} \dots \text{yrs}$
- ▶ Loss-of-load prediction $\text{sec} \dots \text{yrs}$
- ▶ Component selection / sizing (PV, machines, batteries,...) $\text{sec} \dots \text{yrs}$
- ▶ ...

Timescales

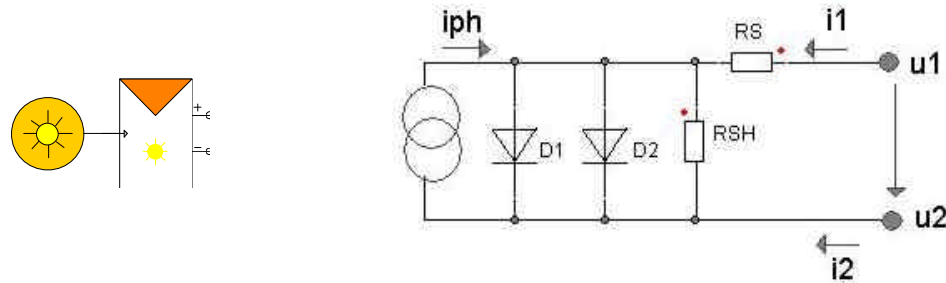
Multi-Level Modeling



Multi-Level Modeling Machines

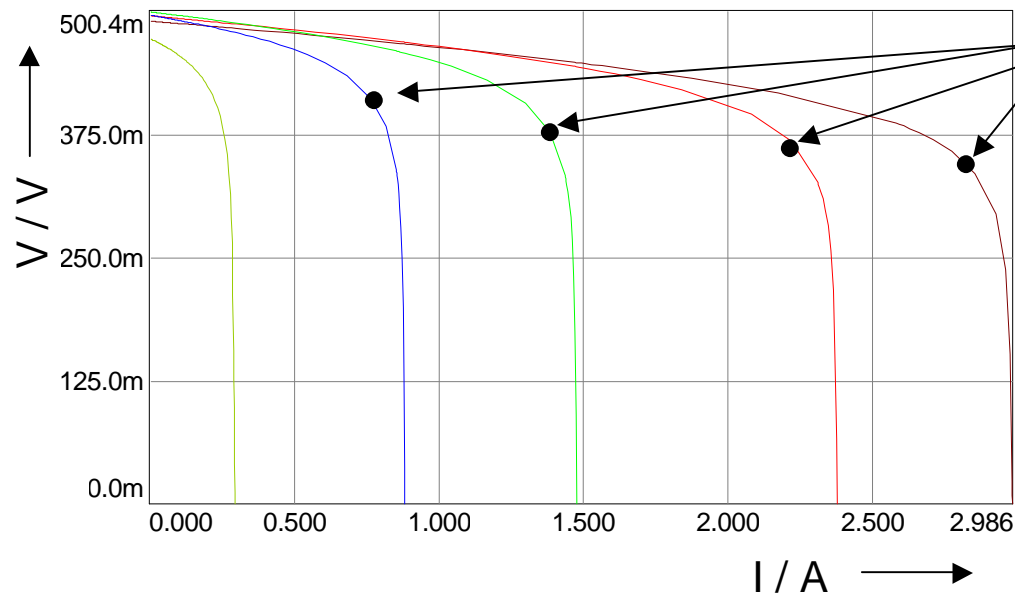


Multi-Level Modeling Solar Cell



Level 1

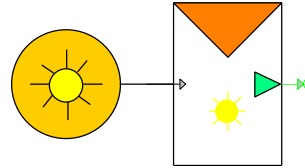
Level 2



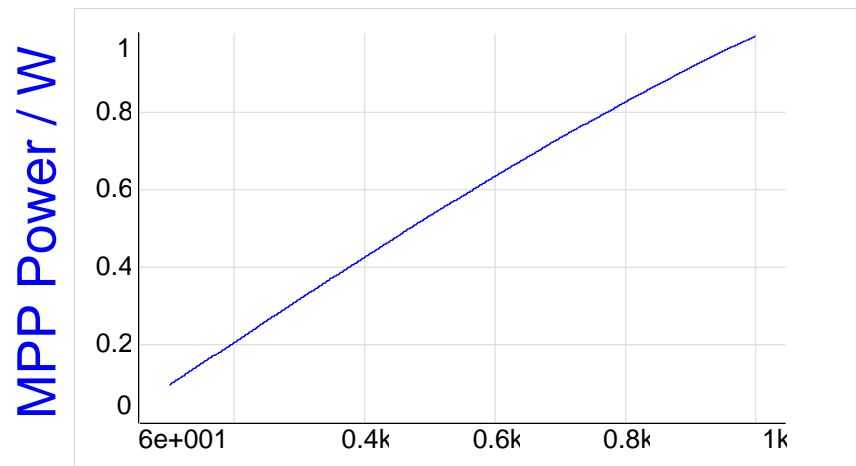
Maximum Power Point *MPP*

- 1000 W/m^2
- 800 W/m^2
- 500 W/m^2
- 300 W/m^2
- 100 W/m^2

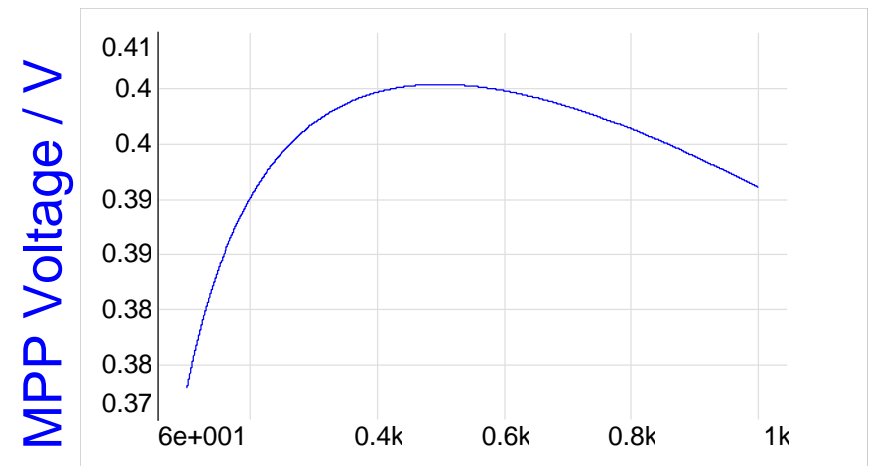
Multi-Level Modeling Solar Cell



Level 3



Insolation / W/m²



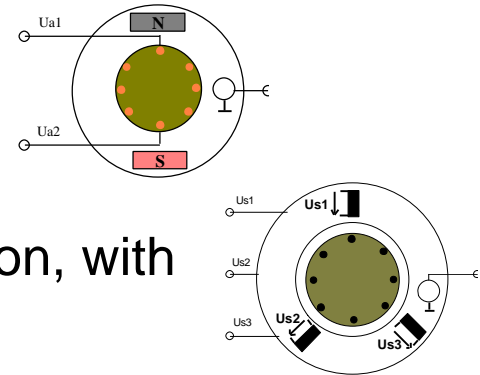
Insolation / W/m²

APL - Components (I)

Loads

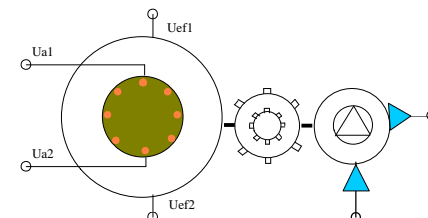
► Machines

- DC: Permanent, linear, nonlinear excited
- AC (induction): cage rotor, slip ring
- AC (synchronous): PM, electrical excitation, with and without damper

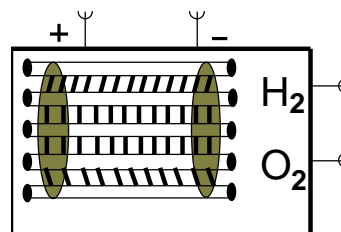


► Pumps

- DC, AC with and without gearboxes



► Electrolyzer

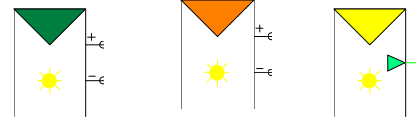


APL - Components (II)

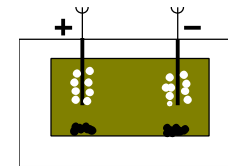
Generators / Storages

▶ Machines

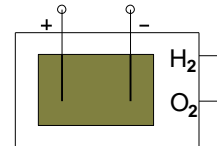
▶ Solar Cells / Modules



▶ Lead-Acid Battery



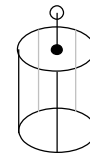
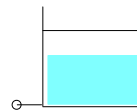
▶ PEM Fuel Cell



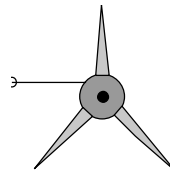
▶ Supercapacitor



▶ Tanks



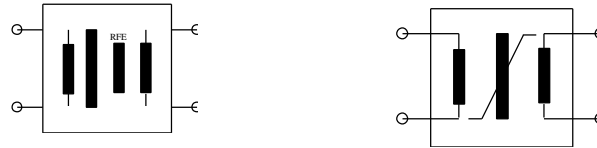
▶ Turbines



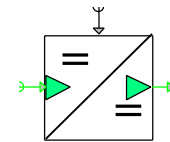
APL - Components (III)

Energy Conditioning Units

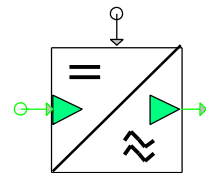
- Transformer: ideal, (non)-linear, with and without losses



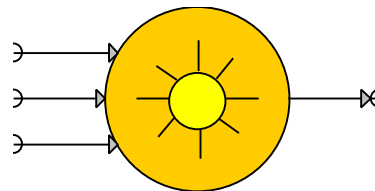
- DC/DC converter, Level 3



- Inverter, Level 3



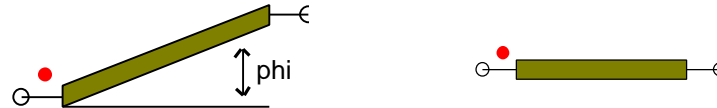
- Solar insolation models: tilt angle, geographic location, diffuse and direct insolation



APL - Components (IV)

Miscellaneous

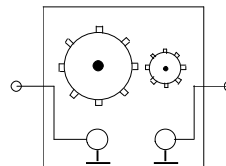
- ▶ Pipes



- ▶ Pneumatic valves

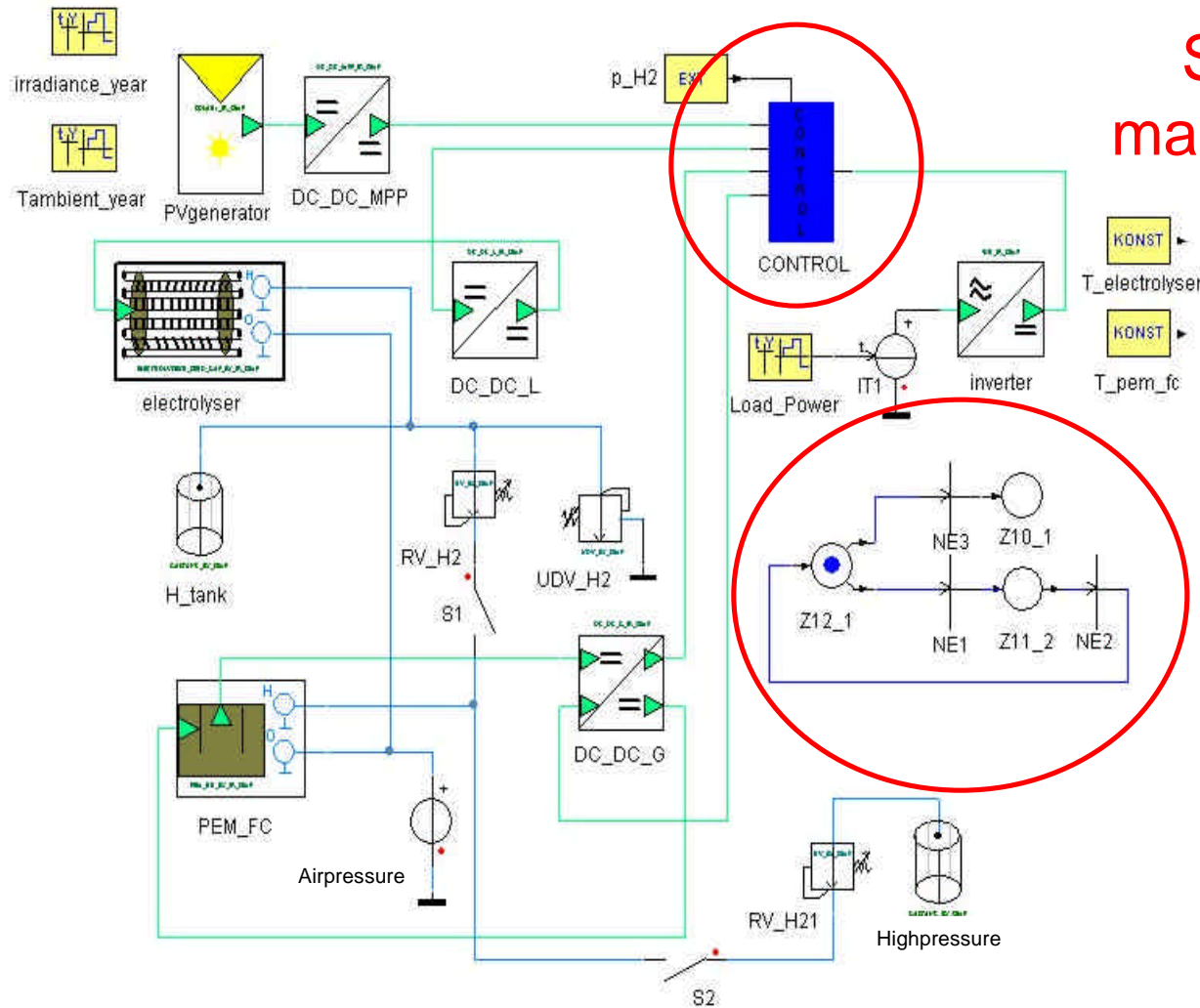


- ▶ Gearbox



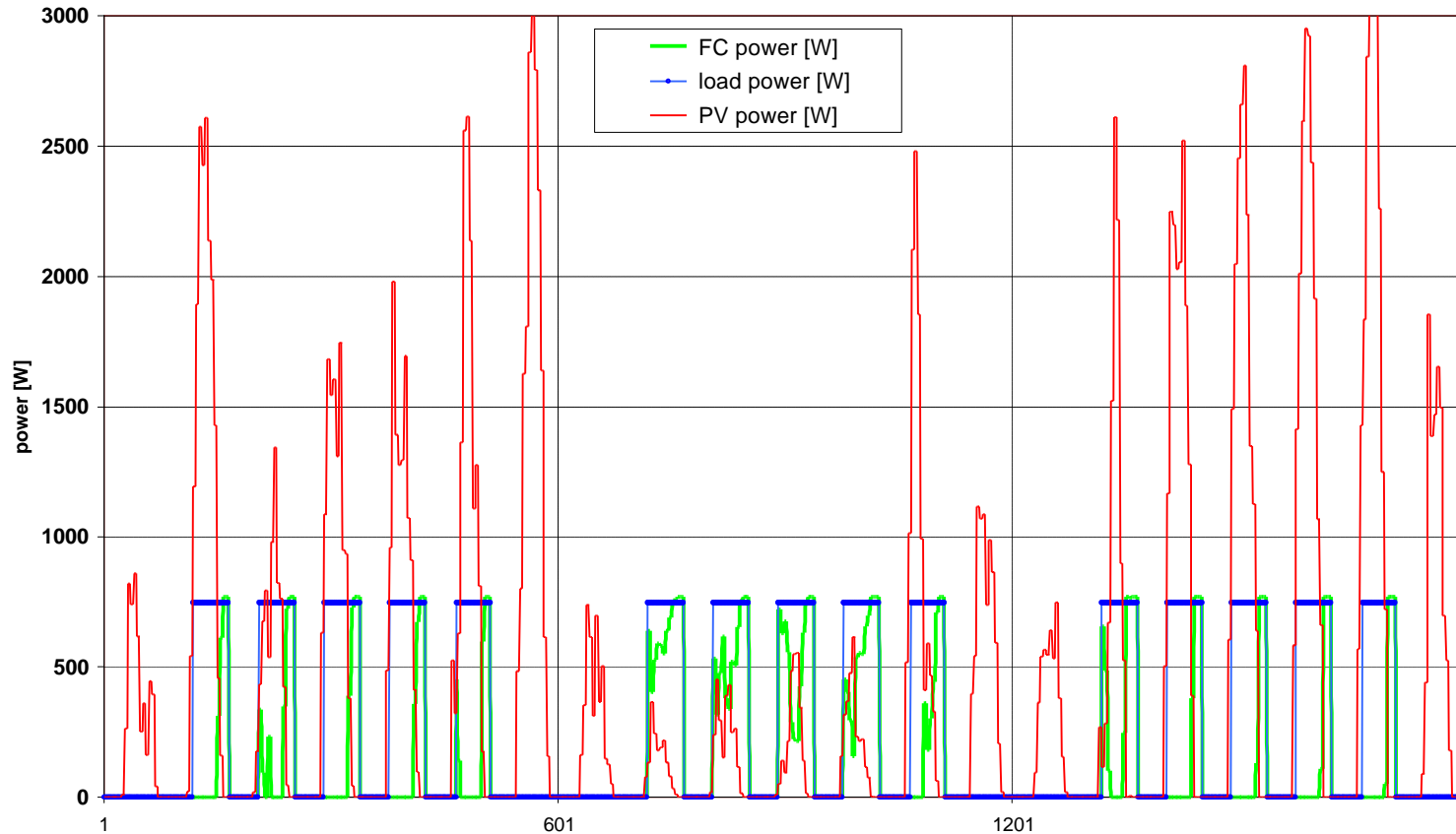
Altogether about 100 different models

Example: PV-FC-EL Island System (L3)



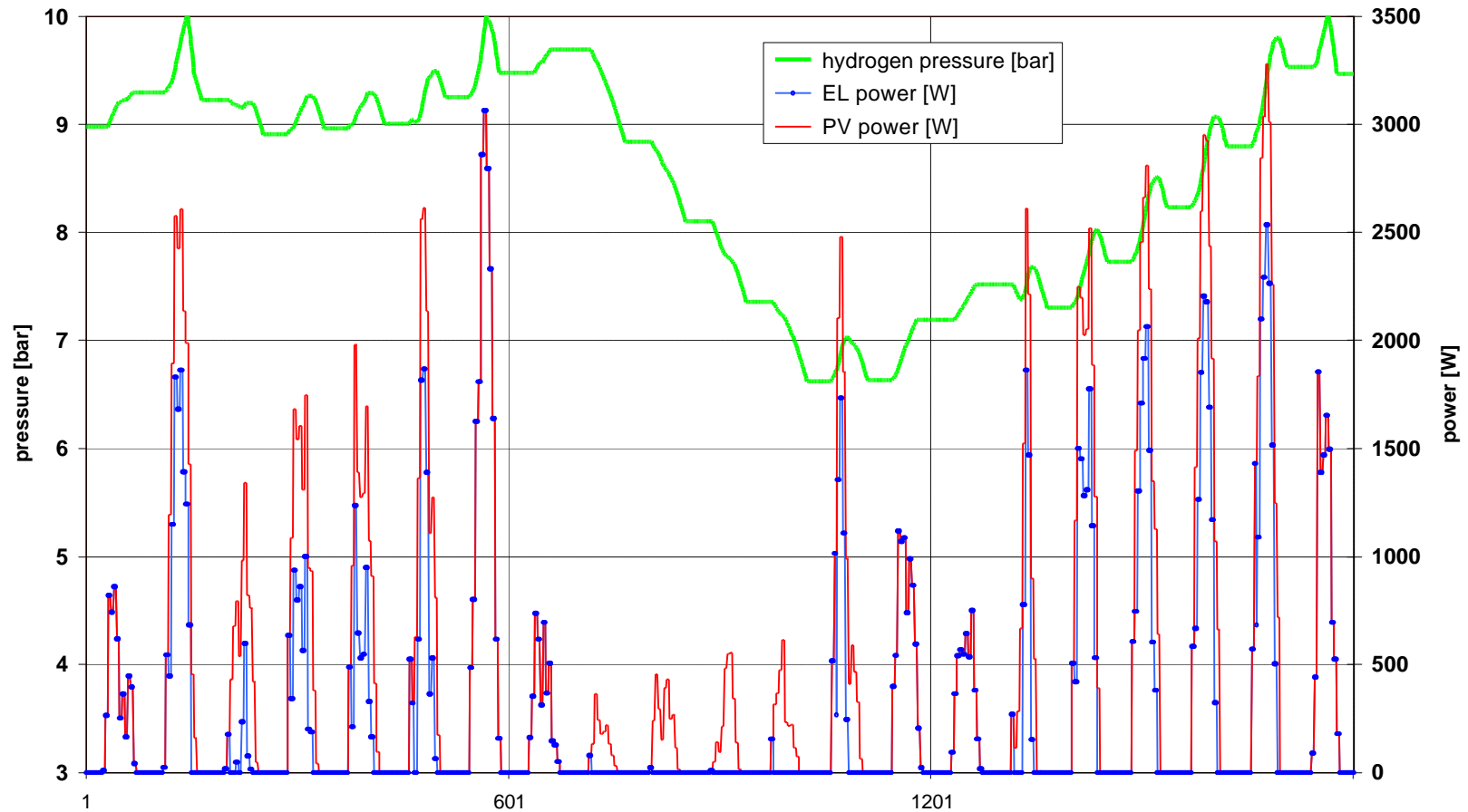
System
management

PV-FC-EL Results (I)



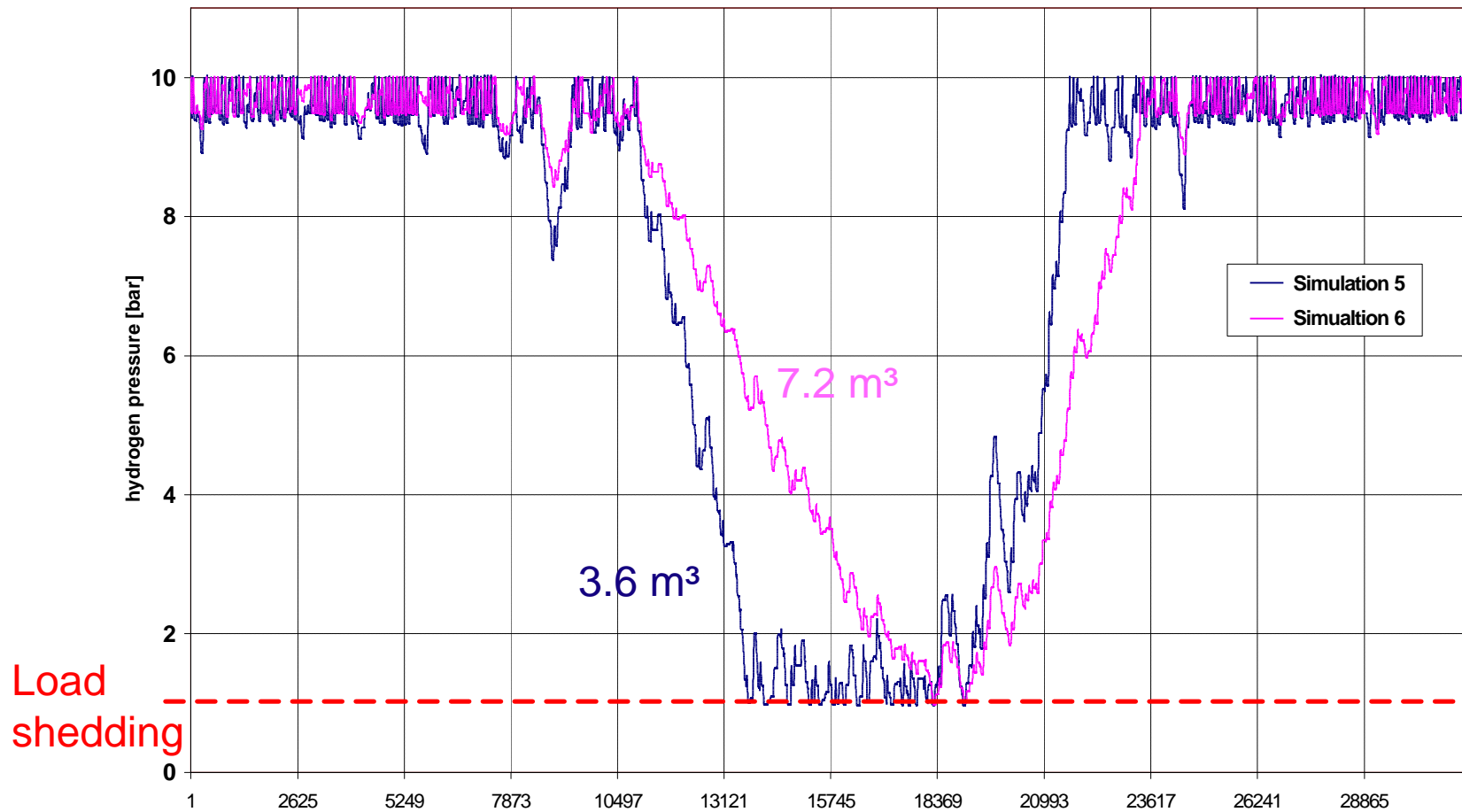
21 days in October in Milan, Italy

PV-FC-EL Results (II)



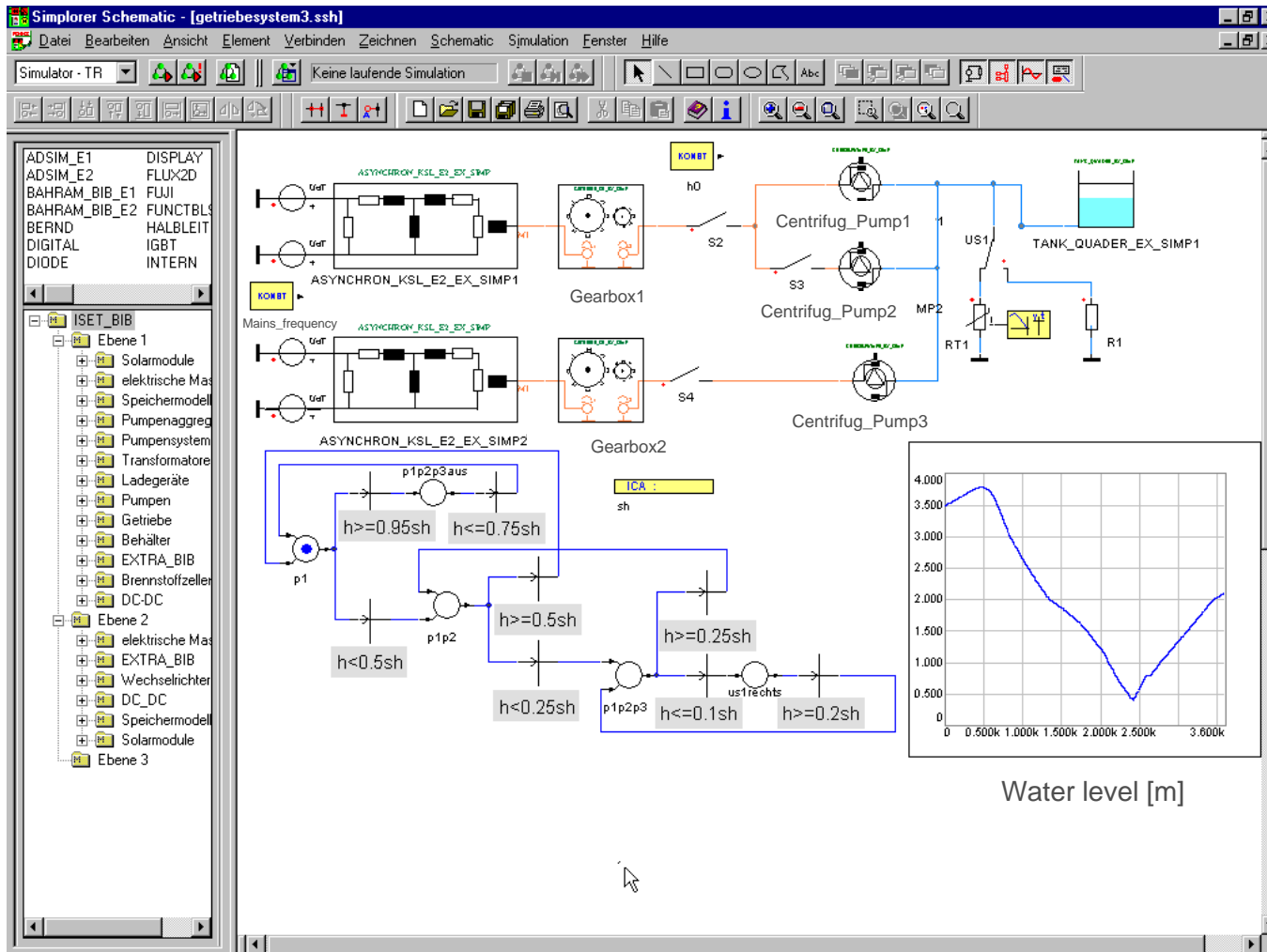
Hydrogen balancing

PV-FC-EL Results (III)

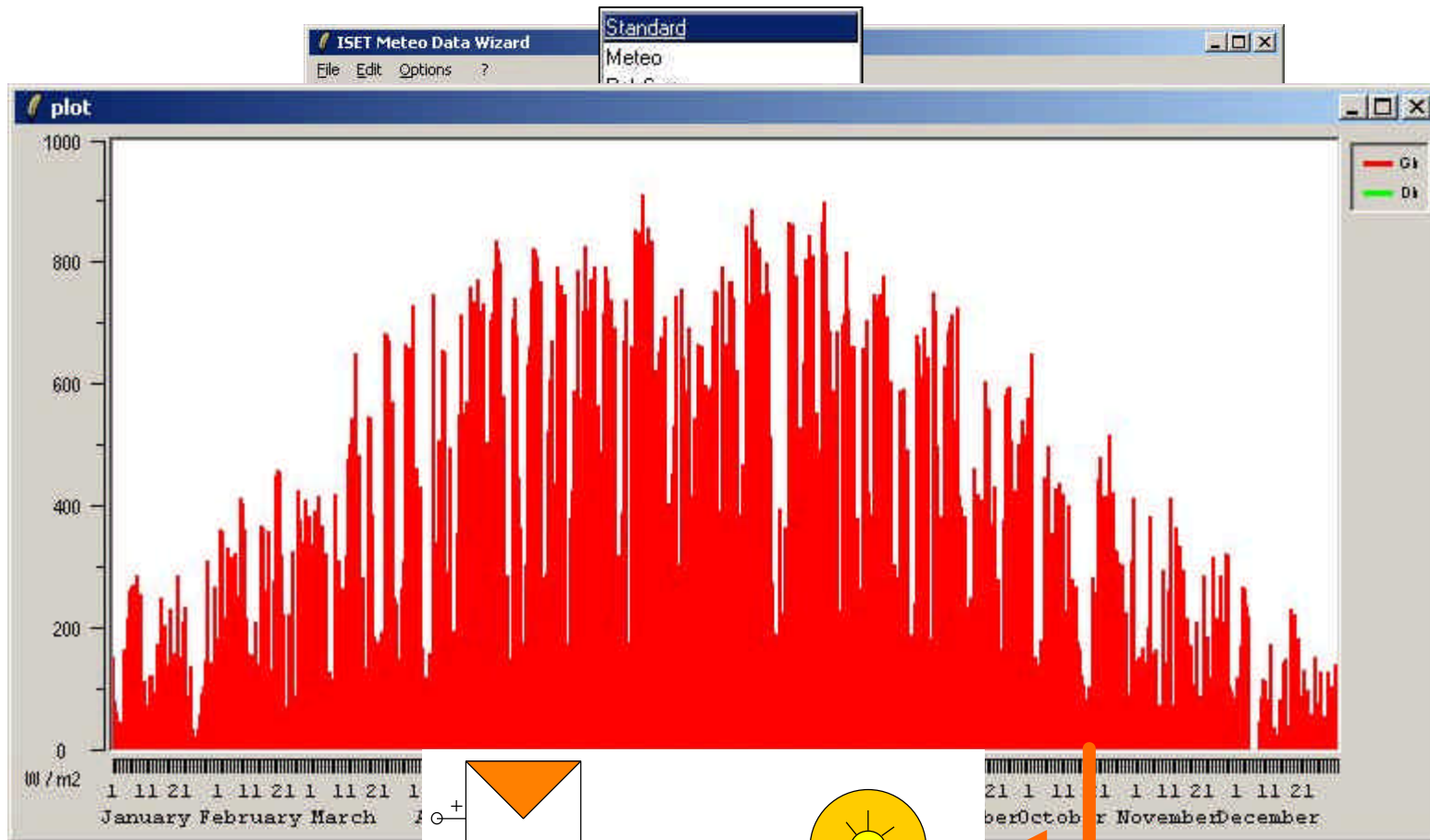


Variation of hydrogen gas tank volume

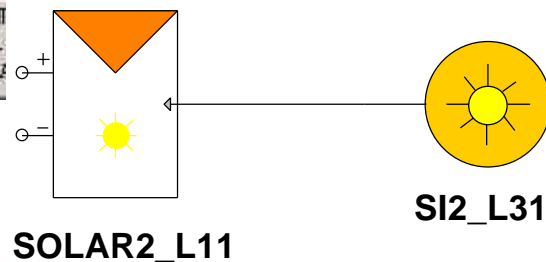
Dual Waterpump System



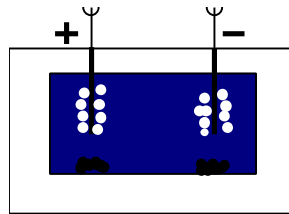
Import of Insolation Data



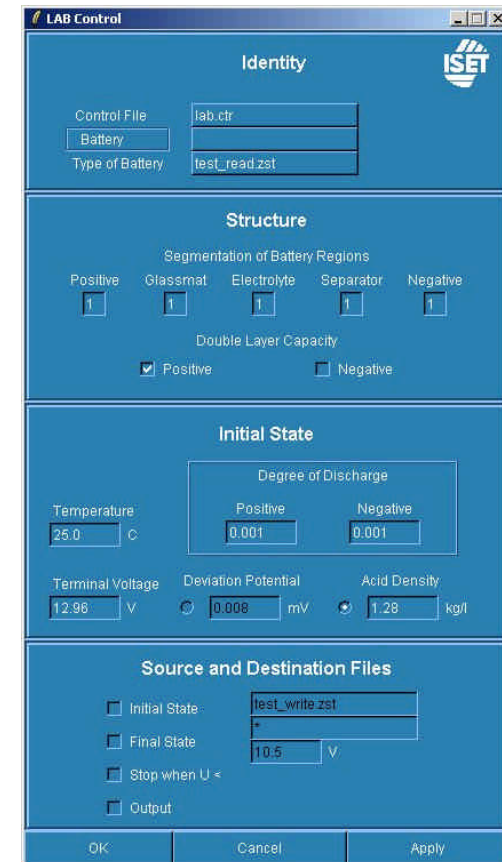
Data
rd



Bonus Feature: ISET-LAB Battery Model (Demo)



- ▶ Lead-acid battery model
 - ▶ bases on modeling of physical processes
 - ▶ useful for transient simulation up to charge balancing on long time scales
 - ▶ widely used in the automotive industry
- ▶ Demo version
 - ▶ fixed parameter set for a specific battery
 - ▶ fixed initial conditions at 20°C (68F)

A screenshot of the ISET-LAB Battery Model control interface. The window is titled "LAB Control" and has the ISET logo in the top right corner. The interface is divided into several sections:

- Identity:** Control File: lab.ctr; Battery; Type of Battery: test_read.zst
- Structure:** Segmentation of Battery Regions: Positive (1), Glassmat (1), Electrolyte (1), Separator (1), Negative (1); Double Layer Capacity: Positive, Negative
- Initial State:** Temperature: 25.0 °C; Degree of Discharge: Positive (0.001), Negative (0.001); Terminal Voltage: 12.96 V; Deviation Potential: 0.008 mV; Acid Density: 1.28 kg/l
- Source and Destination Files:** Initial State: test_write.zst; Final State: *; Stop when U <: 10.5 V; Output

Buttons for OK, Cancel, and Apply are at the bottom.

Conclusion

- ▶ SIMPLORER's Alternative Power Library
 - ▶ About 100 component models for alternative power design and more...
 - ▶ Three levels of detail for use in broad timescale range
 - ▶ Models provide connectivity to other SIMPLORER Multi-Domain components (mechanical, hydraulic,...)
 - ▶ Solar Data Wizard eases import of insolation data

