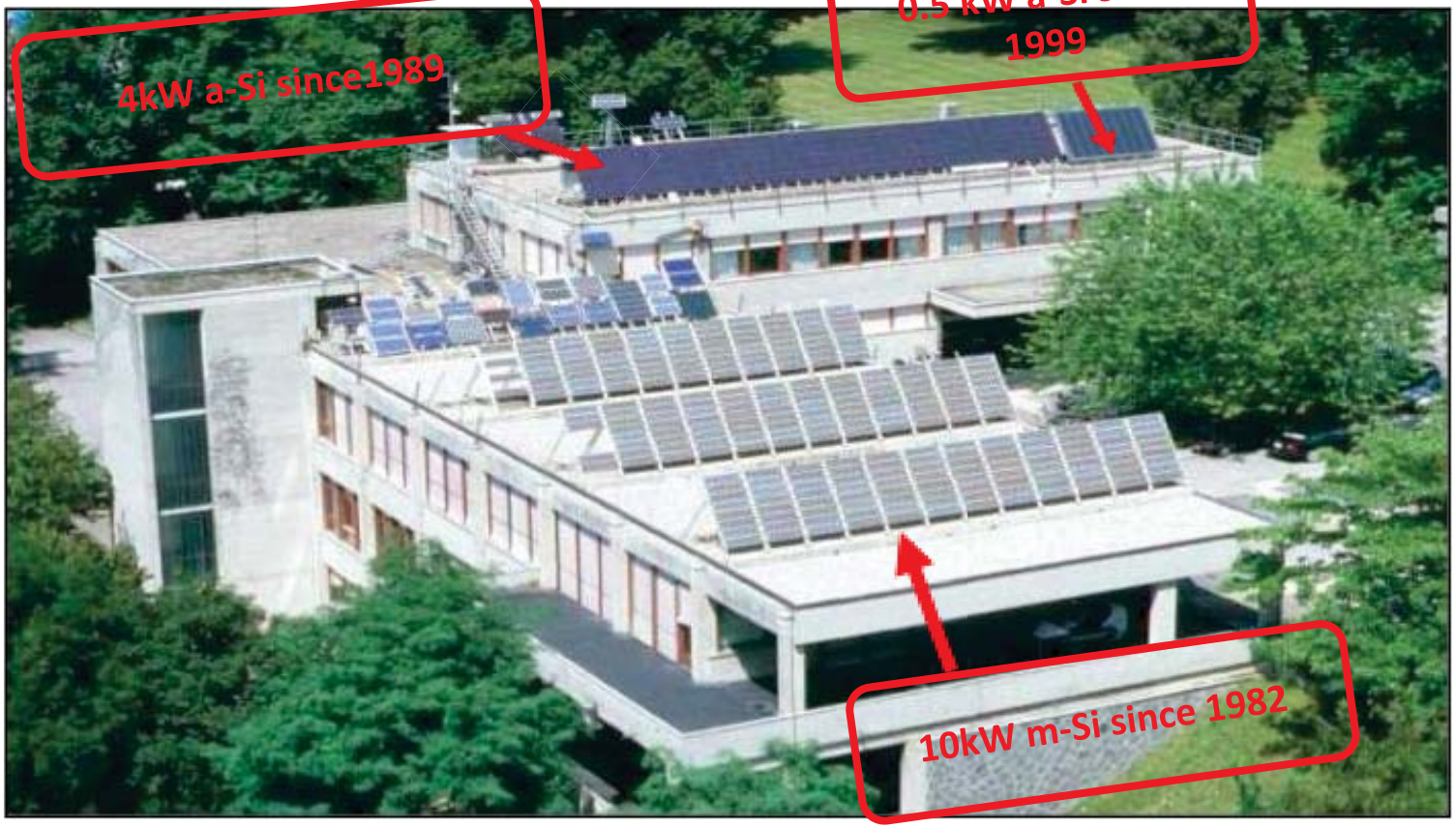
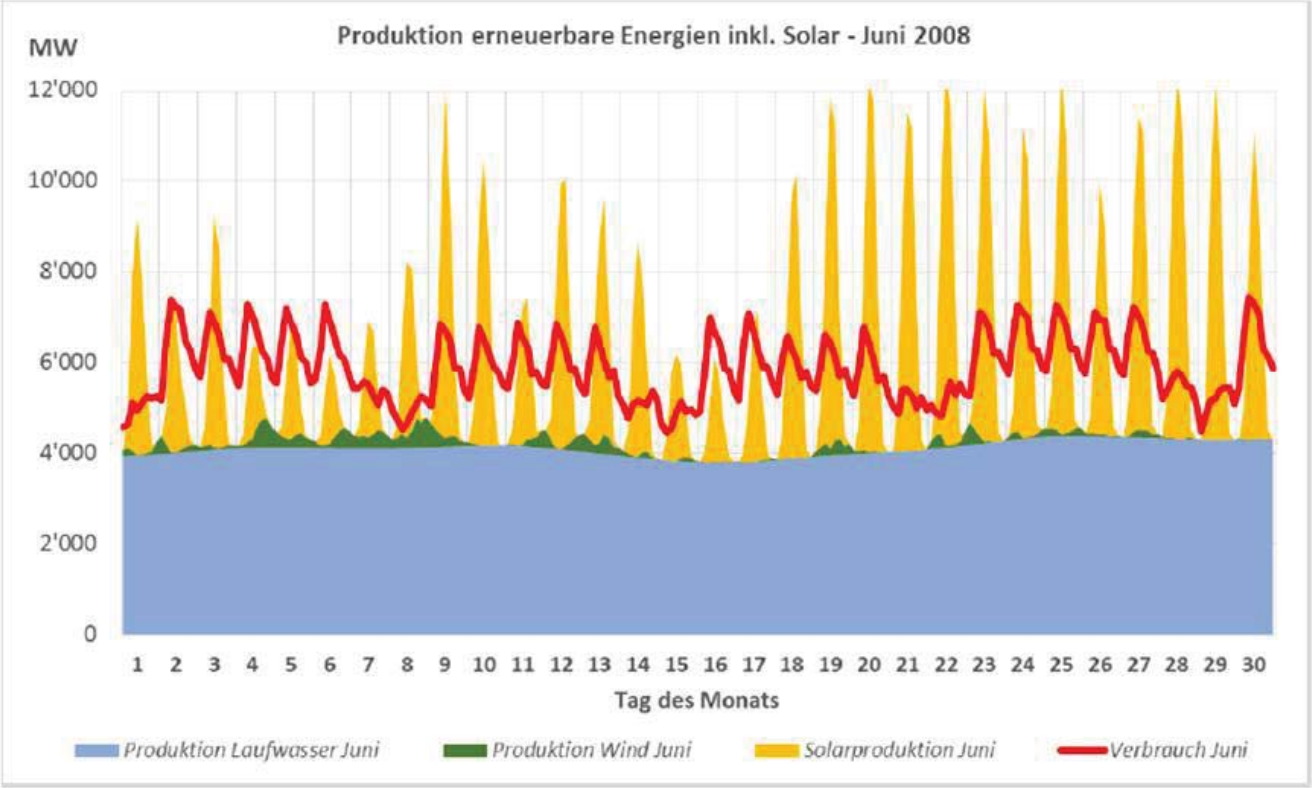
Background and starting point

First grid connected PV plant in Europe



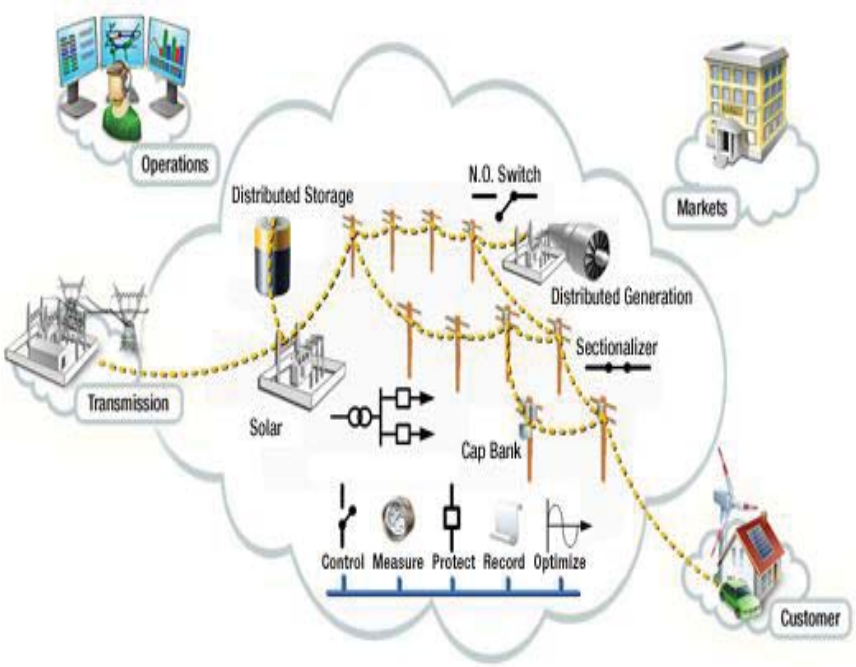
Increasing diffusion of PV will lead to heavy peaks in the grid



→ Massive increase in PV in the distribution grid

Source: swiss utility solutions

New Challenge for the management of the electrical grid



Smart Grids

- Internet of energy
- **Central control unit**
- Massive communication system
- Dynamic price models
- **Prosumers**
- Privacy and security problems
- **High up-front investments**

Smart Grids:
central versus decentralized load management

Mainstream

Centralized Control and load management based on a massive investment and use of ICT

SUPSI/GridSense

Decentralized load management based on local information from the grid and used in a self-learing algorithm (Decentralized intelligence)

IDSIA - Institute for Studies on Artificial Intelligence

The Economist

Artificial intelligence

Riders on a swarm

Mimicking the behaviour of ants, bees and birds started as a poor man’s version of artificial intelligence. It may, though, be the key to the real thing

Aug 12th 2010 | ROME

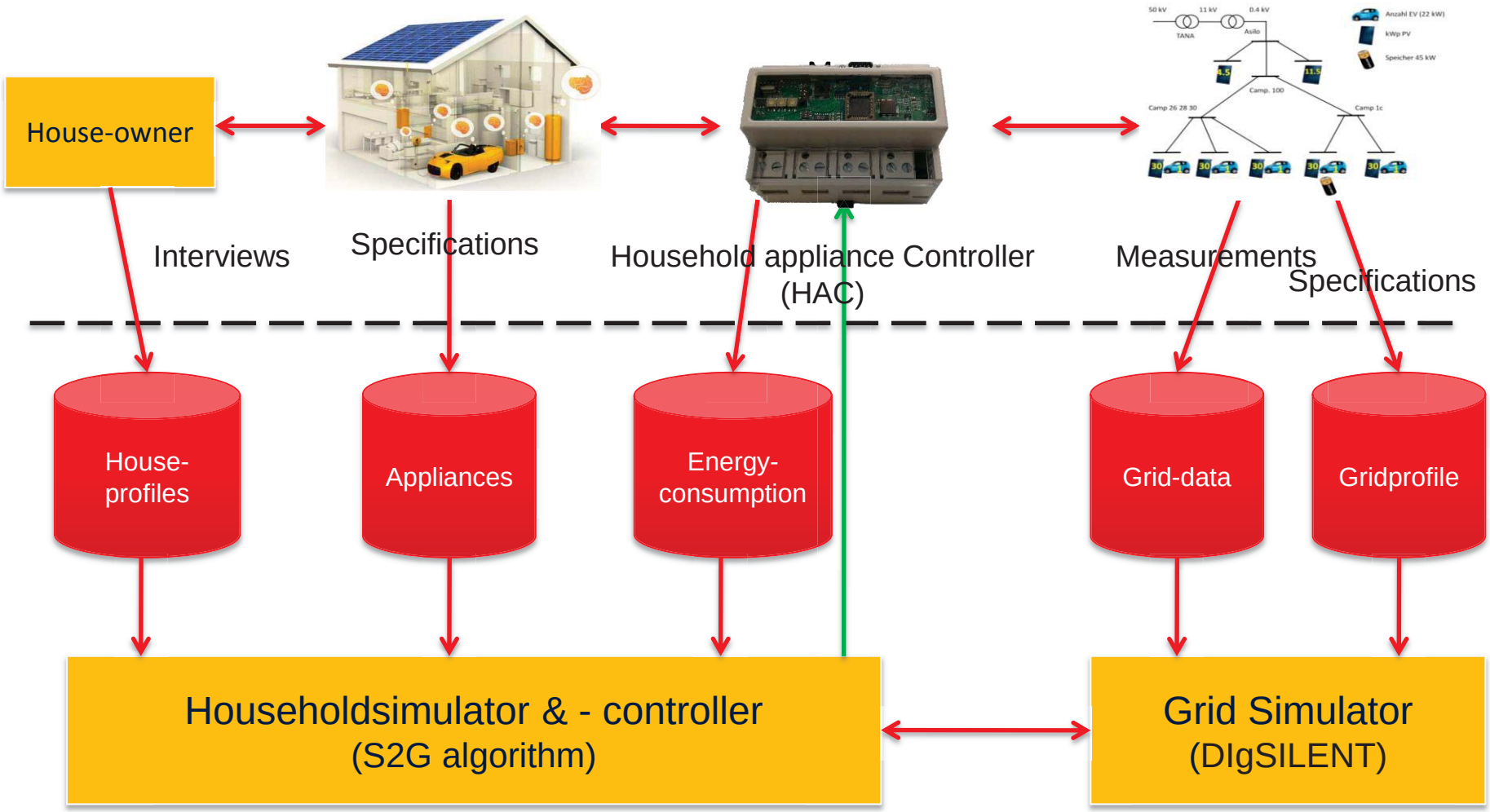
ONE of the bugaboos that authors of science fiction sometimes use to scare their human readers is the idea that ants may develop intelligence and take over the Earth. The purposeful

Istituto Dalle Molle di studi sull’intelligenza artificiale

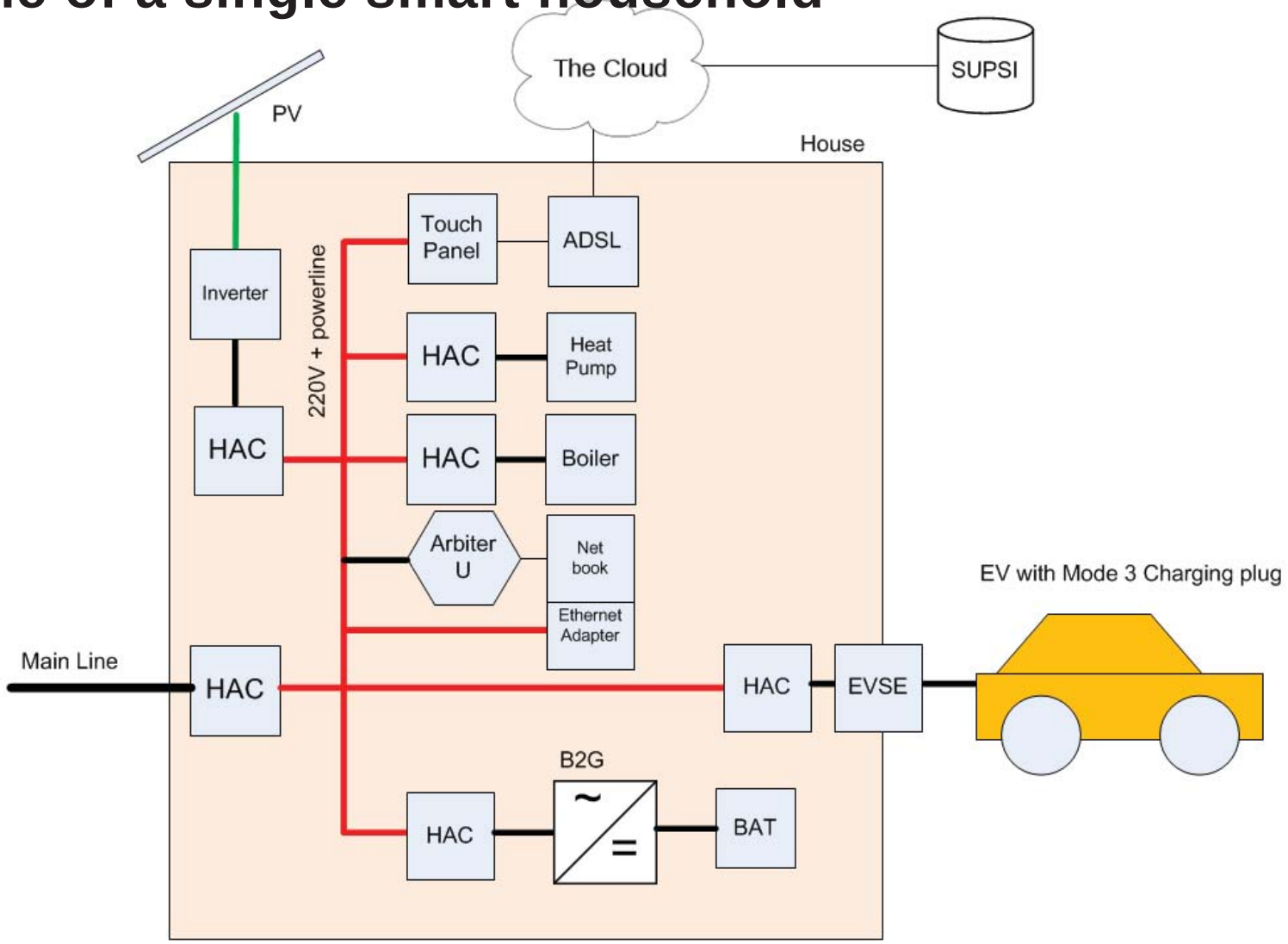
Google DEEPMIND

Pilot and Demonstrationproject in Ticino - Mendrisio

Elements of the system and interfaces



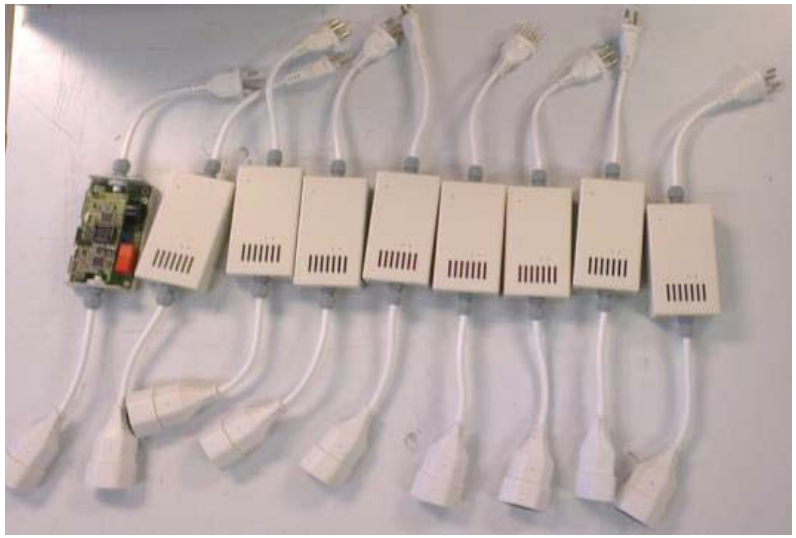
Scheme of a single smart household



HAC: Household Appliance Controller

3-phase HAC

- U, I, P, Q, Freq. Measurements
- Powerline echelon interface
- Relais output
- DIN mounting
- RS232 interface
- CANbus interface
- 2x Temperature sensor inputs
- SD Card



1-phase HAC

- U, I, P, Q, Freq. Measurements
- Powerline echelon interface
- Controllable power supply output
- Easy installation
- SD Card

Devolopment of „Smartmeters“ with algorithm based control mechanism

Microprocessor
Powerline communication: Neuron chip PL3170 using the standard ANSI/***EIA*** 709.2 (LON)
Data analysis: 32 bit ARM Cortex M3 CPU with RTC

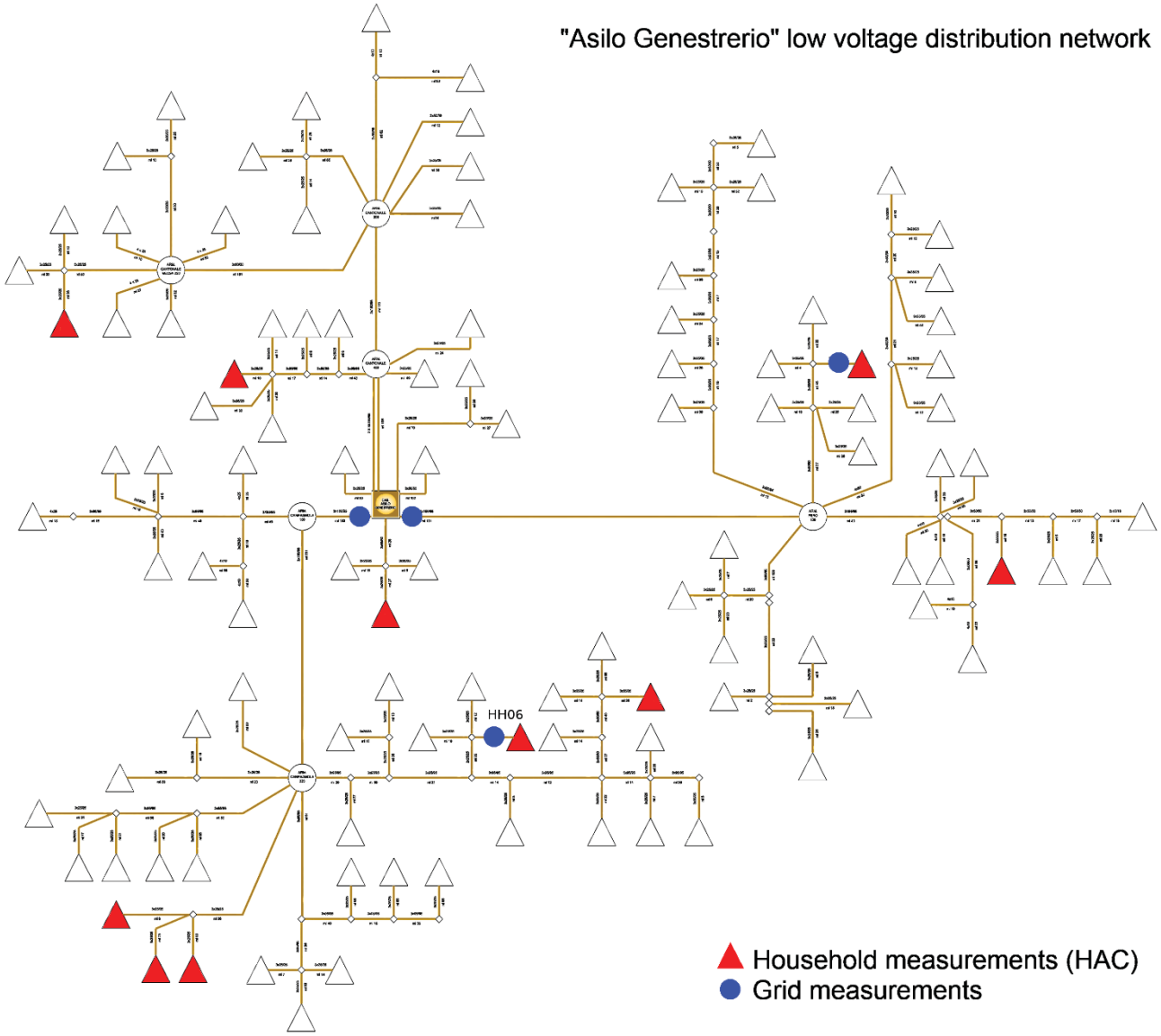
Memory
ARM: Up to 256 kByte FLASH, 64kByte SRAM
PL3170: 4Kbyte EEPROM, 2kByte RAM

Energy measurement
1-3 phase 4 quadrants (ST STPM)

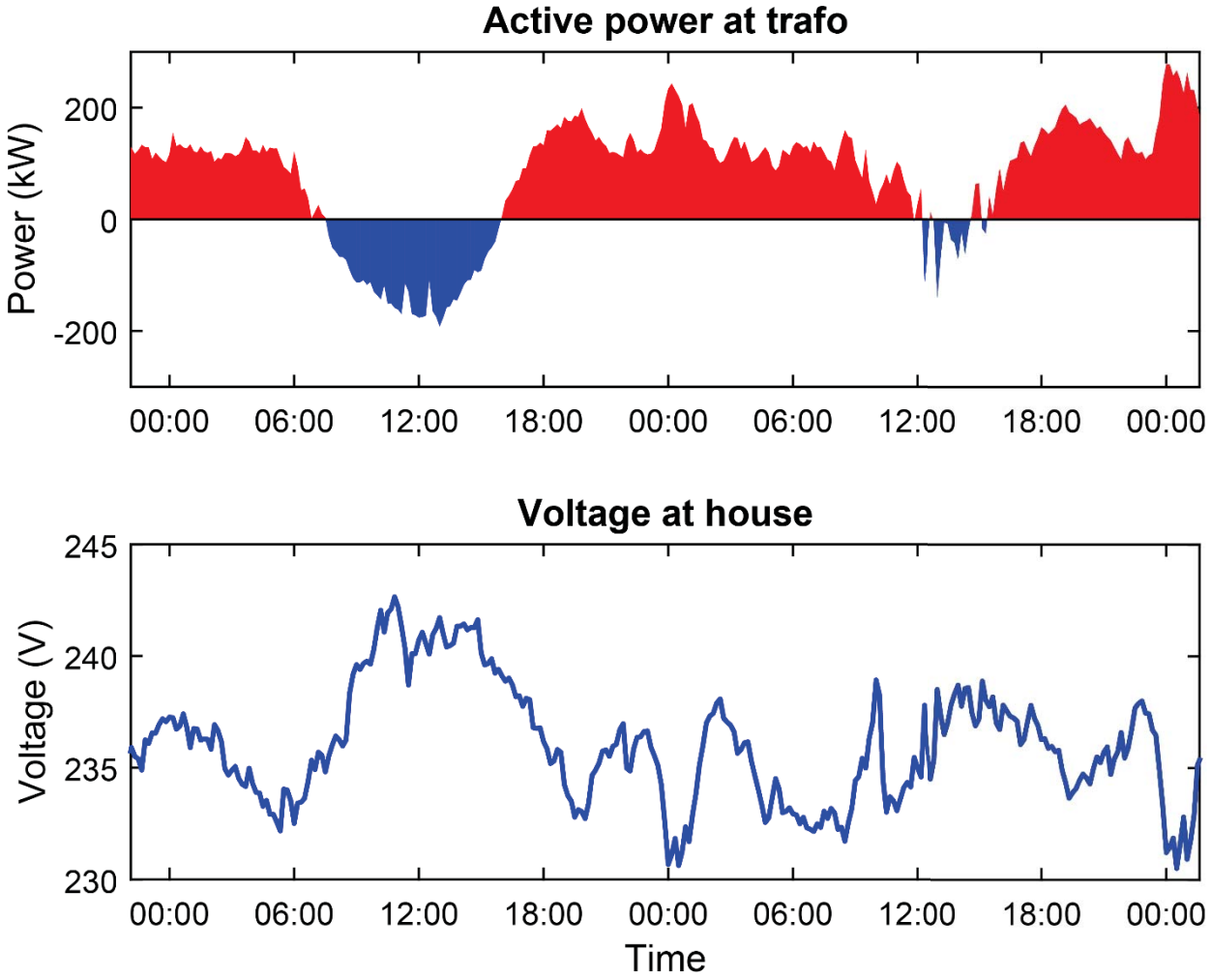
Voltage:	195-265V 0.1V Resolution 0,2% accuracy
Current:	0.1A to 25A 1% resolution and accuracy
Energy:	0.1% Wh accuracy over temperature and 2000:1 range
Stability:	10ppm/C (precision ultra-stable voltage reference)
Frequency:	49-51Hz, 1mHz resolution and accuracy
Phase:	0-360˚

Temperature Sensors
2 inputs -40...+100C range for serial digital Input (PWM)

Schematic design of the grid and points of measurement

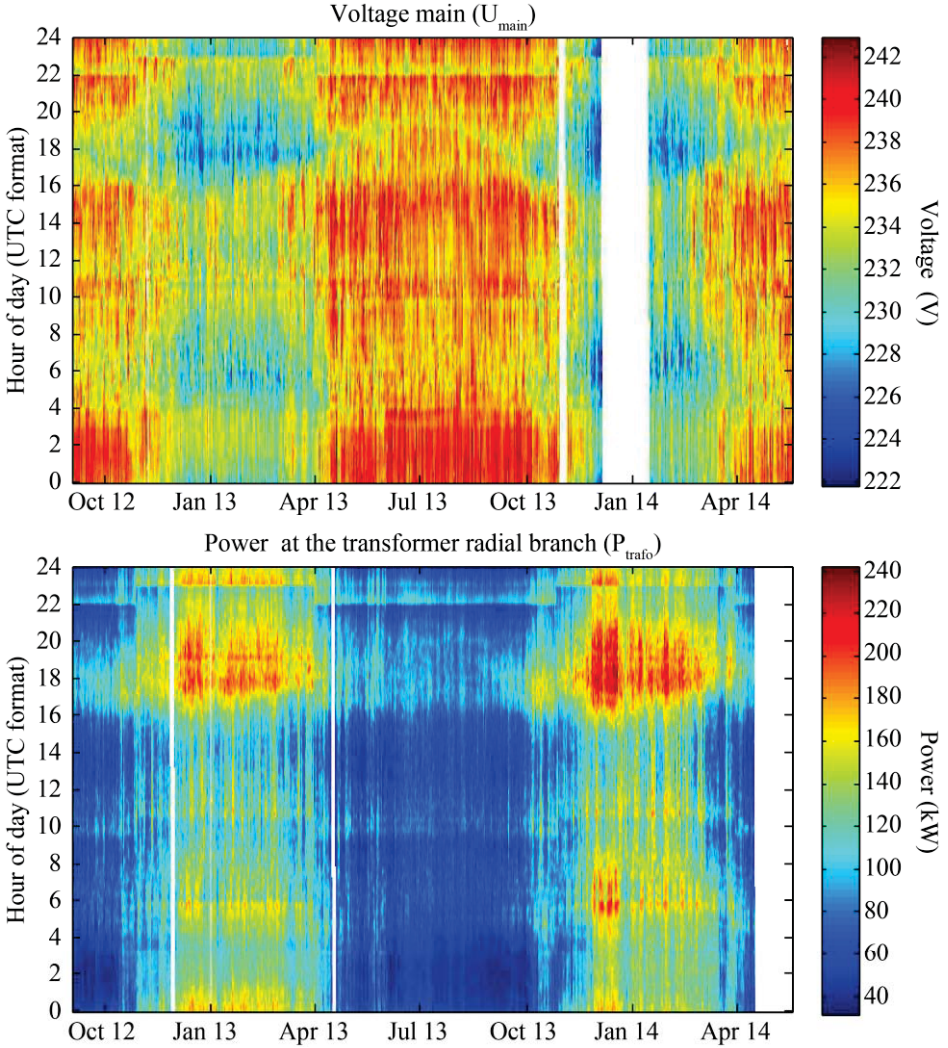


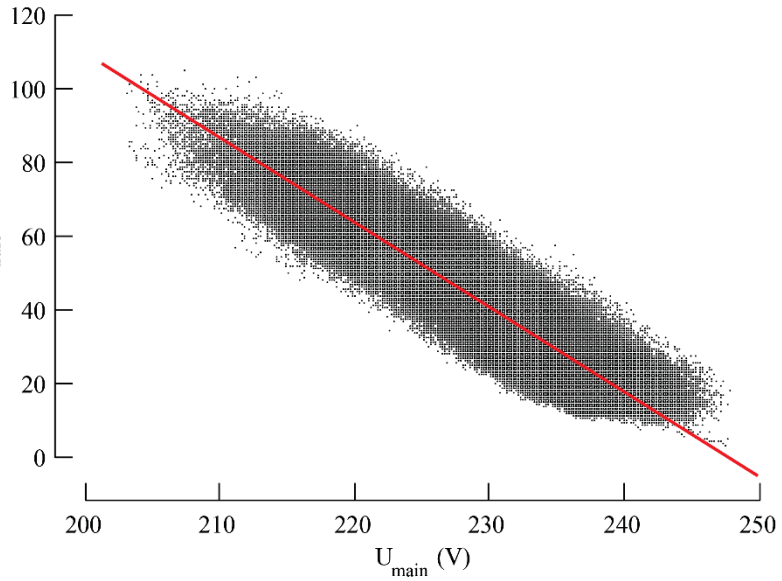
Impact of PV on power and voltage in the grid



Source: SUPSI-Measurements in the distribution grid

Voltage at the main meter versus the power at the transformer





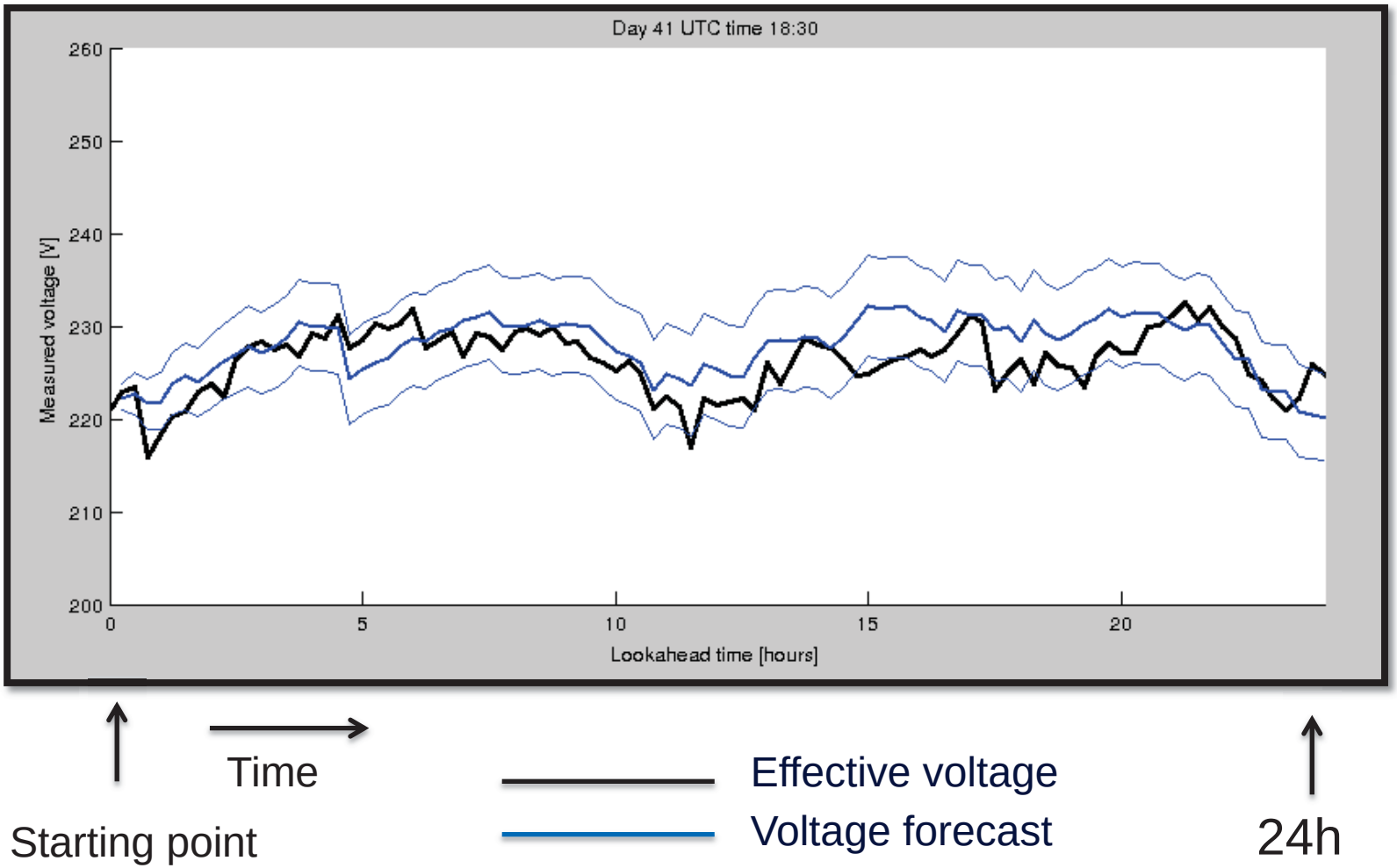
Statistical correlation between the voltage an the main plug in a house and the power at the transformator point

(R = -0.927)

Source : SUPSI – Data from the measurement in Mendrisio

Learning and forecasting multiobjective algorithm

24 hour forecast and 5 days of learing process for each appliance



Functionality of the algorithm

The algorithm controls with a dedicated software without communication the loading process of specific appliances (Boiler, thermal pump, electric vehicle, batteries) by :

- a constant learing and adaption process on the use of the appliances in the passed 5 days (user behaviour), according its technical characteristics and without limiting the comfort
- producing constantly forecasts on the voltage in the local grid for the next 24 hours
- planning the loading/unloading of the appliances under the given circumstances and by optimizing different/multiple objectives such as the energy costs, self-consumption and the grid stability leveling peakloads

Conclusions

- Local information can be used as input for the intelligent loadmanagement
- Independent and decentralized controlled appliances with the developed algortihm lead to a higher grid stability
- Extended use of decentralized algorithms can help to reduce investments in the extension of grid infrastructure without the need to build up a special ICT – infrastructure necessary in other smart grid approaches
- New market designs with power or voltage dependent tariffs would be important incentives for gridfriendly behaviour and loadmanagement

Thank you for your attention

www.supsi.ch/ISAAC