FRAUNHOFER IWU

Fraunhofer Symposium Tokyo, 9. November 2011
Green Technology made in Germany - Efficient Use of Energy and Resources

Torsten Münch

Resource Efficient Production - Green Manufacturing

IWP Institut für Werkzeugmaschinen und Produktionsprozesse

Fraunhofer IWU

OUTLINE

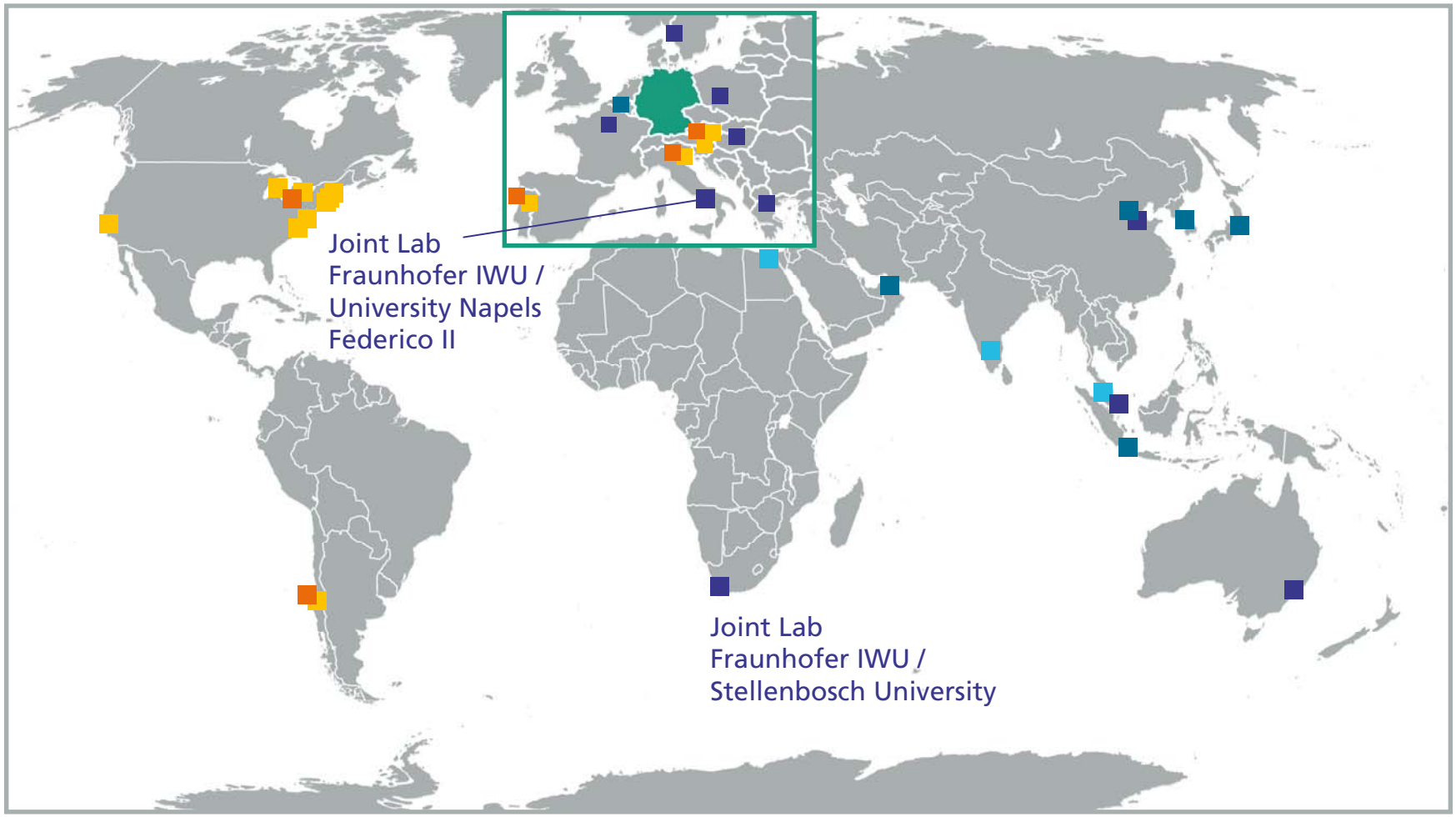
1. Introduction
2. Fraunhofer IWU as a part of the Fraunhofer Gesellschaft
   - Profile of IWU
   - Core Competencies
3. Megatrends with relevance to production technology
4. Fraunhofer Strategy „Resource Efficient Production“
   - Leading projects of Fraunhofer IWU
   - Status and results
5. Summary and Outlook

1 Introduction

Definition of efficiency is … the relation between the achieved results of a process and the used resources.

(ISO 9000:2000)

2 Fraunhofer worldwide



Fraunhofer subsidiary
Fraunhofer Center
Fraunhofer Project Center / strategic cooperation
Fraunhofer Representative Office
Fraunhofer Senior Advisor

IWP WERKZEUGMASCHINEN UND PRODUKTIONSPROZESSE

Fraunhofer IWU

2 The Fraunhofer IWU
Locations in Germany

Facts and figures:

- founded on July 1st, 1991
- about 450 employees
- 28,5 million euro budget
- Project group in Augsburg since January 2009
- Project group in Zittau since October 2011

2 The Fraunhofer IWU

Industry in Saxony

A lot of world-famous technical and industrial inventions are initially based in Saxony: in the mining, in textile or machine tool industry as well as in manufacturing of cars.

Due to the leading role, in the past Chemnitz was also named as the “Saxon Manchester”.

CHEMNITZ UNIVERSITY OF TECHNOLOGY

High technology research cluster in Chemnitz / Saxony

Archivierungsangaben

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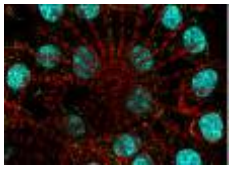
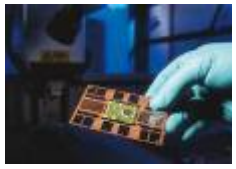
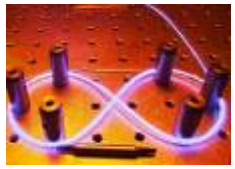
Fraunhofer IWU

2 The Fraunhofer IWU

Story of success

- started in 1991 with 37 employees and with a strong focus on forming technology
- in 2011 working with 6 divisions and a large spectrum of competencies and experiences
- From successful regional networks to international collaboration

2 IWU as part of the Fraunhofer-Gesellschaft


7 Groups:

- Information and Communication Technology
- Life Sciences
- Microelectronics
- Light & Surfaces
- **Production**
- Materials and Components – MATERIALS
- Defense and Security

Group Production
(founded 1998)

- IFF Magdeburg
- IML Dortmund
- IPA Stuttgart
- IPK Berlin
- IPT Aachen
- IWU Chemnitz / Dresden / Augsburg / Zittau
- UMSICHT Oberhausen

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2 The Fraunhofer IWU in Profile







Fields of expertise

- Machine Tools
- Mechatronics
- Cutting Technologies
- Forming Technologies
- System Technology

in close cooperation with

- Chemnitz University of Technology
- Fraunhofer-Gesellschaft
- Machine tool industry
- German and international automobile industry
- Ancillary industry (forming, cutting, tool and die making)

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2 Core Competencies of Fraunhofer IWU (1)
Machine Tools

Machine tool and component design (forming and cutting)

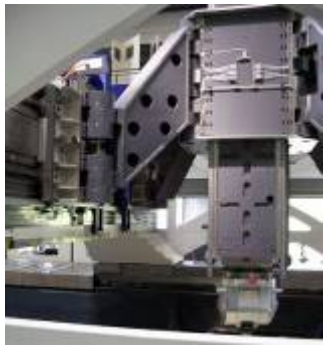
- Concepts, function design, accuracy determined components
- Development of handling equipment, e.g. parallel kinematic applications
- Determination of properties, FEM calculation, Optimization of thermal behavior

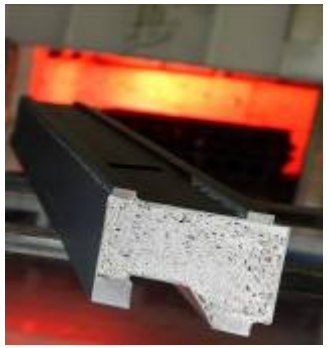
Lightweight design

- Structure optimization, metal foam applications
- Generative manufacturing of lightweight structures

Hydraulic systems

- Equipment and drives planning
- Hydraulic simulation, Experimental testing






2 Core Competencies of Fraunhofer IWU (2)
Mechatronics

Machine tool control

- Mechatronic design, calibration methods
- Control of parallel kinematic machines, redundant machine tool axes
- Development and control of feed drive components

Data processing

- Video imaging, Classification algorithms

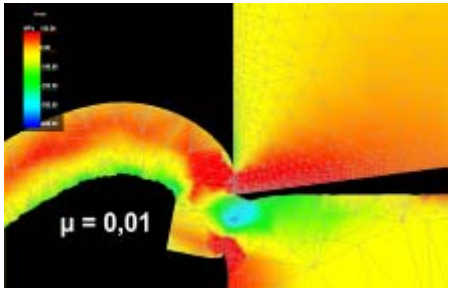
Adaptronics

- Application and optimization of active materials
- Design of sensor-actuator components
- Intelligent components
- Determination and optimization of acoustic bahavior
- Medical applications
- Generative manufacturing of adaptronic components and implants

2 Core Competencies of Fraunhofer IWU (3)
Cutting Technologies

Process basis

- Modeling and simulation of cutting processes / optimization of cutting tools
- Design of modular tool systems
- Optimization of coating-substrate-systems
- Clamping of thinwalled workpieces



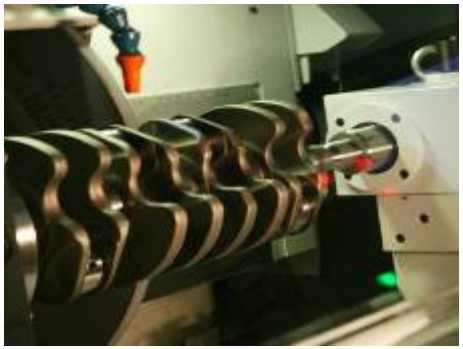
Experimental process and machine tool investigation

- Process monitoring
- Machine tool behavior

2 Core Competencies of Fraunhofer IWU (3)
Cutting Technologies

Process development

- Ultrasonic-assisted deep hole drilling
- Dry cutting (MQL)
- 5-axis milling, hard machining
- Optimization of process chains
- Process combinations / integration



Micro and precision processing

- Development of components and technologies
- Tools for microforming
- Microstructuring of surfaces
- Medical, optical and special automotive applications

2 Core Competencies of Fraunhofer IWU (4)

Forming Technologies

Sheet metal forming

- Controlled deep drawing process
- Hydroforming
- Forming at high velocities
- Fine blanking
- Technology development / tool concepts
- Generative technologies

Bulk metal forming

- Forging, Prototype forging die
- Cross rolling, Spin extrusion
- High gear rolling

“interdisciplinary“

- Forming of alternative materials (highstrength steels and aluminum alloys, titanium, magnesium, patches…)
- Identification of specific forming parameters

2 Core Competencies of Fraunhofer IWU (5)
System Technology

Facility and component design

- Concepts for joining and assembling systems
- Development and optimization of function determined components as well as handling systems

Joining technologies

- Thermal joining technologies
- Joining by forming (development, modification and integration of technologies)
- Process monitoring

Assembling technique

- Weak point analysis, Process optimization, Databasis

E-Services

- Production data management
- Teleservice, Data mining

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3 Megatrends
with relevance to production technology

Demographic growth

Limitation of resources

Climate change

3 Megatrends
Demographic growth

Demographics [1] :

2011: 7 billions of people
1,5 billions in economic wealth
5,5 billions in „move“

2050: > 9 billions of people ...

challenges:

- to increase production tenfold
- to reduce resource consumption to 10%
- to reduce the environmental impact significant

Conclusion:

A change of philosophy is required from „maximum of profit by minimum of capital“ to „maximum of profit from a minimum of resources“

cognitive Innovations!

[1] Sources: United Nations, 2008
Dt. Stiftung Weltbevölkerung, 2010

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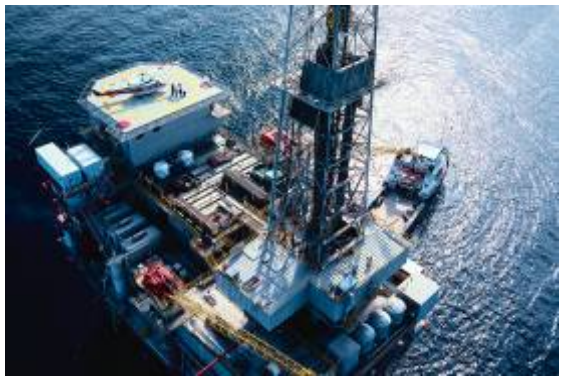
3 Megatrends
Limitation of resources

Fossil Fuels = Material Resources



Daily World Consumption

11 Mio. t mineral oil
9 Mio. t coal
8 Bn. m^3 natural gas

limited
available
reserves
!

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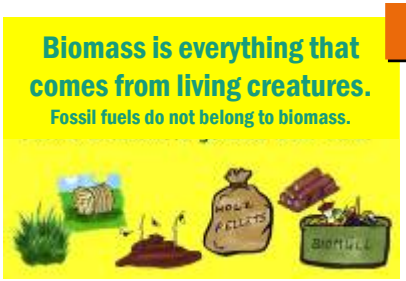
3 Megatrends

Limitation of resources – alternatives regarding nuclear power

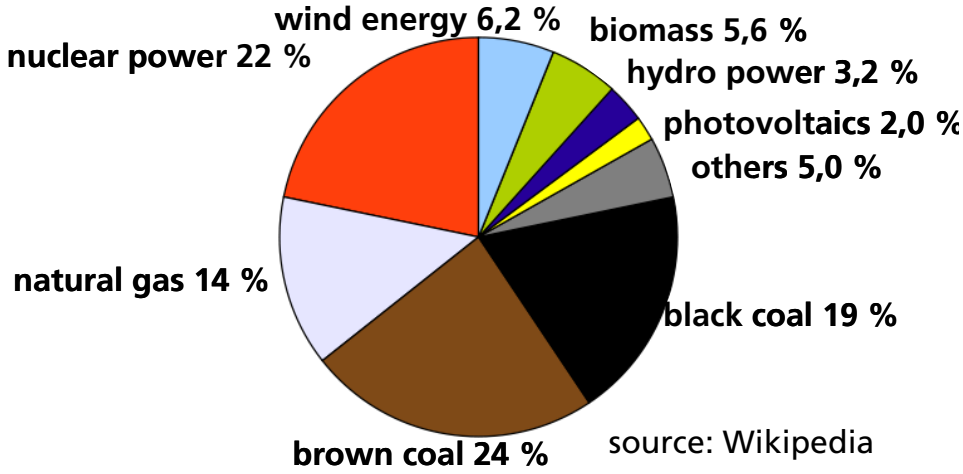
renewable energy sources

- wind energy
- solar energy
- geothermal energy
- biomass

covering
energy need



∑ renewable energy: 17 %
(within 20 years)



source: Wikipedia

Current Mix Germany

gross current generation 2010

4 Fraunhofer Strategy „Resource efficient production“

New competitive factors are

- resource prizes + **resource availability** =
  precondition for success in economic competition
- **success in business** =
  f (quality, productivity, flexibility + **energy costs***)
- **efficient technologies** lead to **sustainable** competition advantages

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* increase in electricity costs 2000-2008: approx. 100 % (automotive industry)

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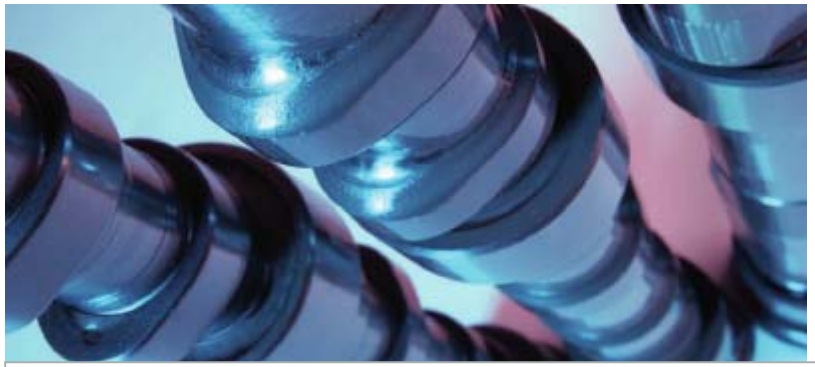
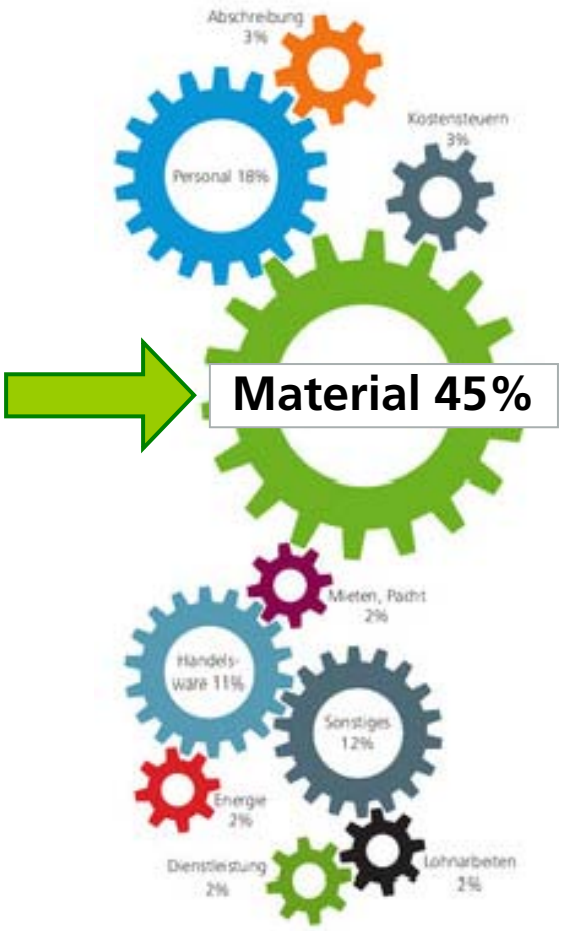
4 Fraunhofer Strategy „Resource efficient production“

More profit by minimized use of resources



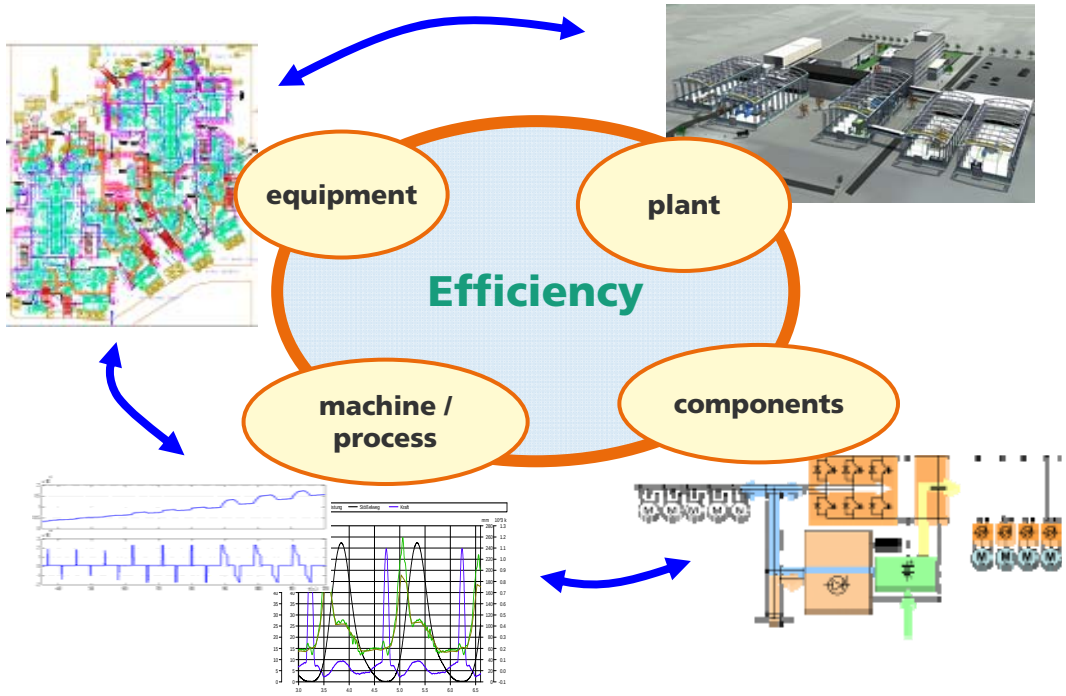
High material costs are significant for product prices. In the manufacturing industry today material costs effect the total costs with approx. ~ 45% !

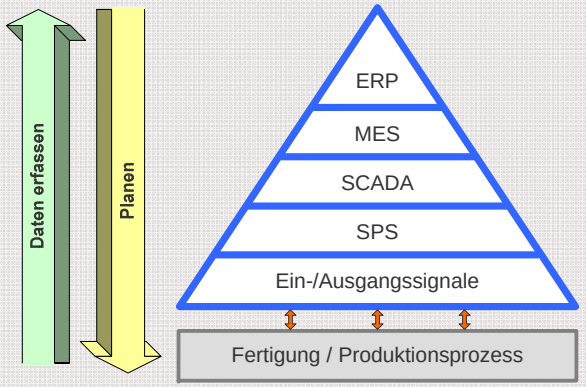


* Source: statistisches Bundesamt 2009

4 Fraunhofer Strategy „Resource efficient production“

Overview of energy monitoring in automation processes





ERP - Enterprise Ressource Planning
MES - Manufacturing Execution System
SCADA - Supervisory Control And Data Acquisition

Consideration of „efficiency-thinking“ during the total **life cycle** of any production equipment

different action levels

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4 Fraunhofer Strategy „Resource Efficient Production“
Leading Projects

Fraunhofer-Future

Green Powertrain Technologies

Innovations-Allianz Green Carbody Technologies

Innovation Alliance

Green Carbody Technologies

eniPROD

Cluster of Excellence

eniPROD

Excellence Center

Automobile Production

Fraunhofer IWU Research Plant

Resource Efficient Production

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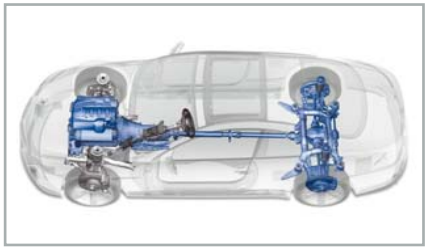
4 LEADING PROJECTS (1)
Green Powertrain Technologies



- Objective: development of resource efficient technologies for lightweight powertrain components
  - Saving of material
  - Economic production processes
  - Application of new materials
- Key products:
  - low energy engine
  - lightweight gear
  - lightweight drive shaft
- Project partners: 7 Fraunhofer Institutes
- General management: Fraunhofer IWU

4 LEADING PROJECTS (1)

Green Powertrain Technologies

Fields of activity

production
of components

Use
of components

Ressource-efficient production

- efficiency in material use
- energy-efficient production
- Reduction of manufacturing costs

Efficiency of components at working mode

- Function / degree of efficiency
- Lightweight design
- Life cycle of components

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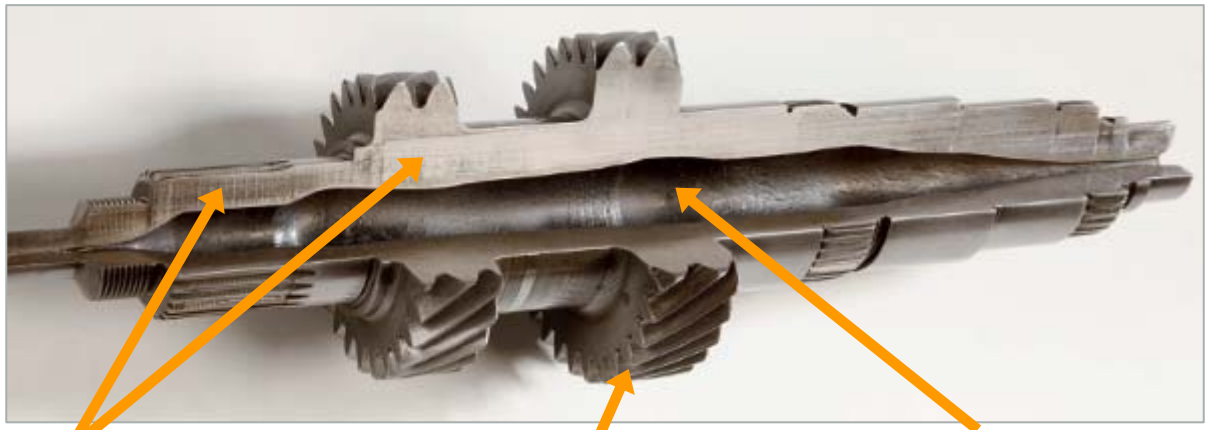
4 LEADING PROJECTS (1)

Green Powertrain Technologies

Forming technology for manufacturing of hollow drive shafts by considering requirements of acoustic design



Form lightweight design
graded material thickness
to minimize weight

Form lightweight design
Contact pattern and ***noise-optimized*** *high gearing design*

Structural lightweight design
Saving of mass and material by using ***hollow structures***

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4 LEADING PROJECTS (1)

Green Powertrain Technologies

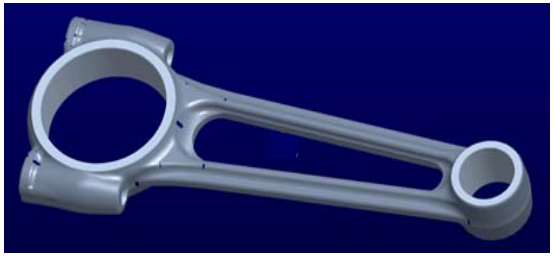
Benchmark = serial conrod
(petrol engine R1.4)

billet mass 0.595 kg

Research goal: **Development of a light weight conrod**

- Minimization of accelerated masses (conrod and crank shaft)
- Resource efficient manufacture without cost increase
- Part design meeting forging process requirements, load distribution adaptation and final property requirements

billet mass 0.300 kg



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4 LEADING PROJECTS (1)

Green Powertrain Technologies

Development of cold rolling technologies at Fraunhofer IWU

our own and latest research results

Cold rolling of gears with tooth height factor bigger than 2 **is owned by the Fraunhofer IWU Chemnitz**

$$y = \frac{\text{tooth height}}{\text{module}}$$

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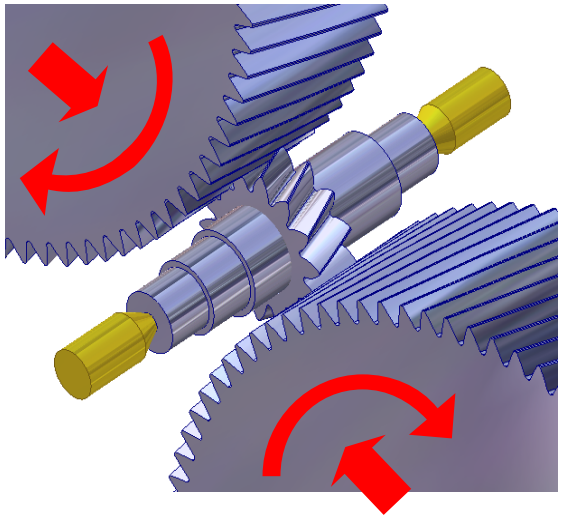
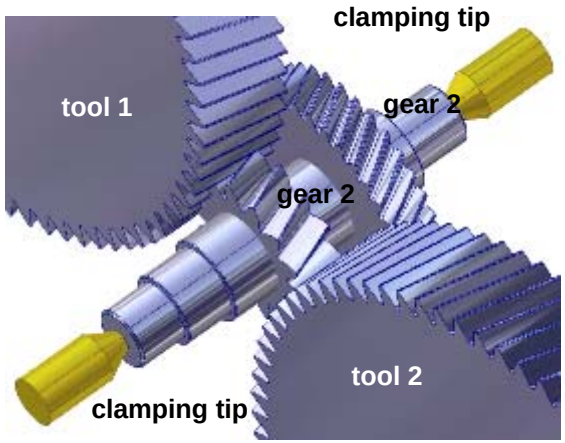
4 LEADING PROJECTS (1)

Green Powertrain Technologies



- Process advantages (selection)
  - low forming forces
  - good utilization of material (no cutting chips)
  - short process times (~ 30 … 60s)
  - hardness increase (tooth flank, tooth root)
  - mirror-like surface layer …. etc.



- Rolling of narrow located gears on shafts
  - non-locking clamping device
  - no assembled unit – one single part
  - transmission for higher forces and torques
  - Rolling of several gears on one shaft … etc.

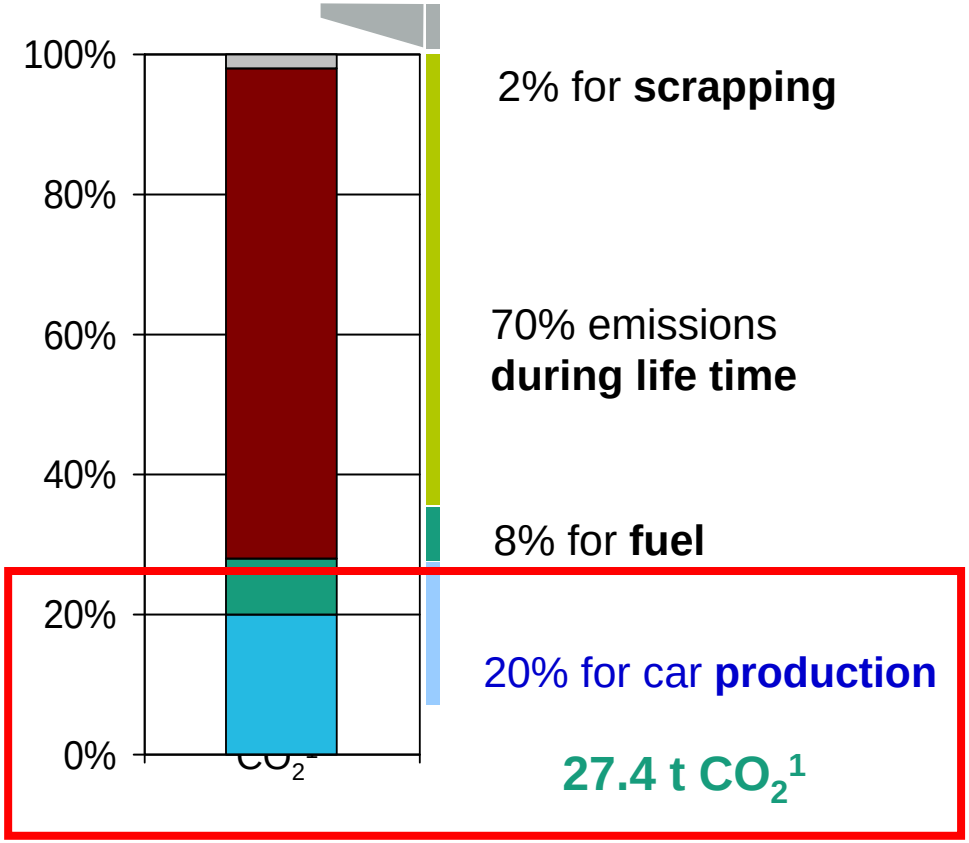
4 LEADING PROJECTS (2)
Innovation alliance „Green Carbody Technologies“

- Objective: resource efficient optimization of the process chain “Lacquered Car Body“
  - Reduction of energy
  - Saving of resources
- Partners:
  - Volkswagen (leading OEM), AUDI, Daimler
  - 60 companies (automotive supplier of OEM and steel industry)
  - 3 Fraunhofer Institutes
- Duration: 3 years (2009 – 2012)
- Total project budget ~ 30 M€
- General Management by Fraunhofer IWU

4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

consumption of CO_2 equivalents of a Golf VI model during life time *)



1: CO_2-equivalents, e.g. methan, nitrous oxide, refrigerant R134a; incl. of all materials and production processes; 150.000 Km, incl. efforts for fuel production

***) Prof. Heizmann, VW AG; speech at ICMC, 29.9.2010 Chemnitz**

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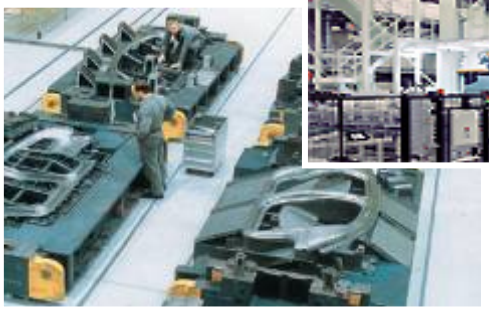
4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

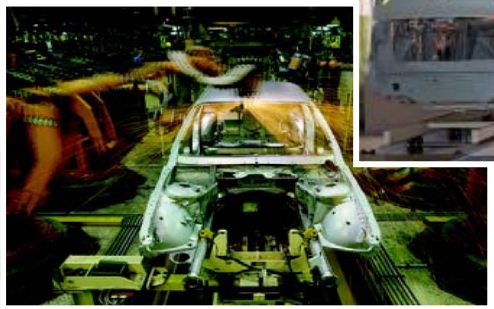
Alliance and **technology cluster:**
→ from blank sheet material to the painted car body
→ refered to **car body manufacturing**

Semi-finished material



Tool manufacturing

Press shop



Body shop

Painting of cars

Common platform of „production engineering“

→ for an integrated planning and control of production processes

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4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

TODAY

up to 50 (60) **% cutting scrap**

example
12 % scrap (failure)**;**
65 % energy lost (press cushion)

example
energy need in joining:
mechanically/ thermally = 1/3

example
energy need in lacquering:
blank/structure = 1/5

research focus

holistic planning — **system boundary**

tool/die making → **press shop** → **car body construction** → **lacquering**

TOMORROW

resource-optimized (costs, time, material, energy) **car body manufacturing**

VISION: 50 % reduction of energy use possible ?

Bundesministerium für Bildung und Forschung

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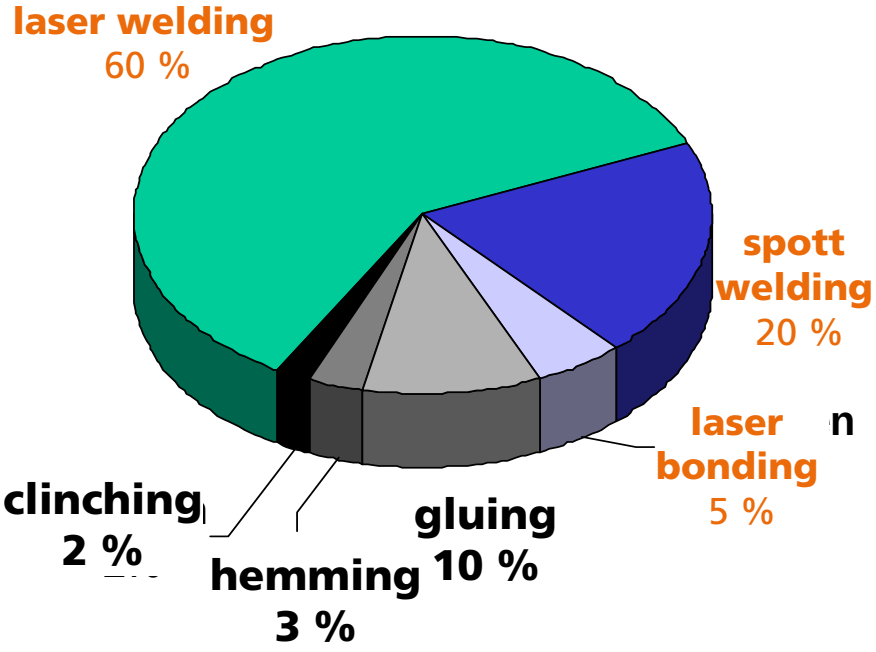
4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

Initial Situation

Share of thermal joining processes in car body manufacturing: 85 %



thermal

mechanical

Energy per Strength

150 J/kN		50 J/kN
3	:	**1**

Flange dimensions

1	:	1,7

Need for Research

- identification of potential applications
- determination of process limits

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4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

OEM – production line for car bodies

For production of:
Doors,
Combined parts,
structures ...

supplier – body shop equipment

Innovation + Data + best practice

Technology – Joining, Clamping, Control, Laser, media supply (air, electrical supply, Coolant, etc.)

VW Wolfsburg
Golf VI model
(Door production)

Sample for production efficiency in car body manufacturing

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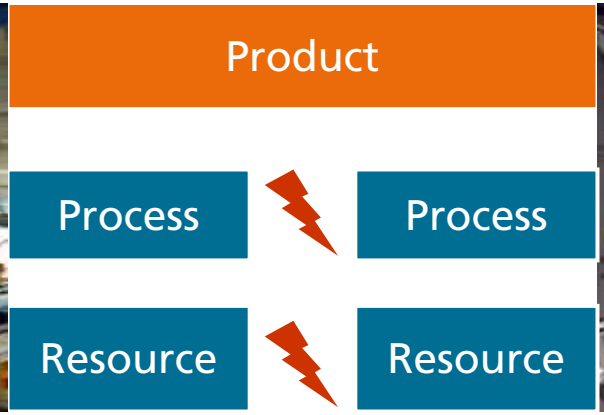
4 LEADING PROJECTS (2)

Innovation alliance „Green Carbody Technologies“

Information exchange between production areas (PLM “worlds”)

- in automobile production, **processes** and **resources** differs greatly across shop floors (press shop, body shop, paint shop)
- engineering requires independent **software tools**, utilizing specialized process and resource libraries, only linked by the product *(press shop output = body shop input)*



Images : Volkswagen, Audi

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4 LEADING PROJECTS (3)
eniPROD: Cluster of Excellence

- **eniPROD: energy efficient product and process innovations in production engineering**
- Winner of the Saxon regional excellence competition 2008
- Vision: quasi energy autarkic plant
  - efficiency optimized production
  - closed energy loops
  - renewable powered
- Duration: 5 years (2009 – 2014)
- 16 project parts in 5 fields of activities
- Partner: Fraunhofer IWU and TU Chemnitz

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4 LEADING PROJECTS (3)

eniPROD: Vision of the project

Step 1 **Effectiveness-optimized production**

- process reliability
- low-energy production systems

➔ **efficency**

Step 2 **Total Energy Management**

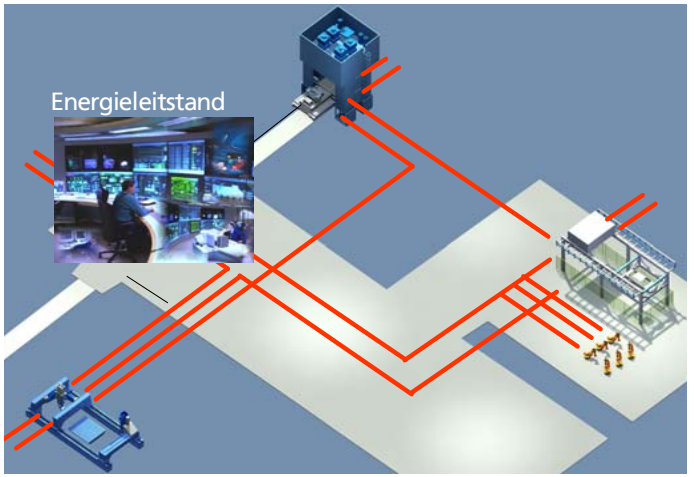
- „closed“ energy systems / loops

➔ **sustainability**

Step 3 **Use of alternative energy sources**

- geothermal / solar / wind energy

➔ **substitution**



Energetic interaktion
Process – Production systems – facilities

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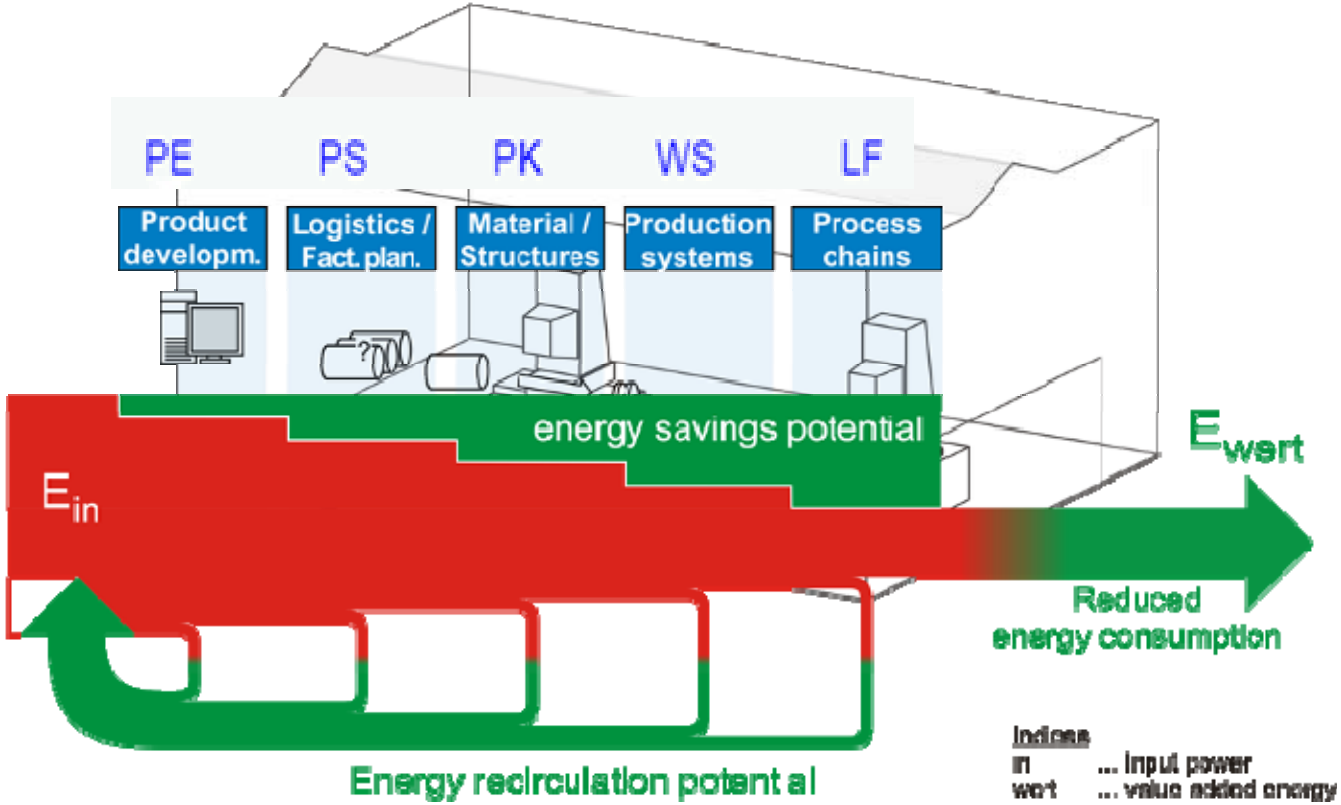
4 LEADING PROJECTS (3)

eniPROD: concept and activities

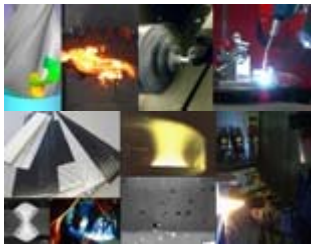


The vision of the **Concept "E³ Plant"** is an energy-autarkic, emission-free and ergonomic production.

4 LEADING PROJECTS (3)
eniPROD: Fields of Activities

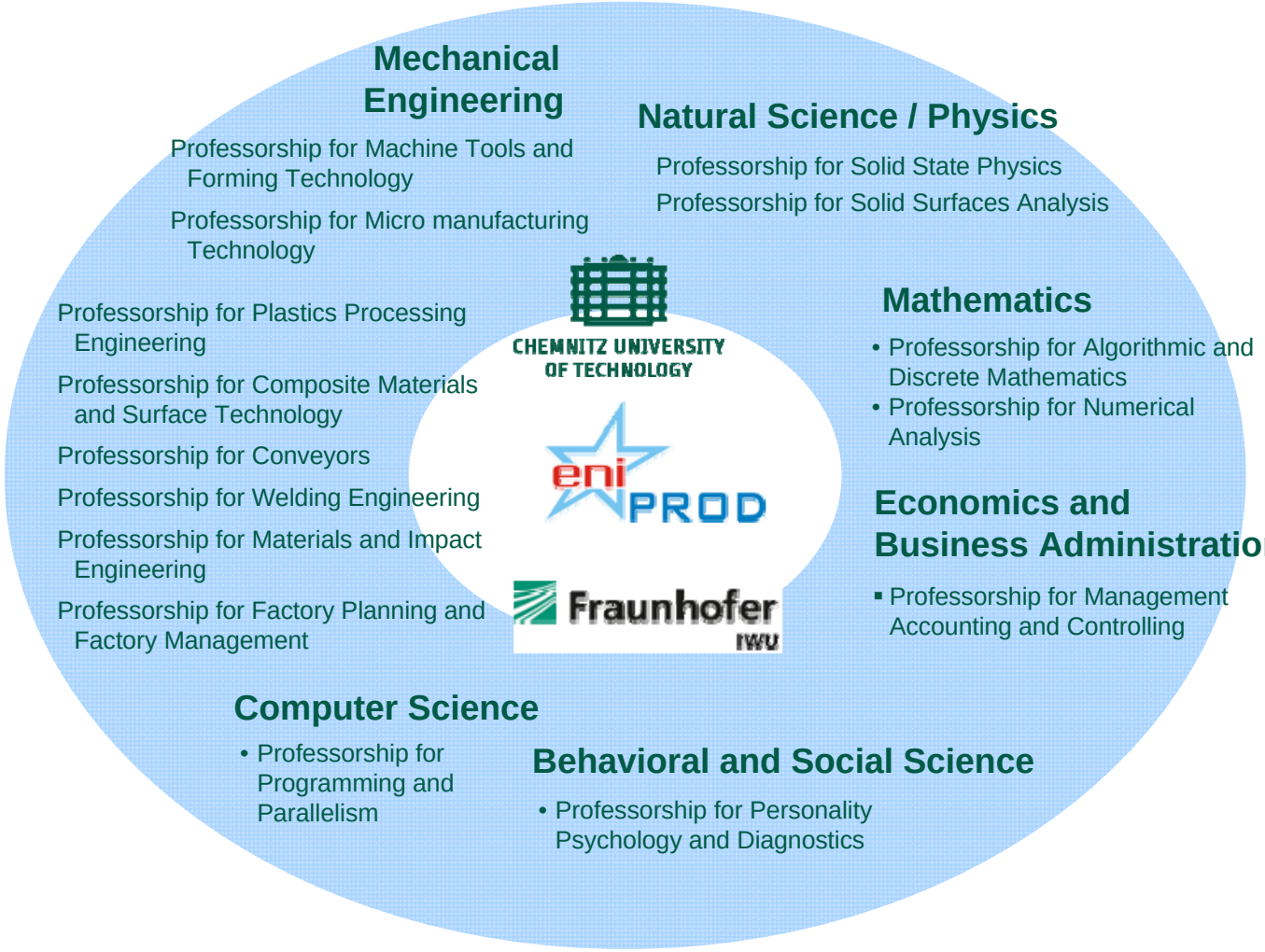
Five fields of Activity with 16 project parts

- Virtual **product development** for energy-efficient products and processes (PE)
- Active principles for intelligent **production systems** with poor energy demand (PS)
- Design of highly integrative **process chains** with a poor energy demand (PK)
- Energy-optimized and resource-saving **materials** and **structures** (WS)
- Energy-efficient systems and processes in the **logistics** and **factory planning** (LF)



4 LEADING PROJECTS (3)

eniPROD: the cooperation network



4 LEADING PROJECT (3)
eniPROD: location at technology campus

TECHNISCHE UNIVERSITÄT CHEMNITZ

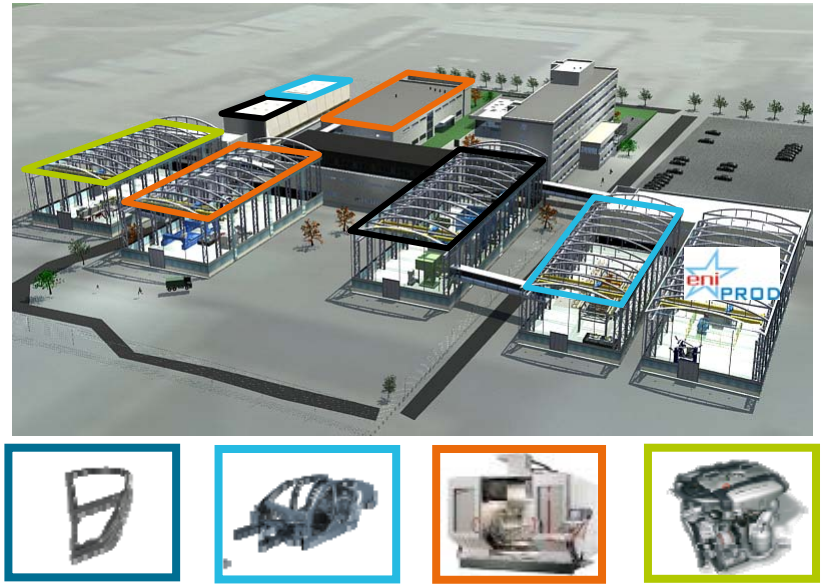
IWP WERKZEUGMASCHINEN UND PRODUKTIONSPROZESSE

Fraunhofer IWU

4 LEADING PROJECTS (4)
Excellence Center Automobile Production

- Integrative part of the research plant “Resource Efficient Production“
- Bilateral master project between Fraunhofer IWU and Volkswagen AG
- Focus:
  - Carbody manufacturing
  - Tool making
  - Powertrain
- Duration: 8 years (2008 – 2016)

4 LEADING PROJECTS (5)
"Research Plant Resource Efficient Production"



- Objective: development of efficient technologies and systems
- Consisting of
  - Forming Technology Lab
  - Machine Tool Lab
  - Carbody Lab
  - Powertrain Lab
- Fraunhofer IWU Strategy
  1. Efficient production
  2. Total energy management
  3. Utilization of alternative energy sources

4 LEADING PROJECTS (5)

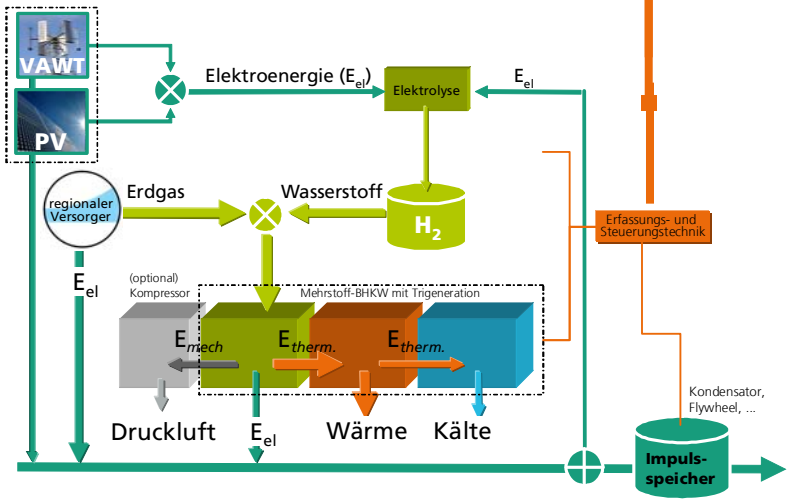
“Research Plant Resource Efficient Production“

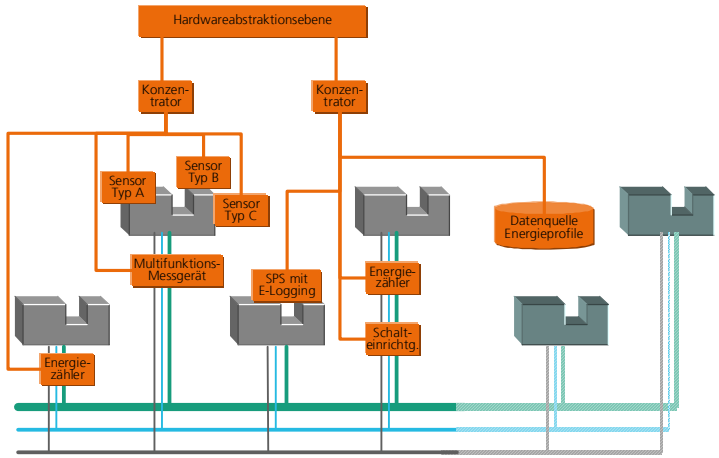
LF

Total resource control

Visualisation, control system

Facility control system





facilities, supply systems

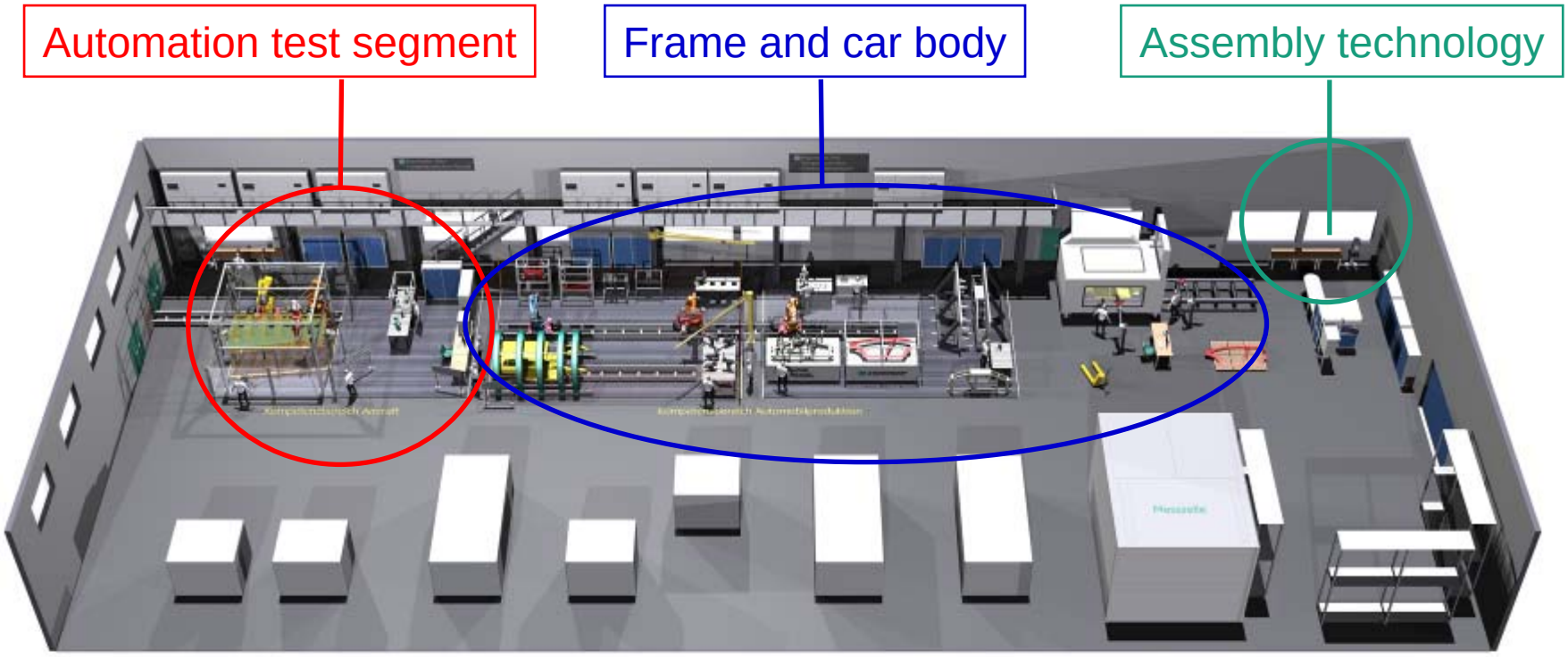
Process (machines, equipment)

Archivierungsangaben

Fraunhofer IWU

4 LEADING PROJECTS (5)

“Research Plant Resource Efficient Production“



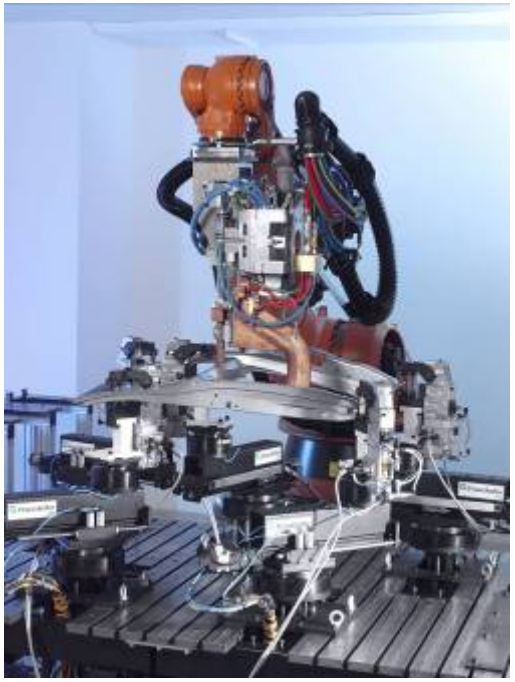
Concept layout ideas for the research plant

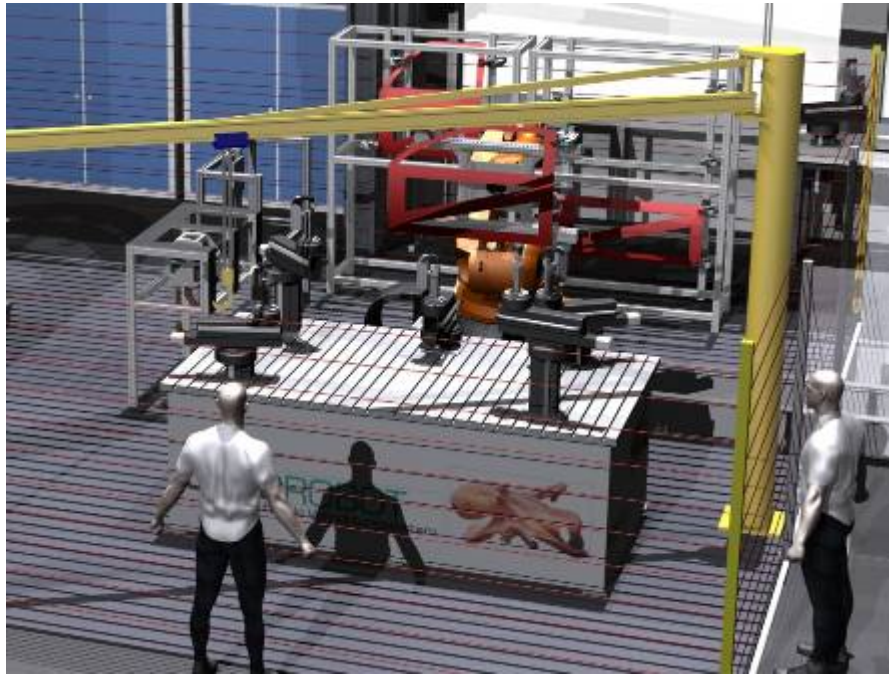
4 LEADING PROJECTS (5)

"Research Plant Resource Efficient Production"

Area of competence Automotive production:

Sample: Realisation of the module for research and analyses of flexible fictures and gripper concepts





IWP Werkzeugmaschinen und Produktionsprozesse

Fraunhofer IWU

5 Summary and Outlook

Summary:

- Fraunhofer research enables worldwide sustainable production.
- By using the results of the shown activities an efficient use of energy and resources in the field of production technology will be possible.
- Green production technology will established as a product „made in Germany“.

Outlook: ***Paradigm Change is required !***

„ … from maximum profit realized by minimum funds to a
maximum added value
by using minimum resources.“

(Prof. Reimund Neugebauer, Fraunhofer IWU)

Activities in Nov 2011:

The future has been started !

IWP WERKZEUGMASCHINEN UND PRODUKTIONSPROZESSE

Fraunhofer IWU

Thank You.

IWP Institut für Werkzeugmaschinen und Produktionsprozesse

Fraunhofer IWU