Stockholm| 28.05.2014

TECHNISCHE UNIVERSITÄT DARMSTADT

4th Conference on Learning Factories

The η-Factory –

An interdisciplinary learning factory approach to boost the energy performance of production

Prof. Dr.-Ing. Eberhard Abele
Christian Eisele
Martin Beck

ENERGY-EFFICIENCY
TECHNOLOGY AND
APPLICATION CENTER

Bundesministerium für Wirtschaft und Technologie

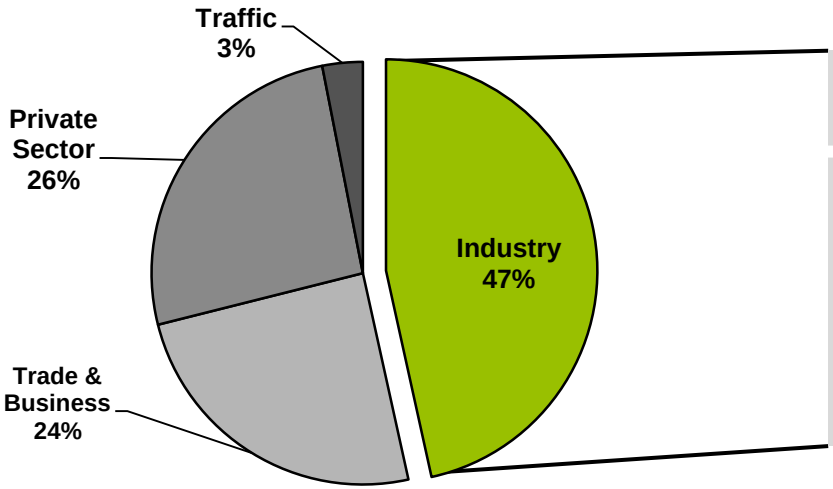
Projektträger Jülich
Forschungszentrum Jülich

Facts and Figures of energy consumption in industry

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Electr. Power Demand Germany 2011

Total consumption 540,8 Mrd. kWh



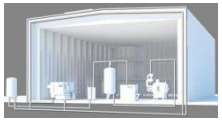
Saving Potential

20 - 40% of the electrical power is lost as heat, this corresponds to 5 - 10 Mrd. € per year

Source:: AG Energiebilanzen und VDI Nachrichten Nr.39/2012

Saving Strategies

System Design



Intelligent interaction of Machines, Buiding and Technical Building services

Machines

Optimization of Machines and research of innovative processes

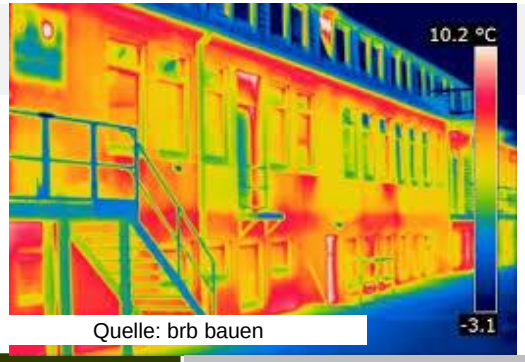
User behaviour

Training of personell and staff

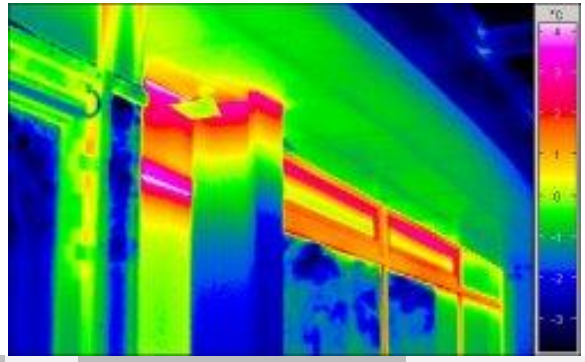
Waste heat in Manufacturing environments

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Building



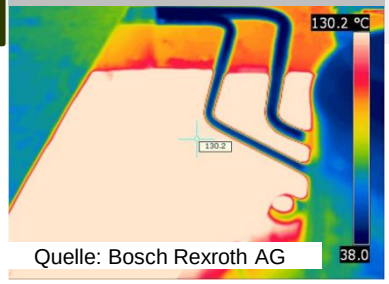
Quelle: brb bauen



- Insulation
- Re-Use

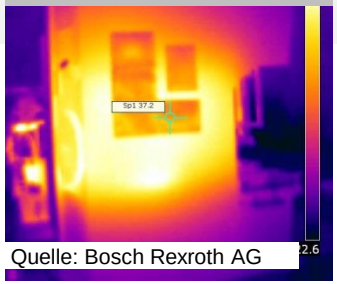
Process Chain/ Machines

Heat Treatment



Quelle: Bosch Rexroth AG

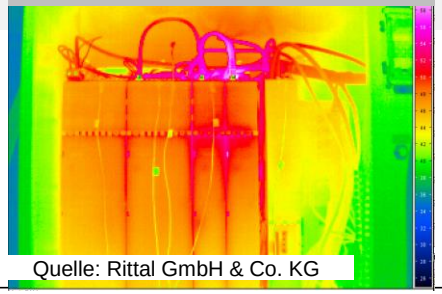
Cleaning Machine


Quelle: Bosch Rexroth AG

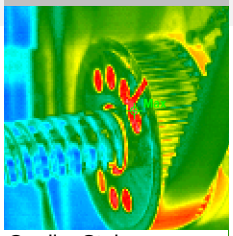
- Energetic Interaction

Machine Components

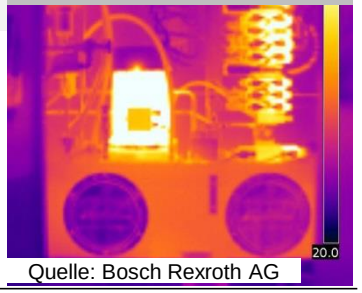
Speed Controller


Quelle: Rittal GmbH & Co. KG

Ball Screw


Quelle: Steinmeyer GmbH & Co. KG

Hydraulik Unit



Quelle: Bosch Rexroth AG

The Challenge:
Holistic increase of energy efficiency

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Today: Optimization of subsystems within their system boundaries

Subsystem Building

Quelle: Prof. Dipl.-Ing. J. Eisele

Subsystem Technical Infrastructure

Subsystem Machine

Total energy saving potential limited on the Subsystems

Our vision: Holistic factory optimization including all subsystems

High saving potential by realization of energy networks

Interaction of:

- **Machines**
- **Process chains**
- **Buildings**

Synergies by energy-controlling and recovery measures

The idea behind the model project η-FACTORY

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

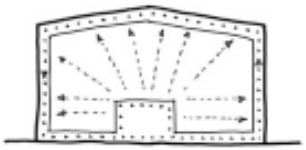
- **Establishing a research and training center in the middle of Campus**
- **Developing an interdisciplinary approach for reducing CO_2 emissions (Including research in architecture and civil engineering)**
- **Involvement of industry from the beginning of the concept phase**
- **Educational integration of energy efficiency, training concepts**

- **International notable lighthouse project**
- **Source for innovation and technology development**

Fields of Innovation in η-FACTORY

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Energetic interaction

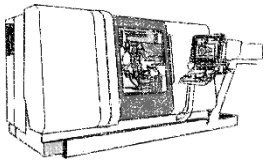


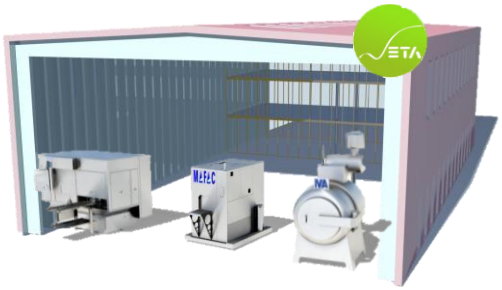
source:
F. Lang – EuB TU Darmstadt

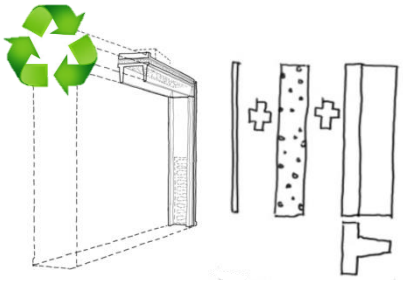
→ Energy exchange between building and machines
→ Energy network between all energy sources and sinks

Efficient Production

→ Energy efficient equipment
→ Energy efficient production scheduling







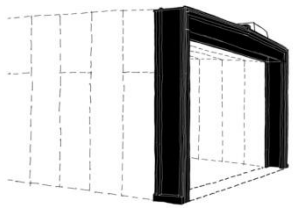
source:
F. Lang – EuB TU Darmstadt

Recyclability

→ single-material cladding construction

Changeability

→ Modular and flexible Building construction



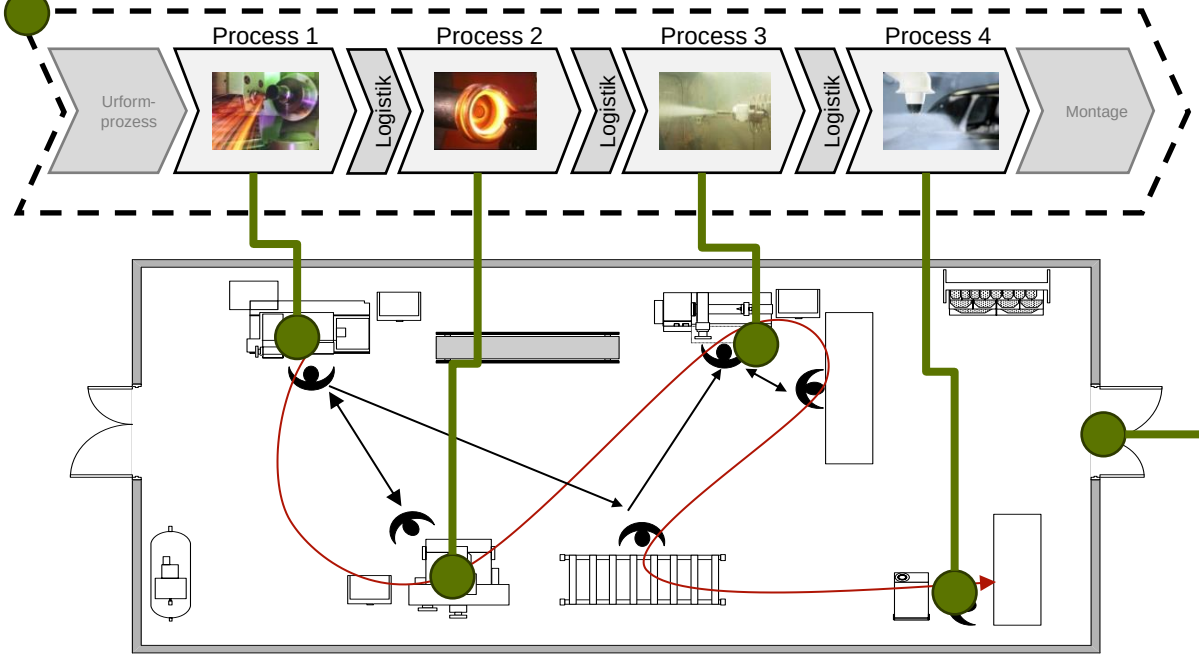
source:
F. Lang – EuB TU Darmstadt

The η-FACTORY concept:

ENERGIEEFFIZIENZ TECHNOLOGIE-UND ANWENDUNGSZENTRUM

Construction of a real existing process chain for practice-oriented, interdisciplinary research to different topics of energy and resource efficient production

Installation of a new research building for the integration of the process chain and the realization of experiments about the interaction between processes and buildings



Development of a **training concept** to **transfer** the research results into **practice**

Project structure

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Subproject 1
The virtual energy efficient factory

Subproject 2
Energy controlling and energy management

Subproject 3
Energy efficient part cleaning

Subproject 4
Energy resource efficient heat treatment

Subproject 5
Energy efficient machining processes

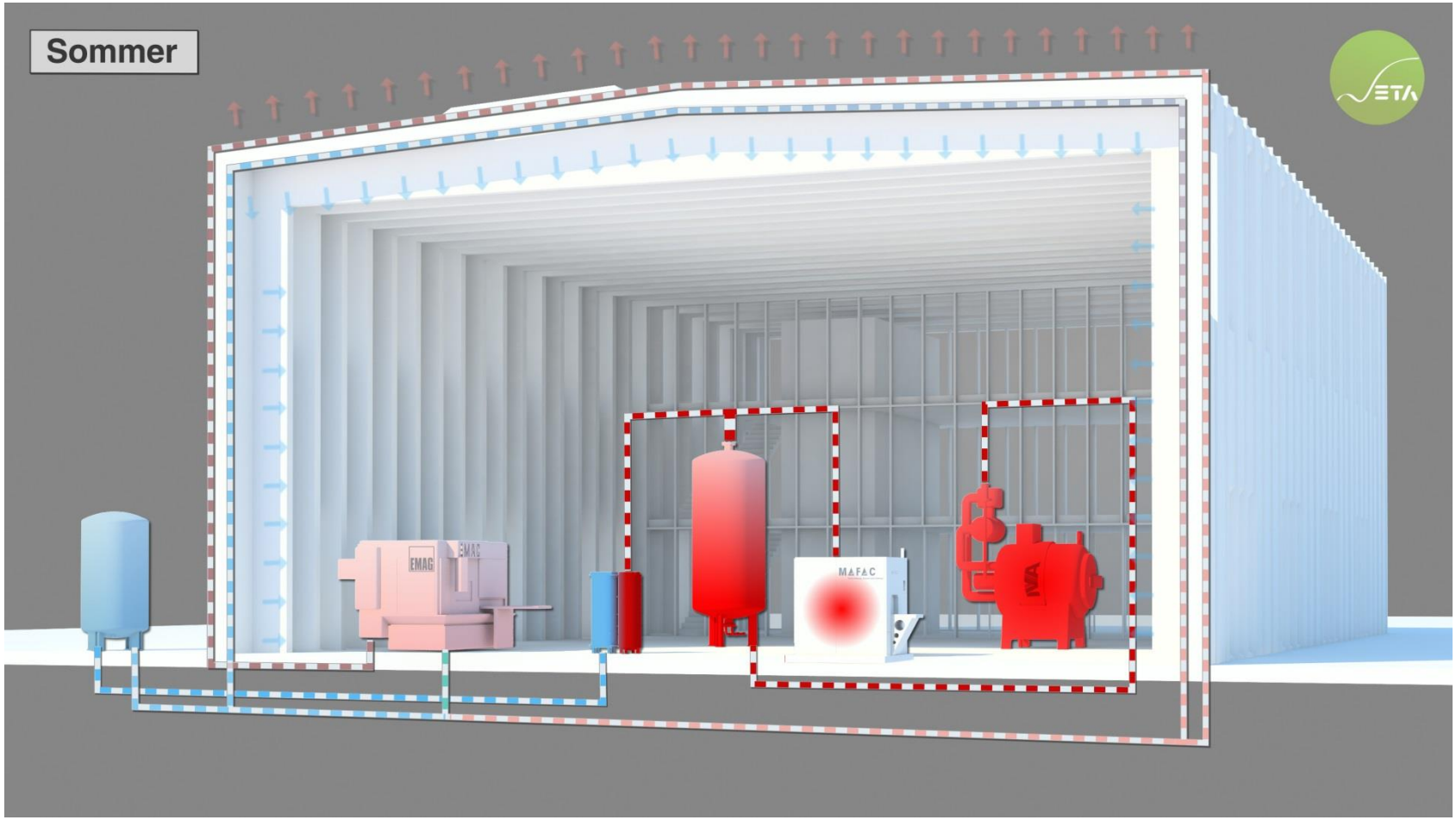
Subproject 6
Flywheel mass battery

Subproject 7
Thermal interaction between building, infrastructure and production machines

Subproject 8
Energy efficient Building

Energy flows and energy recovery in the η-Factory

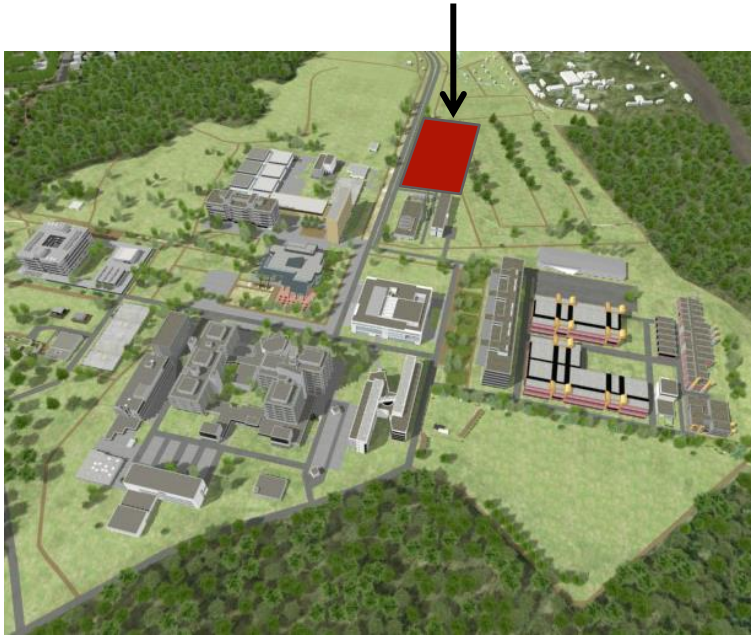
ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

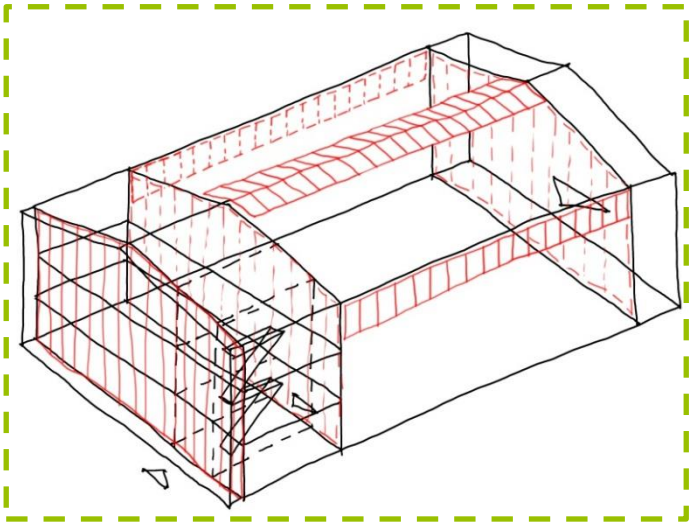


Realisation of the η-Factory at TU Darmstadt

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Future position of the η-Factory





- Dimensions:
  45,80 m x 23,00 m x 12,00 m
  (length x width x height)
- shop floor: 650m²
- office area: 650 m²

ETA-LearningFactory – Concept

Challenges

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

How to present Energy-Efficiency in a Learning factory?

Energy

- ✘ how to measure Energy? (frequency, sensors, measuring points)
- ✘ has different forms (electrical, thermal, chemical, etc.)
- ✘ can be dangerous
- ✘ is used by many consumers in the factory (machines, peripheral systems)

Efficiency

- ✘ criterias are hard to define
- ✘ is difficult to quantify
- ✘ is challenging to visualize

ETA-LearningFactory - Concept

Target Audience

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

Industry

- Factory & Production Planners
- Managers
- Controllers
- Energy Managers
- Machine Designers

Technical Planners

- Architecture
- Heating & Climatization
- Energy Networks
- Pressurized Air

picture source: tab Fachmagazin TGA

University Students

- Bachelor *‚raise enthusiasm‘*
- Master *‚deepen knowledge‘*

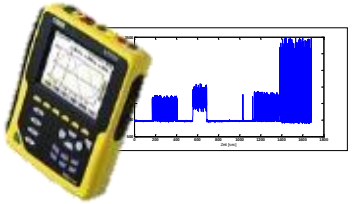
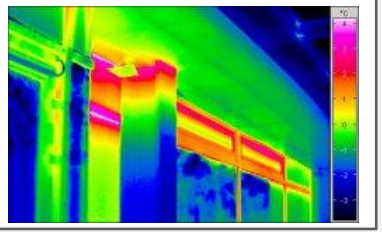
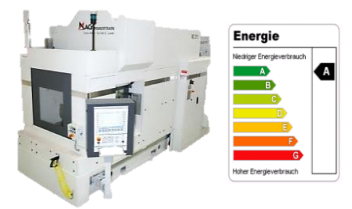
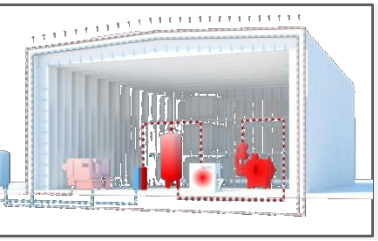
General Visitors

- Politicians
- Association Members
- Funding Parties

ETA-LearningFactory - Concept

Training Modules

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

training module		*topics*
	**Energy Flows in Factories**	• Measuring Equipment and Installation of Sensors for different Energy forms • Measuring Strategies (measuring points, accuracy, time resolution, duration) • Visualization and Monitoring of Energy Flows
	**Assessment of Energy Efficiency Potentials**	• Interpretation of Energy Measurement Data • Methods for Identfying and Quantifiying Energy Efficiency Potentials • Key Perfomance Indicators for Assessing and Tracking the Energy Consumption and Efficiency
	**Levers to Increase Energy Efficiency**	• Technical Levers (Improvement of machines and components, usage of alternative manufacturing technologies) • Organizational Levers (establishing organizational structures, influencing user beaviour)
	**Design of Energy Networks**	• Linkage of Energy Sinks and Sources • Storage and Re-use of different Energy Forms • Conversion of Energy, e.g. heat to cold • Control Strategies for Energy Flows

ETA-LearningFactory - Concept

Training Means

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER

„The Way to Energy Efficiency“

Lectures

- Oral Presentations
- Powerpoint

Learning Cells

- Posters
- Touchscreen Learning PCs

Workshops

- Brainstormings
- Technology Analyses
- Quality Function Deployment (QFD)
- Business Cases
- Thermographic Analyses

Guides

- Handouts
- Books
- Tablet/Smartphone App
  * QR-Code / NFC spots in the factory
  * Augmented Reality feature

- Video Clips & Animations
- Live Data (Machines, Building)
- Exhibits
- Augmented Reality Overlays
- Interactive Simulations
- Educational Games

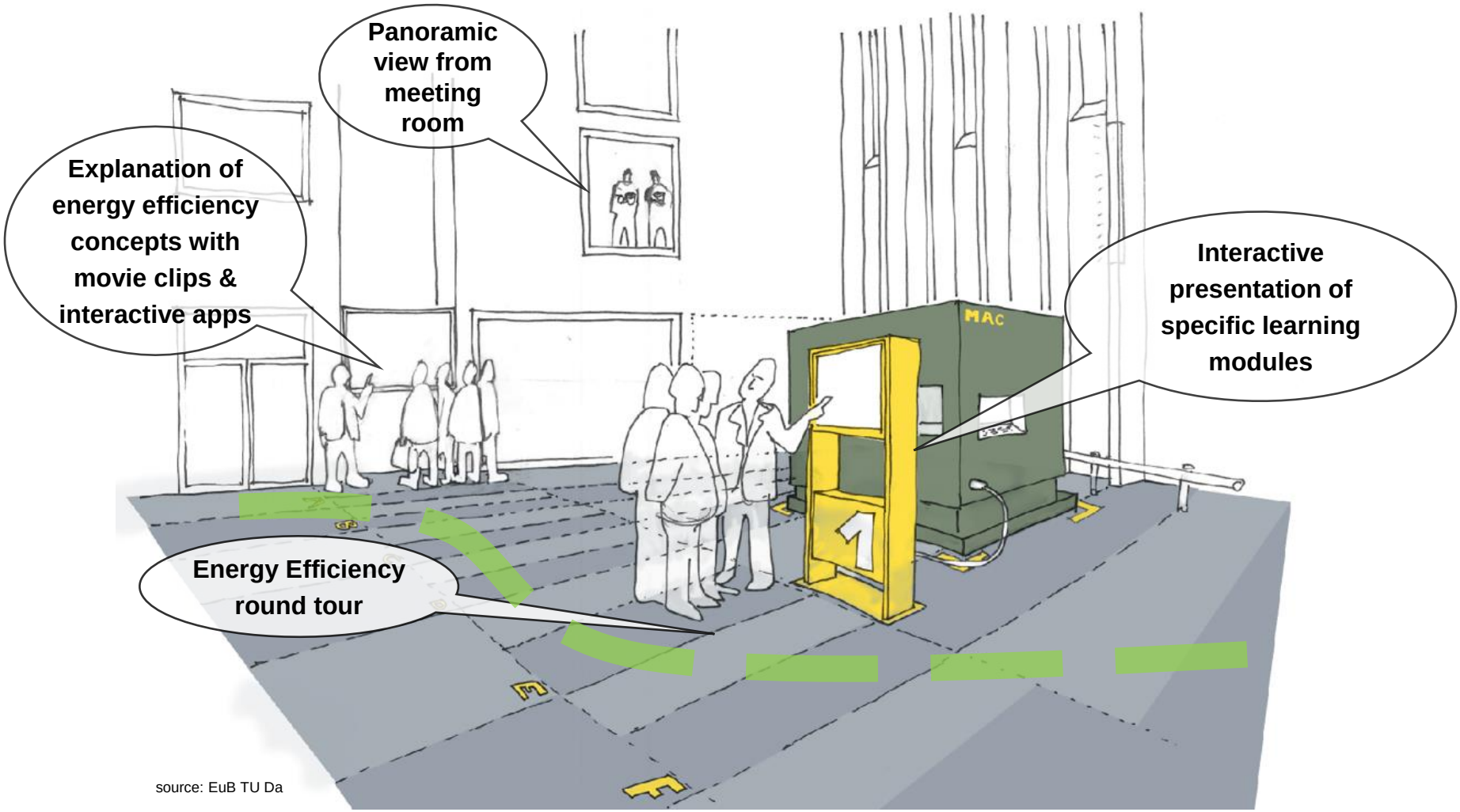
Hearing & Reading
Seeing & Feeling
Thinking & Speaking
Doing
Recapitulation

Knowledge → **Implementation**

ETA-LearningFactory - Outlook

Example of presentation techniques

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER



TECHNISCHE UNIVERSITÄT DARMSTADT

Thank you for your kind attention!

Prof. Dr.-Ing. E. Abele
Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen
Technische Universität Darmstadt

Petersenstr. 30
64287 Darmstadt

Tel: 0 61 51 | 16 21 56
Fax: 0 61 51 | 16 33 56
e-mail: info@ptw.tu-darmstadt.de
Internet: www.ptw.tu-darmstadt.de

ENERGY-EFFICIENCY TECHNOLOGY AND APPLICATION CENTER