November 16, 2010

Vienna, Austria

SmartCoDe Expert Cooperation Workshop

organised by

edacentrum

Welcome to the SmartCoDe Expert Cooperation Workshop on Energy Efficiency in Buildings 2010!

The world must de-carbonize its energy production and consumption. But how? How can we achieve the necessary improvements in energy efficiency? How can we give consumers more visibility and control over consumption? How can local - often, unpredictable - renewable energy sources schedule their output for maximum efficiency? How can we optimize the mix of local energy production and the main power grid for maximum efficiency? How do we manage energy consumption at the building level - and even at the level of individual home appliances and office equipment? Just how do we implement intelligent demand management and smart metering and also protect them from malicious hack attacks? And how do we implement building-level energy storage?

This workshop discusses how. The workshop - the first of three between now and 2012 - is ideal for anyone who wants a better understanding of the technological and market requirements that affect these issues. It is given by industry experts and prestigious academics involved in the SmartCoDe project.

I hope you will enjoy the event!

Peter Neumann
Project Coordinator

SmartCoDe has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013]) under grant agreement n°247473

SmartCoDe Expert Cooperation Workshop 2010

Agenda

Time	Modul	Speaker
8:30	Registration / Coffee	edacentrum
9:30	Welcome	P. Neumann / Dr. C. Hansen edacentrum
9:40	Keynote: Global Energy Perspectives and the Role of New Technologies	Prof. Dr. N. Nakicenovic Vienna University of Technology
10:25	Energy Forecasting for Distributed Generation in Local Energy Neighbourhoods	Dr. T. Bertényi Quiet Revolution Ltd.
10:55	**Coffee break**	
11:25	Invited Paper: Building Simulation and Control	Dr. G. Zucker Austrian Institute of Technology
11:55	Smart Energy Management	Prof. Dr. F. Schmidt, ennovatis GmbH
12:25	**Lunch / Coffee**	
13:45	Keynote: Electric Energy Storage in Smart Buildings	Dr.-Ing. B. Lenz Next Energy
14:30	Security Considerations for SmartCoDe Network	J. Hájek Ardaco, s.a.
15:00	**Coffee break**	
15:30	An Architecture for Energy Management in Smart Appliances	Prof. Dr. C. Grimm Vienna University of Technology
16:00	SmartCoDe - On the Way to a Miniaturised Wireless Sensor Node for Monitoring and Control of Appliances	T. Herndl Infineon Technologies Austria AG
16:30	Closing words	Dr. C. Hansen edacentrum
16:40	**End**	

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Keynote:
Global Energy Perspectives and the Role of New Technologies
Prof. Dr. N. Nakicenovic (Vienna University of Technology)

Nebojsa Nakicenovic is Professor of Energy Economics at the Vienna University of Technology, Deputy Director of the International Institute for Applied Systems Analysis (IIASA), and Director of the Global Energy Assessment (GEA). Among other positions, Prof. Nakicenovic is member of the United Nations Secretary General Advisory Group on Energy and Climate Change; Member of the Advisory Council of the German Government on Global Change (WBGU); Member of the Advisory Board of the World Bank Development Report 2010: Climate Change; Member of the International Council for Science (ICSU) Committee on Scientific Planning and Review, and Member of the Global Carbon Project; Member of the Energy Sector Management Assistance Program (ESMAP) Expert Panel on Sustainable Energy Supply, Poverty Reduction and Climate Change; Member of the Panel on Socioeconomic Scenarios for Climate Change Impact and Response Assessments; Member of the Renewable Energy Policy Network for the 21st Century (REN21) Steering Committee; and Chair of the Advisory Board of OMV Future Energy Fund (Austrian oil company).

He is also on Member of Editorial Boards of the International Journal on Technological Forecasting and Social Change, International Journal on Climate Policy, the International Journal of the Institution of Civil Engineers, and the International Journal of Energy Sector Management.

Prof. Nakicenovic was a Coordinating Lead Author of the Intergovernmental Panel on Climate Change (IPCC), the Fourth Assessment Report, 2002 to 2007, Coordinating Lead Author of the Millennium Ecosystem Assessment, 2001–2005, Director, Global Energy Perspectives, World Energy Council, 1993 to 1998, Convening Lead Author of the Second Assessment Report of the Intergovernmental Panel on Climate Change, 1993 to 1995, Convening Lead Author of the IPCC Special Report on Emissions Scenarios, 1997 to 2000, Lead Author of Third Assessment Report of the IPCC, 1999 to 2001, Convening Lead Author of the World Energy Assessment: Energy and the Challenge of Sustainability, 1999 to 2000, Member of the International Science Panel on Renewable Energies (ISPRE), 2006 to 2008, and Guest Professor at the Technical University of Graz, 1993–2003.

Prof. Nakicenovic holds bachelor's and master's degrees in economics and computer science from Princeton University, New Jersey, USA and the University of Vienna, where he also completed his Ph.D. He also holds Honoris Causa Ph.D. degree in engineering from the Russian Academy of Sciences.

Among Prof. Nakicenovic's research interests are the long-term patterns of technological change, economic development and response to climate change and, in particular, the evolution of energy, mobility, information and communication technologies.

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Abstract
The last two centuries of unprecedented development in the world have improved human condition enormously. The gross world product now stands at almost ten thousand dollars per capita, which is sufficient to provide for a good average quality of life. However, at the same time, inequities are increasing and the “bottom billion” has to live on barely a dollar a day. A predominant social issue that is increasingly becoming a major preoccupation for world leaders is addressing social inequality and poverty, especially in the developing world. These contrasting developmental patterns have not only resulted in increasing gaps between the poor and the rich but also in adverse environmental impacts on all scales, from indoor air pollution to climate change and biodiversity loss. Fundamental, game-changing transformations are needed for a shift toward more sustainable development paths. By significant investment in new technologies and decarbonization multiple co-benefits can be achieved – from provision of affordable access to modern energy and creation of new business and economic opportunities to addressing the threat of climate change. Global energy perspectives will be presented that addresses these paradigm-changing, multiple energy challenges toward more sustainable futures.

Decarbonization of the global economy toward a carbon-free future is such a paradigm-changing transformation. In the energy area, this implies a shift from traditional energy sources, in the case of those who are excluded from access, to clean fossils and modern renewable energy, and in the more developed parts of the world a shift from fossil energy sources to carbon-free and carbon neutral energy services. In all cases this means a vigorous improvement of energy efficiencies, from supply to end use, expanding shares of renewables, more natural gas and less coal, vigorous deployment of carbon capture and storage, and in some cases (where it is socially acceptable and economically viable) also nuclear energy.

All of these energy supply technologies need to mesh with emerging innovations in energy networks and end use in direction of smart integration. This would occur at a number of levels, from local and distributed to centralized generation. The very nature of energy end use is undergoing fundamental transformation as well toward more self-organization and internet-like structures and integration.

The emerging new energy systems require two complementary co-evolutions – one is technological and the other institutional. With new technologies and systems, new business models and institutional arrangements will emerge. All of these complementary and co-evolving transformations will require market, regulatory and behavioral changes.

The cumulative nature of technological and associated institutional changes, all compounded by deep uncertainties, require innovations to be adopted as early as possible in order to lead through experimentation and evolutionary changes to lower costs and wider diffusion in the following decades. The longer we wait to introduce these advanced technologies, the higher the required costs and emissions reduction will be as well as the “lock-in” into the old structures. The transformational change toward more sustainable futures requires enhanced research, development and deployment (public and private) efforts as well as early investments to achieve accelerated diffusion and adoption of advanced energy technologies and systems.

The ever more evident crisis of the “old” development patterns is an opportunity for the “new” ones to emerge.

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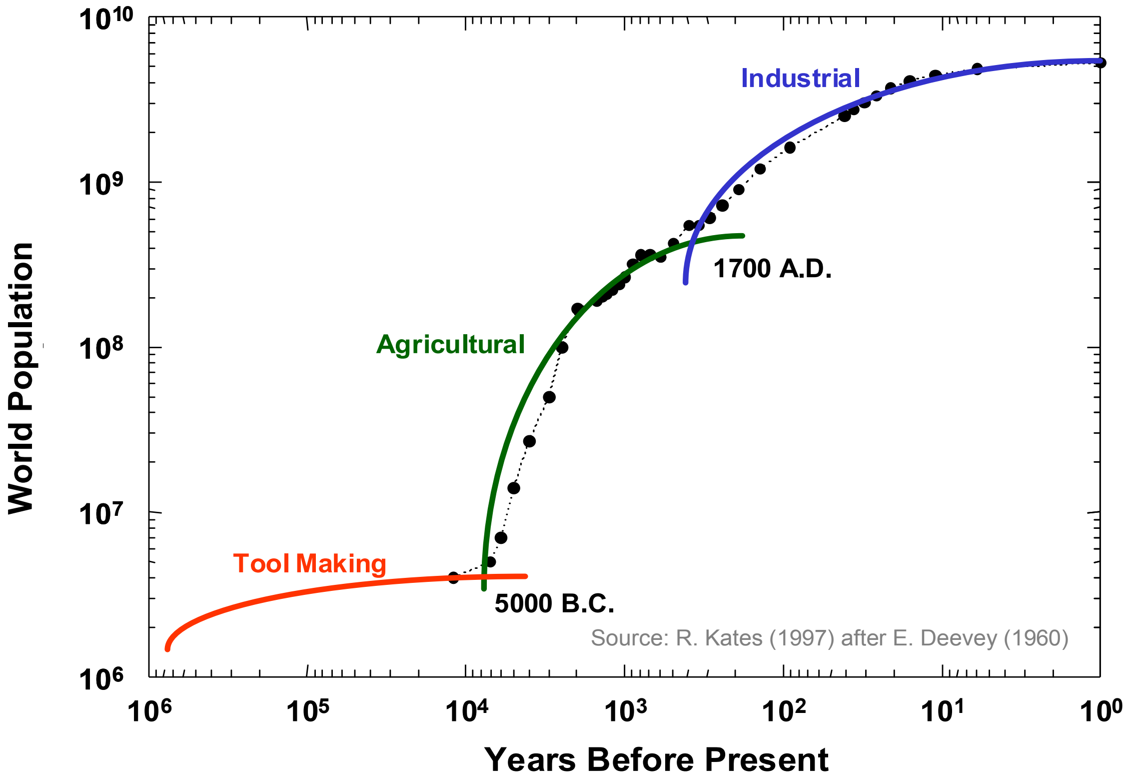
Global Energy Perspectives and the Role of New Technologies

Nebojša Nakićenović
Technische Universität Wien
International Institute for Applied Systems Analysis
naki@eeg.tuwien.ac.at

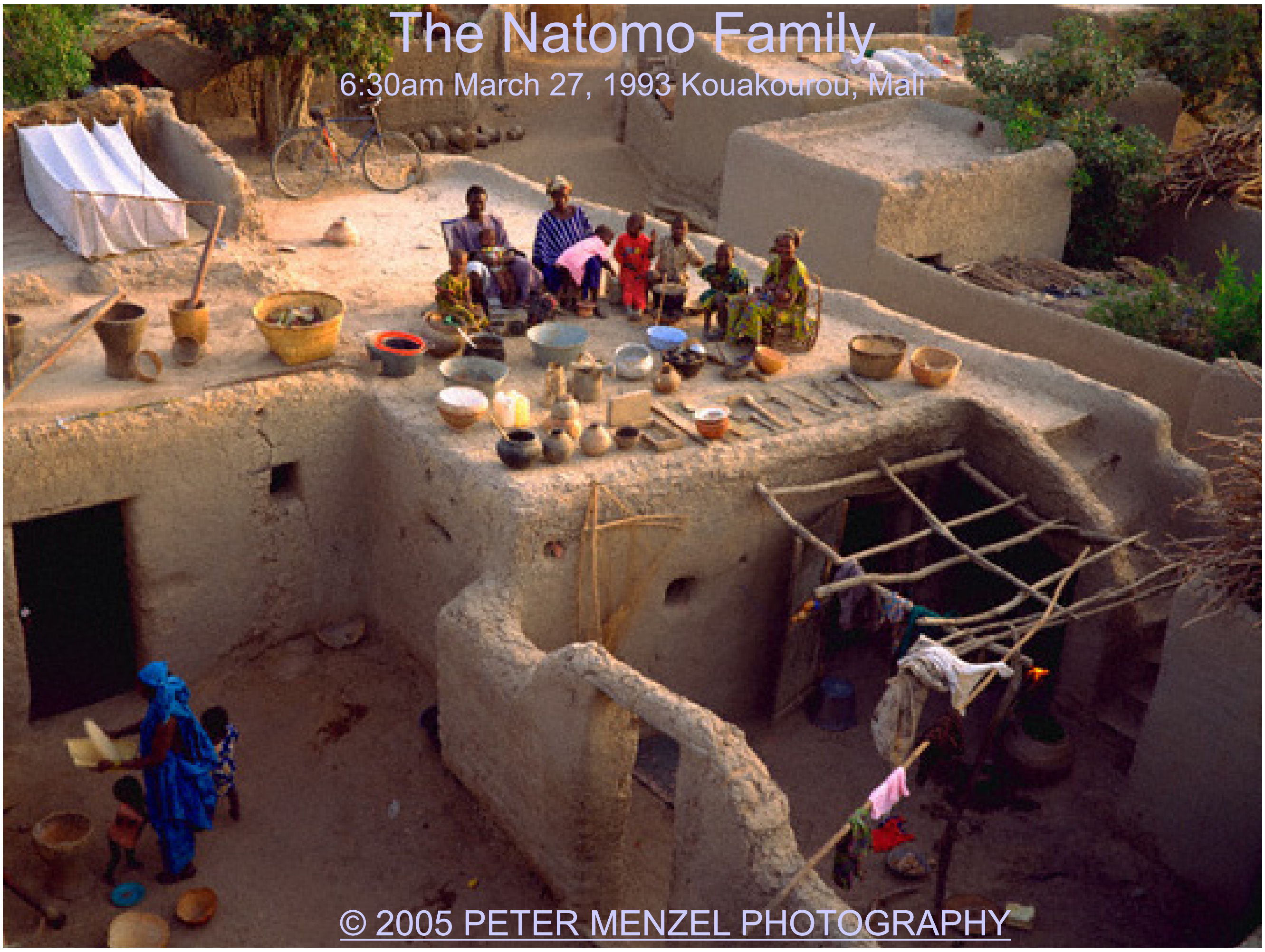
SmartCoDe Expert Cooperation Workshop 2010, Vienna – 16 November 2010

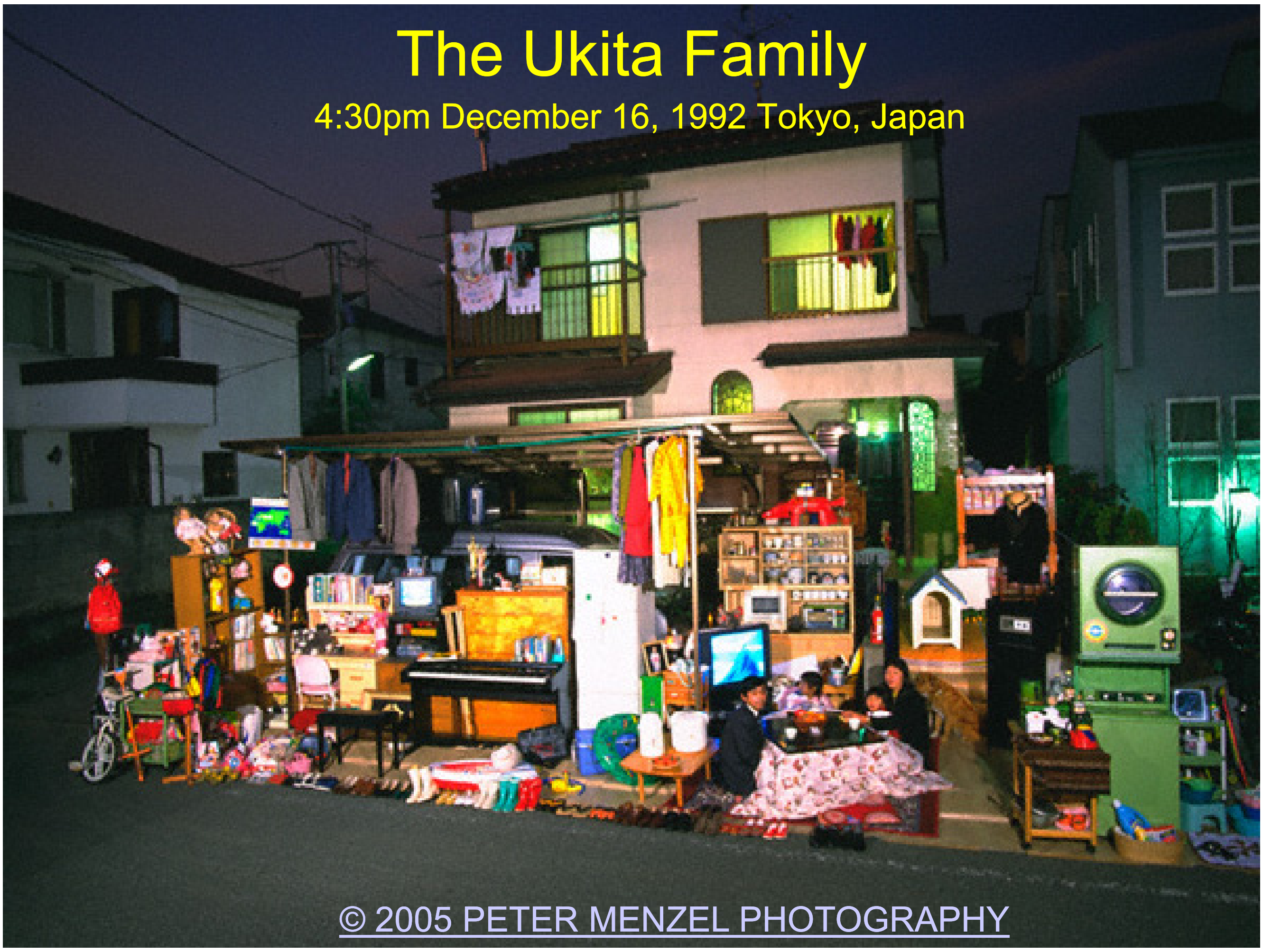
New Worlds: Grand Transformations



Global Energy Transformations

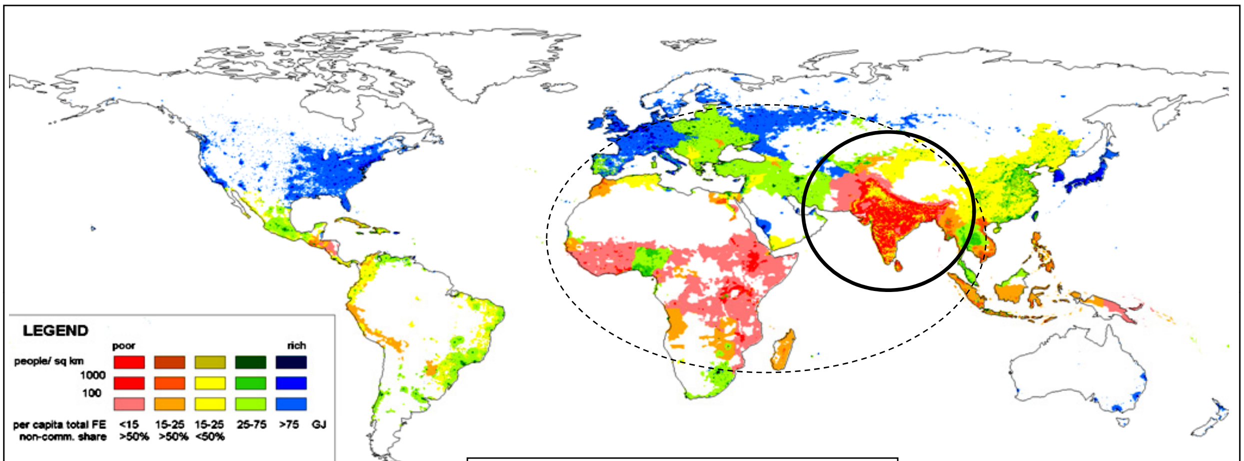
- Access to energy and ecosystem services (a prerequisite for MDGs & wellbeing)
- Vigorous decarbonization for mitigating climate change brings multiple co-benefits
- Energy transformations require R&D and rapid technology diffusion & deployment
- Sustained energy investments are needed and would result in multiple co-benefits





Mapping Energy Access

Final energy access (non-commercial share) in relation to population density



Billions of people:

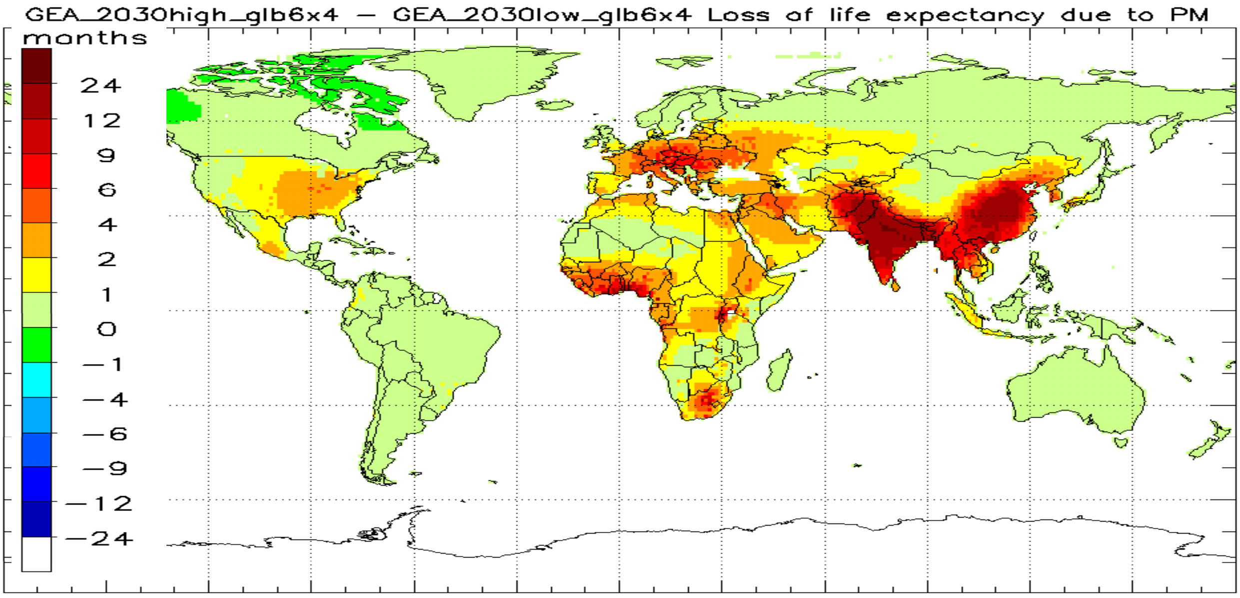
Abject poverty: 1.3
Poor: 0.6
Less poor: 1.4
3.3

Middle class: 1.4
Rich: 1.2
2.8

Source: Gruebler et al, 2009

Health Benefits of Pollution Control

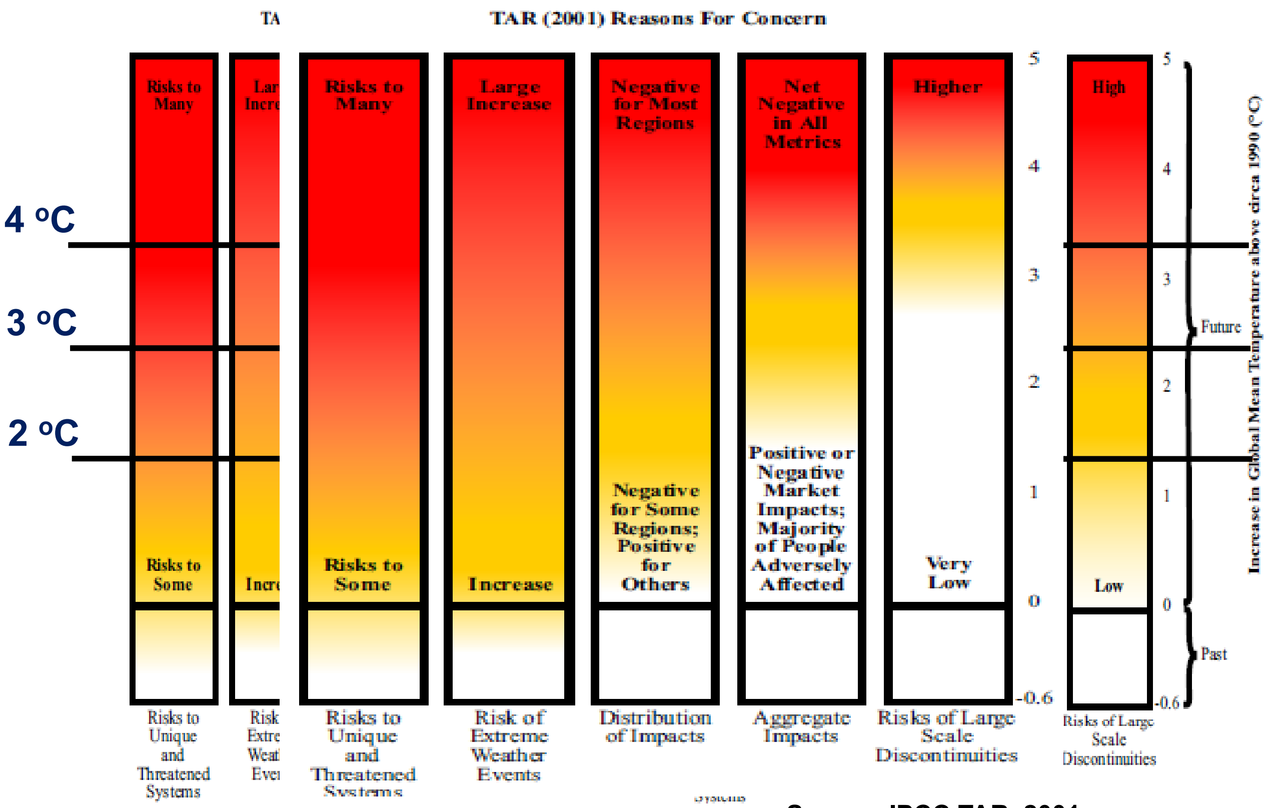
(loss of stat. life expectancy - PM)



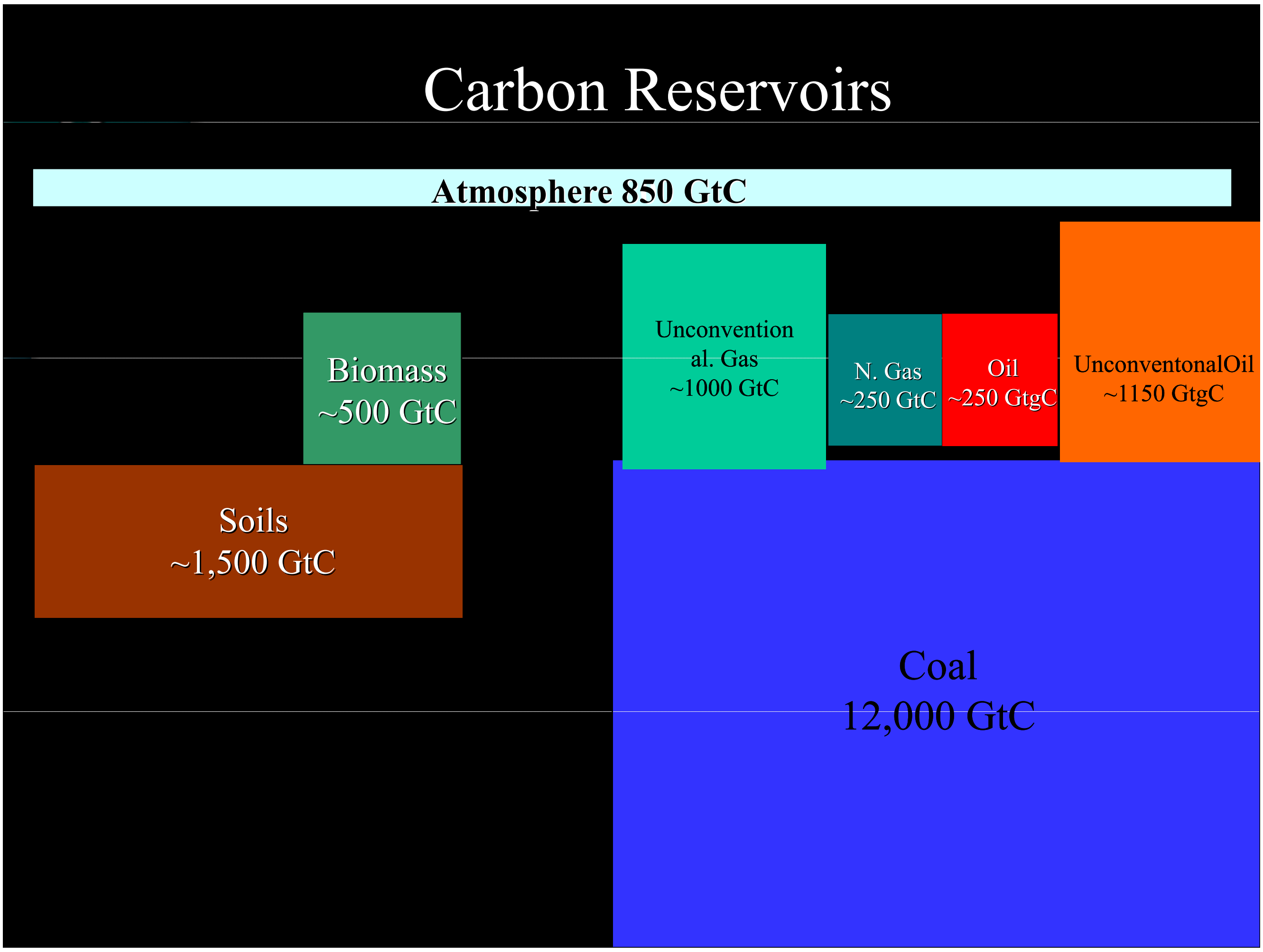
Source: Smith et al, 2009

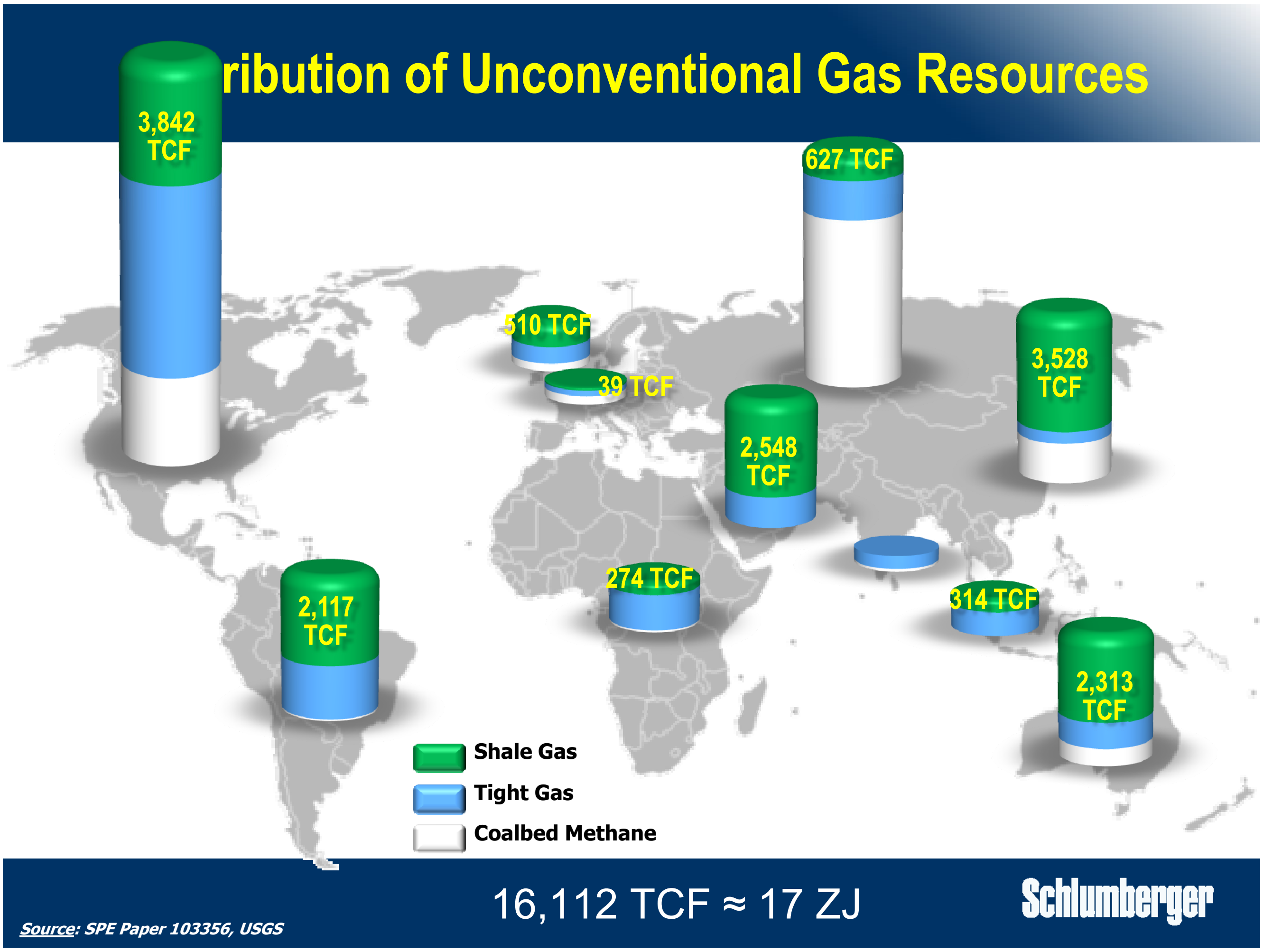
#7

Reasons for Concern – "Red Amber"

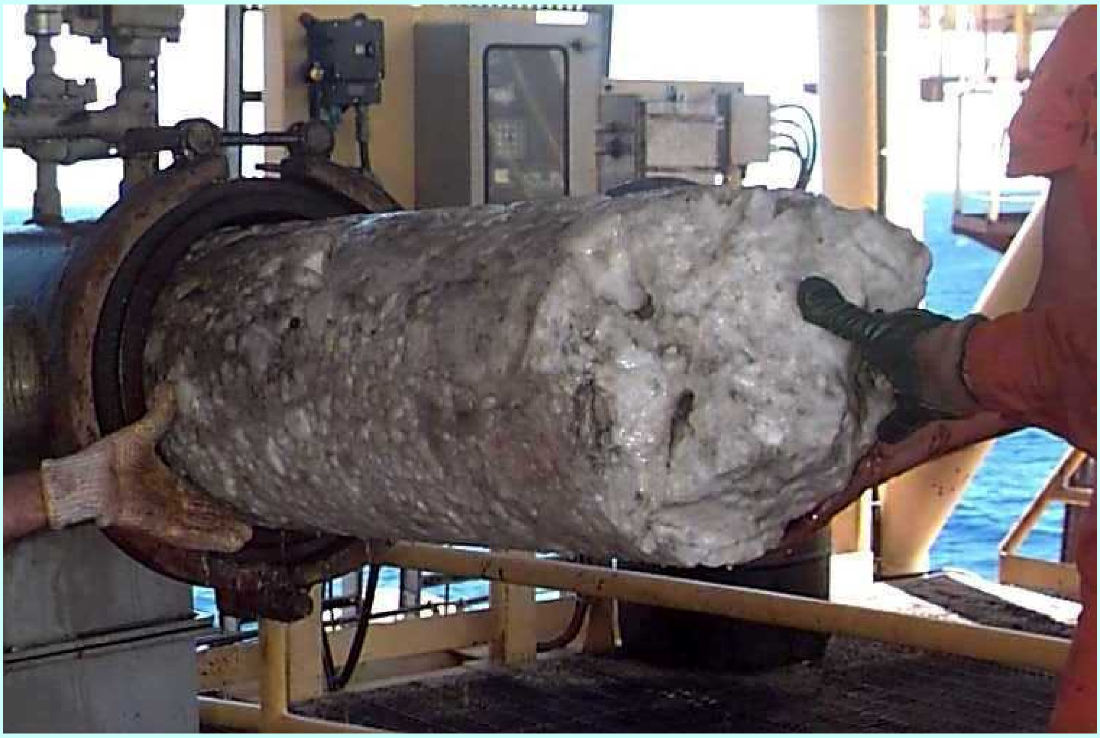


Source: IPCC TAR, 2001


Carbon Reservoirs
Atmosphere 850 GtC
Biomass
~500 GtC
Soils
~1,500 GtC
Unconvention
al. Gas
~1000 GtC
N. Gas
~250 GtC
Oil
~250 GtgC
UnconventonalOil
~1150 GtgC
Coal
12,000 GtC


ribution of Unconventional Gas Resources
3,842
TCF
627 TCF
510 TCF
39 TCF
3,528
TCF
2,548
TCF
274 TCF
314 TCF
2,117
TCF
2,313
TCF
Shale Gas
Tight Gas
Coalbed Methane
16,112 TCF ≈ 17 ZJ
Schlumberger
Source: SPE Paper 103356, USGS

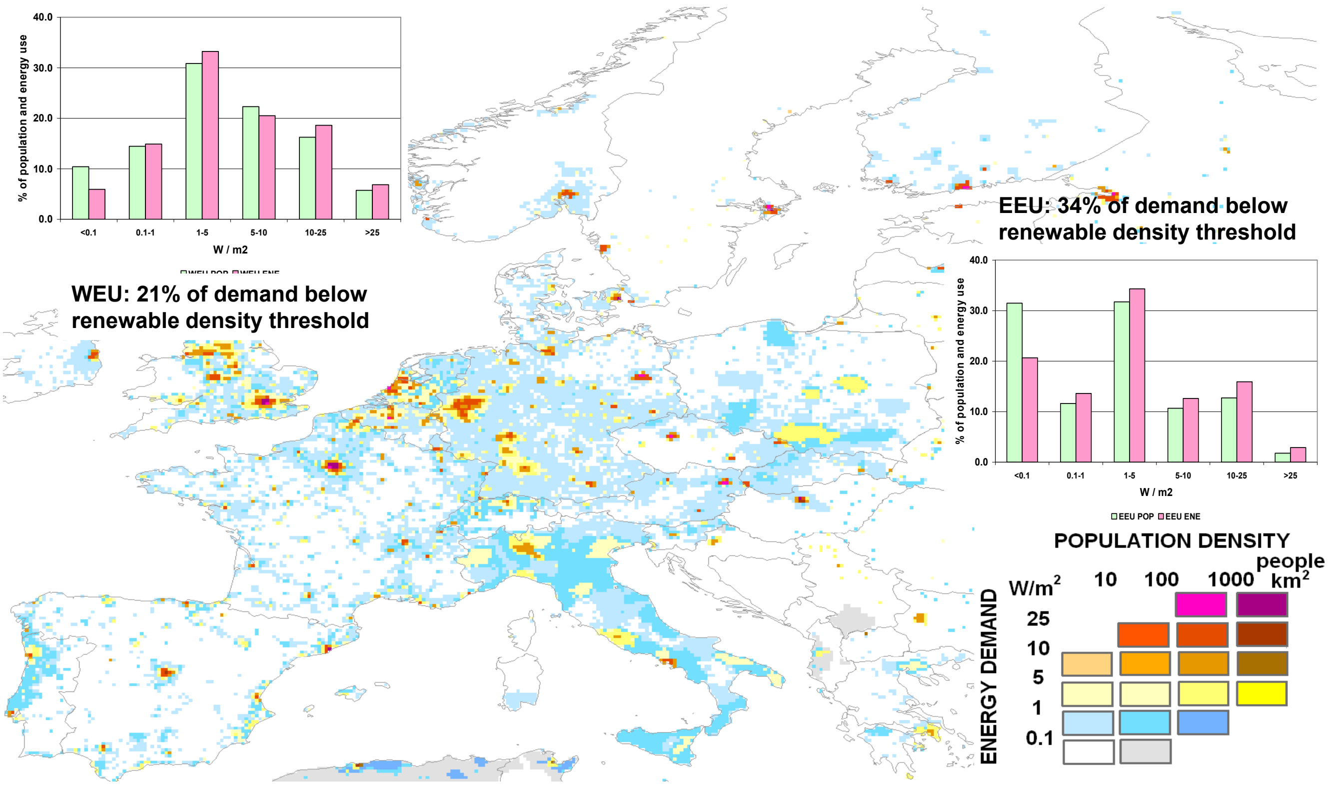
Methane Hydrate



Office of Naval Research GLOBAL Science & Technology

Europe Population vs. Energy Demand Density

Note in particular renewable supply density threshold of maximum 0.5-1 W/m²

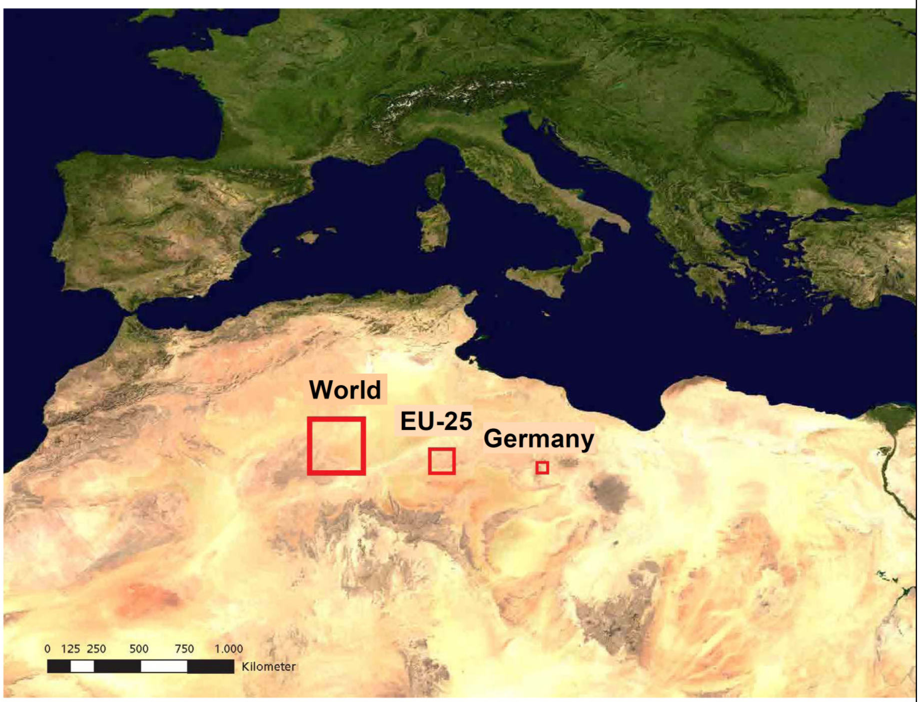


Required desert area for the sustainable supply of electricity

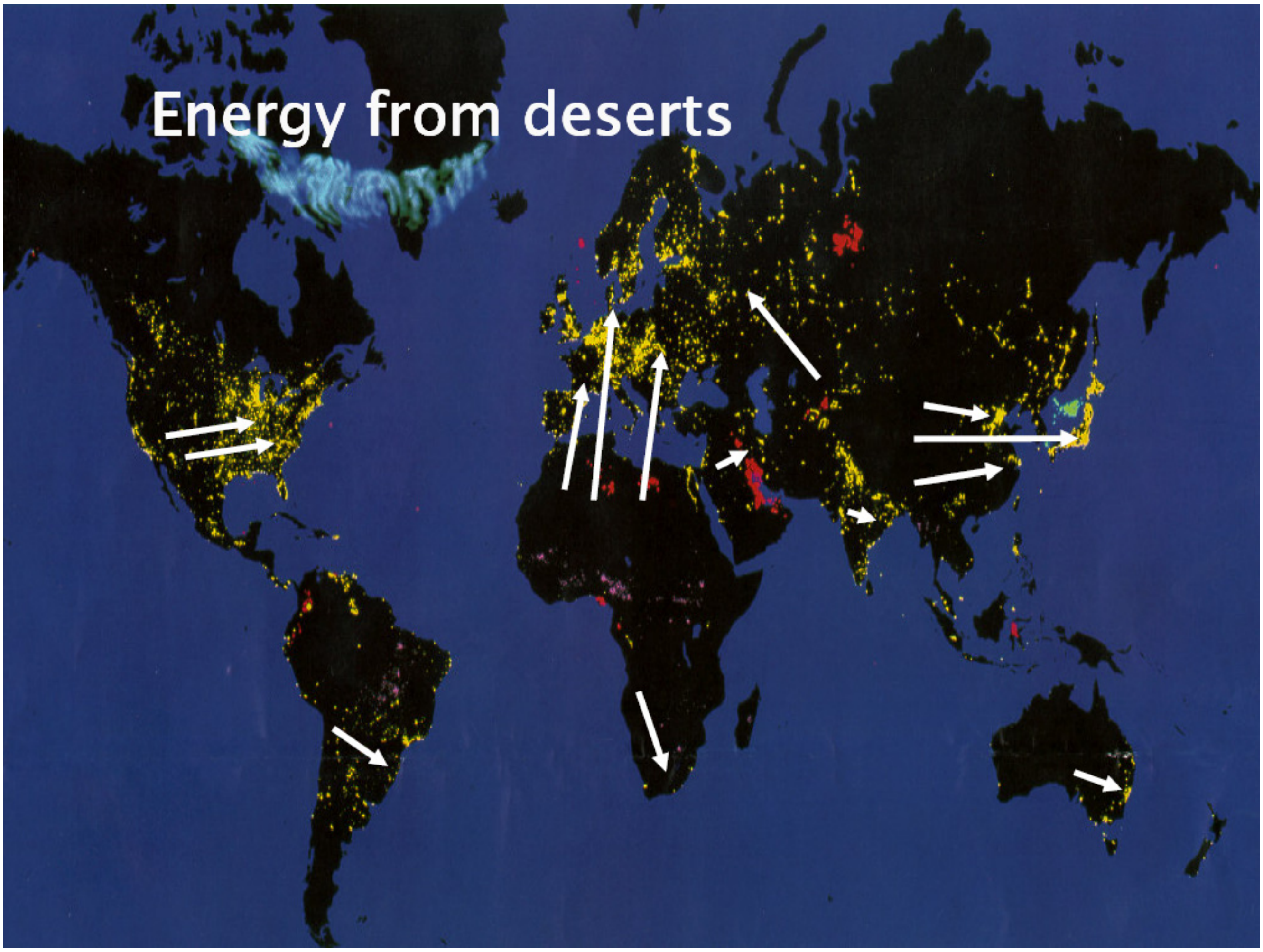
World 300 x 300 km²

EU-25 150 x 150 km²

Germany 50 x 50 km²



Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft



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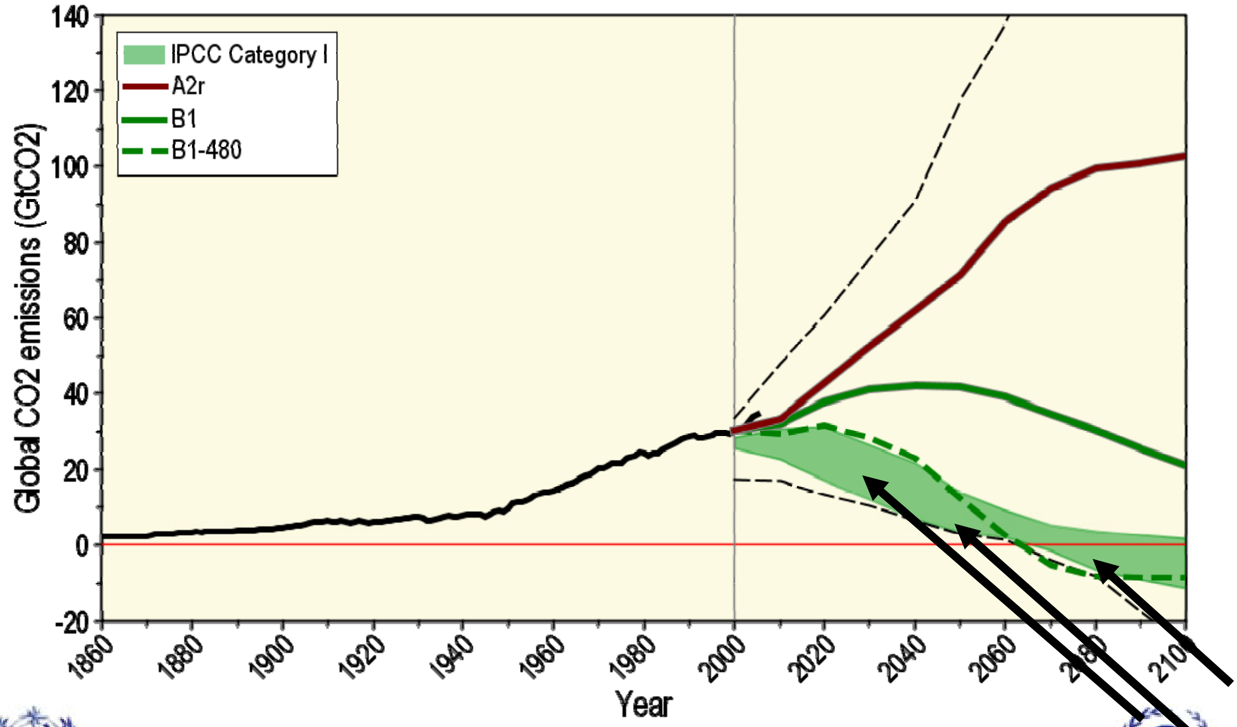
Global CO_2 Emissions



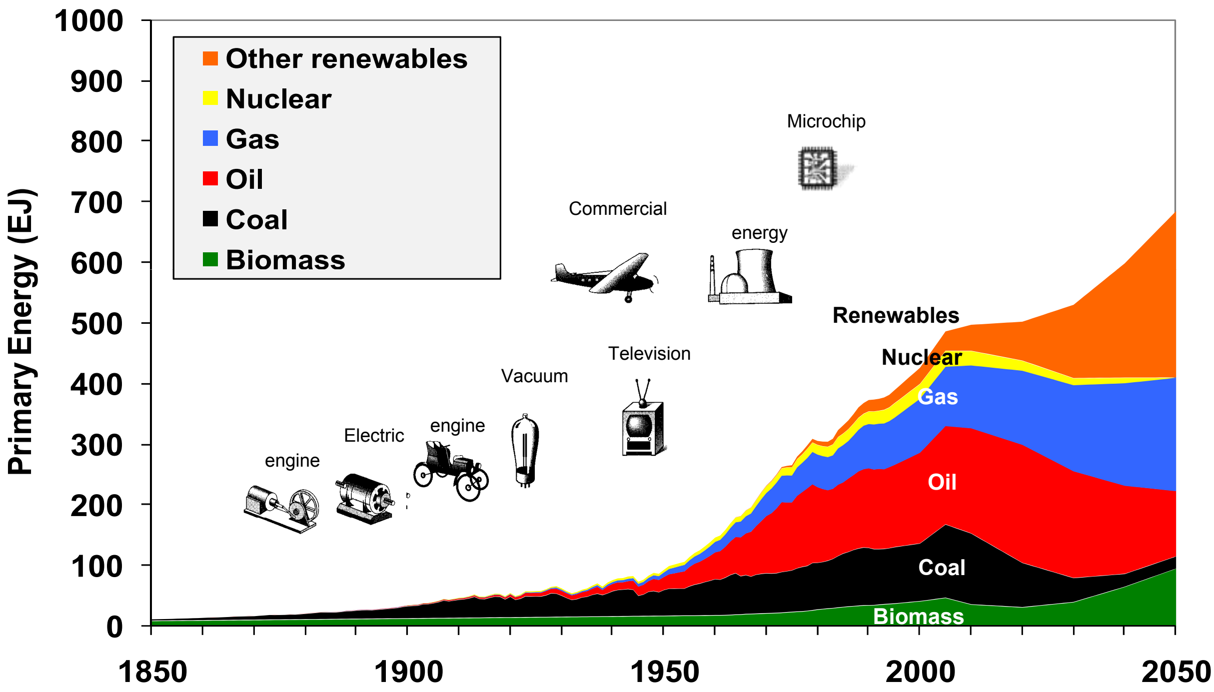
WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

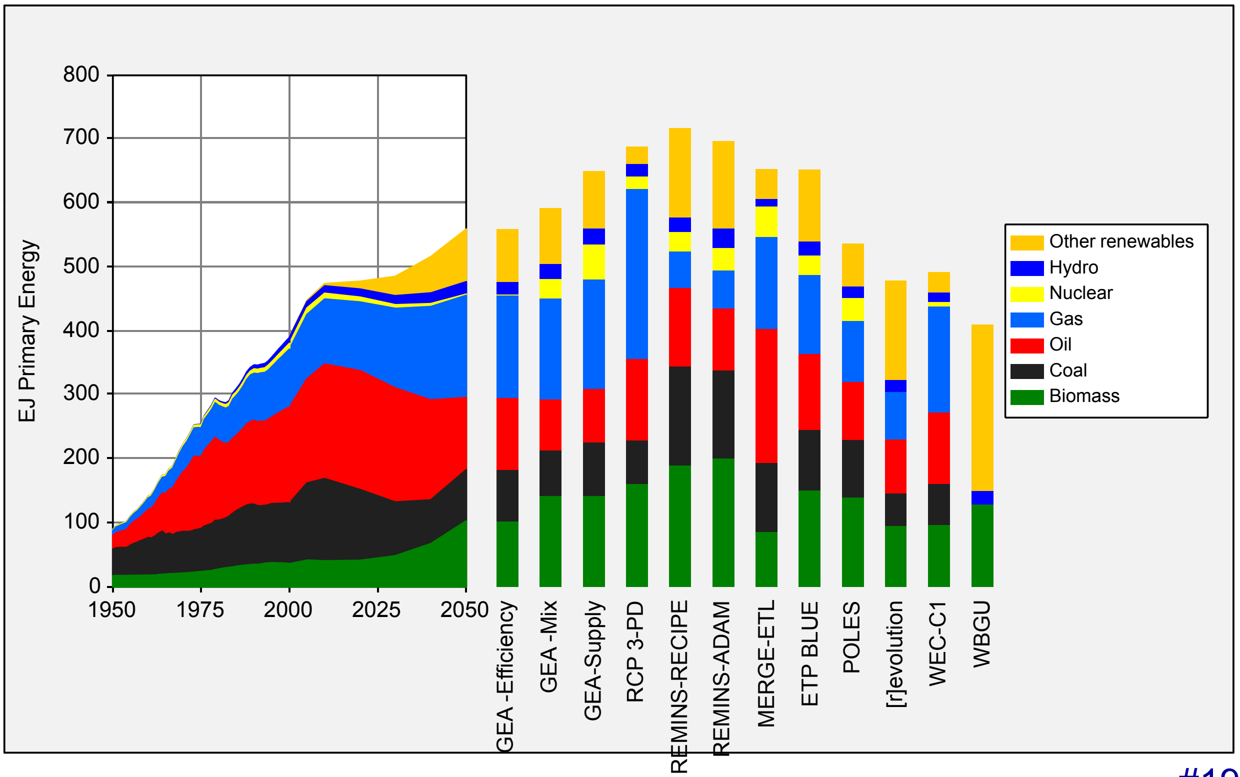
UNEP

Global Primary Energy

IIASA GEA



Global Primary Energy



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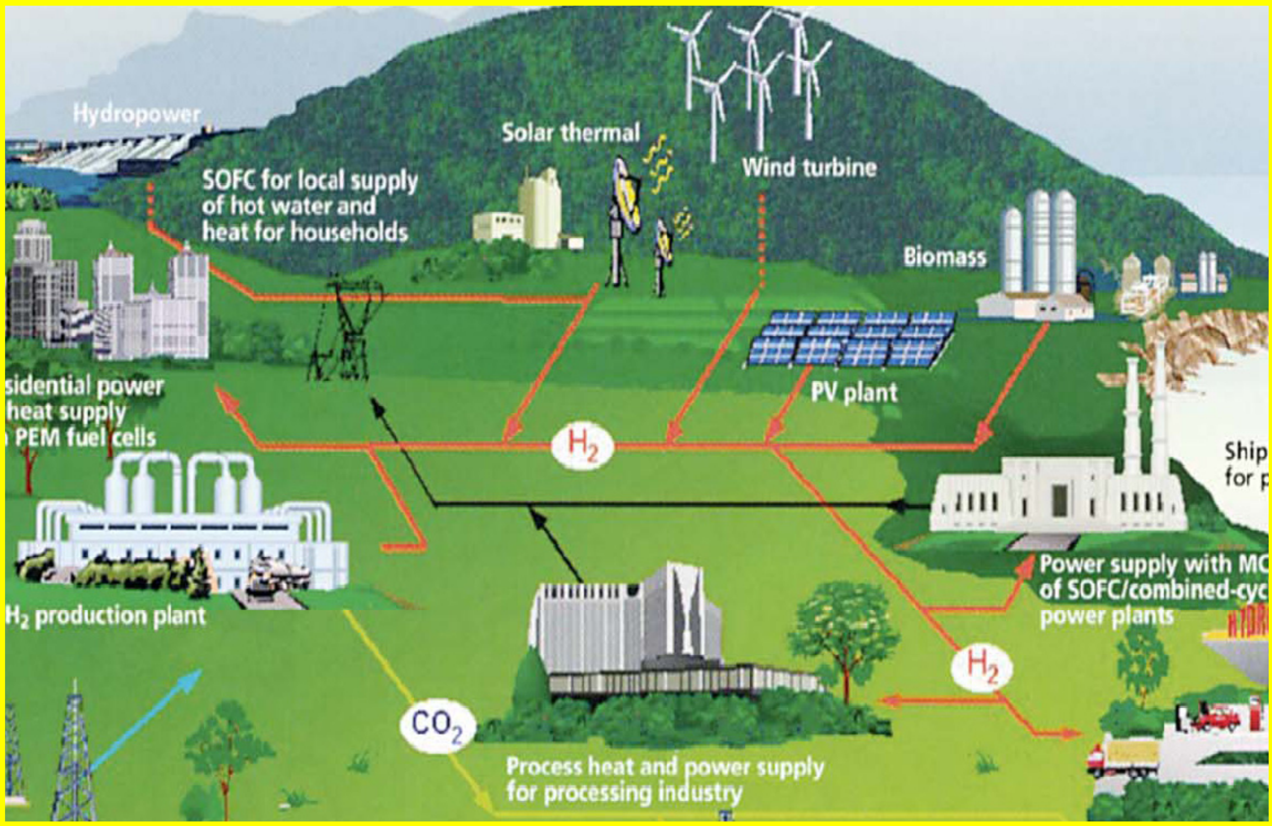
Mitigation Portfolios (which technologies we need) *versus* R&D (which technologies we develop)

All IEA countries

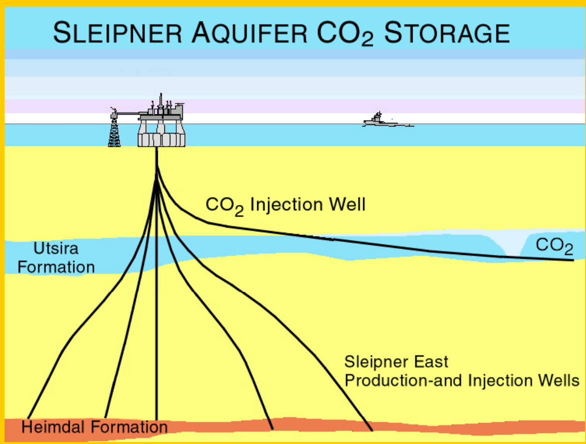
	cumulative emission reduction 2000-2100 (mean of all scenarios) GtC	%	cumulative R&D (1974-2007) 10^9 US$2007	%	current R&D 2007 10^9 US$2007	%
Energy efficiency	1662	*57.5*	38	*8.9*	1.6	*13.0*
Fossil Fuels	171	*5.9*	55	*12.8*	1.4	*11.3*
Renewables	537	*18.6*	37	*8.7*	1.5	*12.3*
Nuclear	269	*9.3*	236	*54.8*	4.6	*38.0*
Others	252	*8.7*	64	*14.8*	3.1	*25.4*
Total	**2890**	*100.0*	**431**	*100.0*	12.0	*100.0*

A Vision of a Future Energy System



Existing and Planned Projects

- Sleipner Project, saline formation, North Sea
- Weyburn, EOR, Saskatchewan, Canada
- In Salah, gas reservoir, Algeria (development)
- Snohvit, off-shore saline formation, North Sea
- Gorgon, saline formation, Australia (planning)

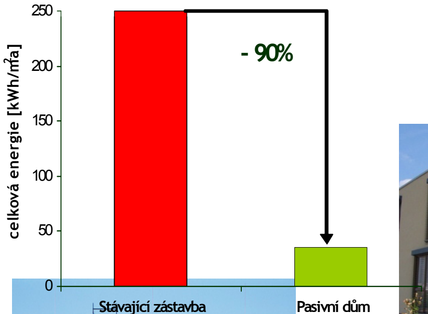


Nakicenovic #23

Source: Sally Benson, 2003

Buildings utilizing passive solar construction ("PassivHaus")

IIASA GEA



Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz

#24

Example of savings by reconstruction

Before reconstruction

Reconstruction according to the passive house principle

-90%

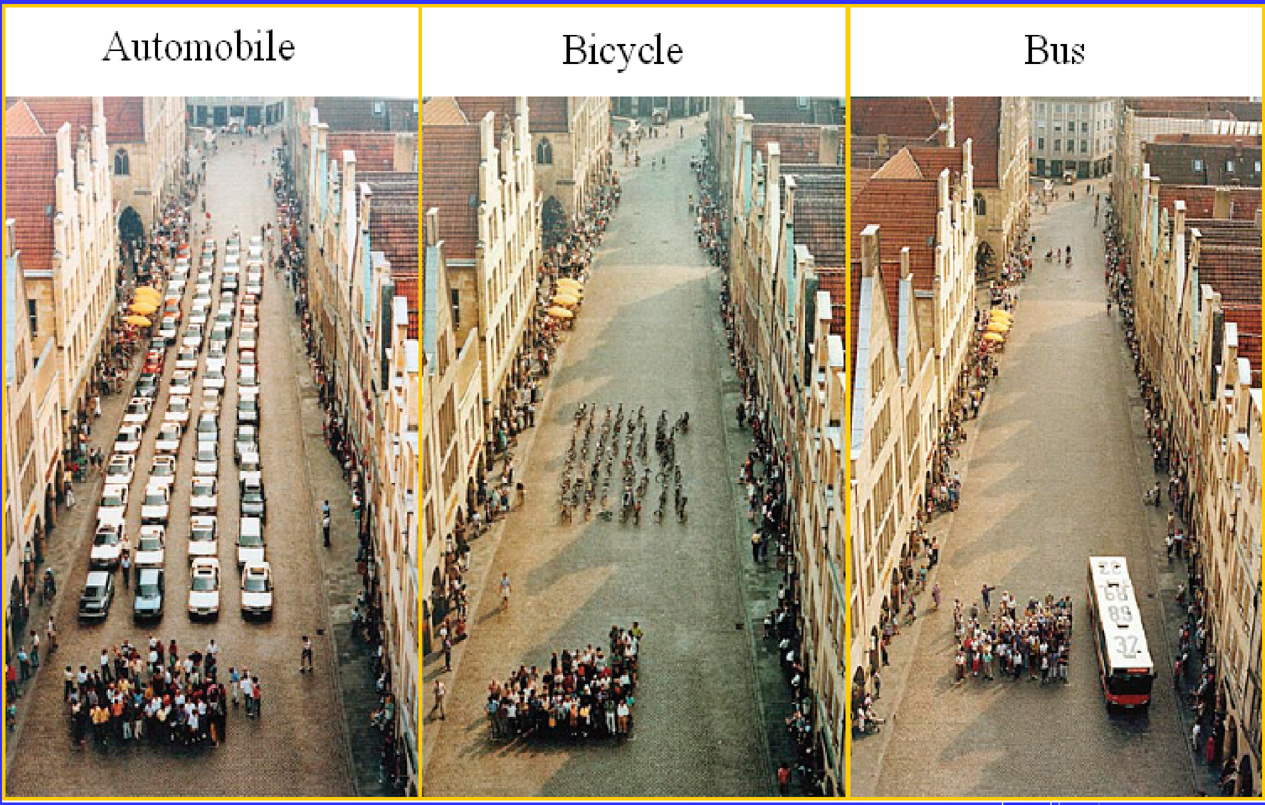
over 150 kWh/(m²a)

15 kWh/(m²a)

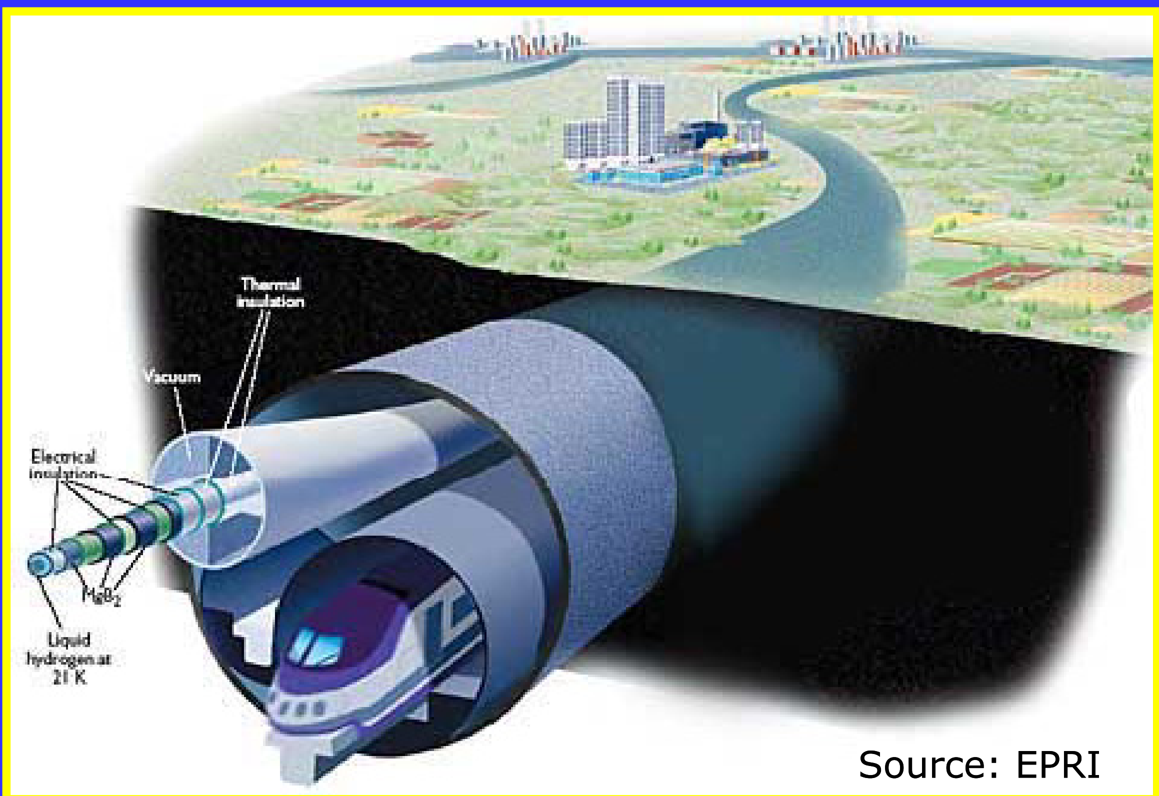
Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz, EEBW2006

CITARO H_2 Fuel Cell Bus

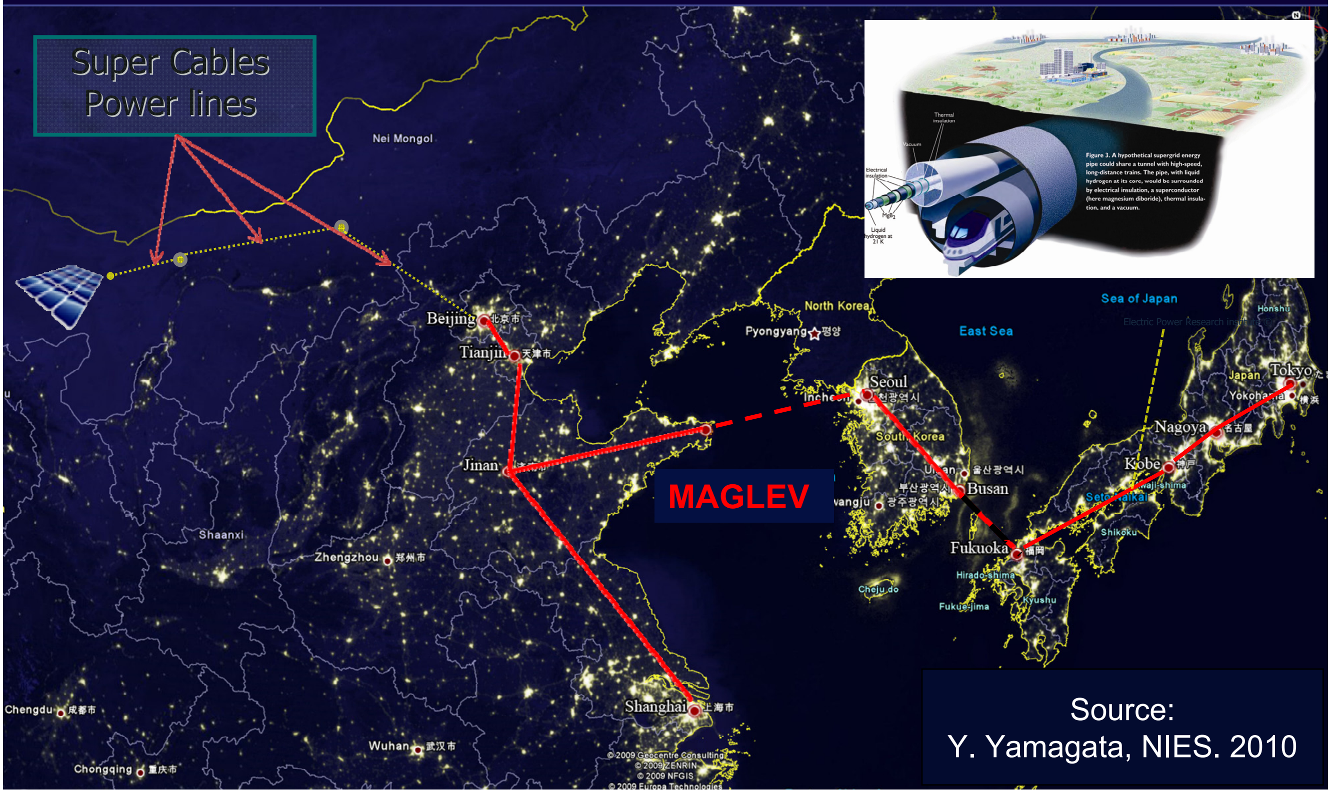
Area Occupied by Various Transport Modes



Energy SuperGrid and MagLev Trains



Potential Synergies between New Energy and Transport Infrastructures: Asian "Supergrid"



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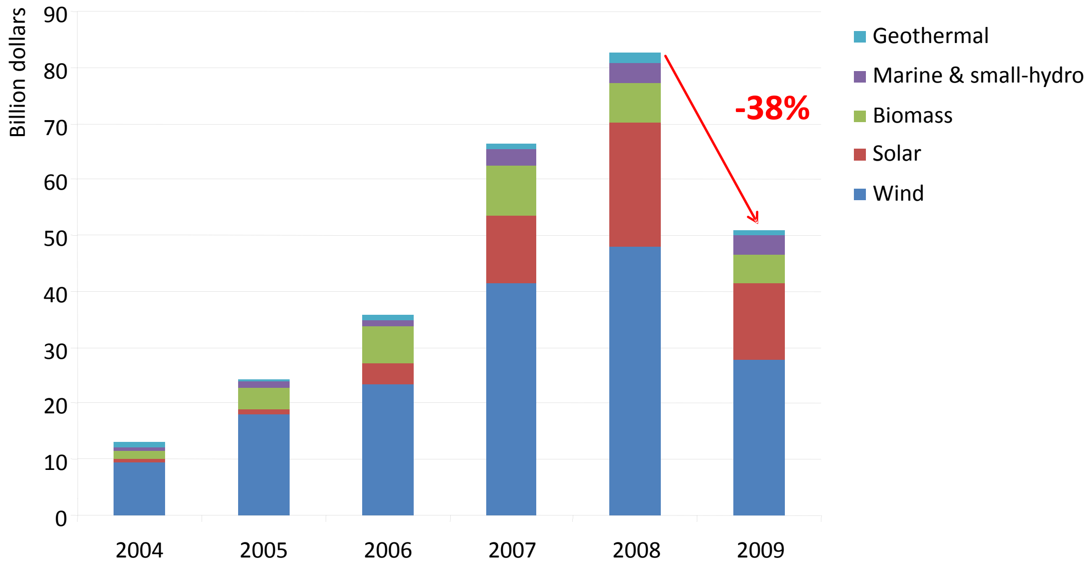
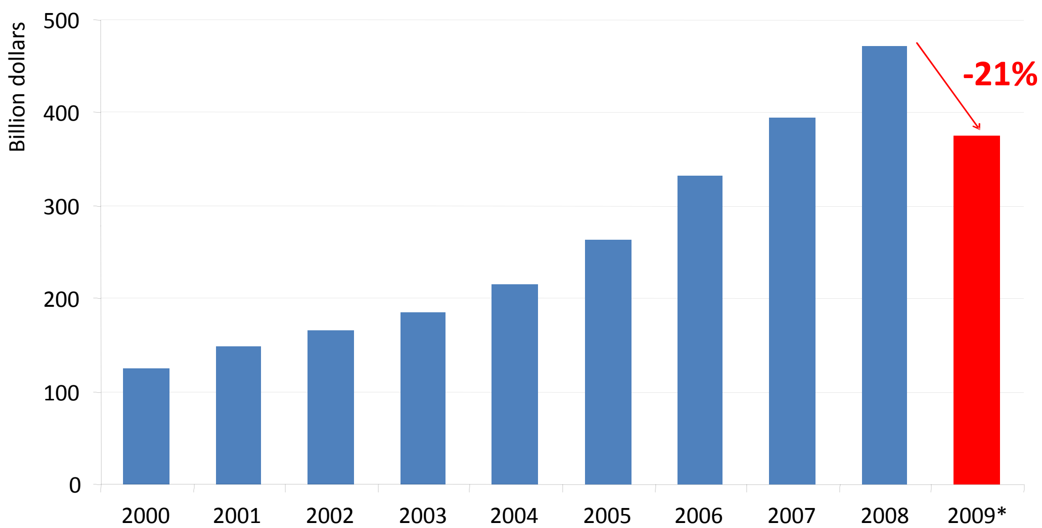
Global Investments in New Renewables



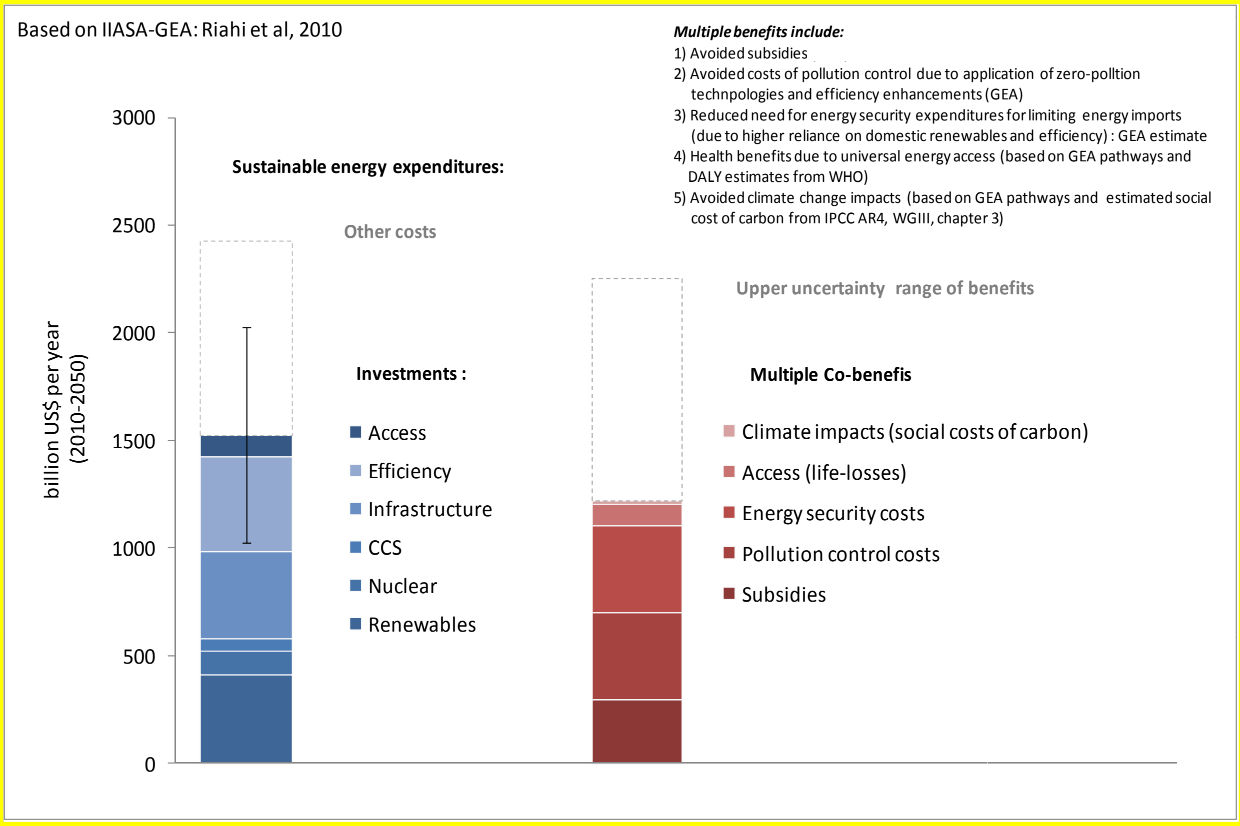
Source: IEA, 2009 #31

Global Investments in Upstream Oil and Gas



Source: IEA, 2009 #32

Co-Benefits of Energy Investments



www.GlobalEnergyAssessment.org
Towards a more Sustainable Future

- The magnitude of the change required in the global energy system will be huge
- The challenge is to find a way forward that addresses simultaneously climate change, security and equity issues.
- Paradigm change is needed: radical improvements in energy end-use efficiency, new renewables, advanced nuclear and carbon capture and storage.

Energy Forecasting for Distributed Generation in Local Energy Neighbourhoods

SmartCoDe Expert Cooperation Workshop on Energy Efficiency in Buildings 2010

Author: Tamás Bertényi, Quiet Revolution Ltd.

Date: November 16, 2010

Dissemination Level: Public

SmartCoDe and the Local Energy Producer (LEP)

- DSM and SmartCoDe project becomes a lot more interesting if there is a **Local Energy Producer**
- SmartCoDe is working on the specific example of **small-scale wind energy** integrated with the local energy neighbourhood
- Optionally to include some degree of local energy storage
- Provides end user with options:
  - use locally generated energy (offset local consumption)
  - or sell back to grid (export)
  - potential to engage in spot energy market (strategically timed export)
  - SmartCoDe can maximise the value of the LEP

The QR5 Wind Turbine

- Small Scale: <50kW and <200m^2
  - QR5: 7.5kW peak aerodynamic, 13.6m^2
- Decentralised energy production
- Integrated with society
- Cost: £20,000 + installation
- Design life: 25 years

SmartCoDe

Small-Wind LEP Integrated with Energy Neighbourhood

Energy Forecasting for Energy Neighbourhood

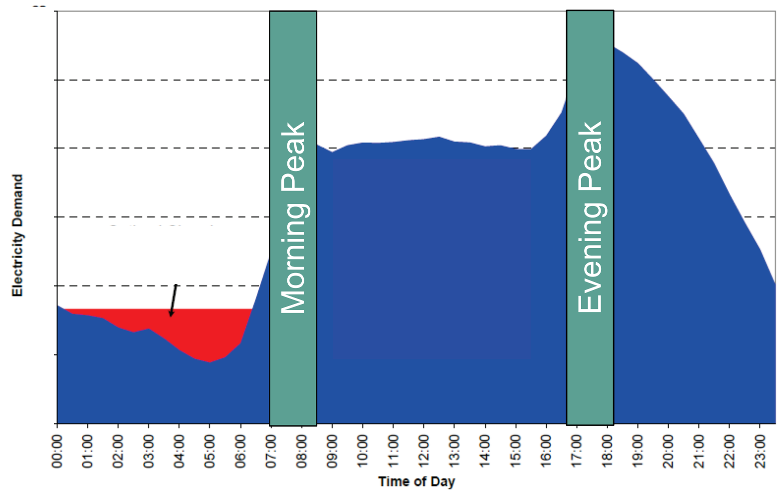
› To make the best use of LEP, SmartCoDe needs a degree of energy forecasting for **decision making**

– How much energy is available in 10 minutes? In one hour? Later today?

– Do we use the energy now - turn on **dispatchable load**

– Should we charge our **energy storage** device for later use

– How will our energy generation profile match with **grid demand**?

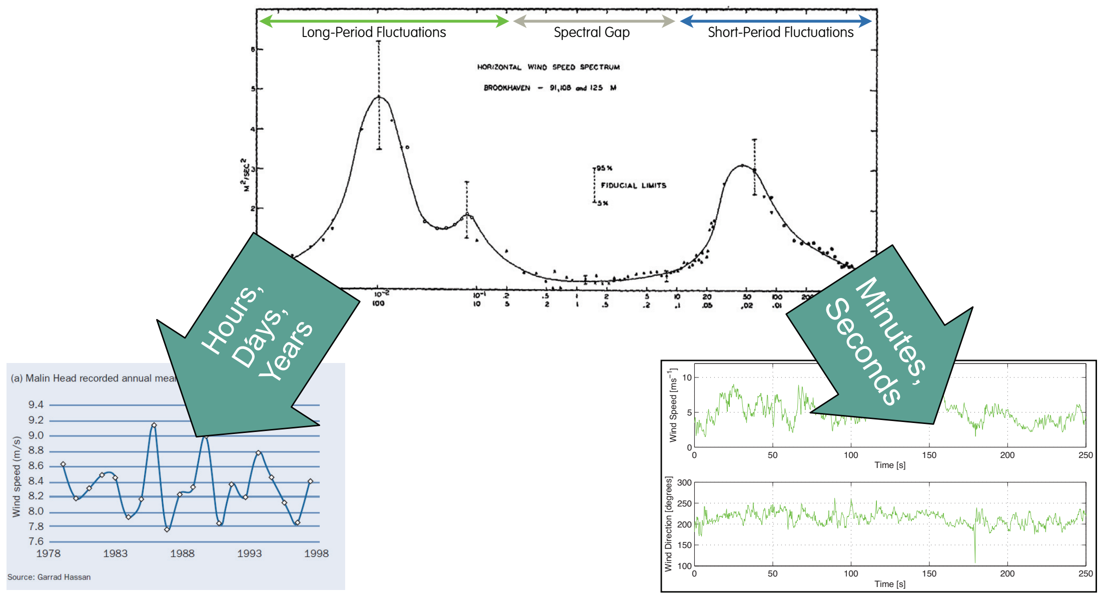


Forecasting Wind Energy - Wind Resource and Unsteadiness

› Forecasting wind energy - what makes it challenging?

› Wind resource is inherently **unsteady**

› Unsteadiness becomes increasingly more important as your wind turbine becomes smaller in size



Characterising the unsteady wind - 10 minute bursts

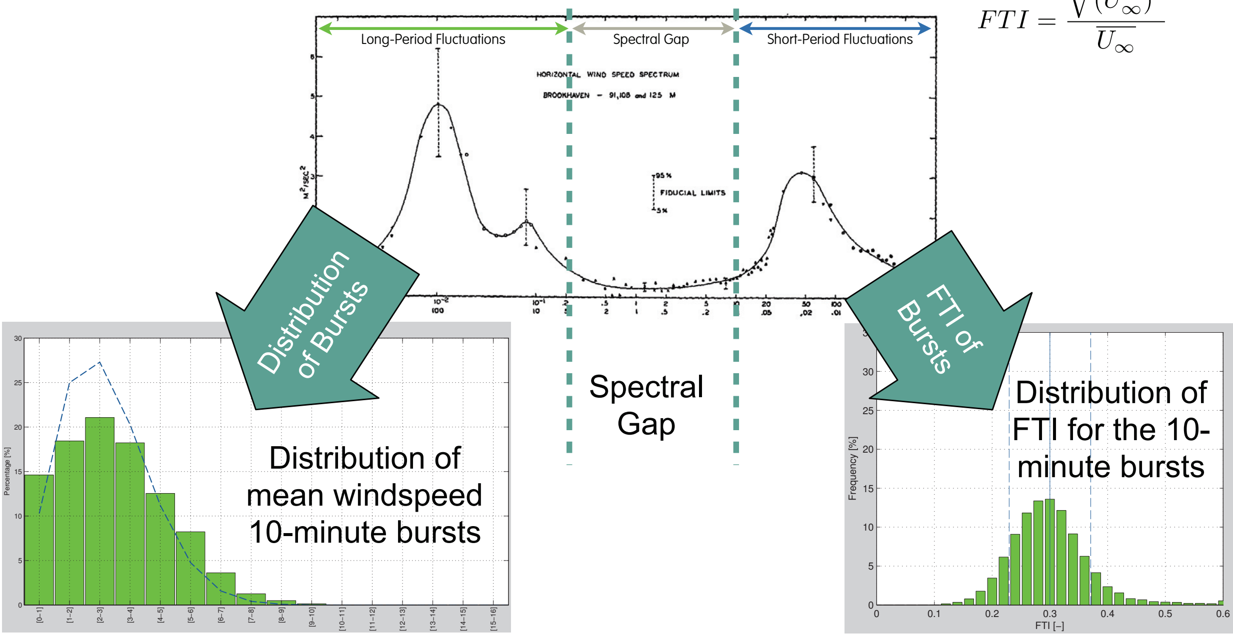
› Unsteady wind resource is neatly divided by the "spectral gap" into long-period and short-period unsteadiness

– Long-period: characterise as distribution of 10-minute mean values

– Short-period: characterise as a statistical summary of *each* 10-minute burst

› Free-Stream Turbulence Intensity (FTI)

$$FTI = \frac{\sqrt{\overline{(U'_\infty)^2}}}{\overline{U_\infty}}$$



Energy Model - Why is it so hard?

› Wind turbine converts wind energy into electrical energy

– wind speed ---turbine---> power, power ---time---> energy

› Need an **Energy Model** for forecasting:

– for a given **wind resource** (10-minute burst) what energy does the turbine deliver?

› Developing an **accurate** energy model becomes more difficult:

– with increasing unsteadiness (small-scale turbine)

– over shorter period of time (errors from simple model tend to average out over the long term)

Duration of Wind Resource	*Simple Model* of Turbine Energy Production	Measured Energy Production	Error
128 days	1978 kWhr	1820 kWhr	109%
108 hours	55.8 kWhr	37.3 kWhr	149%
210 minutes	4.2 kWhr	1.01 kWhr	415%

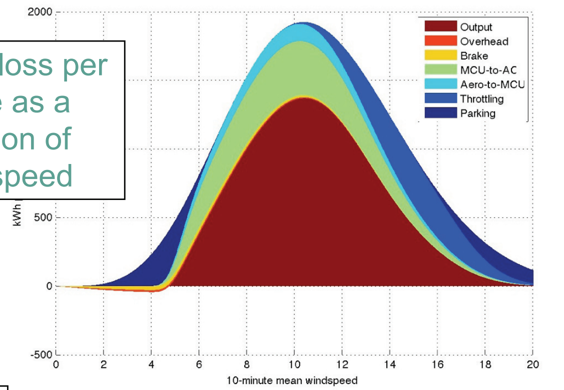
Energy Model - It's in the details!

› Quiet Revolution used large database of field-measurements to develop an **Advanced Energy Model**

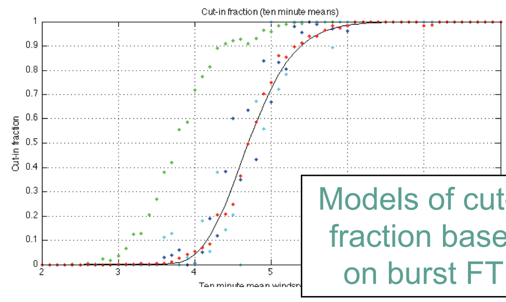
› Considers efficiency of individual blocks in power conversion system and their function

› Accurate cut-in, cut-out and throttling models based on FTI

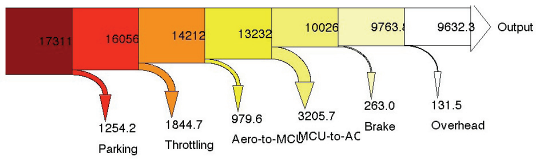
› Validated with field measurements of actual turbines



Energy loss per stage as a function of windspeed



Models of cut-in fraction based on burst FTI



Energy losses across power conversion stages

FP7 ICT-2009 GA-No. 247473

Energy Forecasting - The Problem

› We are **not re-inventing** weather forecasting!

› Use weather forecasting of wind resource as **input** to energy model

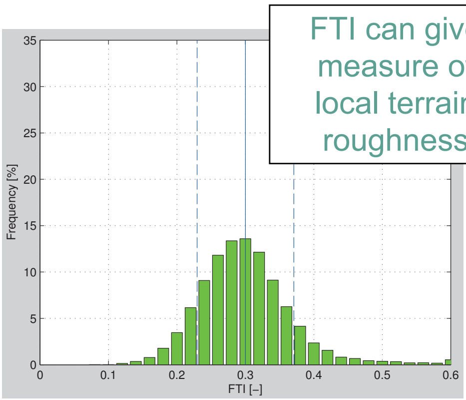
› But long-term wind resource and forecasting information is given at coarse **macro scale** and usually wrong height

› Need to **correct** macro scale forecast to **local micro-scale**

– local terrain roughness

– local height

› Correction method based on standard atmospheric boundary layer models



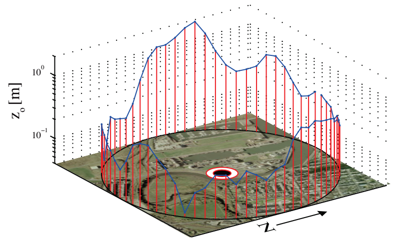
FTI can give measure of local terrain roughness

Knowledge of site gives local height correction

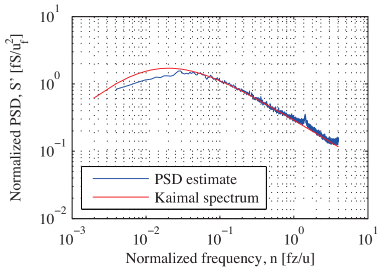
FP7 ICT-2009 GA-No. 247473

Long-Term Forecasting - Determining Z_0

- Local terrain roughness, Z_0, *seems* to be universally correlated to local power-spectrum density measurement (McIntosh, 2009)
- Move away from very subjective and inaccurate Z_0 assessment to measurement-based approach
- **Work ongoing** to relate Z_0 to local FTI measurements
- Need to also account for **directional variation** in FTI and Z_0



from McIntosh 2009



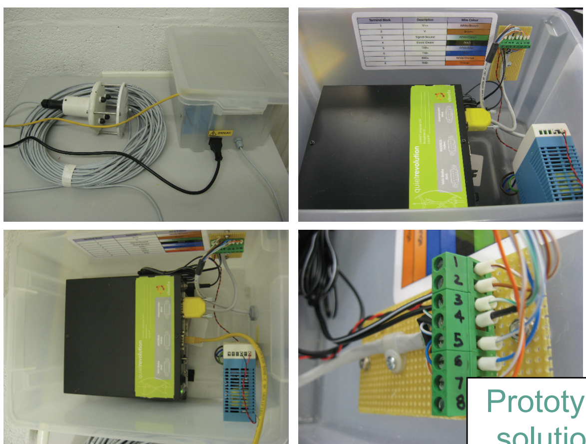
z_o [m]	Classification	Landscape description
0.0002	Sea	Water surface: Open sea or lake, tidal flat, snow-covered plain
0.005	Smooth	Featureless land surface: Beaches, marsh and fallow open cou
0.03	Open	Level open country: Heather, moor and tundra.
0.10	Roughly open	Open agricultural: Cultivated or natural area, low crops or plant cover.
0.25	Rough	Built agricultural: Cultivated or natural area, high crops and buildings.
0.5	Very rough	Suburban: Intensely cultivated landscape with many large obstacles.
1.0	Skimming	Towns: Densely built-up area.
⩾ 2	Chaotic	High-rise: City centres with a mixture of low and high-rise buildings.

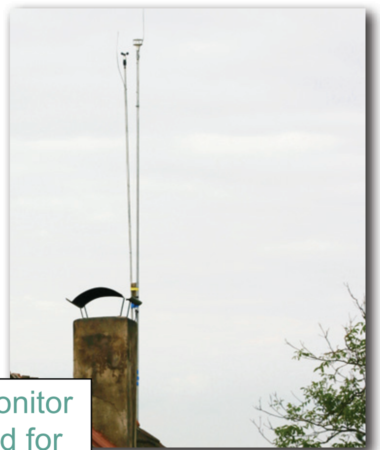
Existing classification of Z_0 is very subjective and prone to significant error

from Davenport 2000

Long-Term Forecasting - Application

- Local FTI data can be measured in a **few weeks** as opposed to years of measuring local wind speed resource directly
- FTI can be measured using appropriate **wind monitor tool**, such as developed in SmartCoDe programme
- Long-term forecasting via short-term FTI measurement to be demonstrated in SmartCoDe project





Prototype Wind Monitor solution developed for SmartCoDe

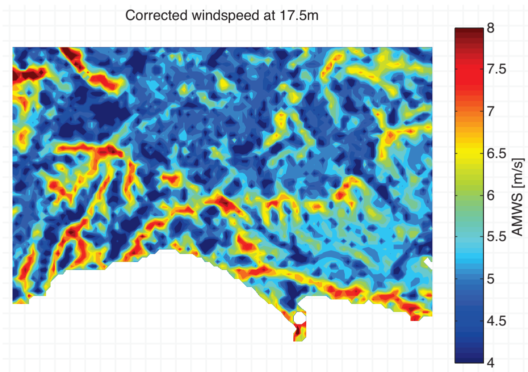
Long-Term Forecasting - Automation

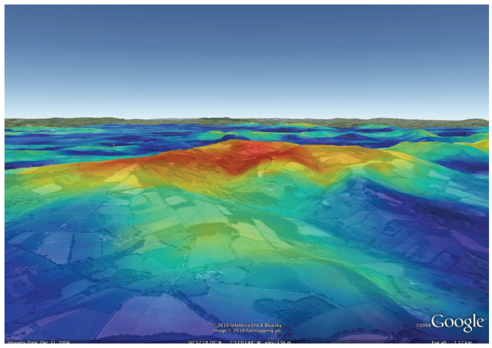
› Long-term (multi-year) wind resource data available, for example UK NOABL database

› QR is investigating automation of correcting database for local micro-scale factors

› Can be used for deciding on siting of turbines within an area

– as such, potentially very valuable outcome of this research project!



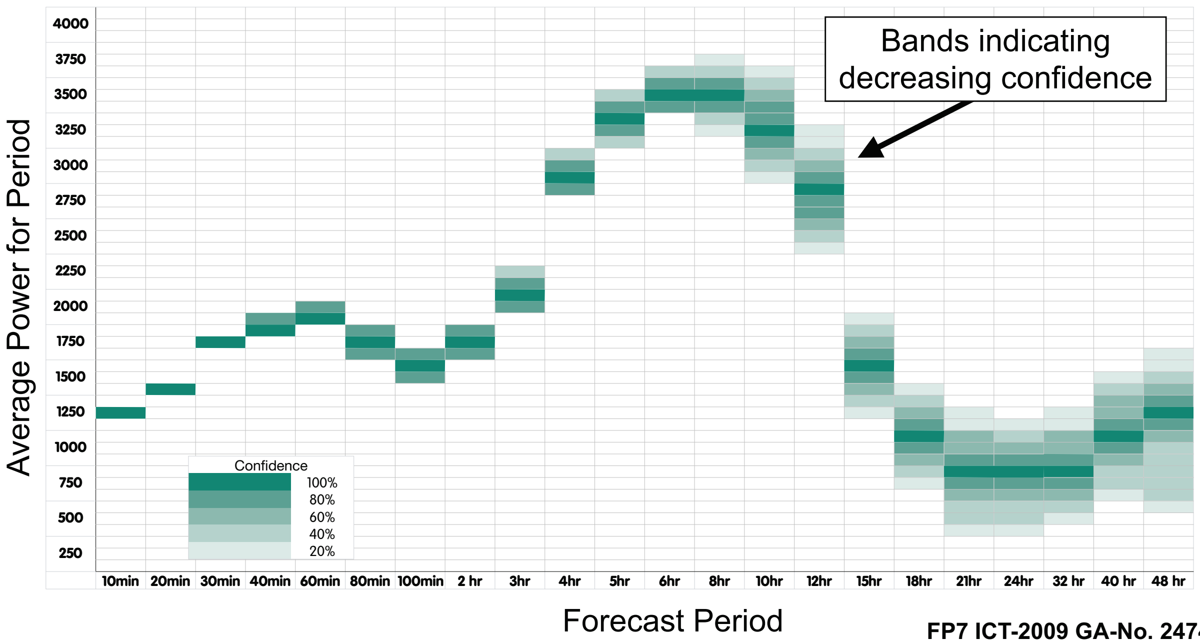


Short-Term Energy Forecasting

› Not "now casting", just short-term forecast into future

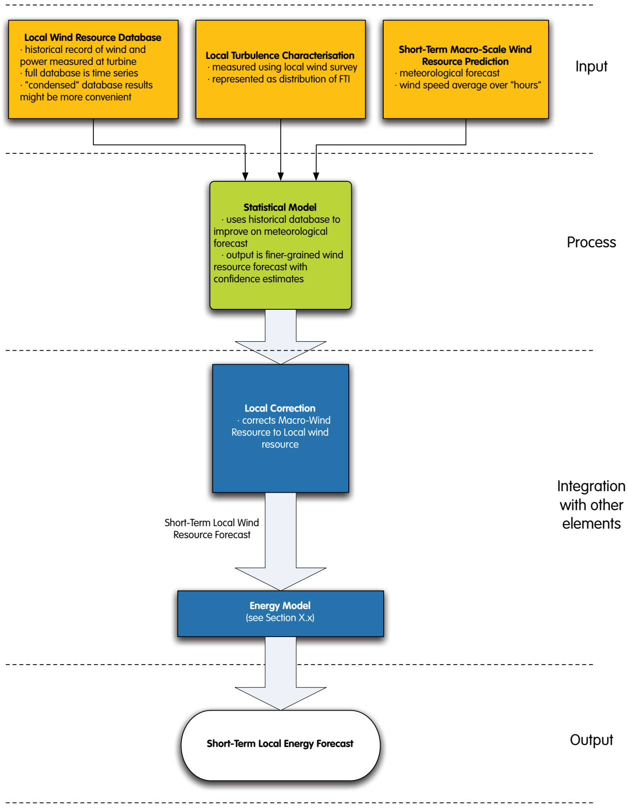
› Forecast of LEP energy yield up to 48 hours into future in **10-minute blocks** or coarser

› Statistical approach will provide **estimate** and **confidence**



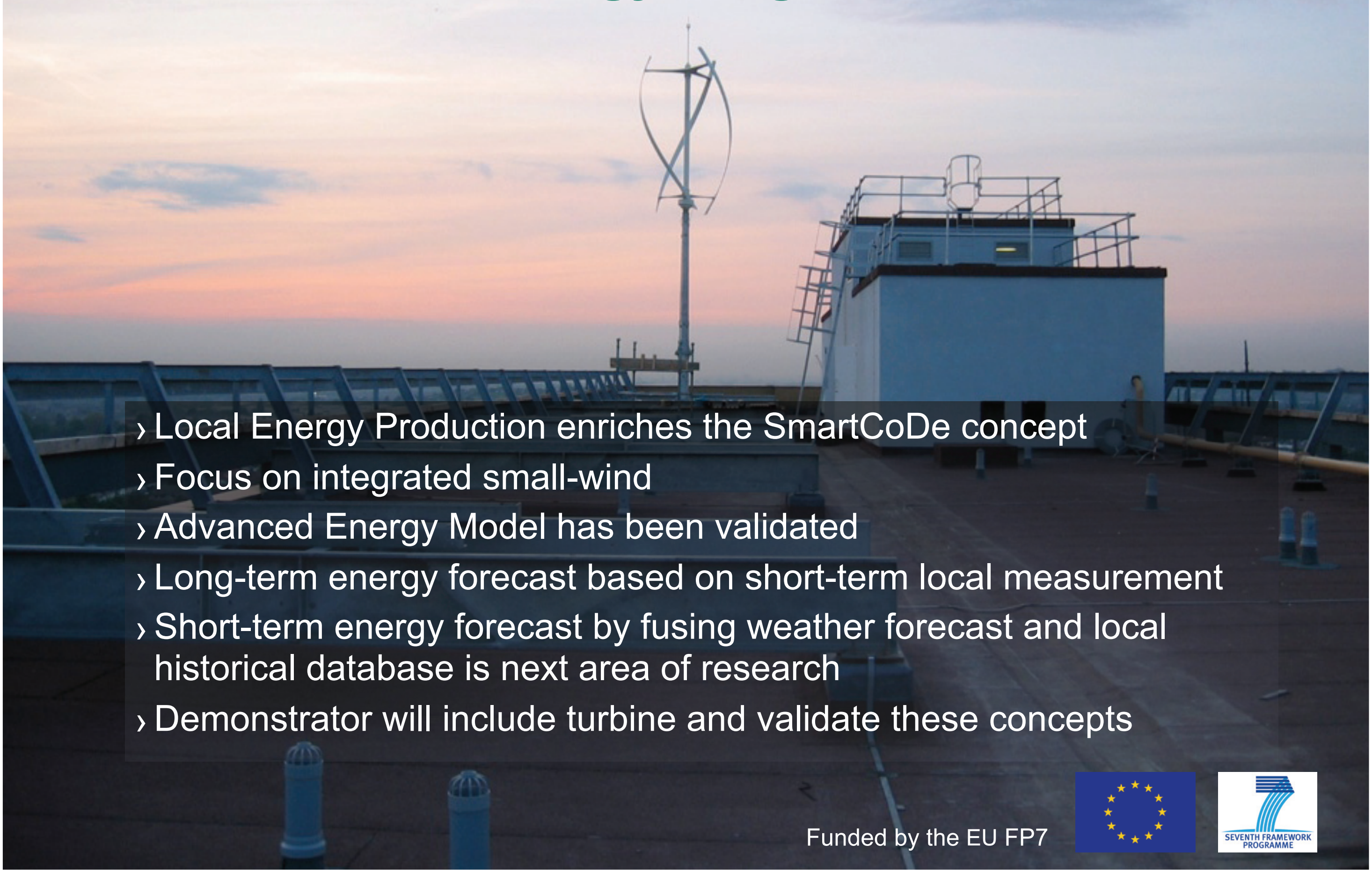
Short-Term Energy Forecasting - Future Work

› Builds on approach of long-term forecasting
› Input:
  – Macro-scale wind resource weather forecast (internet)
  – Local correction factors (measured FTI)
  – Database of local wind resource history
› Process:
  – Statistical model from database applies first correction to weather forecast
  – Local micro-scale correction (as for long-term forecast)
  – Energy model
› Output:
  – short-term energy forecast



FP7 ICT-2009 GA-No. 247473

Energy Forecasting for Distributed Generation in Local Energy Neighbourhoods



› Local Energy Production enriches the SmartCoDe concept
› Focus on integrated small-wind
› Advanced Energy Model has been validated
› Long-term energy forecast based on short-term local measurement
› Short-term energy forecast by fusing weather forecast and local historical database is next area of research
› Demonstrator will include turbine and validate these concepts

Funded by the EU FP7

Invited Paper:
Building Simulation and Control
Dr. G. Zucker (Austrian Institute of Technology)

Dr. Gerhard Zucker (né Gerhard Pratl) is a senior researcher at Austrian Institute of Technology (AIT) since February 2010 in the field of sustainable building technology. His research area includes building automation and controls for optimization of energy efficiency and he works on methods to recognize and evaluate behavior of persons for optimizing building usage and maximizing comfort. He finished his diploma in 1998 at Vienna University of Technology and his Dr. techn. (PhD), viva-voce exam with excellence at TU Vienna in April 2006. In the following he worked on different projects in the field of building automation and artificial intelligence before he did the technical project management of various projects in basic research as well as projects in cooperation with different companies.

Gerhard Zucker has a significant publication record, he is editor of two books and numerous scientific publications. He is associate editor of the special issue “Building Automation, Control and Management” in the journal “IEEE Transactions on Industrial Electronics” and lead guest editor of the special issue “Networked Embedded Systems for Energy Management and Buildings“ in the “EURASIP Journal on Embedded Systems”. He was session chair and track chair in various conferences, the latest being track chair at the IEEE “Conference on Industrial Informatics” (INDIN 2010) and special session chair at the “IEEE Human System Interaction 2010 (HSI 2010)”.

Abstract

Different tools for thermodynamic simulation of buildings are available today. By creating a model of the building envelope, room structure, window areas we gain information about the building behavior, i. e. time constants for temperature changes, dead times and so on. Adding the building systems to the model we can also simulate HVAC systems, heater, ventilation chillers and the like.

Thermodynamic simulation of buildings can be run in real-time, which allows us to take a look into the future. We can derive how a building will behave tomorrow, and test different control strategies without actually applying it to the building and its inhabitants.

The next step is to consider weather predictions: having an estimate on how temperature, humidity and sun radiation will be we can adjust the current control strategy to meet the given constraints, e. g. by starting to cool the building earlier in the morning, if a hot and sunny day lies ahead.

Building Simulation and Control

Gerhard Zucker
Austrian Institute of Technology
Energy Department

Building Simulation

- Thermal model of the building
- Coupled electric and thermal simulation of the energy systems
  - Heating, ventilation, air condition
  - Lighting
  - Heat pump, solar thermal, photovoltaics
- Simulation of internal loads
  - Occupancy
  - Computers, white goods etc.
- Outside climate
  - Temperature, humidity, solar radiation

- Create a complete multi-domain simulation of building and environment

Goals

- Optimization
  - Energy Efficiency
  - Use of self-produced energy
  - Grid-friendliness
  - Costs
- Failure Detection
  - Comparison of real values with simulation
- Virtual Plant
  - Participation in energy stock exchange

TOMORROW TODAY

ENERGYbase

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ENERGYbase: Office Building – Passive House Standard

South View

North View

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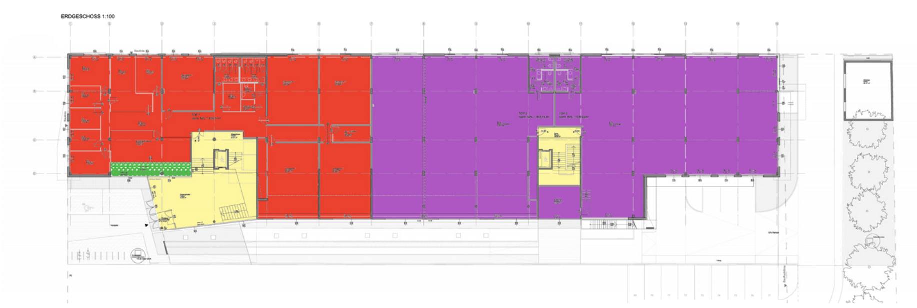
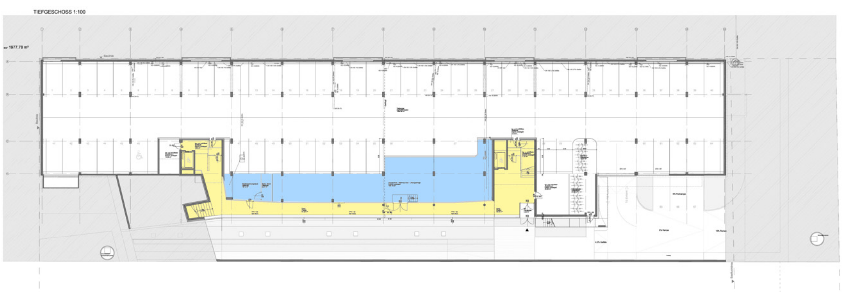
ENERGYbase: Usage



Erdgeschoss

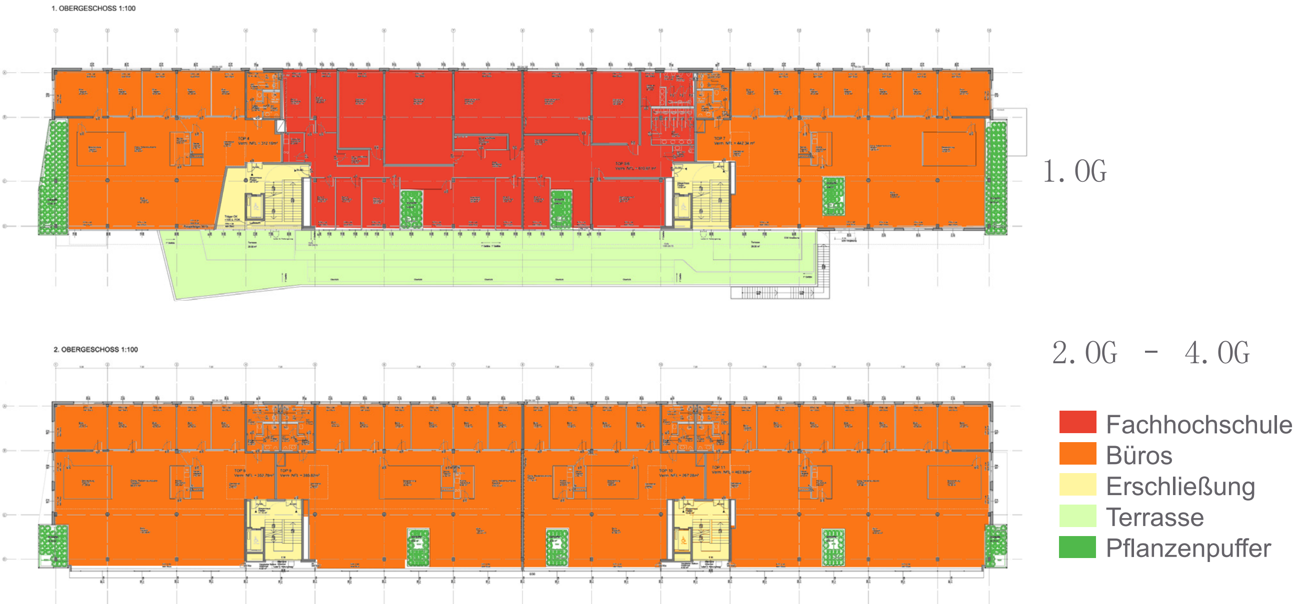


Keller

- Fachhochschule
- Labore
- Erschließung
- Haustechnik
- Pflanzenpuffer

Quelle: pos-architekten

ENERGYbase: Usage

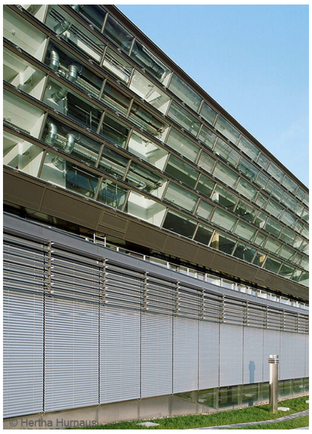


Quelle: pos-architekten

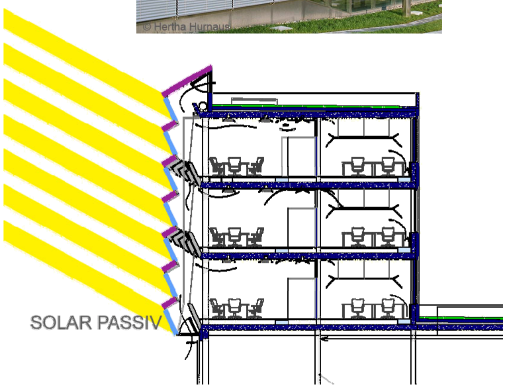
ENERGYbase: Facts & Figures

- Passivhouse Standard
- 400m² photovoltaic systems
- 300m² solar thermal collectors
- Plant buffers for air conditioning
- Heating: Heat pump / concrete core activation
- Cooling: Free Cooling (groundwater pump)/ concrete core activation, supported by solar cooling

Photovoltaic Systems

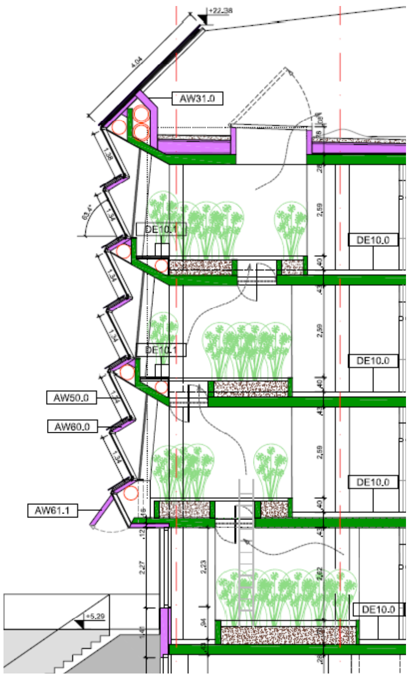


- PV modules integrated into faccade
- Act as blinds for south offices by reducing direct solar radiation
- Orientation and tilting optimized for maximum electric yield
- Comparison of different technologies in long term tests



Plant Buffers

- Ecological humidification and revitalization of air
- Comparison of air qualitiy when using inside or outside plant buffers
- Researching the possibilities with plant buffers



Quelle: pos-architekten

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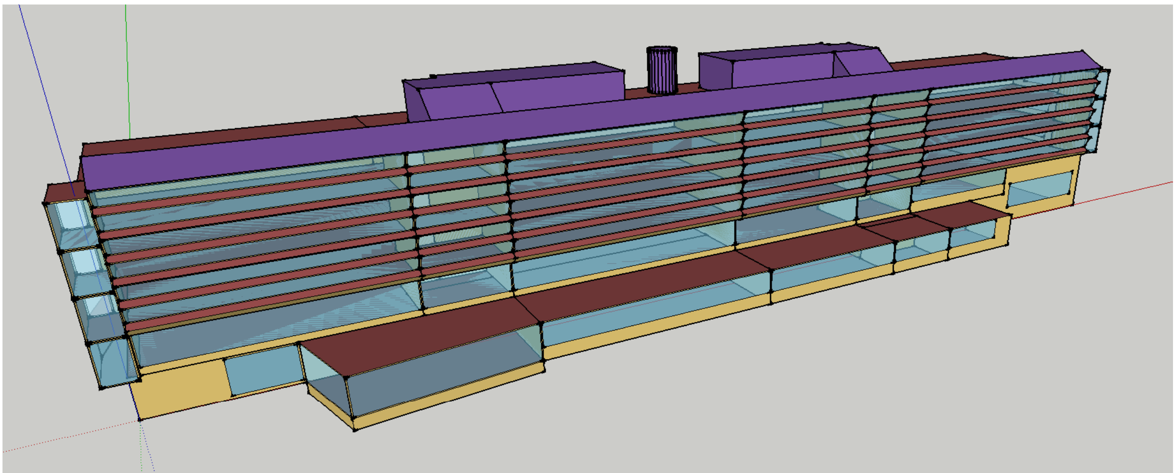
Modelling



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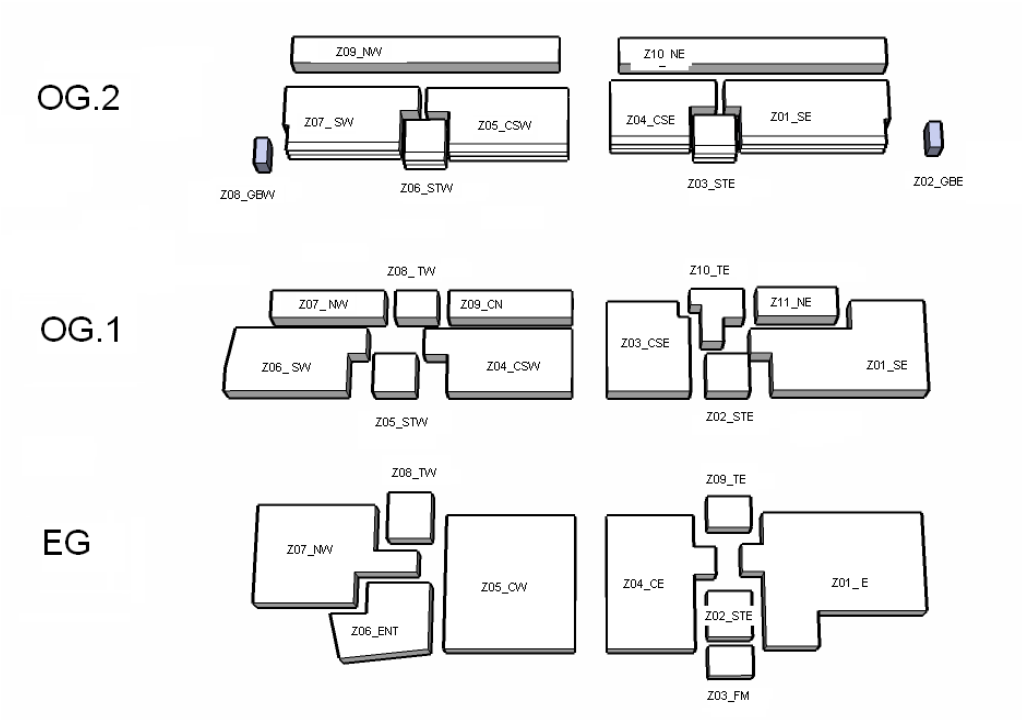
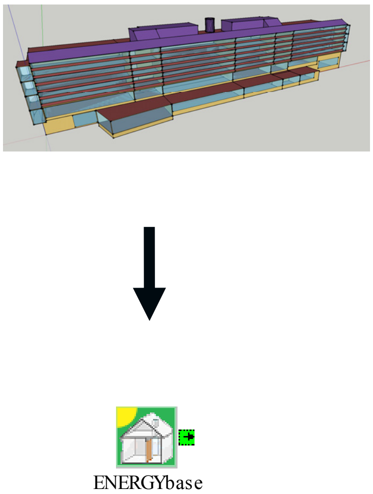
ENERGYBase in SketchUp & TRNsys



EnergyBase in SketchUp & TRNsys



68 Zones
758 walls, ceilings and floors
59 different wall structures
66 different layers
146 windows
8 different window structures

ENERGYbase - Simulation

Goal

- Identification of thermal dependencies of ENERGYbase from outside radiation and temperature

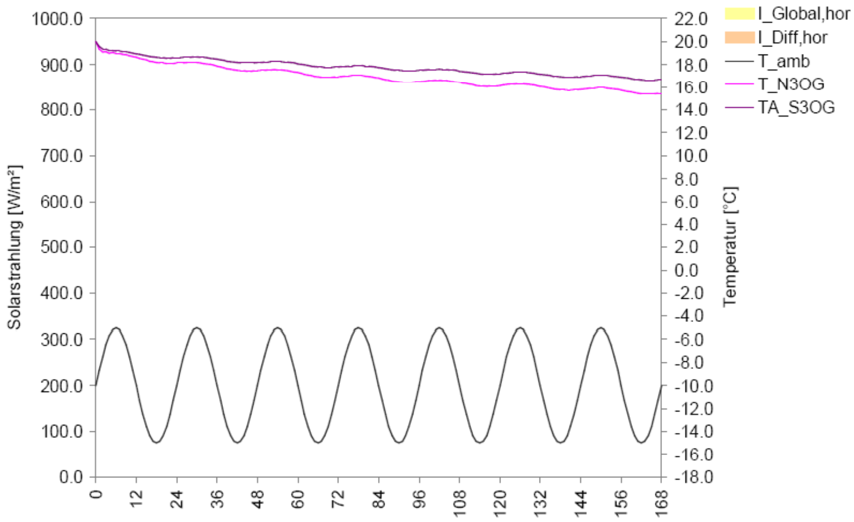
Method

- Using datasets for weather in representative weeks
- Simulating representative room air temperatures in northern and southern office on the third floor

Scenarios

- Typical winter, summer and season changes with idealized outside air temperature and solar radiation

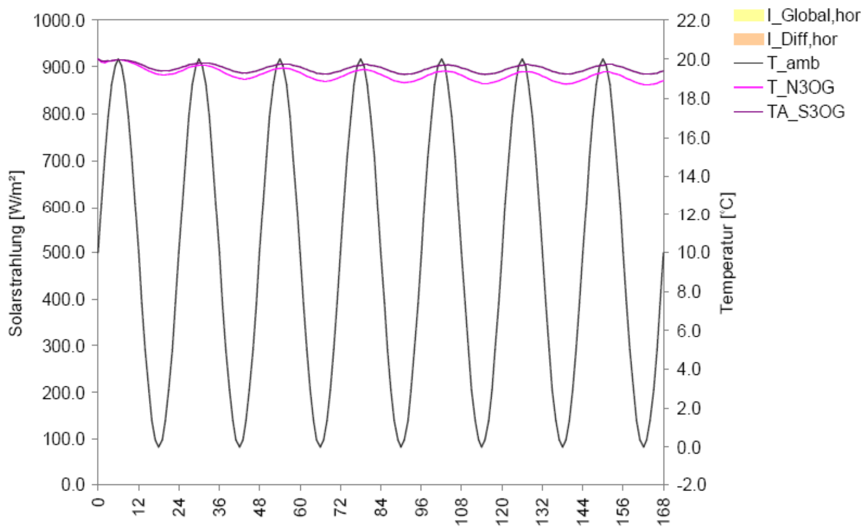
Szenario S2



Winterfall

- Umgebungstemperatur sinusförming um T_Umg = - 10° C schwingend
- Keine solare Strahlung

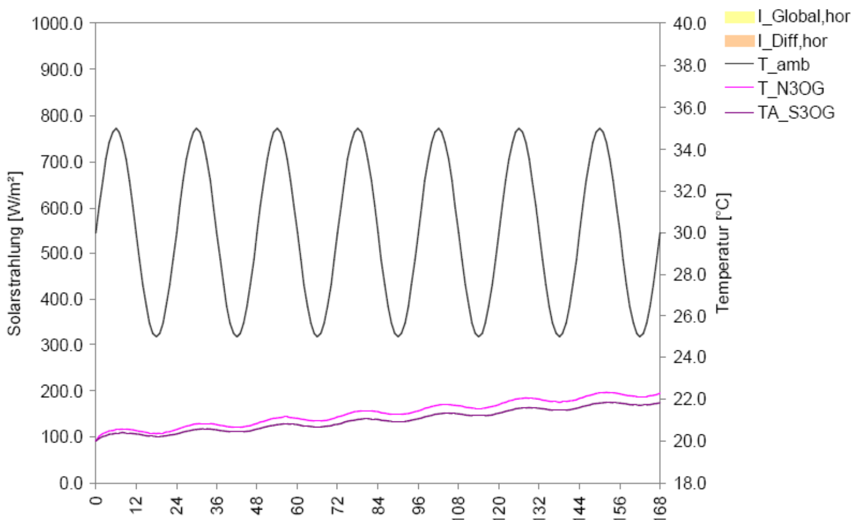
Szenario S3



Übergangszeit

- Umgebungstemperatur sinusförming um T_Umg = 10° C schwingend
- Keine solare Strahlung

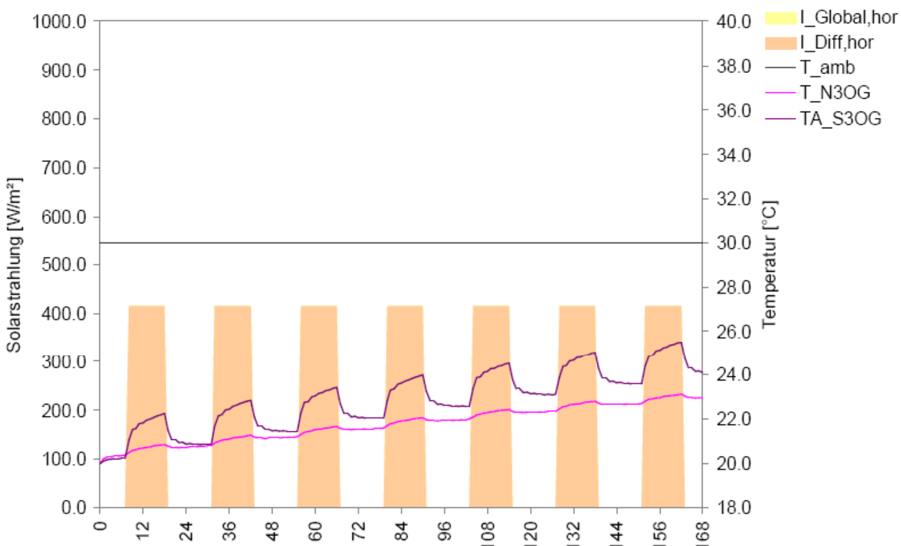
Szenario S4



Sommerfall

- Umgebungstemperatur sinusförming um T_Umg = 30° C schwingend
- Keine solare Strahlung

Szenario S6



Sommerfall

- Umgebungstemperatur konstant mit T_Umg = 30° C
- Konstante Diffuse Solarstrahlung um Idiff = 400 W/m²

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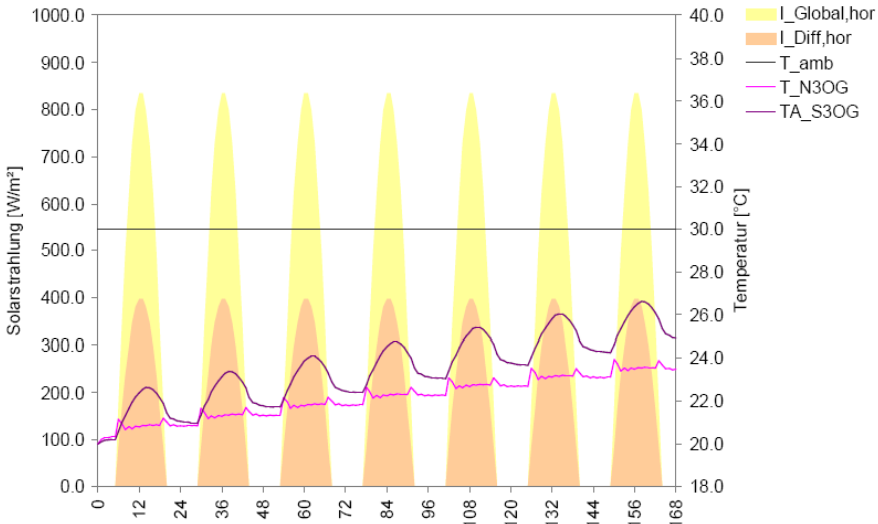
Szenario S7



Sommerfall

- Umgebungstemperatur konstant mit T_Umg = 30° C
- Sinusförmig schwingende Solarstrahlung Iglob_max = 800 W/m²

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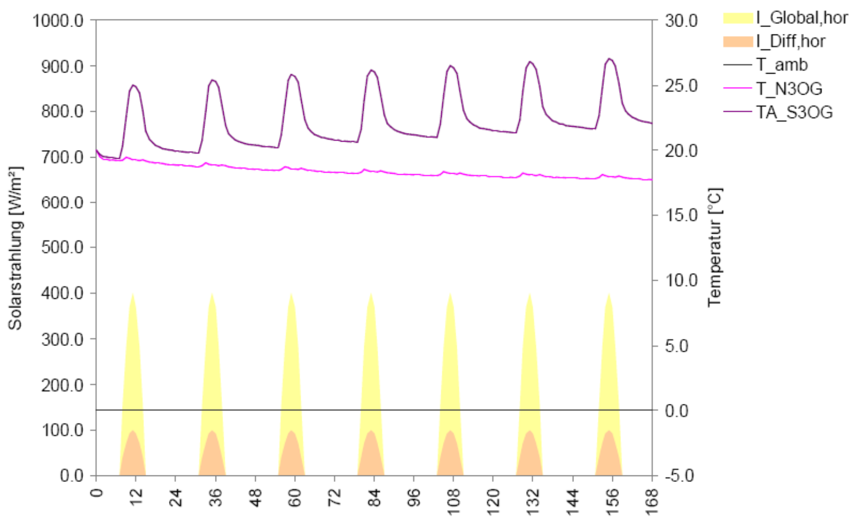
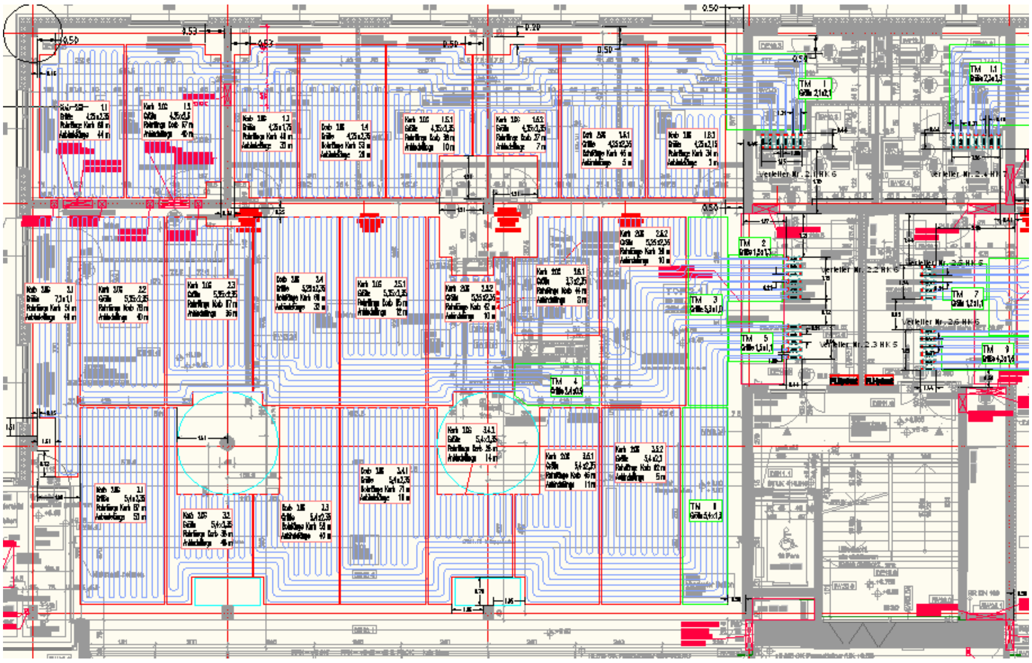
Szenario S8



Winterfall

- Umgebungstemperatur konstant mit T_Umg = 0° C
- Sinusförmig schwingende Solarstrahlung Iglob_max = 400 W/m²

Concrete Core Activation



NCM – schedules (National Calculation Method)

Energy Performance of Buildings Directive (*EPBD*)

2926	2927	2938	2940	2935	2936	124	125	1423	1424	1420	1421
Office_OpenOff_Occ_Wkdy	Office_OpenOff_Occ_Wknd	Office_OpenOff_Light_Wkdy	Office_OpenOff_Light_Hol	Office_OpenOff_Equip_Wkdy	Office_OpenOff_Equip_Wknd	Uni_Lecture_Occ_Wkdy	Uni_Lecture_Occ_Wknd	Uni_Lecture_Light_Wkdy	Uni_Lecture_Light_Wknd	Uni_Lecture_Equip_Wkdy	Uni_Lecture_Equip_Wknd
Area: OPEN PLAN OFFICE Weekday Daily **Occupancy** schedule	Area: OPEN PLAN OFFICE Weekend Daily Occupancy schedule	Area: OPEN PLAN OFFICE Weekday Daily Lighting schedule (Automatically	Area: OPEN PLAN OFFICE Holiday Daily Lighting schedule (Automatically	Area: OPEN PLAN OFFICE Weekday Daily Equipment schedule	Area: OPEN PLAN OFFICE Weekend Daily Equipment schedule			EDUCATION UNIVERSITIES Area: HALL/LECTURE THEATRE/ASSEM	EDUCATION UNIVERSITIES Area: HALL/LECTURE THEATRE/ASSEM	EDUCATION UNIVERSITIES Area: HALL/LECTURE THEATRE/ASSEM	EDUCATION UNIVERSITIES Area: HALL/LECTURE THEATRE/ASSEM
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
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0,25	0	1	0	1	0,05	0	0	0	0	0,05	0,05
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0	0	0	0	0,05	0,05	0	0	0	0	0,05	0,05
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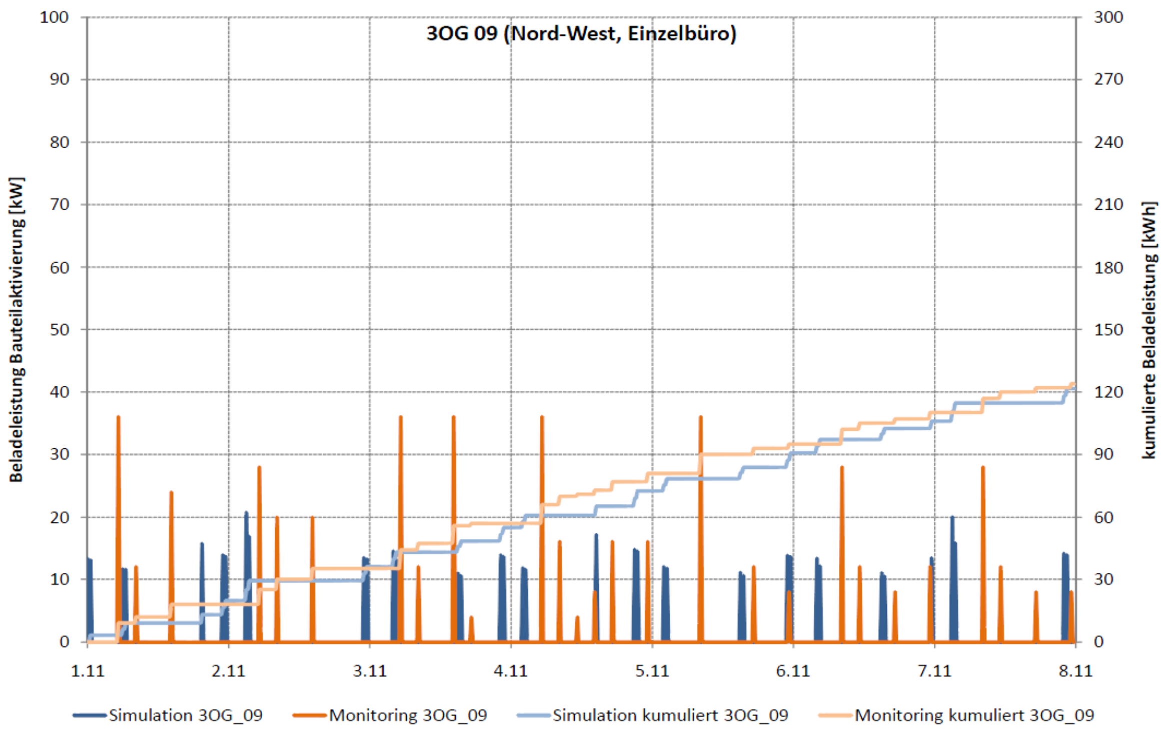

SMARTGRIDS Modellregion Salzburg

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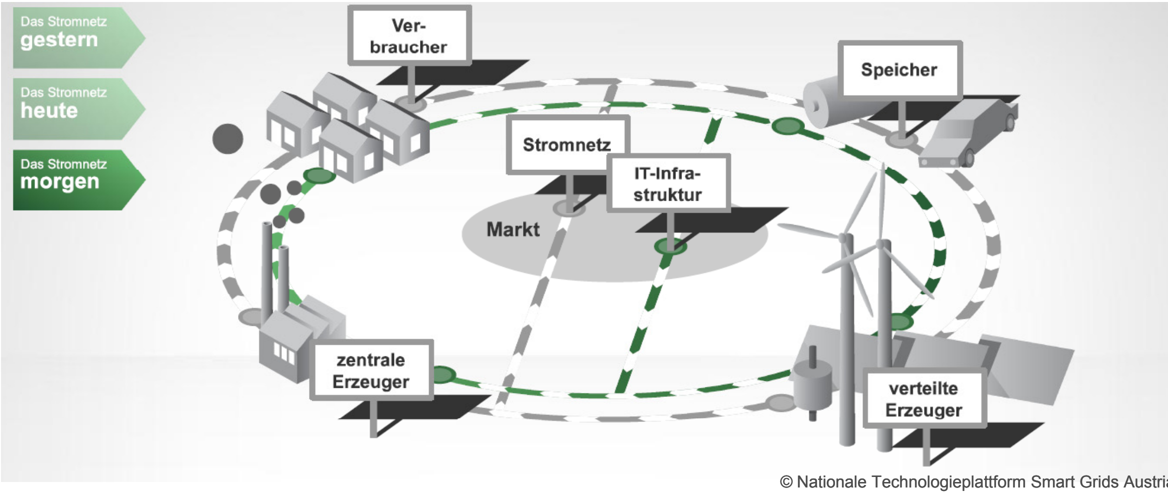
TOMORROW TODAY

B2G – Building to Grid

Power Grid of the Near Future



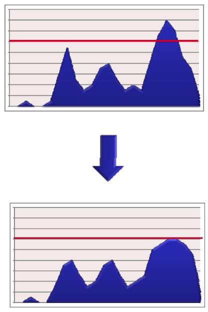
- Many decentralized producers
- Buildings: from consumer to producer & consumer -> prosumer
- Customers adapt their behavior: Smart Meters
- Power Grid combined with IT network
- New decentralized storage to compensate consumption and production (e-mobility)

B2G – Building to Grid

- The challenge
  - High load peaks in the grid
  - Improvement of buildings with no regard to the grid
- The target
  - Intelligent building services enabling cooperative integration into the grid
  - Optimal mains operation by utilising buildings' degrees of freedom
- The method
  - Building simulation to predict status and capacity
  - Equipment and operation of 10 test buildings over one year
- The result
  - Improved load models of buildings
  - Buildings in the role of storage and active participants in a smart grid

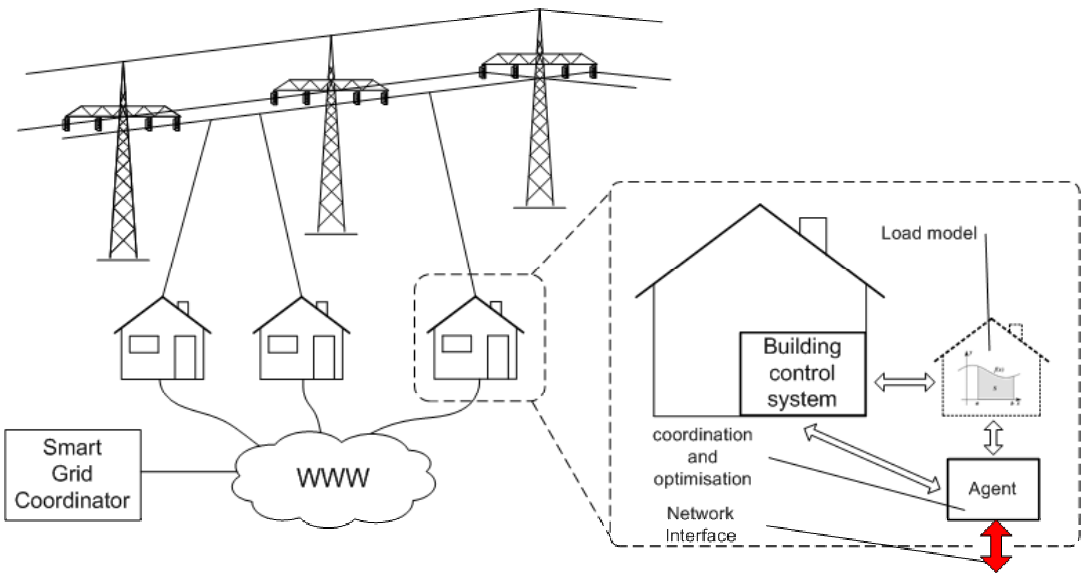
B2G – Building to Grid

- Investigation
  - Selection of appropriate demonstration buildings in Salzburg, Austria
  - Occupancy and use, thermal mass and existing IT infrastructure
- Simplified load model
  - Simplified generic load model for electric-thermal coupling
  - Anticipatory application of storage potential
- Load Shifting
  - Determine maximum time for shifting
  - Avoid heating during grid peak loads



B2G – Building to Grid

- Interaction between the remote action, building control and the smart grid



B2G Outlook

- Find maximum time for switching off loads
  - Minimum of two hours expected
- Determine potential of electric-thermal coupling
- Simplify thermal model
  - Required for online optimization

Next steps:

- Include weather prediction

TOMORROW TODAY

Thank You!

Energy management in small buildings and local grids

Smart Energy Management

Author: Fritz Schmidt

Date: 16.11.2010
Dissemination Level: Public

Content

The objective of SmartCoDe is to enable the application of demand side management and smart metering in private and small commercial buildings and neighborhoods. This requires the development of new methods for automated (or smart) energy management that specifically considers the requirements of energy using products (EuP) in homes or offices and local renewable energy providers (LEP). The consequences for energy management will be described in three steps

1. Basic Definitions
2. Smart energy management
   1. Software: Methods to evaluate measured data
   2. Hardware: Intelligent data logger for data collection and building control
3. Local energy resource cluster for proof of SmartCoDe-concept

Basic Definitions

› Energy **monitoring** means the continuous measuring of energy related data. It is an energy efficiency technique based on the standard management axiom stating that “**you cannot manage what you cannot measure**”

› Energy **controlling** means the process of comparing energy consumption against energy demand according the rules defined from the management

› Ongoing or Continuous **Commissioning** is an ongoing process to resolve operating problems, improve comfort, optimize energy use and identify retrofits for existing commercial and institutional buildings and central plant facilities.

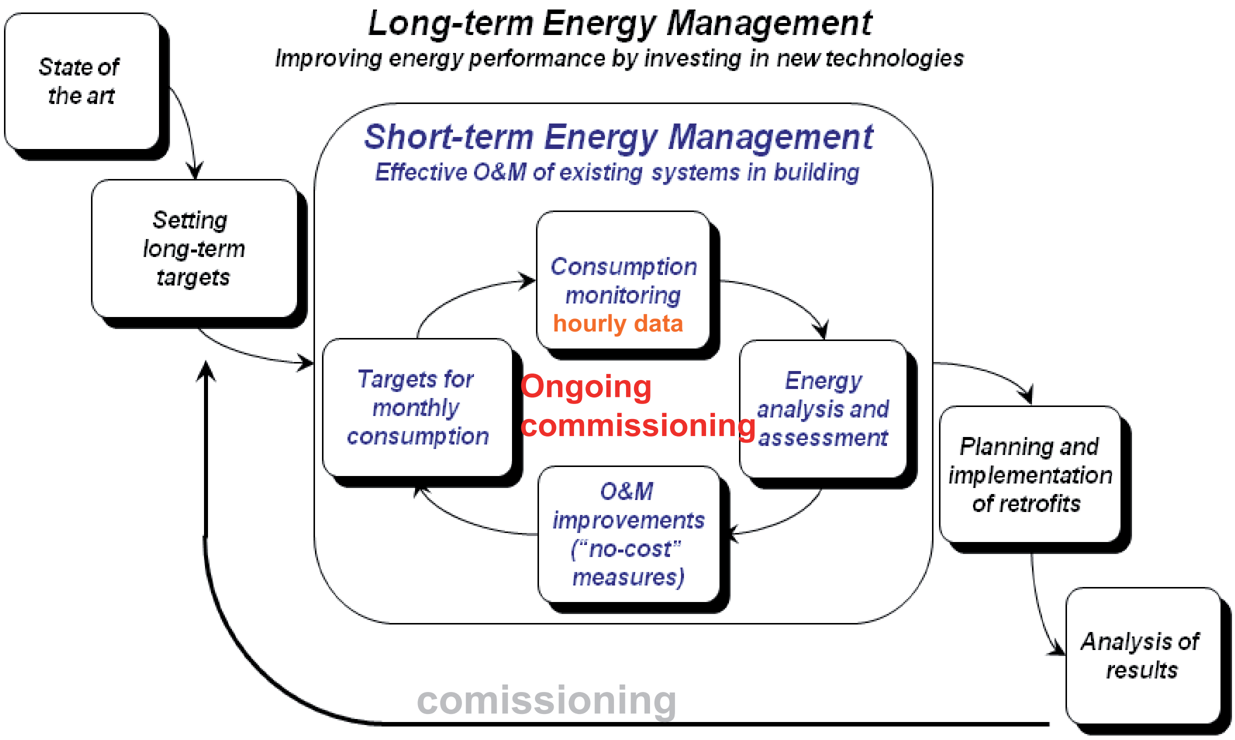
Basic Definitions

› **energy management** means a digital control system that is used to monitor and possibly control the function, operation, schedules, and/or optimization of the central plant equipment, the HVAC equipment, process equipment, and/or building conditions (e.g., lights, temperature) from a central location.

› **smart energy management** supports the user in

- visualizing the measured data in various contexts
- selecting those data which indicate inefficiencies or faults
- control measured data according given rules
- propose measures to optimize operation to meet demand and/or other optimization by various criteria

Short- and long-term perspectives of energy management



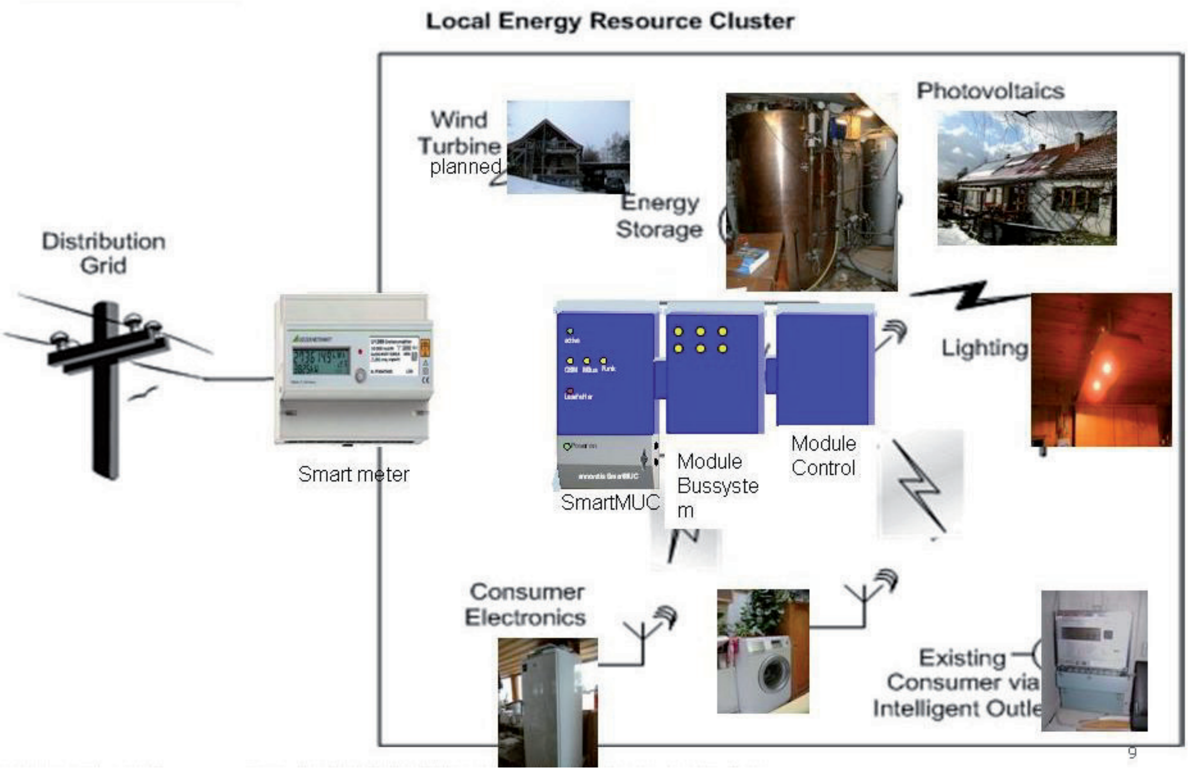
From annex 46

Basic Definitions

› **Smart energy management in small buildings and local grids** includes
  - energy provider through the grid
  - local renewable energy providers like solar or wind
  - Locally available energy storages
  - various energy using products
  - sensor and counters

and
  - combines energy users and energy producers typical for households or small offices
  - tries to optimize energy consumption according to locally given criteria

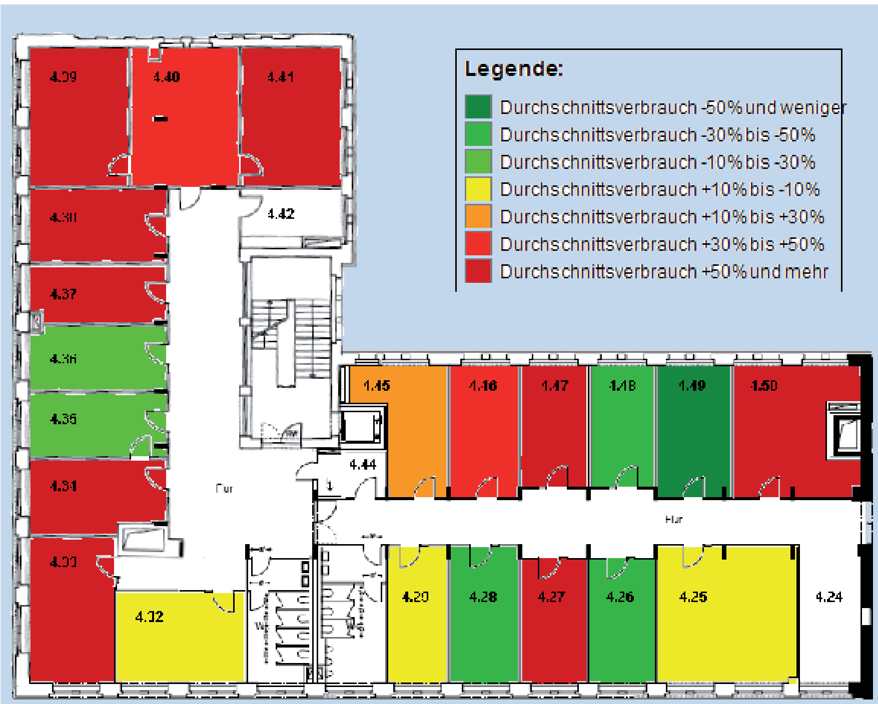
Electricity management in small buildings and local grids Example



Smart EM - methods to evaluate measured data

Intelligent metering

› People view data with high time resolution in various contexts



Comparison of heat consumption in an office daily and room wise

Intelligent metering: variation of heat consumption in appartments

yearly **monthly** **daily**

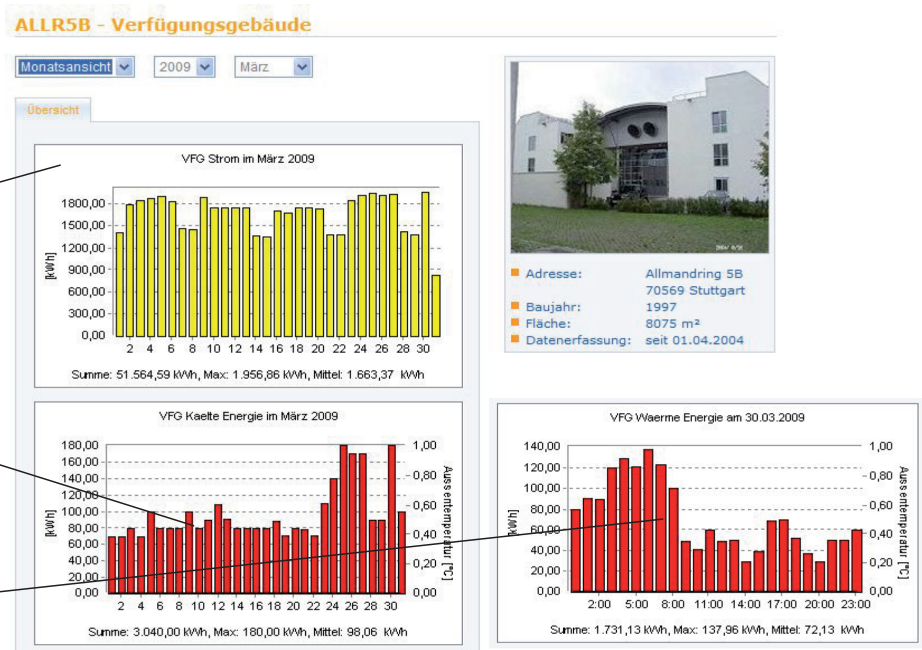
Intelligent metering: time series during operation

1. Patterns and dependencies are not very clear but we can see:

Electricity
base load too high

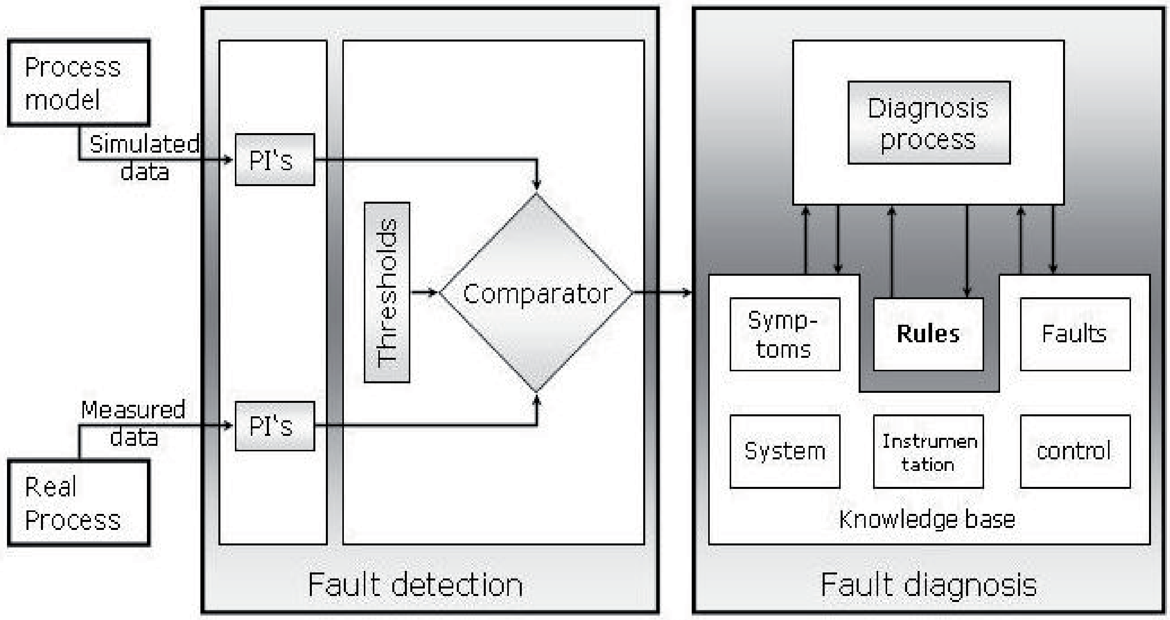
Cold
no weekend set back

Heat
unreasonable heating during night time



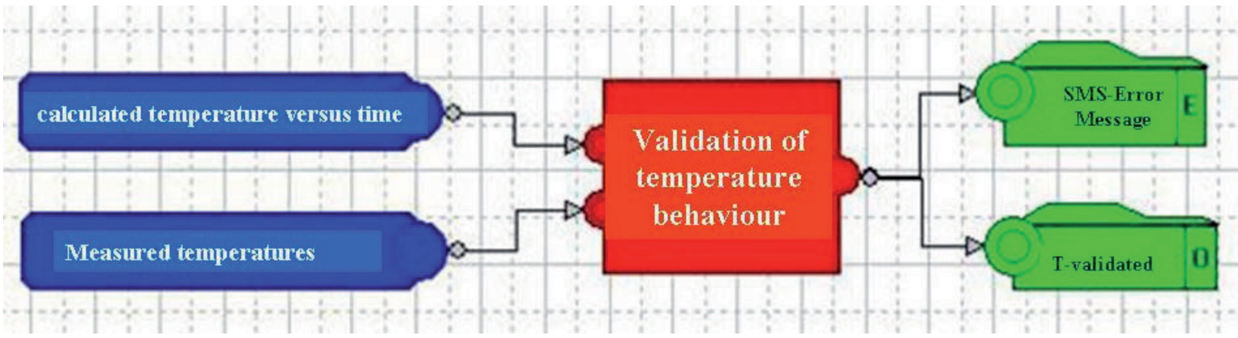
Smart EM - methods to evaluate measured data

2. Model based monitoring - software
   - Derive rules how to interpret consumption data from demand calculations
   - Apply software to fire rules



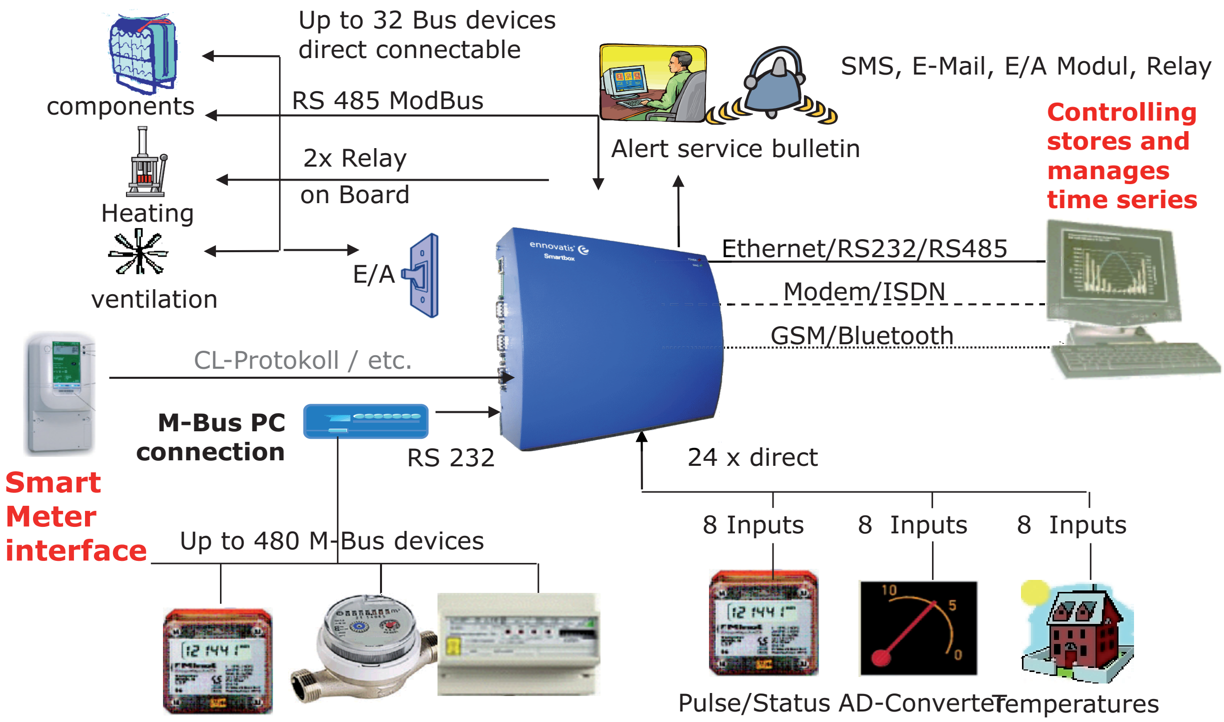
Smart EM - methods to evaluate measured data

3. Rule based monitoring - hardware
   - Derive rules how to interpret consumption data from intelligent metering
   - Apply soft- or hardware to fire rules



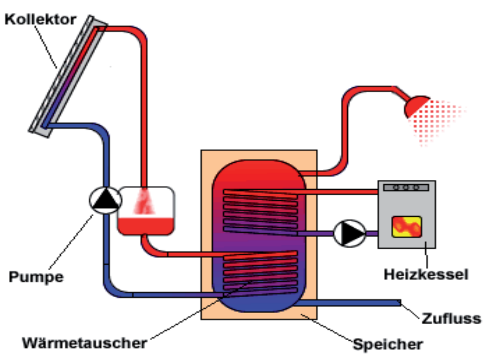
Note: Input can be due to both measurements and calculations

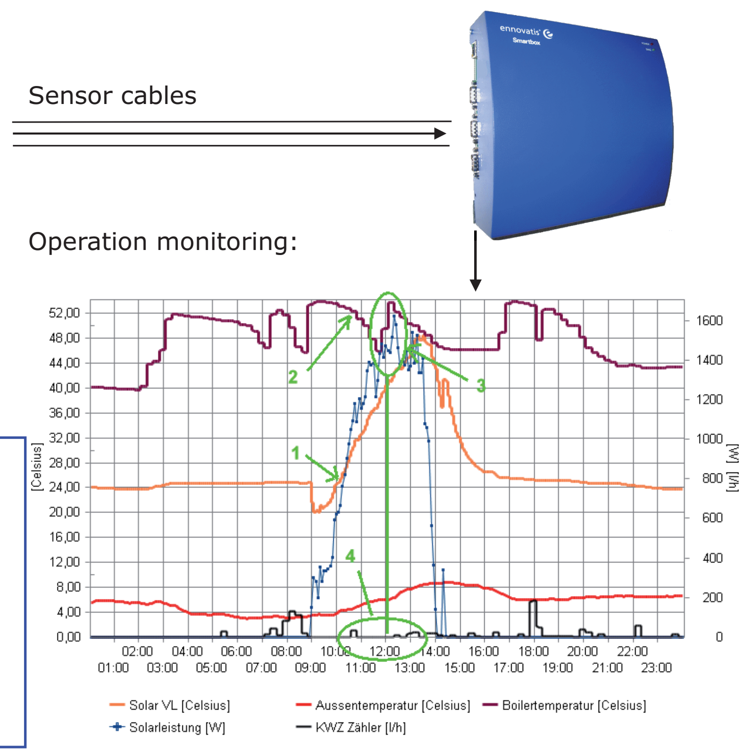
Hardware solution for data collection and building automation intelligent data logger



Detect controlling problem in solar heating system

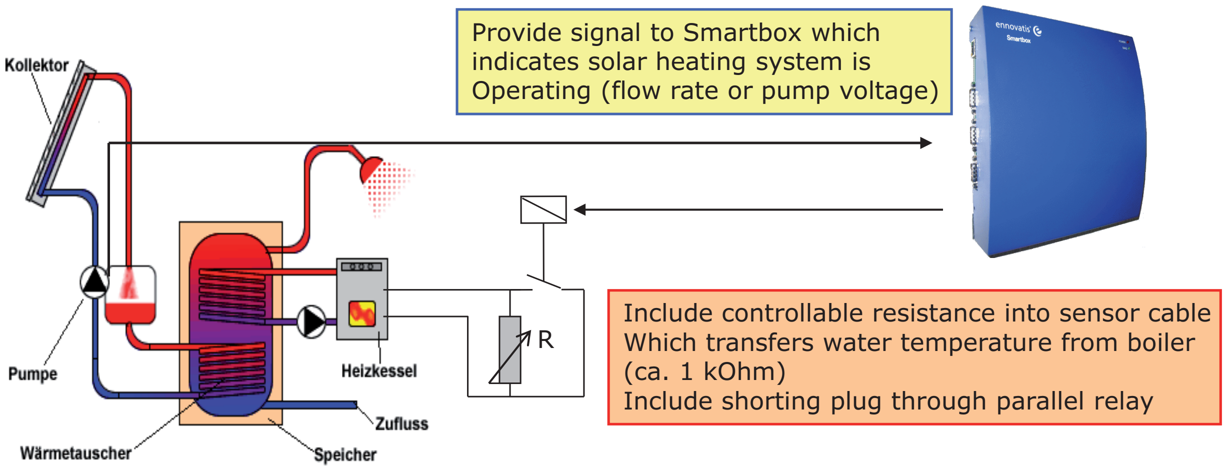
Typical scheme of solar heating system:





1. Begin of solar heating of storage tank
2. Temperature in storage decreases due to mixing
3. Burner starts heating water without
4. Any use of hot water
5. Temperature in storage tank increases and solar gains decrease.

Solve controlling problem with Smartbox



Incorporate the following **rules** in the Smartbox:
If
Solar heating is in operation
and
temperature in storage tank greater 35°C,
than
Open relay to pretend a higher storage temperature
This will avoid to switch on the burner.

SmartCoDe local energy resource cluster

› For the concept of the SmartCoDe project, we consider “local energy resource cluster” that consists of the following energy resources (consumers and producers):

a) **Locally available renewable energies, especially small-scale wind turbines and/or building-integrated photovoltaic's.**

b) **Locally available energy storages such as car batteries (plug-in hybrids, electric vehicles), freezers or hot water systems.**

c) **Energy using products such as HVAC, electric lighting, consumer electronics, white goods, etc.**

› Two demonstration sides are foreseen

– **Almersberg with photovoltaic and home appliances**

– **Buchberg with wind turbine and restaurant appliances**

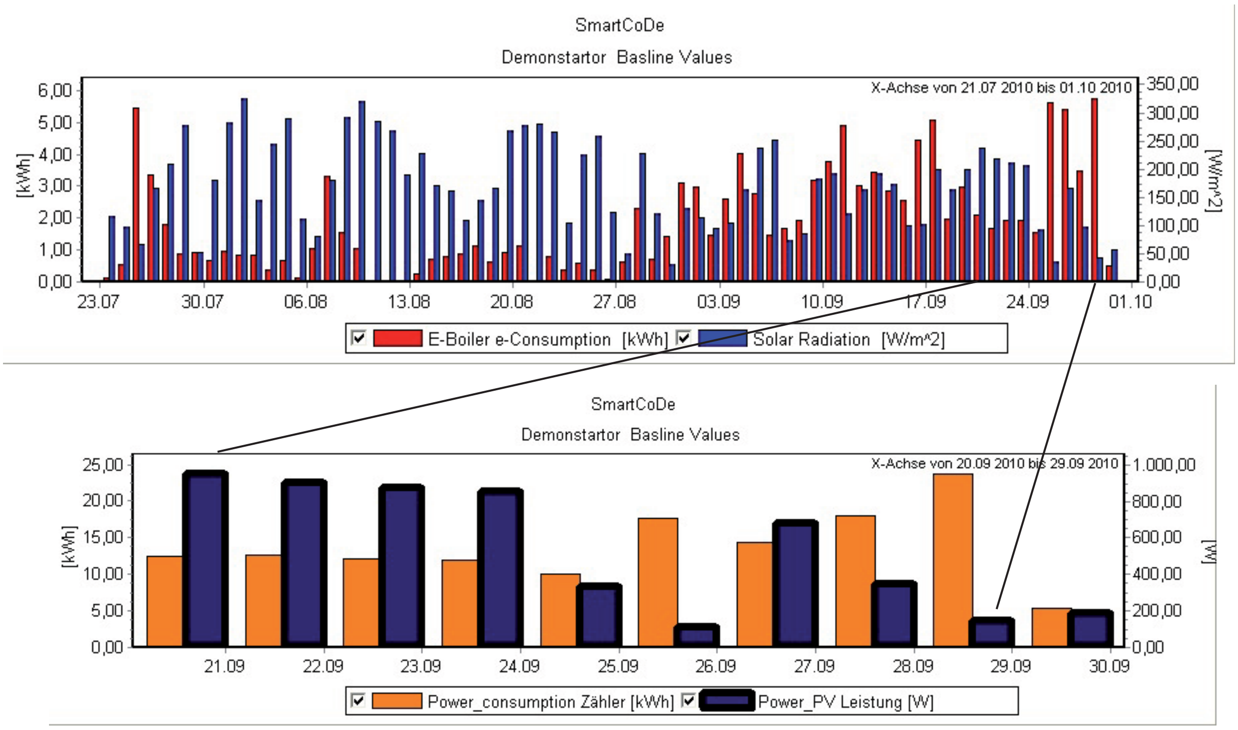
SmartCoDe Demonstrator Almersberg

	
Building with photovoltaic	Heating system

medium period	2005	2006	2007	2008	2009
gas [kWh]	2.306	837	326	339	
electricity pub supply [kWh] 04 -03	10.609	10.776	10.030	5.771	
electricity sold to pub grid [kWh]	0	0	0	0	
electricity production PV [kWh]	0	0	0	0	4.510
warm water [m³]	No data	No data	No data	98	82
heating [kWh]	18.240	16.416	14.592	12.768	0

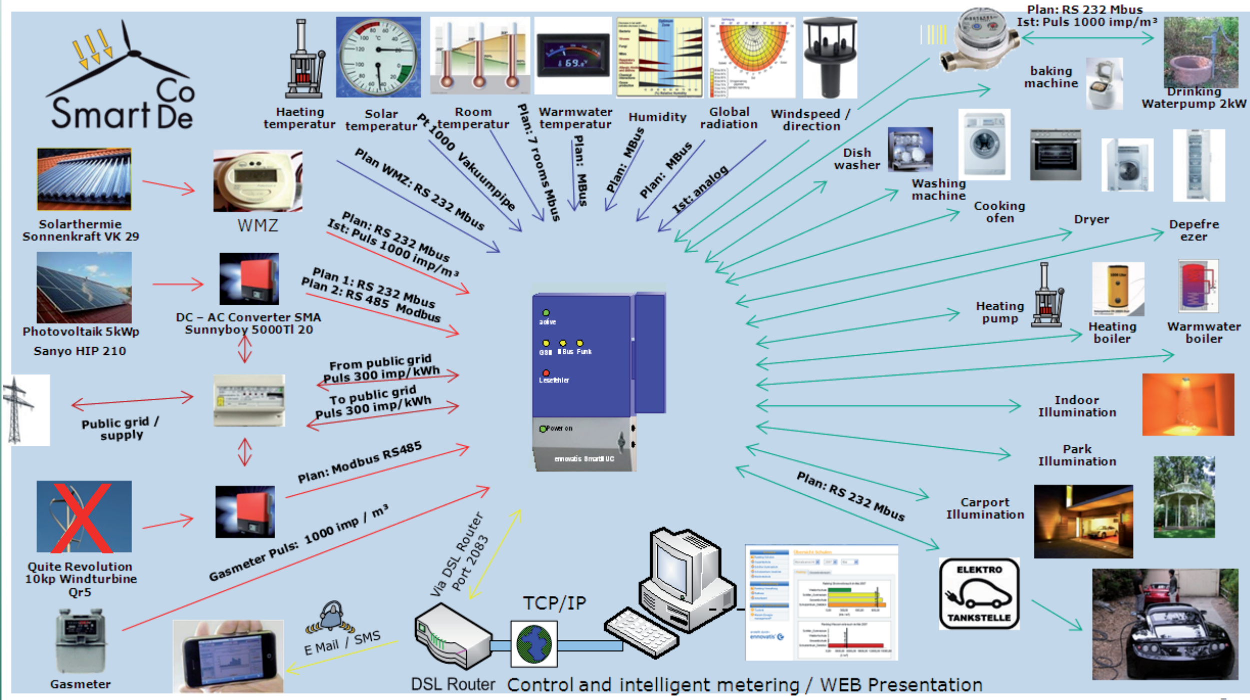
Question is will the SmartCoDe concept allow a higher efficiency in using PV

SmartCoDe Demonstrator Almersberg

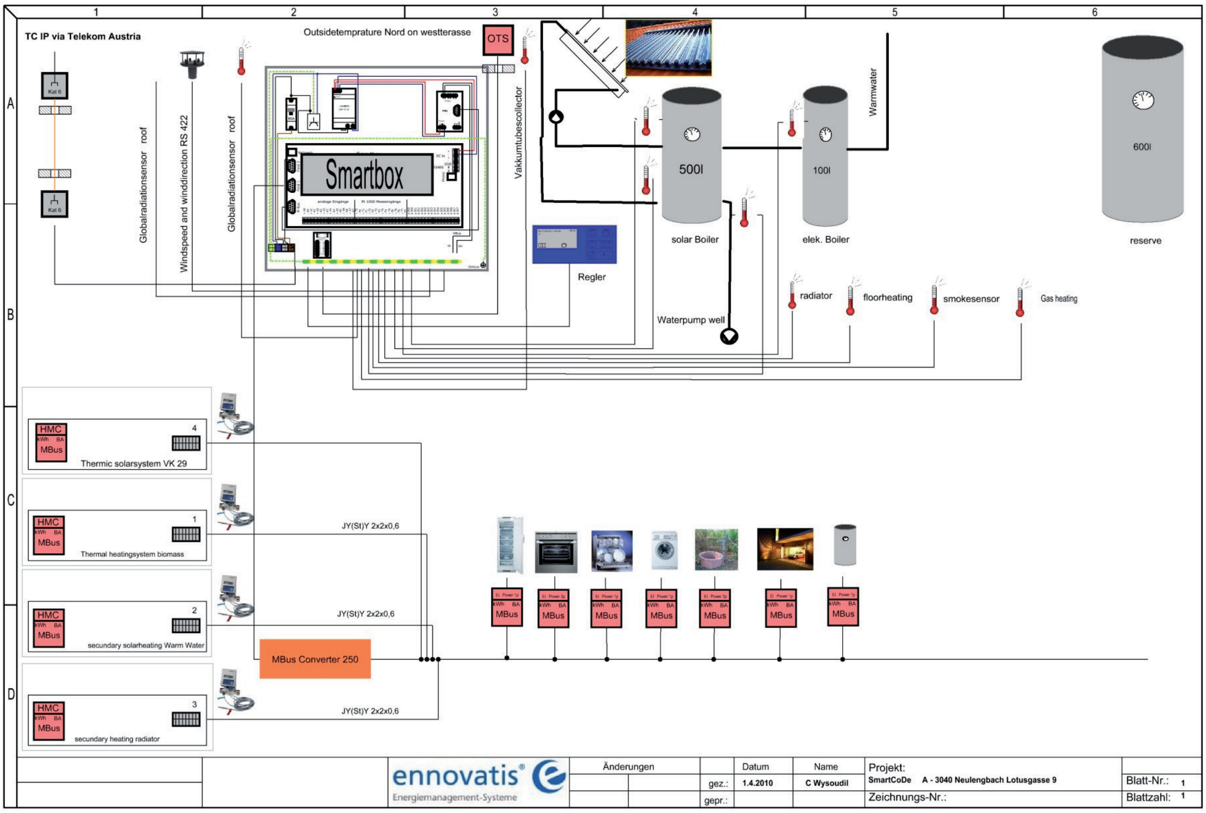


Question is
will the SmartCoDe concept allow a higher efficiency in using PV

SmartCoDe Demonstrator Almersberg



SmartCoDe Demonstrator Almersberg



SmartCoDe Demonstrator - Expansion Buchberg

year	kWh	€
2006	45.873	5.817
2007	51.159	8.286
2008	54.802	9.125
2009	24.999	3.785

Electricity consumption at Buchberg side
note
gas for heating became available in 2008

Installation of wind turbine planned in 2011
expected contribution
in the case of average wind speed of 6.5 m/sec
approx. 10000kWh

SmartCoDe Demonstrator - Buchberg EuPs

Energy using products (EUP)	aprox kW
Fridge	0,05
Deep Freezer & Icecream Freezzer box	0,4
Water pump Gardening	0,22
Heating pump	0,045
Illumination	4,5
Indoor upper floor (Living area)	
Indoor ground floor (restaurant area)	
Outdoor (Park, Terrace)	
Cooling Room	2
Washing machine	2
Dishwasher	2
Water supply pump 1 & 2	2
Circulation pump	0,25
Automat for drinks	0,1250
Electrical heaters for restaurant food warming	6
Ventilation (Kitchen)	0,6
Cooling system for drinks	1
Sightseeing tower (without automat for drinks)	1
Consumption in 2009	**25000 kWh**
Costs in 2009	**3785€**

Thank you very much for your attention

Questions please

contact

E-Mail: F.Schmidt@ennovatis.de

http://demoportal.ennovatis.de

http://www.ennovatis.de

Keynote:
Electric Energy Storage in Smart Buildings
Dr.-Ing. B. Lenz (Next Energy)

Bettina Lenz is the head of the division of energy storage at EWE Research Center for Energy Technology in Oldenburg. She studied mechanical engineering at the university of Stuttgart and made her PHD at the Fraunhofer Institute for Solar Energy Systems in Freiburg on the development of a SOFC based APU for aircraft applications.

Abstract

Distributed feed-in of renewable energy into the low-voltage-grid will increase significantly in the future. The grid-infrastructure already is at a stage where large investments are necessary to cope with this situation. The increase of the own-consumption in households is an obvious step for handling the situation, just recently the German “EEG” was adjusted according to that approach.

As energy storages are usually very cost-intensive devices, buildings have to be made smart so that energy for e.g. laundry machines is used when it is available. Only energy that cannot be used instantaneously in the household should be stored. Power peaks have be smoothened by the grid.

In the presentation the motivation for energy storage in buildings is explained, a review on applicable storage technology is given, a first approach for system sizing is presented.

SmartCoDe has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013]) under grant agreement n°247473

Electric Energy Storage in Smart Buildings

Dr. Bettina Lenz, Meinert Lewerenz| November 2010
SmartCoDe Expert Cooperation Workshop
Vienna 2010

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

Table of Content

- Introduction: NEXT ENERGY
- Motivation
- Storage Technologies
- Battery Storage
- Applications in Low Voltage Grid
- Research Activities NEXT ENERGY

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie e.V.

EWE-Research Center NEXT ENERGY at a glance

EWE

CARL VON OSSIETZKY universität OLDENBURG

Niedersachsen

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie Oldenburg

- Independent & free to work with any other company
- Associated Institute of Oldenburg University
- Staff of ~76; financed by EWE, complemented by third-party funds
- Nonprofit association, results belong to institute and can be published

Target size: ~100 People
New building operational since Q3 2009
>4500m², Laboratories > 1600 m²

EWE Research Center NEXT ENERGY
Carl-von-Ossietzky-Str. 15 Phone +49 441 99906 – 0
26129 Oldenburg/Germany www.next-energy.de

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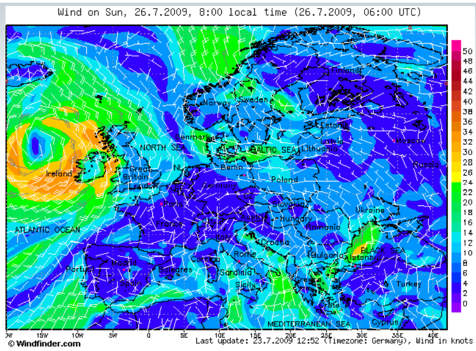
Motivation: Before storing Energy



- Forecasting Energy Demand and Production
  - » Weather Forecast (Solar and Wind Power)
  - » Optimizing PV/Wind/Biogas Balance
- Consume Energy
  - » Demand Side Management (Cold Storage House…)
  - » Energy Distribution (Grid extension)

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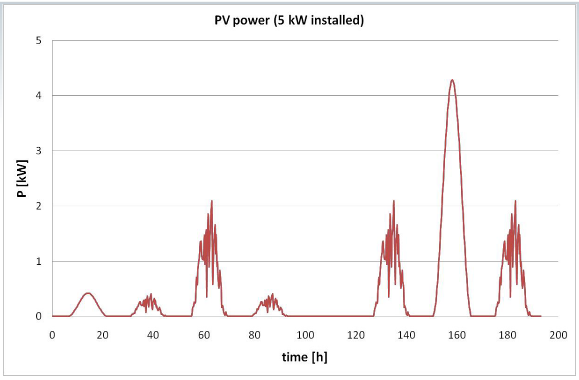
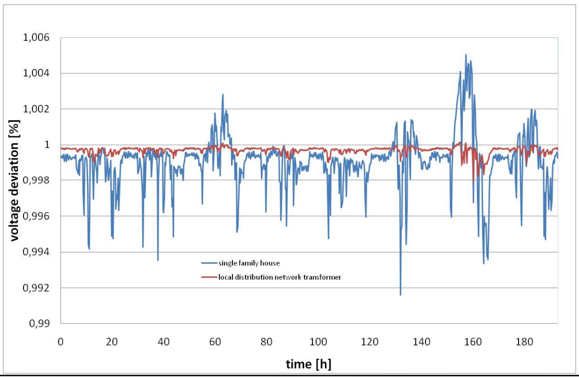
Problems caused by feed-in of PV-power in typical low voltage power grid





- Voltage increase/decrease
- Capacity overload of transformers in the power grid

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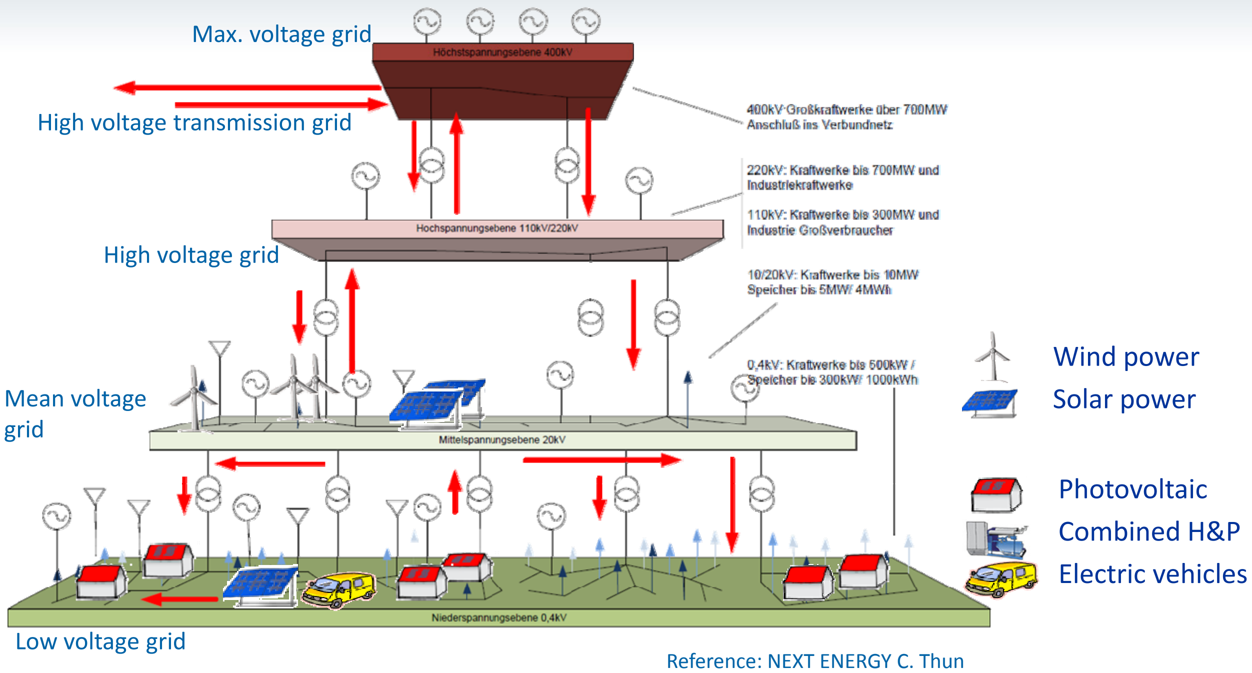
Hierarchical Power Flow



Reference: NEXT ENERGY C. Thun

Storage Technologies

Electricity storage

Mechanical energy

Potential energy
- Pumped hydro
- Compressed air

Kinetic energy
- Fly wheels

Chemical energy
- **Batteries**
- Hydrogen
- (Fossil energy carriers)
- (Biomass)

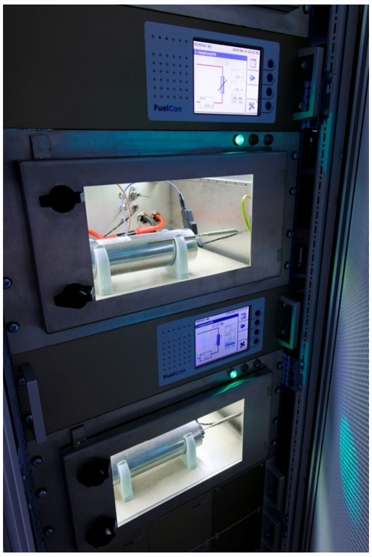
Electrical energy
- Capacitors
- SMES (Superconducting magnetic energy storage)

Battery Storage in General

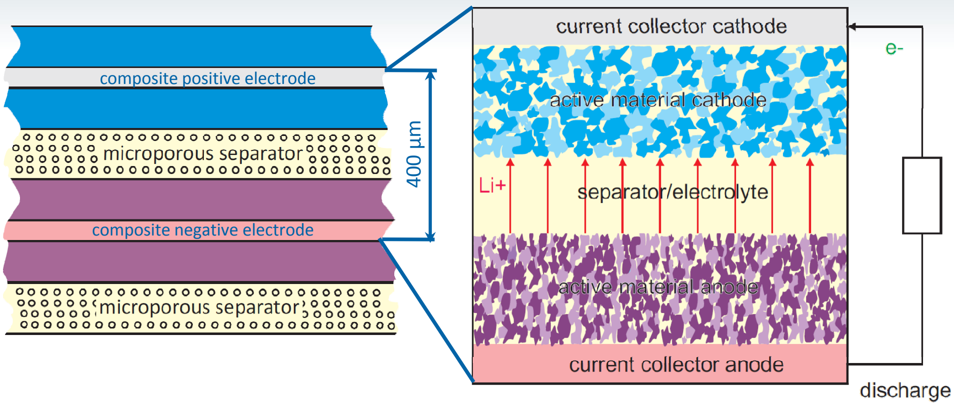
- Fast Responding (in ms)
- Nearly Maintenance free
- Mid Range of Energy-to-Power Ratio
- Modular Setup
- Mid Range Price
  - Price Reduction partially possible
- Best Temperature around Room Temperature (except HT-Batteries)

Battery Storage: Li-Ion

- High Cell Voltage up to 3,6V
- High Power Battery (Low Internal Resistance)
- High Energy Density
- Safety Issues (Overcharging, Overheating)
- Mobile Application (EV, 4C-Market)
- High Efficiency (DC-DC-Efficiency of over 95%)
- Lifetime around 10 Years (2000-4000 full cycles)

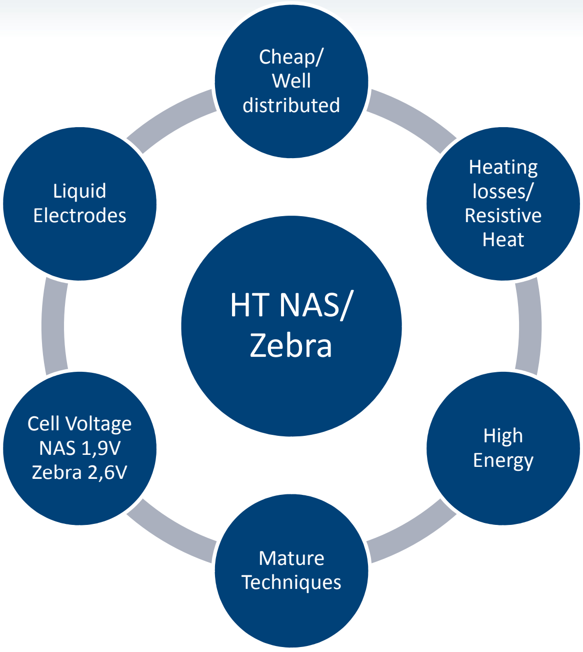


Lithium-ion batteries – Basic principle



Active anode material:	graphite
Active cathode material:	$LiFePO_4$, $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, $Li(Ni_xCo_yMnz)O_2$, etc.
Separator:	PE, PP, ceramic foil (separion)
Electrolyte:	solvent is propylene carbonate, ethylene carbonate, dimethylcarbonate, ethylmethyl carbonate, $LiPF_6$

Battery Storage: High Temperature (Sodium Sulfur and Zebra)



- Application:
  - Sodium Sulfur (stationary)
  - Zebra (mobile)
- Minimal Size Sodium Sulfur 1MW/ 7MWh
- Heating: Minimum Energy Turnover recommended
- Aging in Electrolyte/Separator
- Only two Cell Producers

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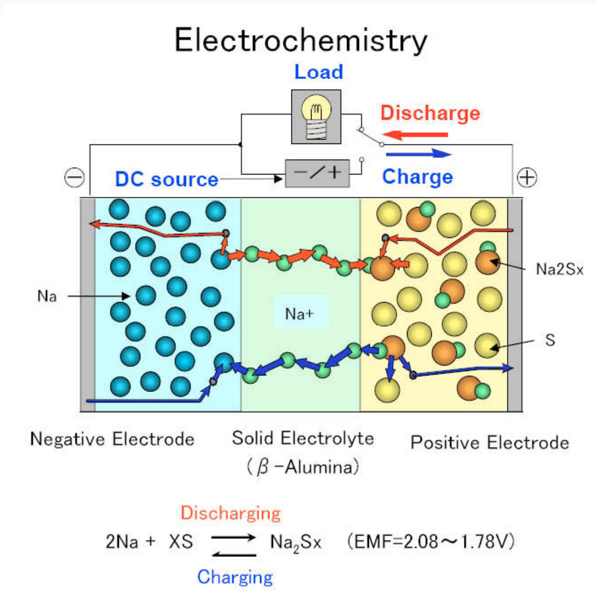
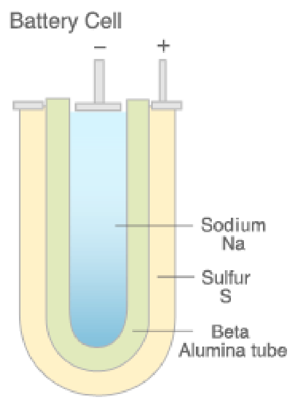
HT-Battery: Sodium Sulfur (NaS)





Source: NGK insulators

Advantages of the Redox Flow Batteries (RFB) :

Redox-Flow-Battery (RFB)

- The energy is stored in liquid electrolyte =>Modular assembly
- The electrolyte is aging slowly and is restorable
- Reliable determination of the state of charge (SOC)
- Deep discharge leads to reversible damages
- Vanadium-Vanadium-H_2SO_4
  - 1,6 – 1,8 V
  - 5 – 40 °C
  - 72 %
  - most promising

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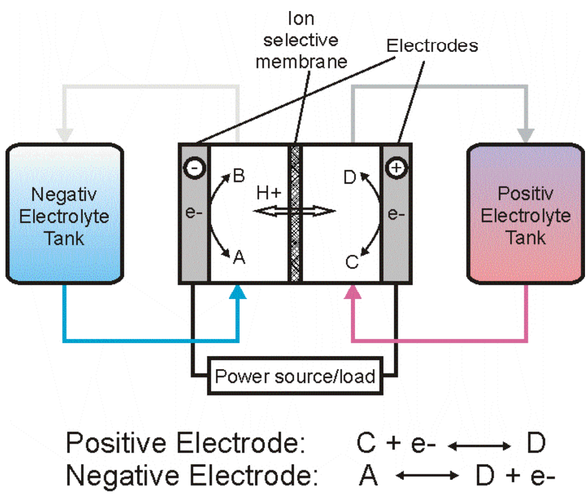
Principle of Redox Flow Cell:

- The redox reactions take place in solution on inert graphite electrodes.
- The reactants flowing across the electrodes are supplied from containers outside the electrochemical cell.
- A special ion- selective membrane prevents the mixing of the two electrolytes.
- The changes in the valence number (oxidation state) of the ions enable the battery to store and discharge electric power.



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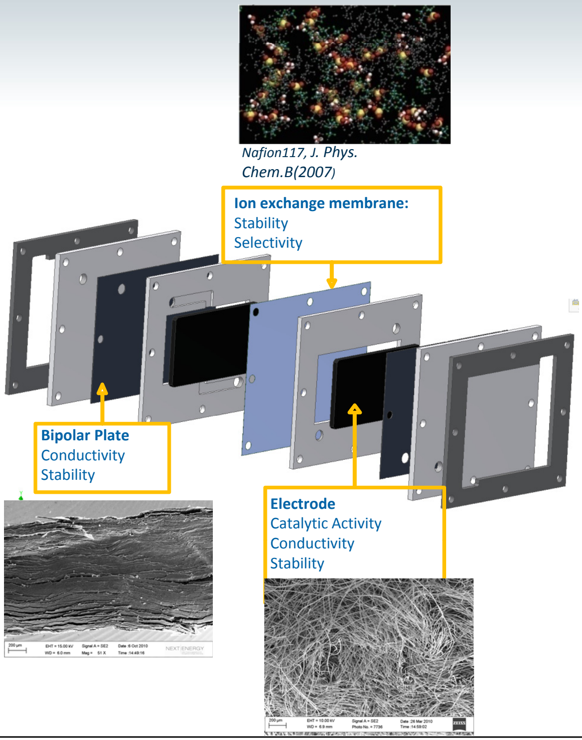
Construction of the Cell Stack:

- The single cell contains 2 carbon felt electrodes separated by an ion exchange membrane
- Multiple cells combined in cell stacks
- Multiple cell stacks can be connected either in series or in parallel, according to the required output of the system
- Modular assembly with variable energy by constant performance



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Battery Storage: Other Mature Storage Technologies

Lead Acid

- Only Few Full Cycles
- Low Energy Density
- Efficiency of 70%
- Calendar Lifetime 7 years

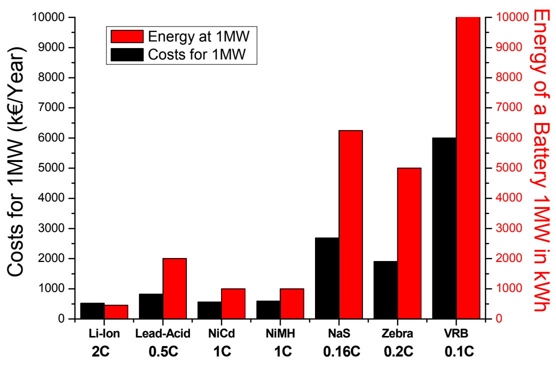
Alkaline: NiCd & NiMH

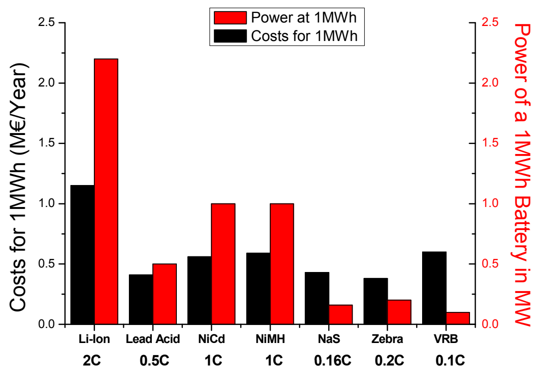
- Many Thousands of Cycles
- Mid Energy Density
- Efficiency of 70-75%
- Calendar Lifetime 10-20 years

Both:

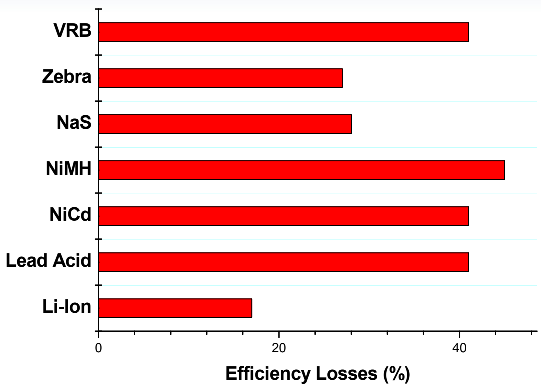
- Recycling system available
- Many Manufacturers
- High Safety
- Toxic Contents

Costs for Energy and Power





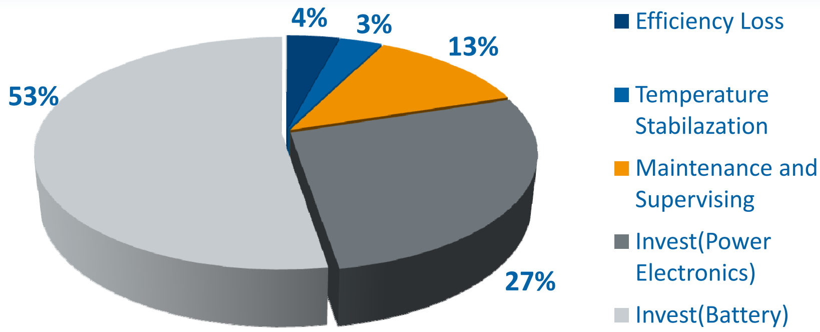
Efficiency Comparison



- Power Electronics
- Battery
- Self Discharge
- Battery Interconnections
- Auxiliary Energy (BMS)

- Complex Values: Temperature, C-Rate, DOD, SOC and Load per Day
- Not included Heating/Cooling
  - 10-50kW for 1MW NaS
  - 3kW for RT

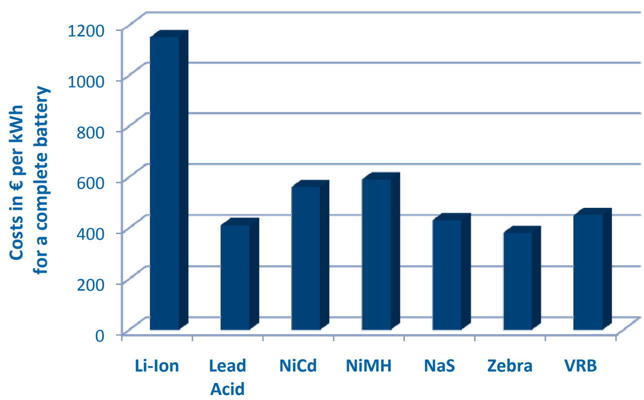
Cost Distribution Normalized for one Year



Example: 1 MW / 700 kWh Lithium Ion Battery

Application: Reserve Power

Costs per kWh



- Additional Costs for VRB of around 1,500€/kW

Applications in Low Voltage Grid

- Local Storage in House
  - Small Sized (Low Power and Energy)
  - Low Maintenance
  - Using the Self-Produced Energy
  - More Expensive than Larger Storages
  - Owner is Landlord
- Vehicle-To- Grid (V2G)
  - Dual Use of Electric Vehicle
  - Grid Connected Battery (Energy Distributer)
  - Economy of Scale
  - Benefits for Owner

Applications in Low Voltage Grid

- Storage for Residential District
  - Big Sized (High Energy Storage)
  - Cheap costs
  - Better Utilization Capacity
  - Cooperative Ownership
- Storage for Grid Stability
  - Energy Provider as Owner
  - Preventing Grid Expansion
  - Power Quality (Shape, Voltage, Frequency)
  - Location at
    - Long Branch Lines
    - Substations

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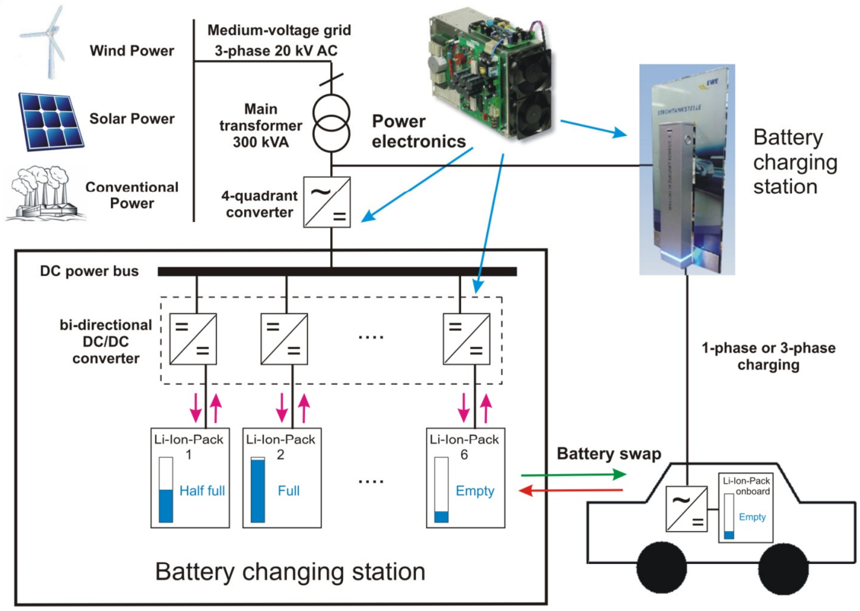
Grid integration and power electronics



- Energy storage and energy dispatch
- Storage capacity: 180 kWh
- Grid integration with FACTS Features (Flexible AC Control System)
- Grid regulation via reactive power dispatch

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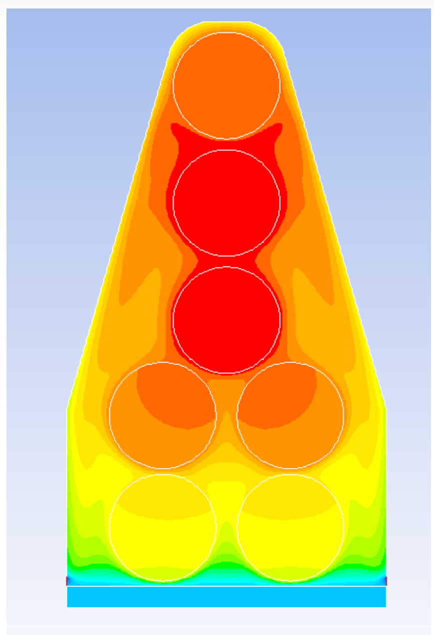
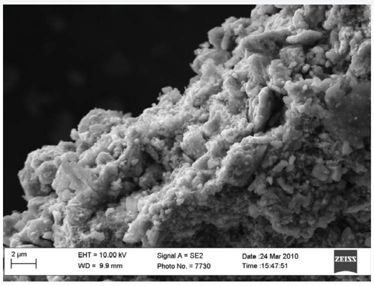
Packaging and battery management

- Next generation battery control for reduced aging and save operation
- Thermal management at cell level
- Characterization of single cells
- Analysis and optimization of battery packs
- Development of multiphysical simulation models
- Efficient thermal management by elaborate design and material choice (passive thermal management)



Development and electrochemical performance of electrodes for Li- Ion Batteries

- Material characterization
- Electrode preparation
- Electrochemical diagnostics in three-electrode arrangements
  - Electrochemical Impedance Spectroscopy
  - Cyclic Voltammetry
  - Galvanostatic and potentiostatic Transients
- Electrolyte optimization
- Innovative test cell designs
- Detection of aging phenomena under dynamic load profiles

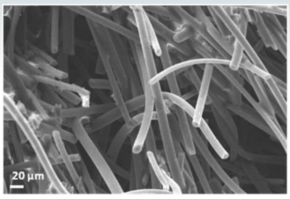


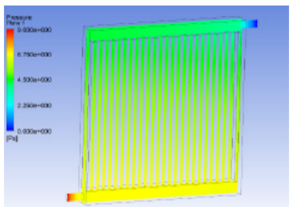
Vanadium Redox Flow Battery (VRB)

- Single cell design - optimization of the electrode geometry and the electrolyte flow field
- Investigation of the properties and the performance of various electrodes materials and membranes
- Electrolyte development and optimization
- Electrochemical diagnostics

  The goals are reduction of aging and self discharge processes, enhancing of the battery performance and cost reduction

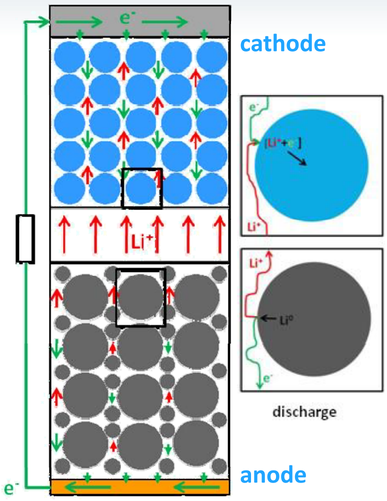
- Stack design - optimization of the electrolyte supply and electrical interconnection
- Long term cycling under real climate conditions and load profiles
- Application of VRB as a stationary energy storage for renewables





Modelling and Simulation, virtual cell design

cathode

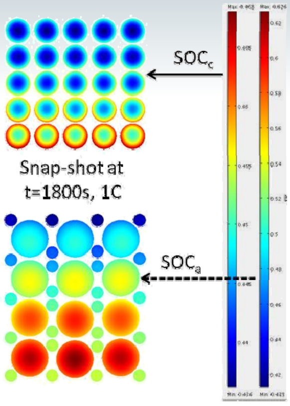


anode

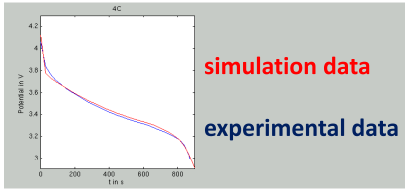
2-dim. model of current collectors, active anode and cathode layers and separator

Transport equations:
- Ohm‘s Law of conduction
- Fick‘s Law of diffusion

Charge Transfer:
Butler-Volmer-equation



Particle-dependent State of Charge



Model validation at 1C-5C, here: 4C

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Thank You!

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Security considerations for SmartCoDe Network

Smart Energy Management

Author: Juraj Hájek
Date: 16.11.2010
Dissemination Level: Public

Latest history – sample incidents

- 2003 – Northeast Blackout - cascading power failure in the eastern caused by software bug in energy management system (affected 55 million people in USA and Canada)
- 2007 - Goodspeed demonstrated that it was possible to write a worm that could spread among MSP 430 chips, which are used by some Smart Grid device makers
- 2008 – Cyber attack had taken out power equipment in multiple regions outside the U.S.
- 2009 – IOActive have created a worm that could quickly spread among Smart Grid devices
- 2009 – USA declared that they electricity grids have been penetrated by spies

Basic security requirements

› ***Confidentiality***: *"Preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information…."*
  A loss of confidentiality is the unauthorized disclosure of information.

› ***Integrity***: *"Guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity…."*
  A loss of integrity is the unauthorized modification or destruction of information.

› ***Availability***: *"Ensuring timely and reliable access to and use of service…."*
  A loss of availability is the disruption of access to or use of service or an system.

Consumer trust and confidence

› Accenture research about customer preferences in Energy Efficiency (April 2010)
  – **More than 9000 consumers**
  – **17 countries**
  – **About 1/3 said they would be** discouraged from using energy-management programs**, such as smart metering, if it gave utilities greater access to data about their personal energy use**

› **Trust** is fundamental to attract customers

› Potential customers have a hierarchy of needs that influences their reasoning

Privacy

- The Smart Grid opens up more opportunities for invasion of privacy
  - **Higher amount of available data**
  - **More granular form (minutes)**

- Privacy categories
  - **Privacy of personal information**
  - **Privacy of the person (e.g. required medical devices)**
  - **Privacy of personal behavior**
  - **Privacy of personal communications**

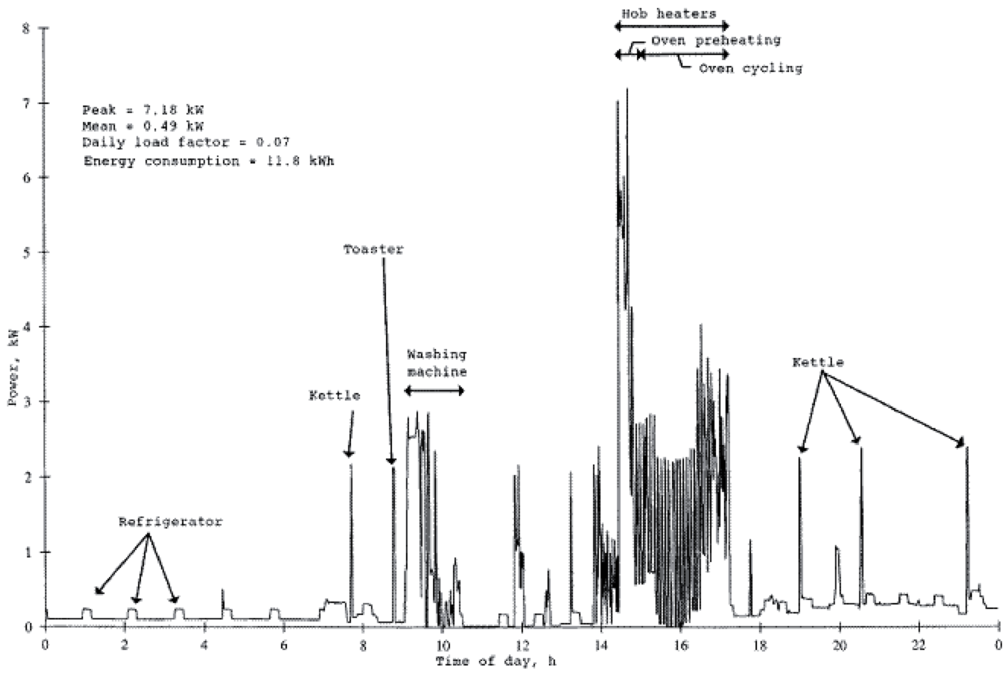
- Who owns Smard Grid Data?

Power usage patterns

- Nonintrusive appliance load monitoring
- It is not required to sniff/decrypt local network communication
- Power usage can be compared with library of existing patterns

- Potential groups of interest
  - **Thieves**
  - **Annoying marketers**
  - **Police investigation (**indoor marijuana plants can be detected also with existing granularity of measurements**)**
  - **People involved in energy trading – manipulation of energy costs at the real-time energy stock market**

Power usage graph



Source: NISTIR 7628 Guidelines for Smart Grid Cyber Security v1.0

Privacy – potential solutions

› Utility company
  - **A part of energy consumption is covered from local energy sources (solar cells, electric and plug-in hybrid cars…). This changes overall power usage pattern**
  - **Data are anonymized to the level sufficient for pricing**

› Transport channels
  - **Strong cryptography**

› Local grid/network
  - **Strong cryptography**

Smart Grid Cryptography- Constraints

› General constraining issues
  - **Computational constraints (CPU,Cryptoporcessor, RAM)**
  - **Channel bandwidth**
    › Encryption - negatively influences lower layer compression algorithms
    › Integrity protection - communication overhead (could be important for limited bandwith and small messages)
  - **Connectivity**
    › access to PKI infrastructure

› General cryptography issues
  - Entropy
  - Cipher Suite (standards base, mature, preferably patent free)
  - Key Management (including certificate lifetimes)

Example - TI MSP 430 (Worm by Goodspeed)

› Parameters
  - **Devices starting at $0.25 USD in 100k units**
  - **Complete LaunchPad development kit for $4.30 USD (including compilers, debuggers)**
  - **No memory protection**
  - **Small stack space**
  - **Limited memory for program code 0.5-2 KB**
  - **Source of entropy cannot be protected**

Common SW problems

› Missing error checking (limited program memory size)
› Buffer/Integer overflows
› Small stack space – e.g. depth 7
› Programming errors in state machines (protocols, authentication schemes)

SmartCoDe – Security scope

› SmartCoDe project is focused on energy management for buildings and neighbourhoods (local grids)

› Within scope
  – **CIA (confidentiality, integrity, authenticity) of local communication**
  – **Security aspects related to commissioning of local network**
› Out of scope
  – **Security of communication between local grid and utility company**
  – **Privacy and legal aspects of data archiving outside of local grid**
  – **Authenticity and trust in the whole supply chain**
  – **Vulnerability management and traceability in the whole supply chain**

ZigBee

› Low-cost, low-power, wireless mesh networking standard
› Based on IEEE 802.15.4-2003
› Application profiles to enable interoperability
  – **Home Automation**
  – **Smart Energy**
  – **Telecommunication Services**
  – **Health Care**
  – **Remote Control**
› Security defined for the MAC, NWK and APS layers
› Security for applications is typically provided through application profiles.
› E.g. Smart Energy
  – **AES 128 encryption**
  – **ECC implicit certificates for authentication and key establishment**
› Existing commissioning cluster supports configuration ,,over the air''

SmartCoDe vs. ZigBee

› „SmartCoDe profile" is in specification phase
› Profile is PHY/MAC layer agnostic
› Security extensions can be implemented on APS layer
› Security building blocks in ZigBee SE are mature. Higher security could be achieved e.g. by
  – **HW - smart cards available in standard low cost nodes**
  – **Well defined and standardized procedures for deploying and maintaining network, supported by specification**
› ZigBee is interoperable on protocol level, business processes affecting security could be different for each vendor (e.g. commissioning)
› High security will be available also for areas, where it is currently not supported by ZigBee (e.g. Home Automation)
› The same application profile can have several security profiles
› Fine grained approach – overhead is extremely important
› Level of compatibility will be 100% clear after specification is finished

SmartCoDe – Business Processes

- Business processes like physical deployment and configuration have impact on protocols and security
- Large constructions:
  - **Separate roles (trust in supply chain, expected skills), e.g.:**
    - Electrician – physically mounts devices
    - Commissioner – responsible for final configuration including security
  - **Output artefacts of each task should be testable**
  - **Independent commission of network parts is possible (e.g. by rooms or floors)**
- Small houses need easy solutions
- *One size fits all* approach is not realistic

Use cases – add new devices (example)

a) Home owner temporary allows join by pressing button in central device. New devices are automatically detected and joined.

b) Home owner temporary allows join by entering password to central device. New devices are automatically detected and joined.

c) Home owner or any responsible person enters password and identifiers of new devices to be joined (e.g. public key or it's part)

d) Electrician collects public keys of mounted devices by 2D bar code scanner. Commissioner creates temporary network of known devices and configures it. Building manager authorizes access to the building trust center by its personal card and joins temporary network to final. In meantime, internal auditor can check outputs of each task.

Conclusion

- New technologies usually introduce new risks and open new opportunities for attackers
- Electricity infrastructure continuously moves from supporting infrastructure to the real IT system
- There are existing standards for security in IT systems + new standards focused especially to Smart Grids
- There are several working groups still working in new standards, e.g. NIST - Guidelines for Smart Grid Cyber Security
- SmartCoDe team wants to deliver higher security also for low cost solutions

Thank you for your attention!

Any questions?

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TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

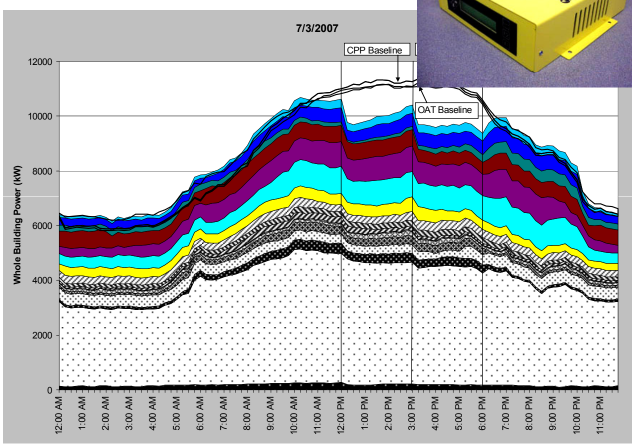
Institut für Computertechnik
Institute of Computer Technology

An Architecture for Energy Management in Smart Appliances

Christoph Grimm
Franz Lukasch
Markus Damm
Stefan Mahlknecht

Energy Management @ Home ?

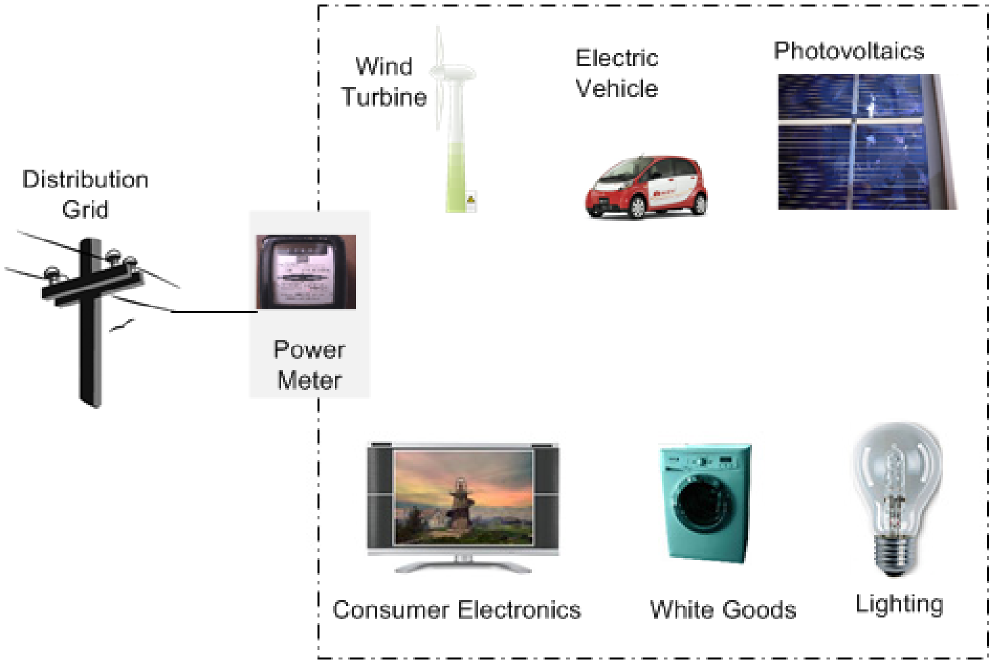
Energy management techniques are well known for large facilities.



<u>But:</u>

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

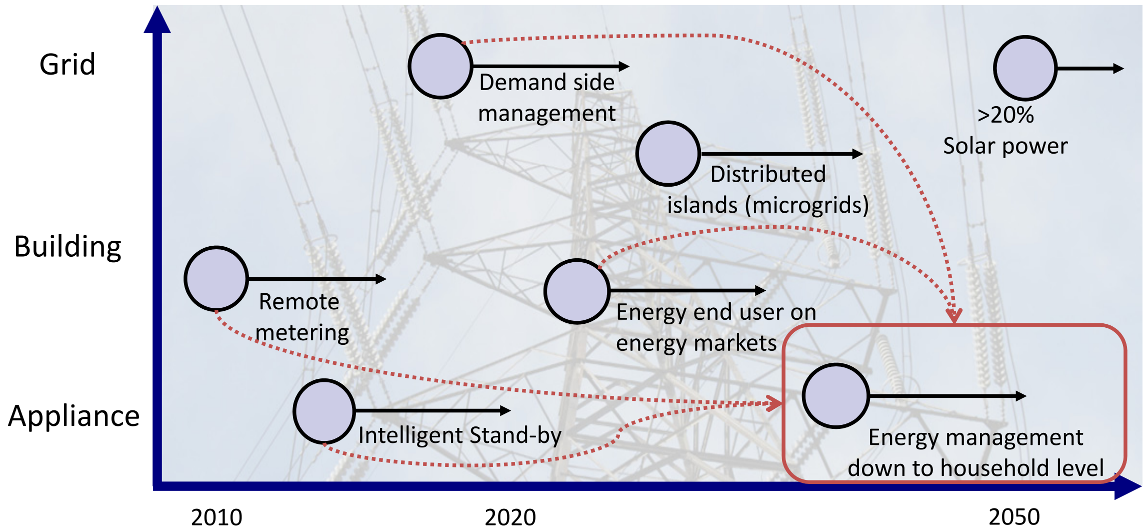
Buildings and Environment



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)

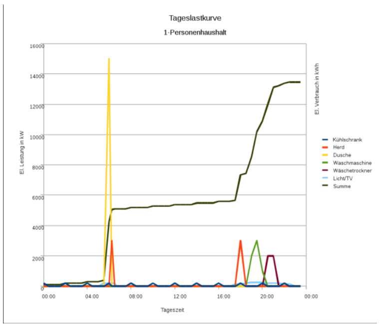
Intelligent Standby

- 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, …

Outline

- Energy Management in Buildings and Environments
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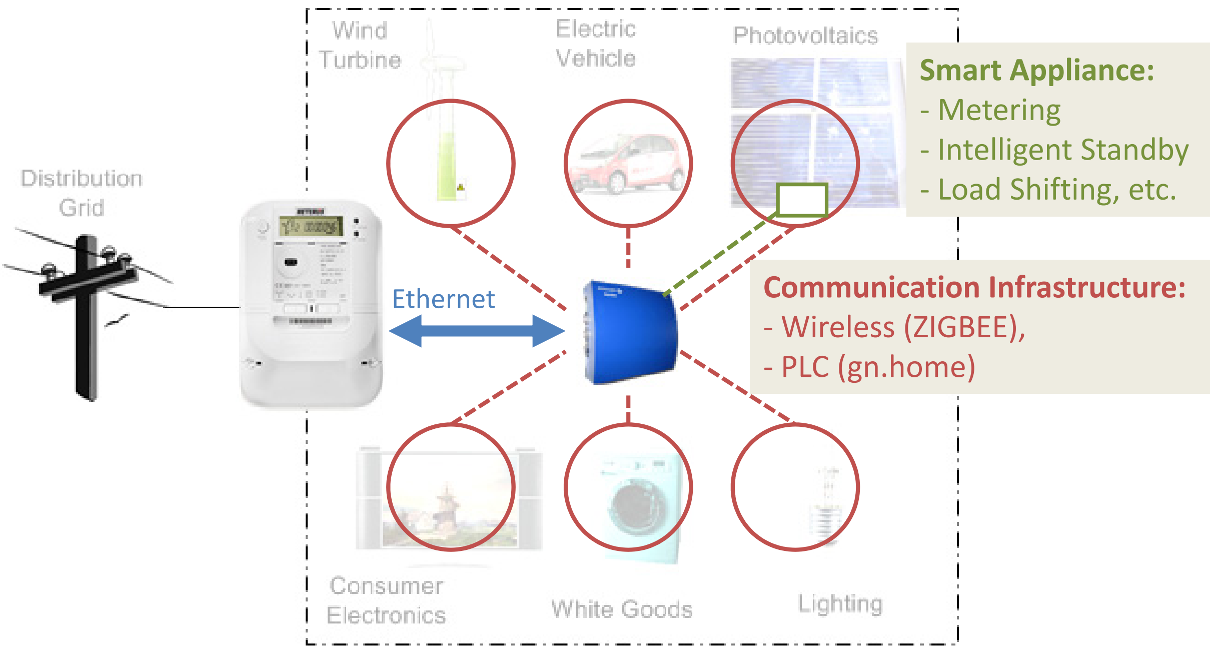
- Outlook

Infrastructure for Energy Management in Buildings and Environment



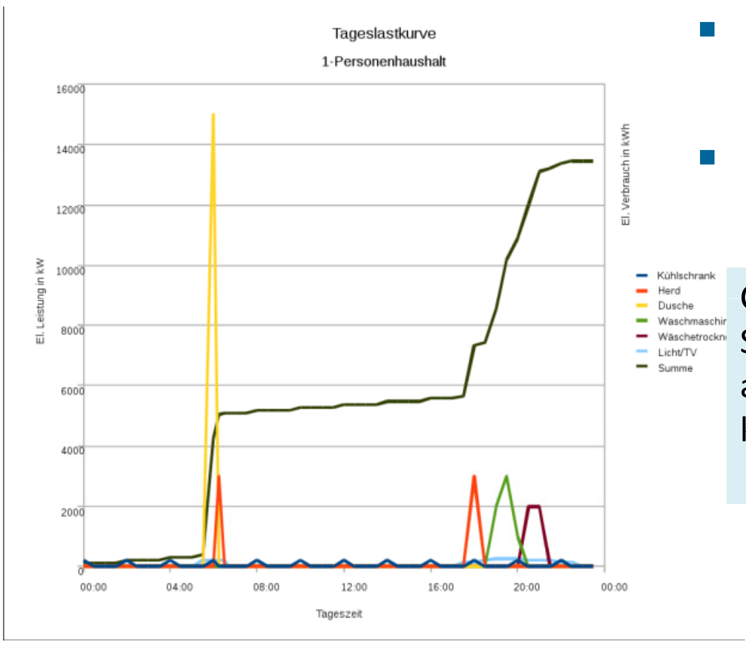
Low-Cost

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

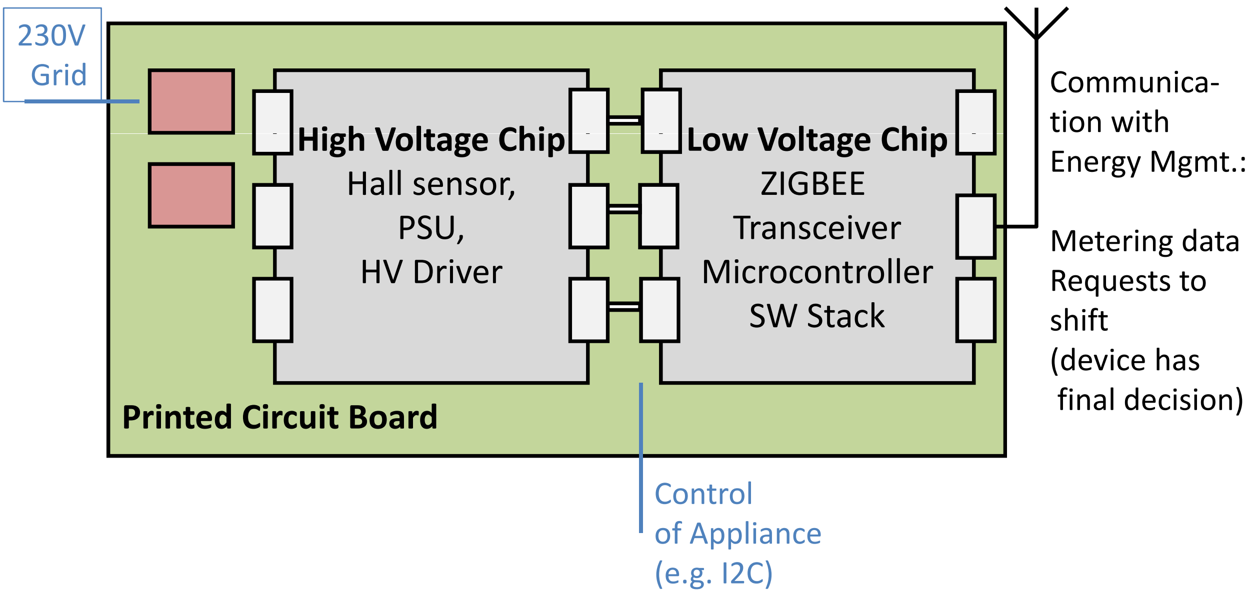
Consequences
Integrated low-power power supply unit (PSU) that can operate grid-connected!

Outline

- Energy Management
- Needs and Objectives
- SmartCoDe Architecture
- Outlook

SmartCoDe PCB demonstrator

~2 discrete components (Capacitors), 2 Integrated Circuits



Communication

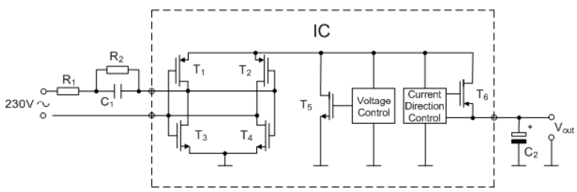
- SmartCoDe node uses ZIGBEE/RF communication (also PLC possible, but other project …)
- Structured network, mesh-routing possible (increases dependability)
- 1st prototype will use existing ZIGBEE chipset with adopted ZIGBEE communication profile

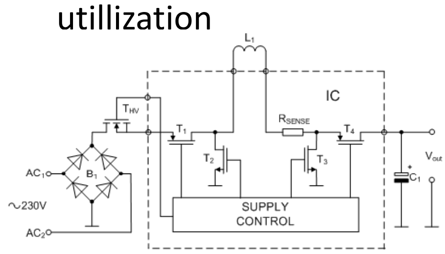
High Voltage Chip

- 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

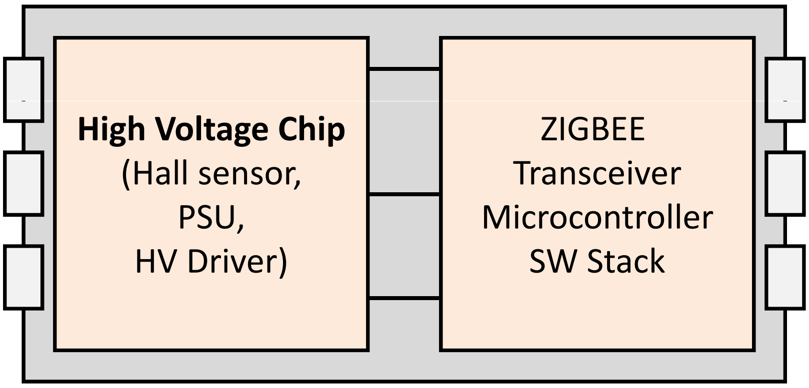




An Architecture for Energy Management in SmartAppliances

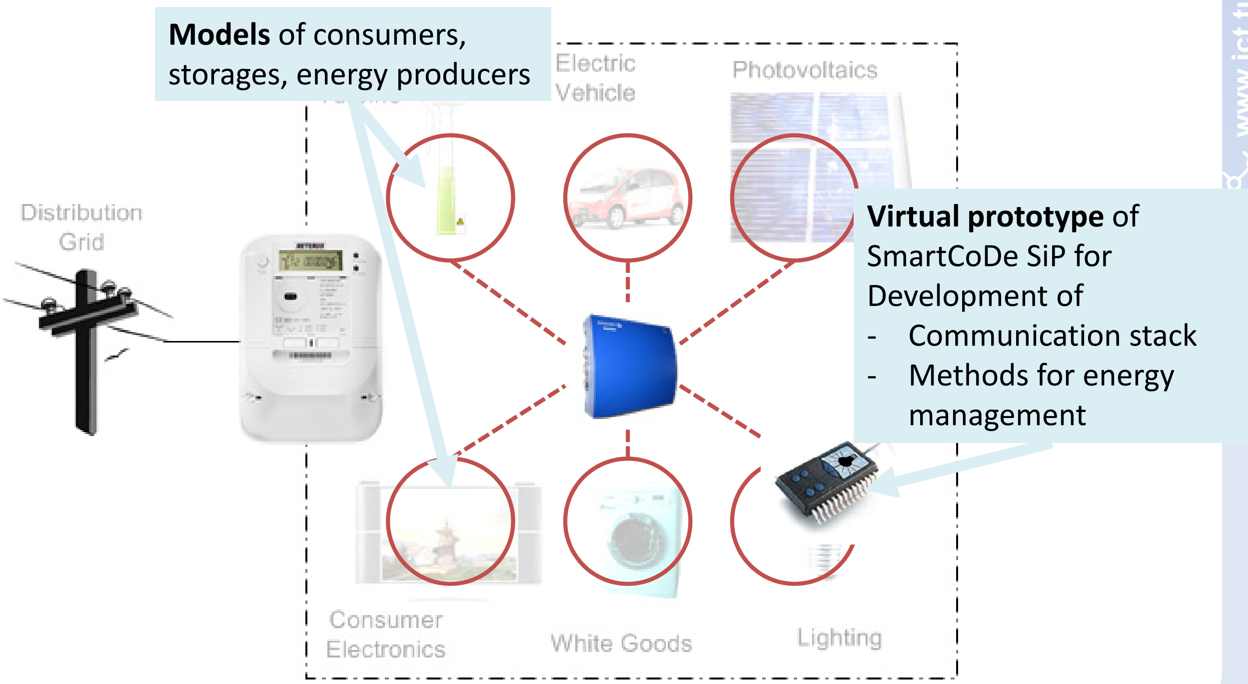
SmartCoDe SiP

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



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

Development tools



Outline

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

www.ict.tuwien.ac.at

Thank you!

On the Way to a Miniaturised Wireless Sensor Node for Metering and Control of Appliances

SmartCoDe Expert Cooperation Workshop Vienna/Austria 2010

Thomas Herndl (Presenter) – IFAT DCGR CRE
Wolfgang Scherr - IFAT DC ATV SC D VI CE
Mario Motz - IFAT DC ATV SC D VI INNO
Infineon Technologies Austria AG

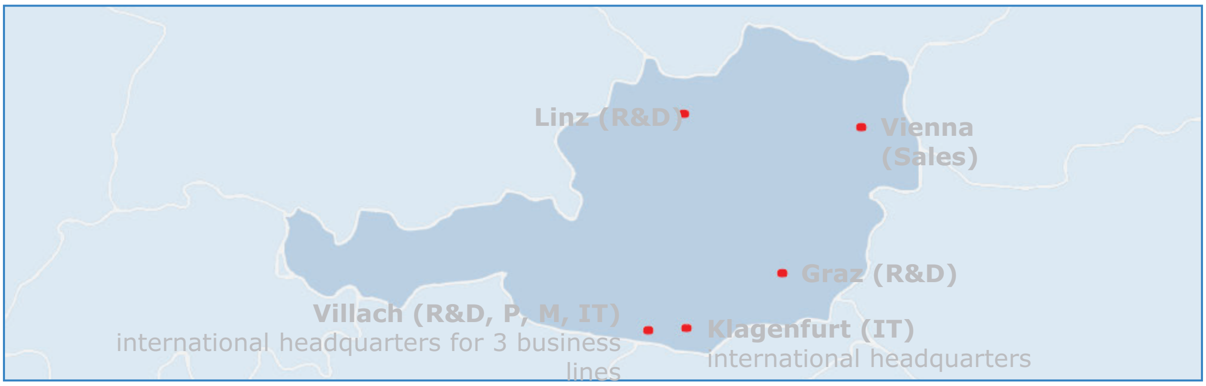
Content

› Introduction & Scope
› SiP Integration Technologies
› Key element: Current sensing
› SmartCoDe Node Integration Concept
› Conclusion

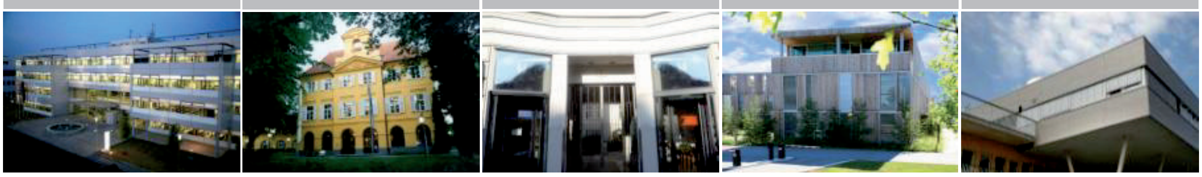
Introduction & Scope

Infineon Austria – Company Overview

Infineon Technologies Austria AG incl. subsidiaries



Villach	Graz	Vienna	Klagenfurt	Linz



foreign subsidiaries:	Kulim (Malaysia)	Bucharest (Romania)

Infineon Holds Leadership Positions in All Target Markets

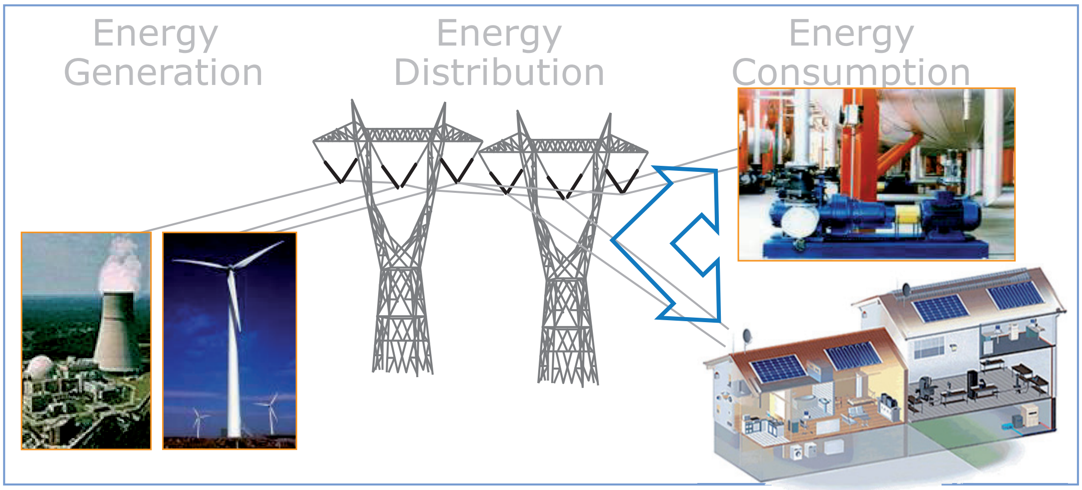
Auto-motive	Power	Chip Card
#1	#1	#1
Market share 9%	Market share 11%	Market share 26%
Calendar Year 2009 Source: Strategy Analytics (SA), May 2010	Calendar Year 2009 Source: IMS Research, preliminary data July 2010	Calendar Year 2008 Source: Frost & Sullivan, July 2009

Environmental Sustainability at Infineon

Enabling a Sustainable Society: Our Products

IFX provides products and solutions for the whole energy value chain

Energy Supply Chain

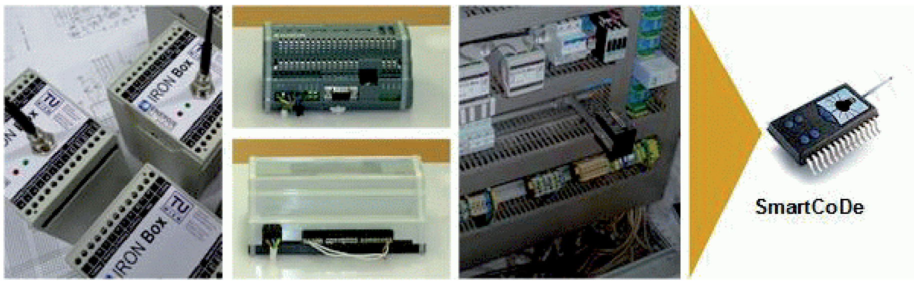


Power SC & Modules

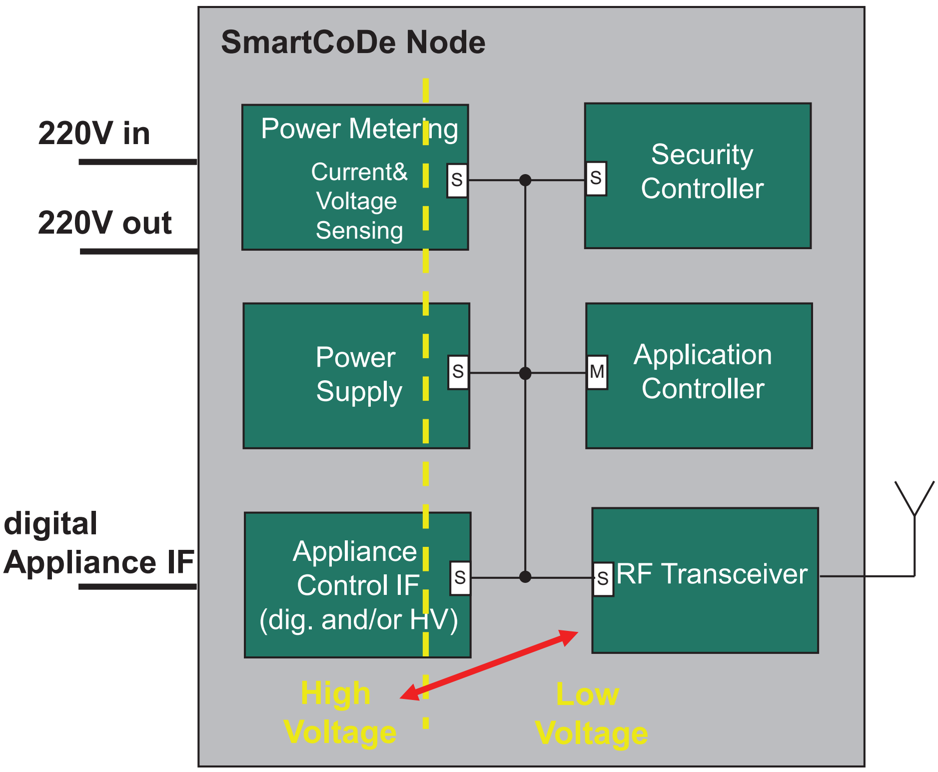
…Now Going Further to the Energy CONTROL Level

SmartCoDe Target Module

› Miniaturized wireless networked smart device for power metering and control of energy using products at low costs
  - **Lighting units**
  - **(Home-) appliances**
  - **Intelligent power plug**
  - **…**



Basic Functional Blocks of the SmartCoDe Node



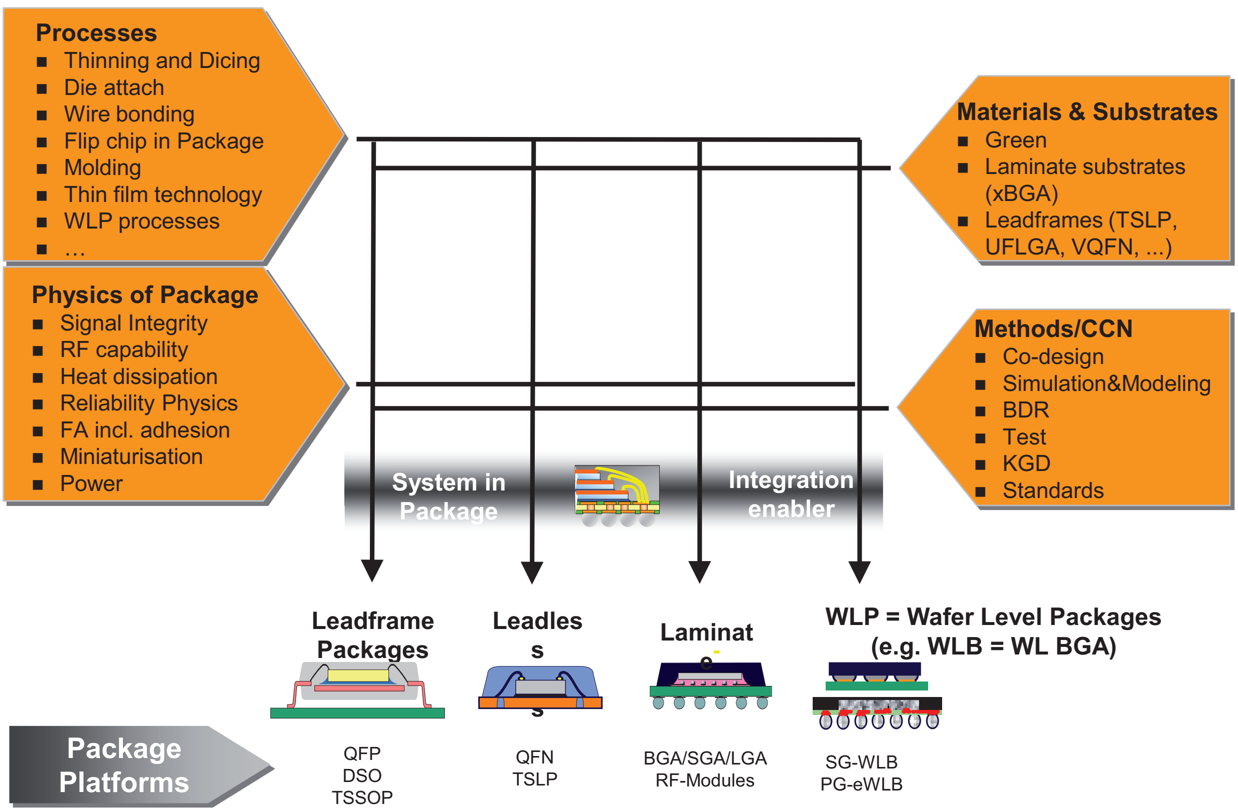
Target:

small and cheap

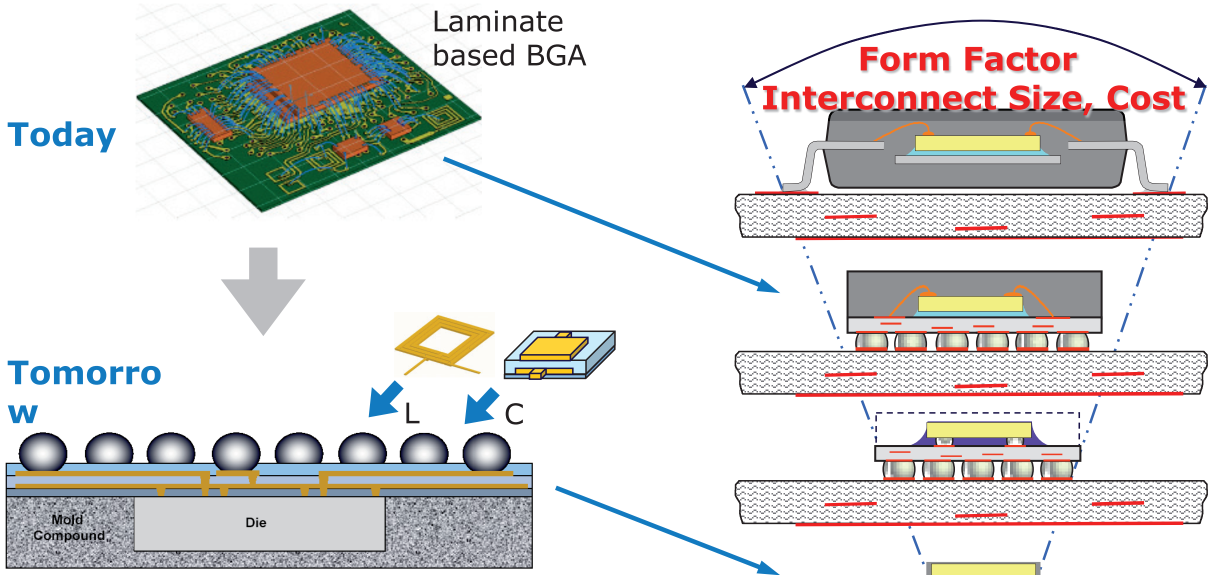
„physically incompatible“

SiP Integration Technologies

Technology Development & Package Development



Trends in Packaging: System-in-Package

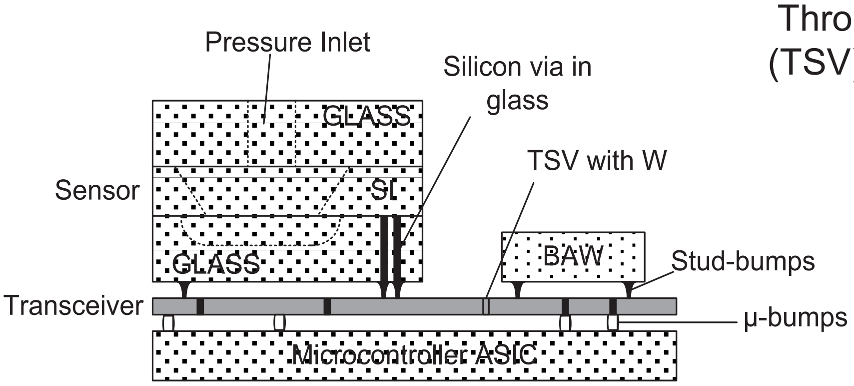


Embedded Wafer Level BGA

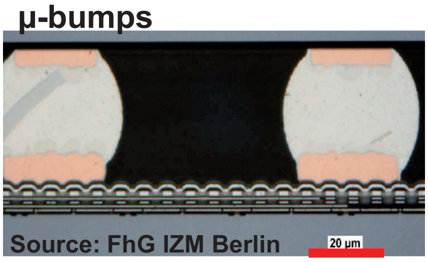
impedance-matched low loss TLs, integrated passives (L, C)

Subsystem Integration 3D Vertical Stacking

3D-Stack employing Through-Silicon-Vias (TSV) Process with W

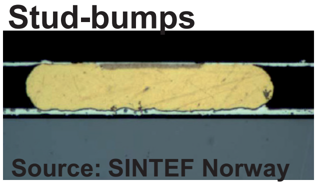


μ-bumps

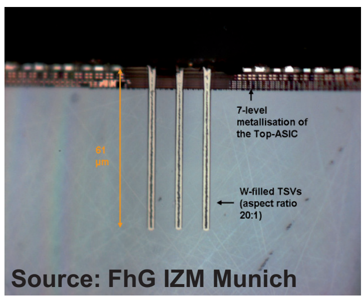


Source: FhG IZM Berlin

Stud-bumps


Source: SINTEF Norway

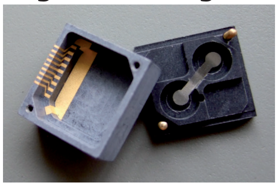
TSVs with W



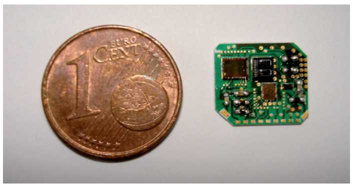
Source: FhG IZM Munich

Other SiP Option: MID-package
(Full Functional Wireless Pressure Sensor Demonstrator)

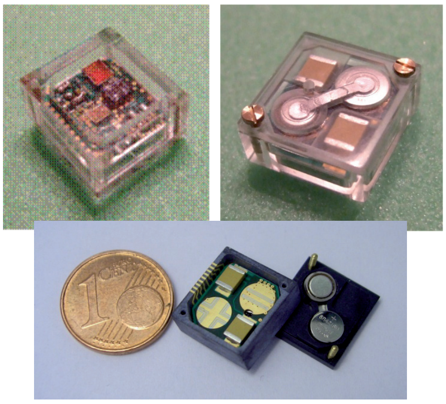
Molded Interconnect Device (MID) package with integrated loop-antenna



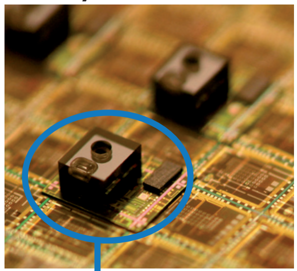
Micro-PCB



Miniaturized System
(Battery Version shown)
V~1cm³



Sub-assembled 3D MEMS/ASIC stack



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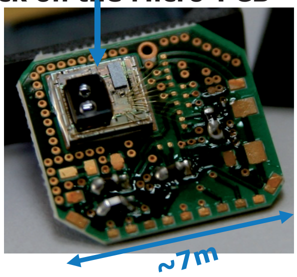
Assembled 3D MEMS/ASIC stack on the Micro-PCB



~7mm

SmartCoDe Node applied SiP Packaging Options

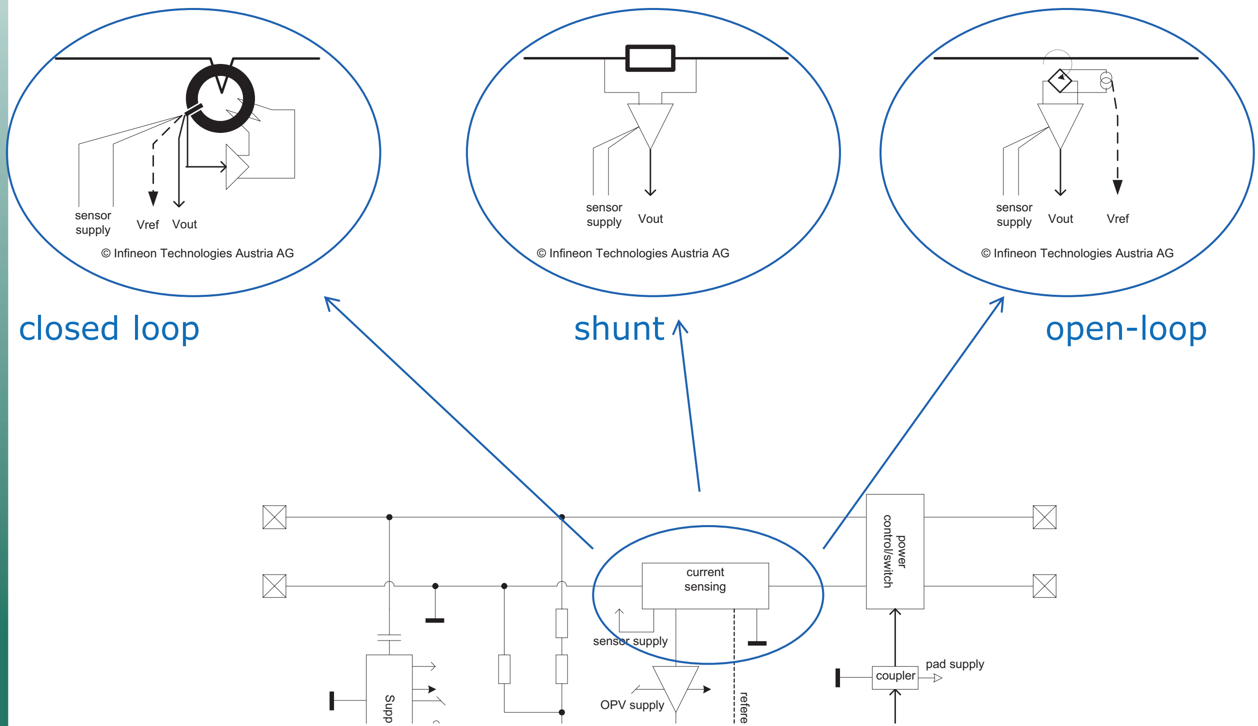
› eWLB exhibits excellent RF performance and allows for integration of high-Q inductors and capacitors
  – can improve electromagnetic shielding
  – eWLB might be an option for sub-packaging of RF-components

› MID package can be shaped arbitrarily
  – it provides 3-dimensional wiring for connectivity of submodules
  – it allows for antenna integration and feeding of control- and HV-signals

Key element: Current (Power) sensing

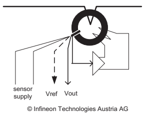
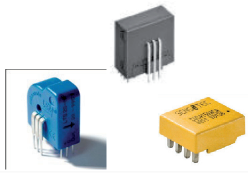
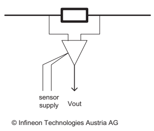
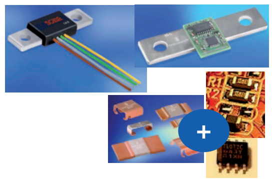
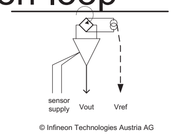
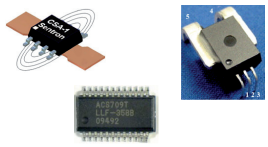
Current sensing:
State of the Art Solutions

› Common approaches

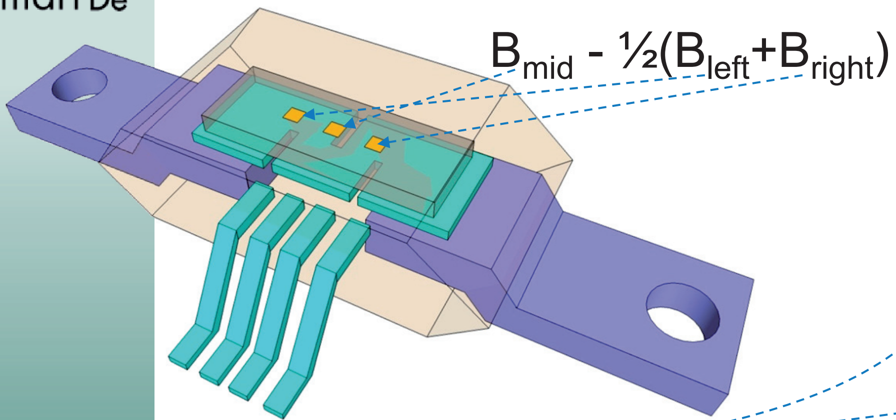


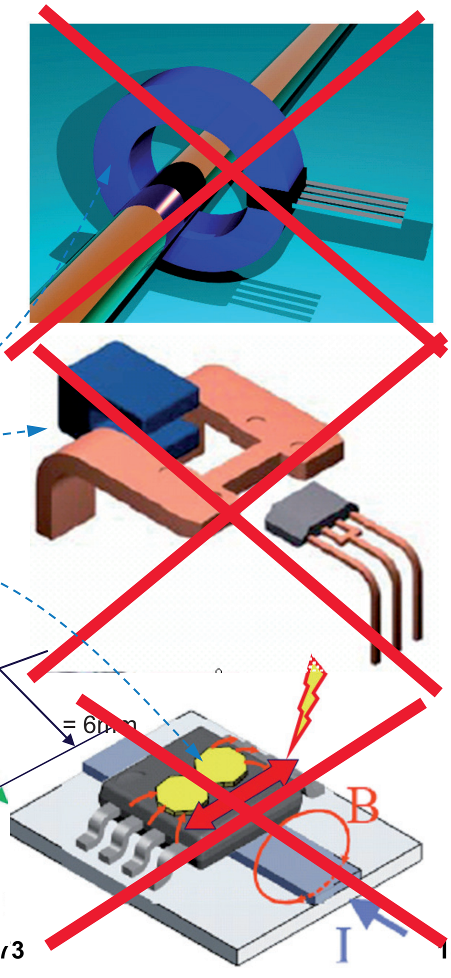
Current sensing:
State of the Art Solutions

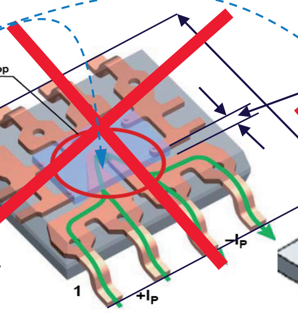
› Common approaches and today's market picture

closed-loop 	high accuracy low power	high price large size, weight analog curr. only	
shunt 	med.-high accuracy medium-low weight low cost	high power loss medium size analog curr. only	
open-loop 	small size low weight low power	med.-low accuracy medium cost analog curr. only	

Current Metering
Advantages Triple-Hall Principle







→ **no magnetic coil required**

→ no hysteresis and saturation effects

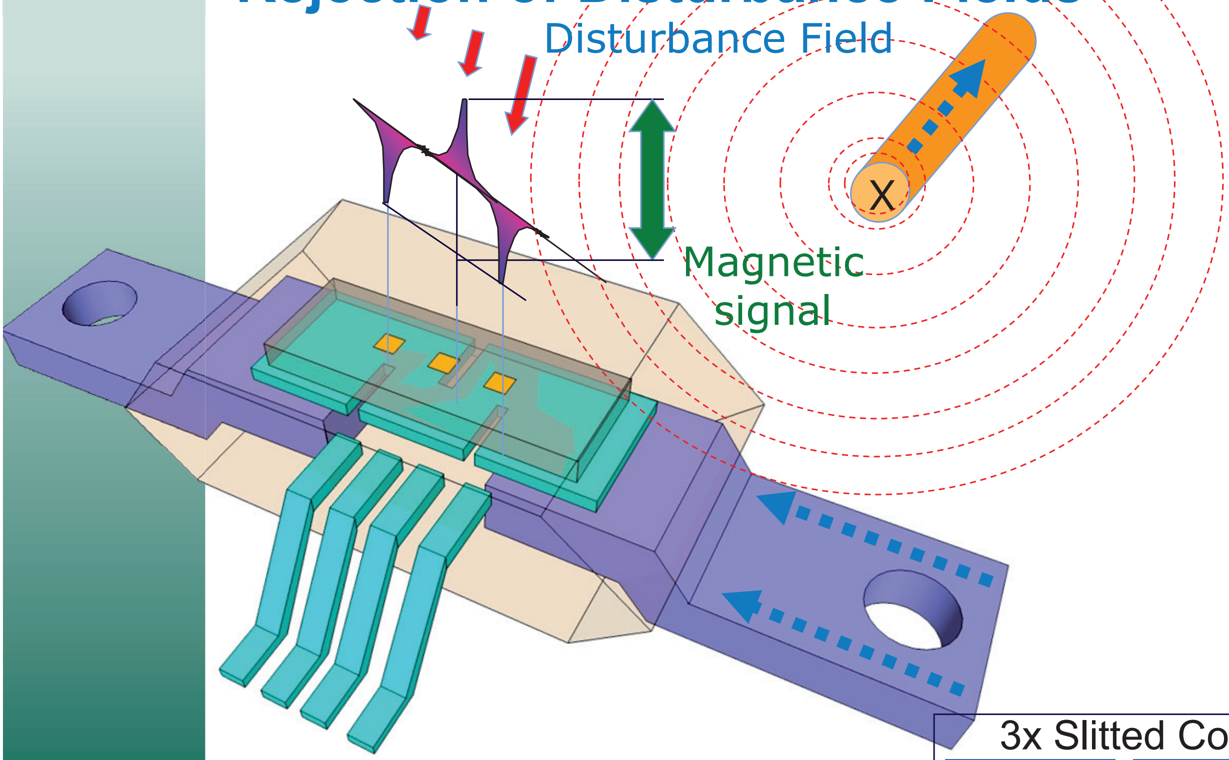
→ **rejection of disturbance field**

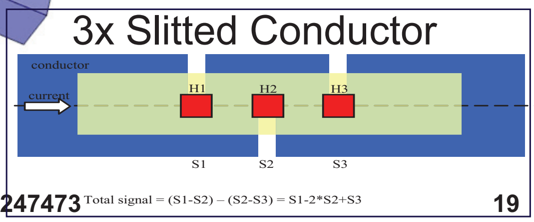
→ overload protected

→ low loss of shunt-power

→ cost-effective standard technology

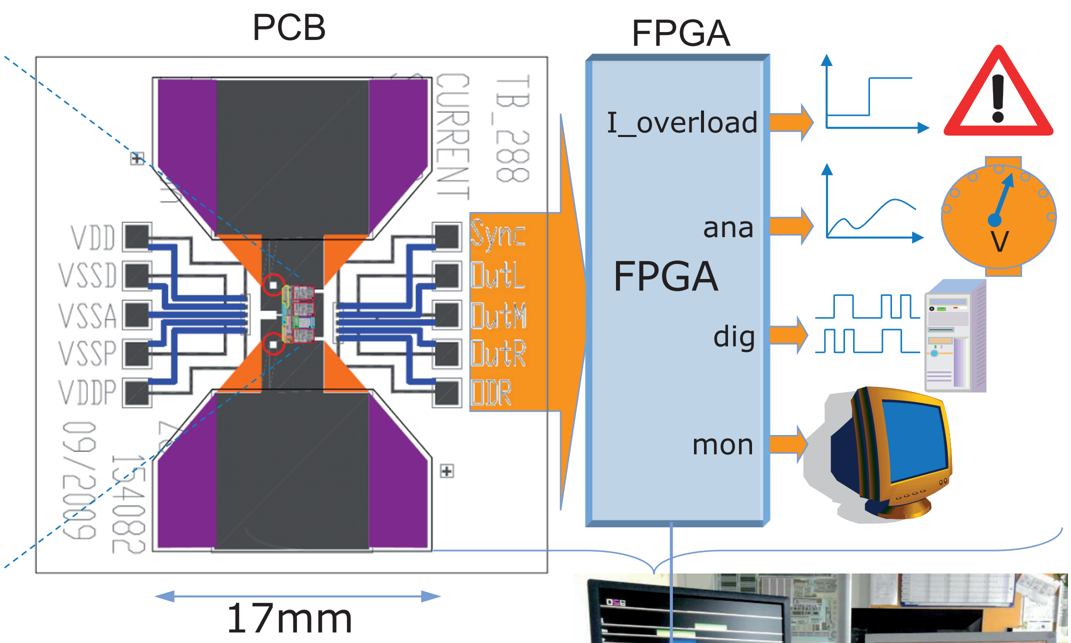
Triple Hall Sensor:
Rejection of Disturbance Fields

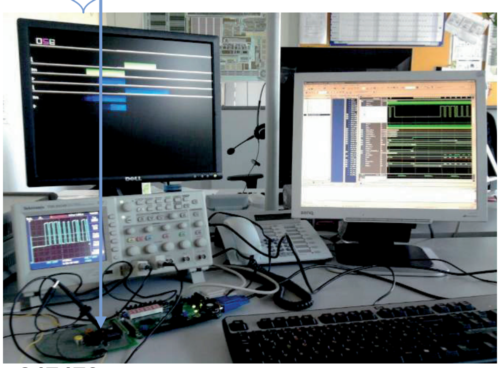




$B_{mid} - ½(B_{left}+B_{right})$

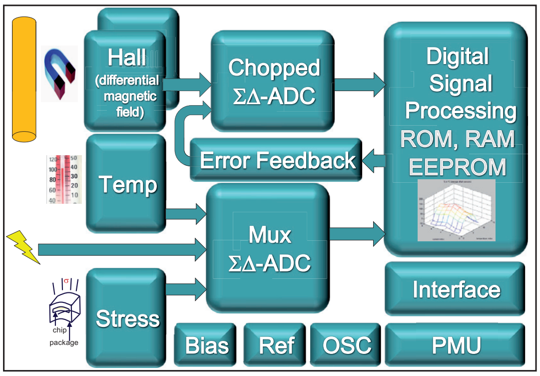
Current Metering - Demonstrator





Demo-PCB:
- 100/150µm isolating thickness
- 400µm Cu thickness current rail

A “power-sensor” approach



- standard silicon technology
- open-loop Hall principle
- Single power supply
  (same as µC)
- Accuracies:
  - **1% over lifetime using on-chip stress-compensation**
  - **1% over temperature using on-chip temperature-compensation**
- Current and voltage measurement, power pre-calculation
- special features, e.g.: low-power mode with wake-up on certain load detected, full power down mode
- standard µC digital interface (e.g. i2c)

SmartCoDe Node Integration Concept

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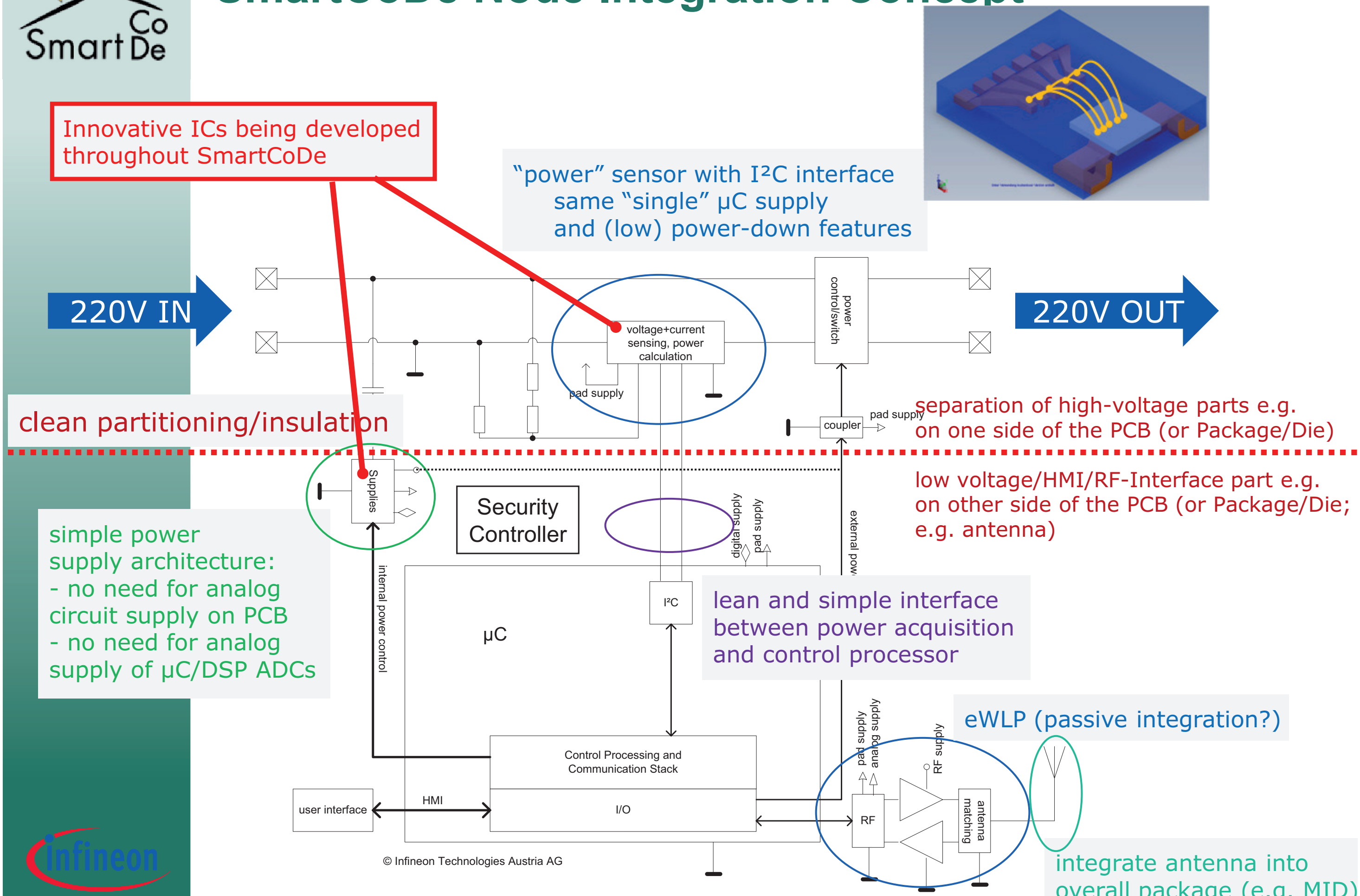
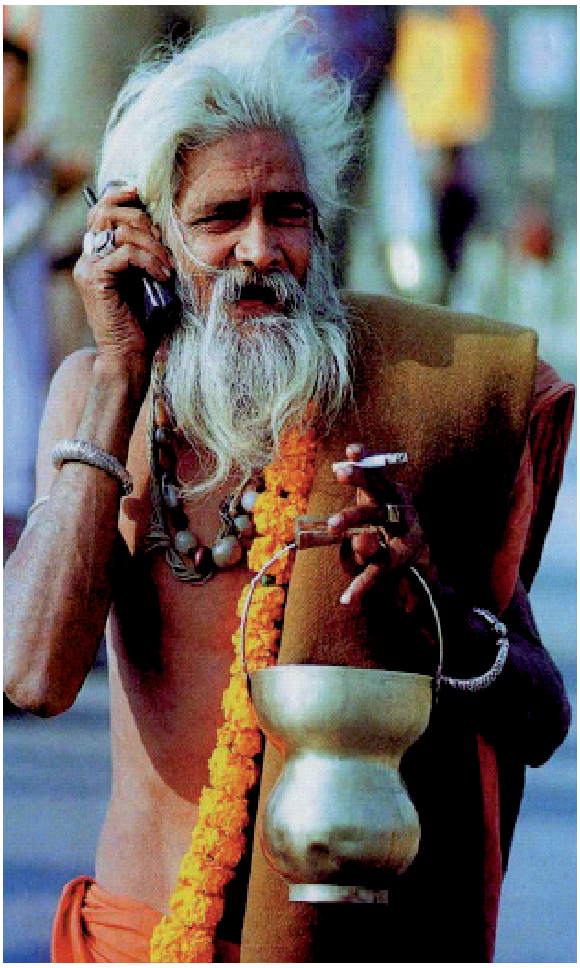


Conclusion

› Basic integration concept defined; refinement ongoing
› 3d-chip stacking doesn't seem reasonable, due to low connectivity needs
› Chip design for integrated power metering and power supply is on the way
› There exists a convergence path for future single-chip integration of (almost) all functions into a SoC by means of integrating CMOS technology



Thank you for your attention…

Never stop thinking