# An Architecture for Energy Management in Smart Appliances

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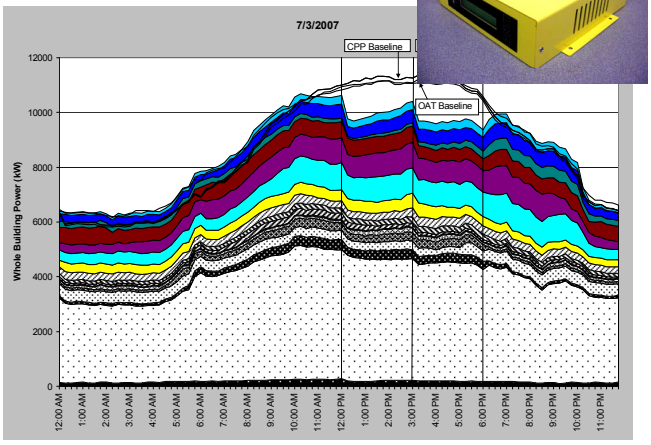
## Energy Management @ Home ?

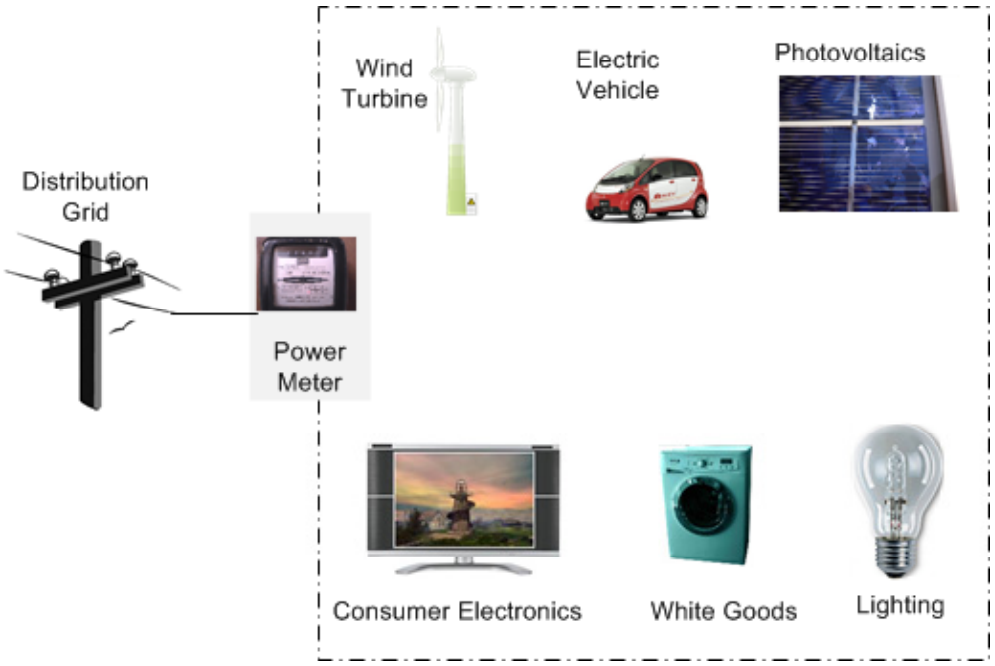
Energy management techniques are well known for large facilities.




But:

*Energy management for smaller buildings and environments has different, new and specific challenges!*

# Buildings and Environment



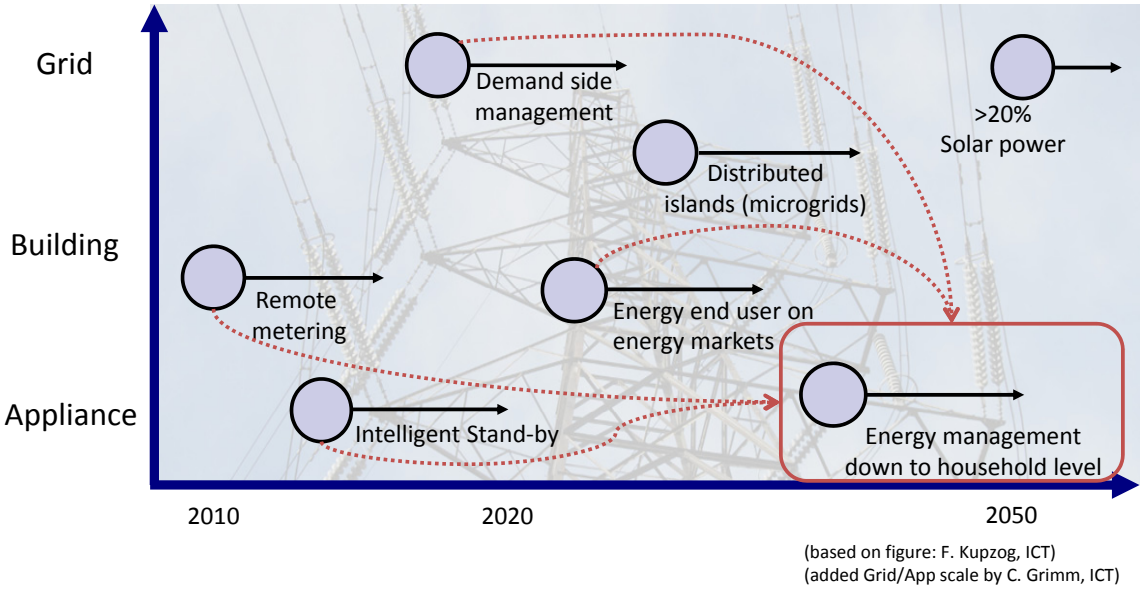





# Outline

- Energy Management in Buildings and Environments
- Requirements and Objectives
- SmartCoDe Architecture
- Outlook

# Energy Management Forecast




(based on figure: F. Kupzog, ICT)
(added Grid/App scale by C. Grimm, ICT)





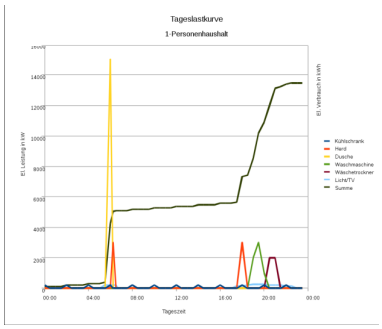
# Intelligent Standby

- Switches off services that are not needed.
  Principle well known e.g. from PC:
  - Appliances whose service is not needed are switched into „sleep“ state
  - Once a user needs service, device wakes up
- Appliance decides wheather service is needed. Required:
  - Many external sensor data
  - Dependable scenario recognition
  - Networking & remote control of appliances

# Remote Metering

Smart meter provides individual time profile of power consumption at home

**Power Grid:**
Smart meter is pre-conditioning for future time-dependent billing by Grid operator / ISO.





**Home/Office user:**
Information on usage of power (awareness).

*Future also:*
Association of consumption with appliances and services



# Demand Side Management in Buildings and Environment!

*Timely planning* of consumption of energy

- Generators:
  Grid, Wind Turbine, Photovoltaics, Electric Vehicle
- Plannable Consumers:
  HVAC, Electric Vehicle, Refrigerator, Oven, …
- Consumers with known use patterns:
  TV (evening, Sat/Sun), …
- Electric lighting, Other users
- Constraints: Cost of power – exchange of estimated/planned power consumption, power grid, weather forcast, …

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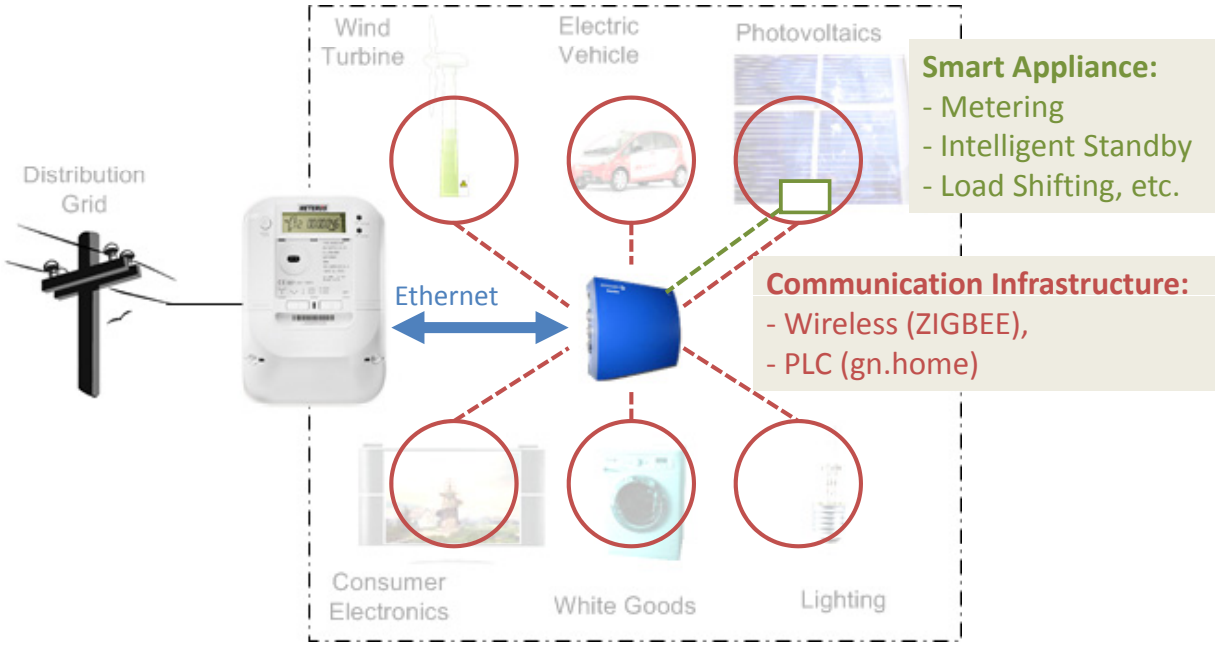
# Infrastructure for Energy Management in Buildings and Environment



# Low-Cost

We might want to make every single appliance „smart“

Thumbs rule - Embedded Systems in Consumer market cost up to 3.141 $

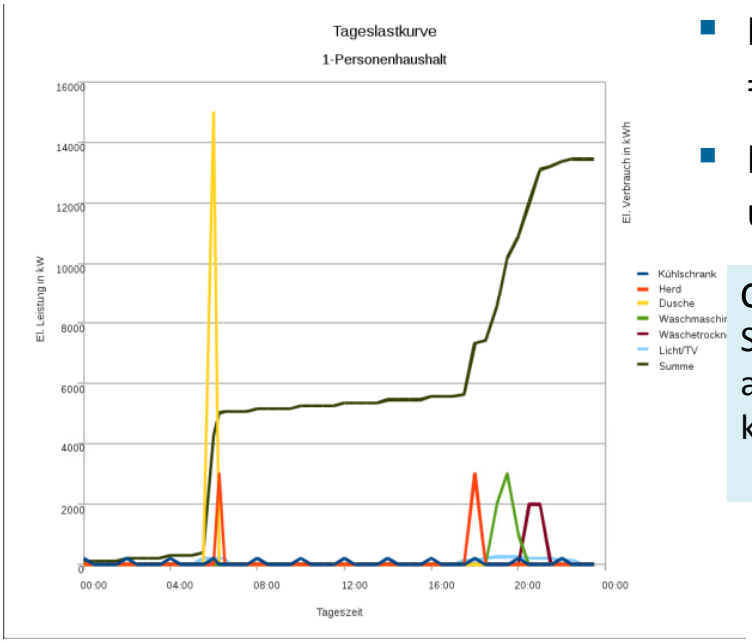

Consequences:

1. Only fully integrated (SoC, SiP) meet cost requirements!
2. Wireless communication or PLC?
   Wireless communication likely cheaper?





# Security and Privacy




- High potential for misuse
  => High security required
- Installation usually by uneducated staff

Consequences
Support for assignment of addresses and distribution of keys must be implemented!

# Ultra-Low Power Standby

- Permanent DSL connection 131 kWh/year (~Refrigerator!)
- 100s of nodes in small building, 100.000s in larger facilities
  - Standby, but able to communicate (~10mW) and wake up!
  - Standby power should be < 100mW
- Standby power is in conflict with cost efficiency!
  - 2 power supplys: 1 for low-power standby, 1 for operation
  - External components

**Consequences**
Integrated low-power power supply unit (PSU) that can operate grid-connected!





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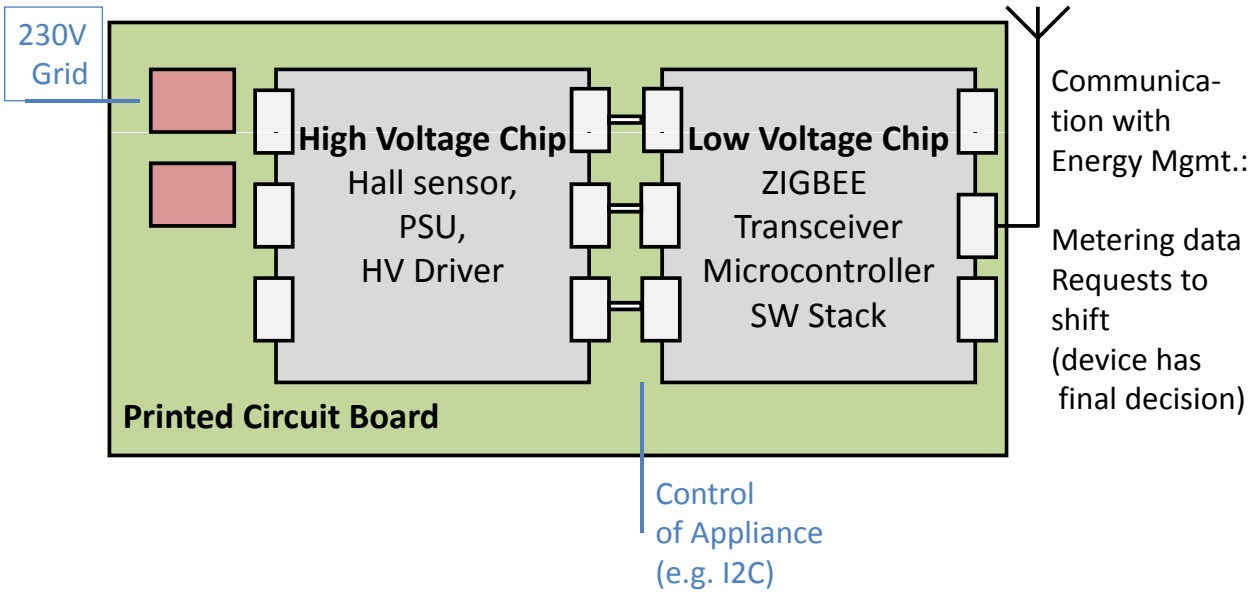
# SmartCoDe PCB demonstrator

~2 discrete components (Capacitors), 2 Integrated Circuits








# Communication

- SmartCoDe node uses ZIGBEE/RF communication (also PLC possible, but other project …)
- Structured network, mesh-routing possible (increases dependability)
- 1st prototype will use existing ZIGBEE chipset with adopted ZIGBEE communication profile

# High Voltage Chip

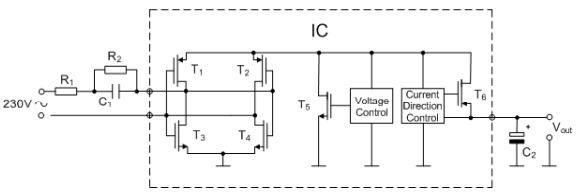
- PSU: Non isolated mains powered wireless node supply
  - Up to 100mW of output power at 3,3V output voltage
  - High efficiency
  - Mostly integrated
  - Ultra low standby consumption
  - Low EMI
- Sensor interface to hall sensor for power metering
- Driver for power switch (230 V), e.g. to switch main PSU on/off

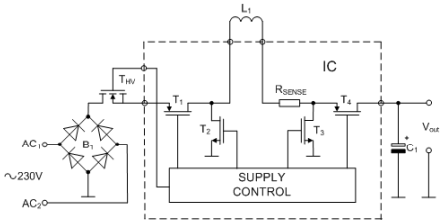




# Ultra Low Power Supply - Approaches

- Capacitive Approach
  - Efficiency of up to 85%
  - External X2 capacitor needed
  - Integrated rectifier bridge
  - 2nd stage SMPS needed
  - Low EMI
  - Reactive input power
- Switched Mode Approach
  - Efficiency of up to 90%
  - Efficiency / EMI tradeoff
  - External rectifier needed
  - External high voltage switch needed
  - Controlled input voltage utillization

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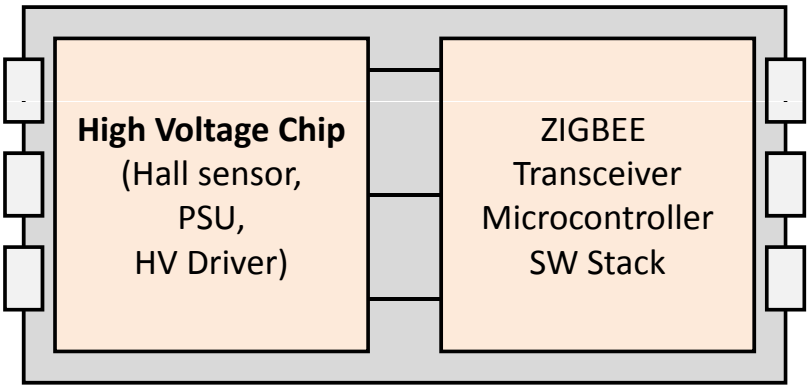
www.ict.tuwien.ac.at

# SmartCoDe SiP

- System in Package = „SiP“ – all in one package!



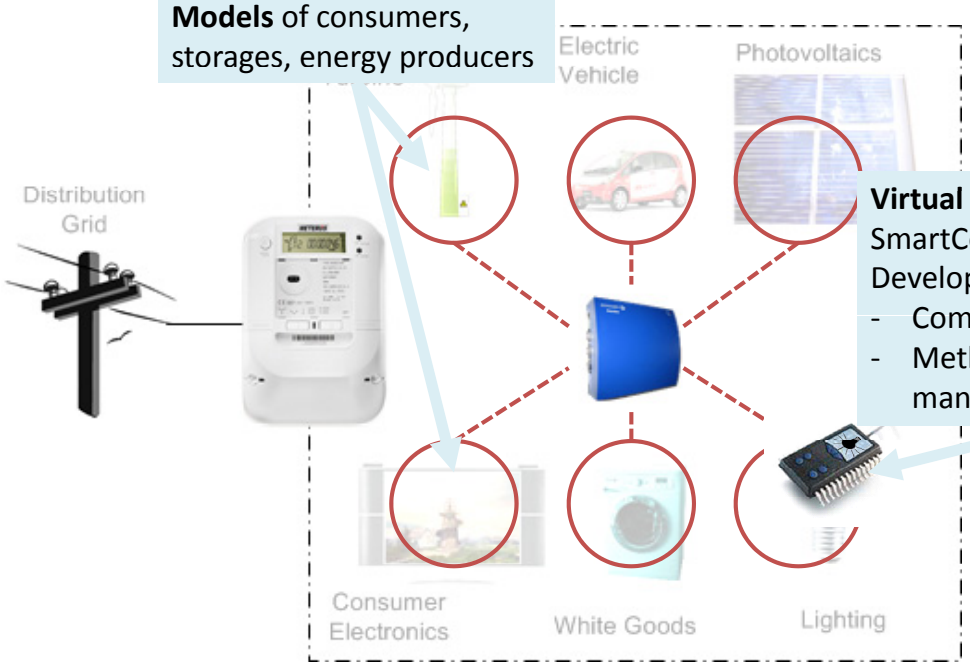

- „Dies“ (=Silicon chips) are in one package, connected by bonding wires





# Development tools

**Models** of consumers, storages, energy producers




**Virtual prototype** of SmartCoDe SiP for Development of
- Communication stack
- Methods for energy management

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- Results and Outlook





# SmartCoDe Virtual Prototype, PCB, SiP

SmartCoDe is work in progress!

- Available in 12/2010:
  - Virtual prototype for simulation of smart home
- Planned for 2011:
  - Demo Kit, PCP Prototype
  - Models of Consumers, Producers, …
- Maybe in 2012:
  - SiP Demonstrator

Overall Demonstration Site

# Thank you!