Future of Industrial Engineering and Management in Europe

LECTURE NOTES IN MANAGEMENT AND INDUSTRIAL ENGINEERING, Looking at the Future of Industrial Engineering in Europe, vol. N. 2, 2014, Springer , ISBN: 978-3-319-04704-1, ISSN: 2198-0772

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Outline

1. International Industrial Competition and European Challenges
2. EU Industrial Engineering Education
3. The Role of the European Academy for Industrial Management
4. Forward an European School of Industrial Engineering
5. Conclusions

International Competition: Country Manufacturing Competitiveness Index Ranking (2013)

(2012 Survey on 550 CEO and Senior Mftg Leaders
Deloitte, Touche Tohomatsu Ltd and The US Council of Competitiveness)

Current competitiveness

Rank	Country	Index score 10 = High 1 = Low
1	China	10.00
2	Germany	7.98
3	United States of America	7.84
4	India	7.65
5	South Korea	7.59
6	Taiwan	7.57
7	Canada	7.24
8	Brazil	7.13
9	Singapore	6.64
10	Japan	6.60
15	United Kingdom	5.81
16	Australia	5.75
		5.75
		5.73
19	Czech Republic	5.71
20	Turkey	5.61

Competitiveness in five years

Rank	Country	Index score 10 = High 1 = Low
1	China	10.00
2	India	8.49
3	Brazil	7.89
4	Germany	7.82
5	United States of America	7.69
6	South Korea	7.63
7	Taiwan	7.18
8	Canada	6.99
9	Singapore	6.64
10	Vietnam	6.50
15	Thailand	6.24
16	Turkey	5.99
17		
18		
19	United Kingdom	5.59
20	Switzerland	5.42

International Competition: Global Drivers of Manufacturing Competitiveness Index ranking (2013)

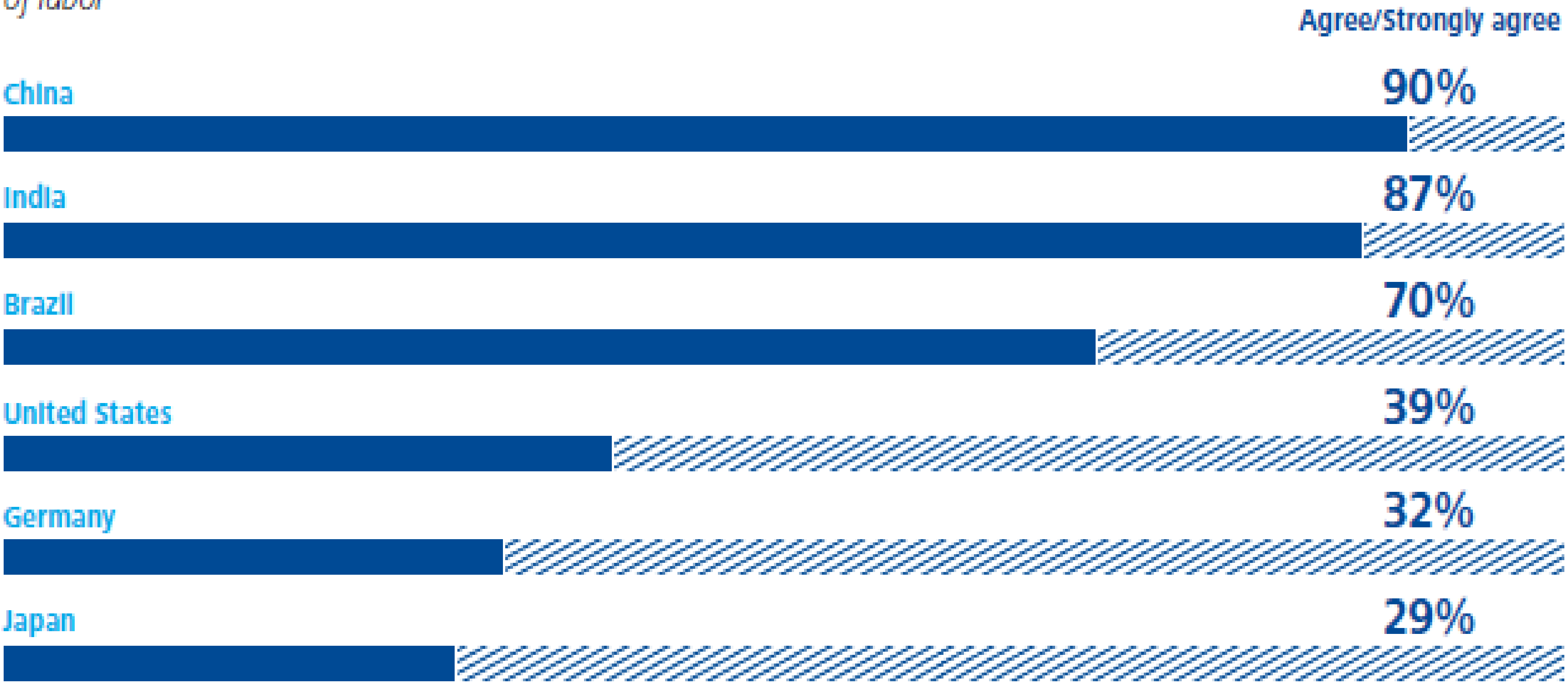
(2012 Survey on 550 CEO and Senior Mftg Leaders
Deloitte, Touche Tohomatsu Ltd and The US Council of Competitiveness)

Overall rank (1–10)	Overall index score	Main driver	Most important sub-components	Sub-component rank (1-40)
1	10.00	Talent-driven innovation	Quality and availability of researchers, scientists, and engineers Quality and availability of skilled labor	1 2
2	8.42	Economic, trade, financial and tax system	Tax rate burden and system complexity Clarity and stability of regulatory, tax and economic policies	3 5
3	8.07	Cost and availability of labor and materials	Cost competitiveness of materials Availability of raw materials	11 21
4	7.76	Supplier network	Cost competitiveness of local suppliers Ability of supply base to innovate in products and processes	8 9
5	7.60	Legal and regulatory system	Stability and clarity in legal and regulatory policies Labor laws and regulations	7 13
6	6.47	Physical infrastructure	Quality and efficiency of electricity grid, IT and telecommunications network Quality and efficiency of roads, airports, ports, and railroad networks	4 16
7	6.25	Energy cost & policies	Cost competitiveness of energy Ongoing investments to improve and modernize energy infrastructure	14 20
8	3.99	Local market attractiveness	Size and access of the local market Intensity of local competition	27 36
9	2.48	Healthcare system	Cost of quality healthcare for employee and society Regulatory policies (e.g., pollution, food safety, etc.) that are enforced to protect public health	26 33
10	1.00	Government investments in manufacturing and innovation	Government investments in R&D: science, technology, engineering and manufacturing Private and public sector collaboration for long-term investments in R&D: science, technology, engineering and manufacturing	29 30

Labor Cost and Availability of Labor

Talent-driven Innovation Country Level Competitiveness Perception

Percentage of executives that reported a country was extremely competitive with respect to the local cost and availability of labor



Source: Deloitte Touche Tohmatsu Limited and U.S. Council on Competitiveness, 2013 Global Manufacturing Competitiveness Index

Country Level Drivers of Competitiveness

Selected Country/Manufacturing Competitiveness Drivers	Germany	U.S.	Japan	China	Brazil	India
Talent-driven innovation	9.47	8.94	8.14	5.89	4.28	5.82
Economic trade, financial and tax system	7.12	6.83	6.19	5.87	4.84	4.01
Cost of labor and materials	3.29	3.97	2.59	10.00	6.70	9.41
Supplier network	8.96	8.64	8.03	8.25	4.95	4.82
Legal and regulatory system	9.06	8.46	7.93	3.09	3.80	2.75
Physical infrastructure	9.82	9.15	9.07	6.47	4.23	1.78
Energy cost and policies	4.81	6.03	4.21	7.16	5.88	5.31
Local market attractiveness	7.26	7.60	5.72	8.16	6.28	5.90
Healthcare system	9.28	7.07	8.56	2.18	3.33	1.00
Government investments in manufacturing and innovation	7.57	6.34	6.80	8.42	4.93	5.09

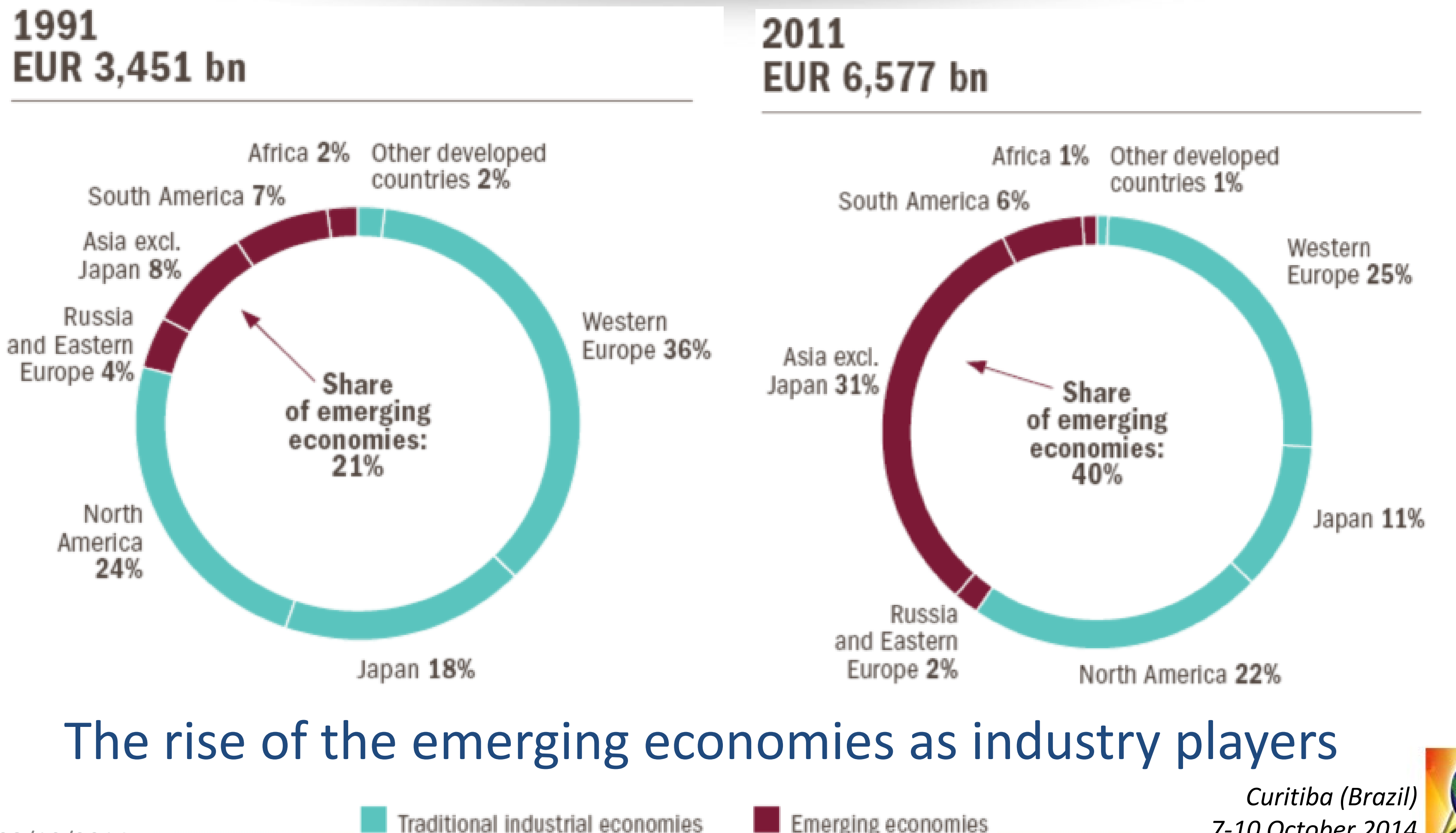
Most competitive — Least competitive

Scores on a 10 point scale, where 1 being "Least competitive" and 10 being "Most competitive" — adjusted for country, size, and industry

Source: Deloitte Touche Tohmatsu Limited and U.S. Council on Competitiveness, 2013 Global Manufacturing Competitiveness Index

Lost Ground of European Industry in last two decade

Manufacturing Value Added



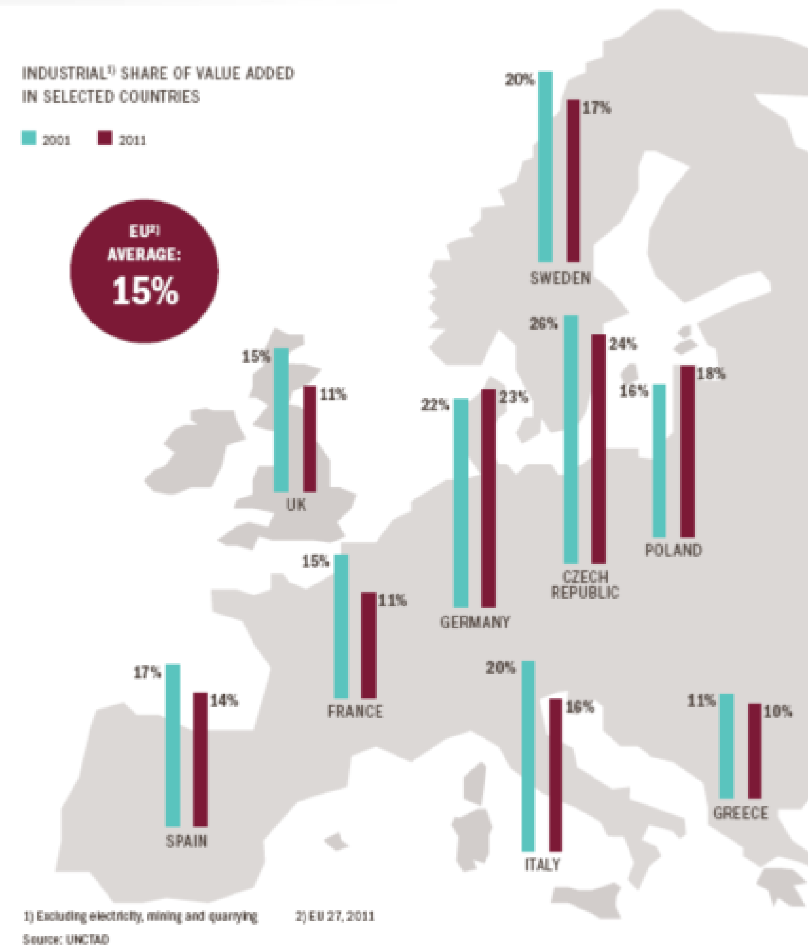
EUR (2005 exchange rate)

The rise of the emerging economies as industry players

Europe – a diverse picture

Market share of French and British Industry, on the road of deindustrialization, shrink since 2000 …
… while …
German and Eastern European industrial sectors are gaining market

Many losers, few winners



Think act, Roland Berger Strategy Consultants, 2014

Focusing on the European Industry

European industry generates:

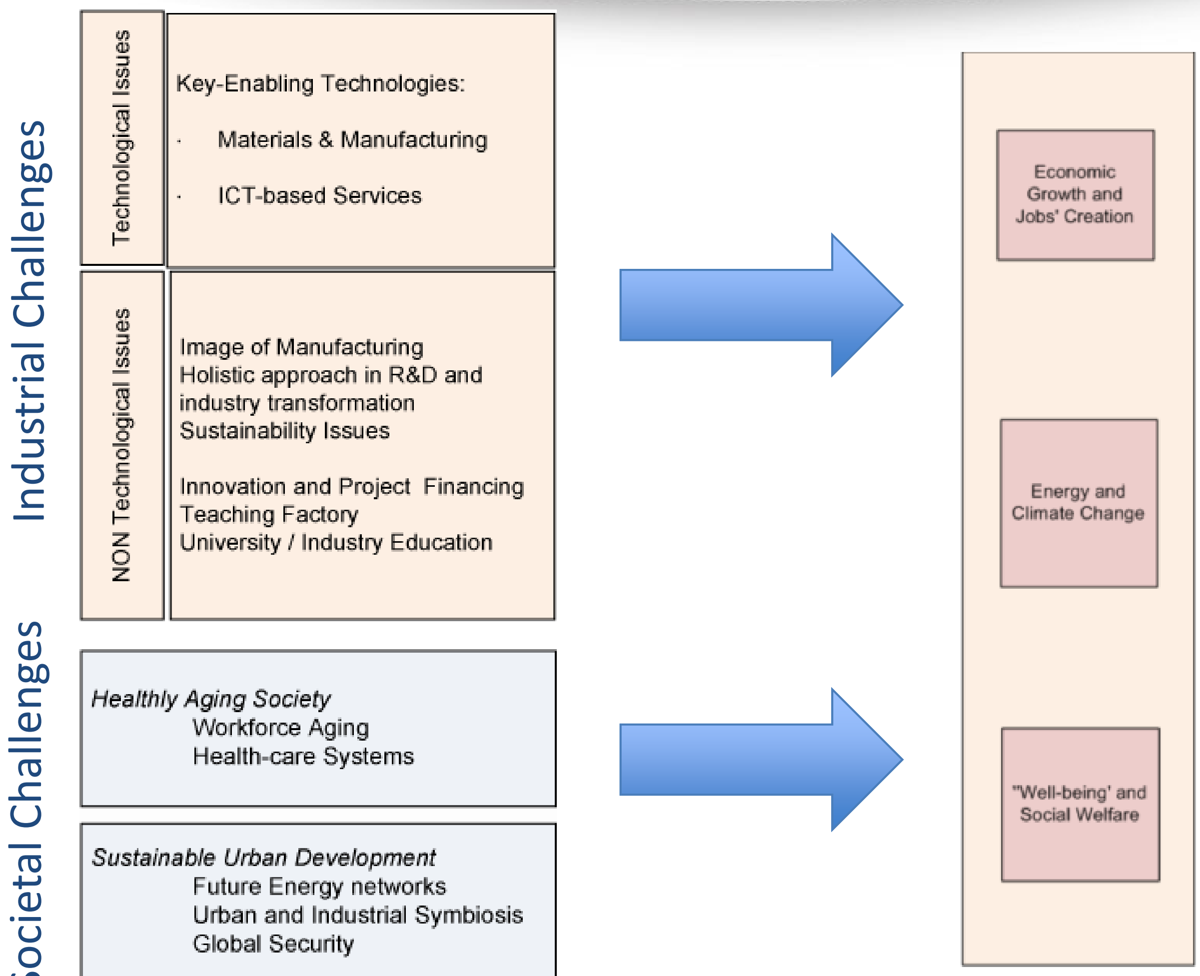
- 15 % of EU Added Value
- 75 % of EU Export
- 80 % of EU Innovation

European Manufacturing aims at increasing its contribute to GDP from 15 % to 20 % by 2020

EU Strategy:
‘Horizon 2020’ & ‘Industry 4.0’

‘Horizon’ 2020 EU Strategy

80 b€ for Research and Innovation EU program over 2014 – 2020 period



Grand Challenges of the EU 2020 Strategy

Industrial Challenges

A KETs-based product is (*):

'(a) an enabling product for the development of goods and services enhancing their overall commercial and social value;
(b) induced by constituent parts that are based on nanotechnology, micro / nano electronics, industrial biotechnology, advanced materials and/or photonics;
(c) produced by (but not limited to) advanced manufacturing technologies.'

(*) European Commission, June 2012

Technological Issues

Key-Enabling Technologies:

- Materials & Manufacturing
- ICT-based Services

Jobs' Creation by KETs in EU

- Nanotechnology: 160.000 workers (+ 25% from 2000)

- Micro / nano – electronics: 700.000 additional jobs during the last decade in Europe (more service-oriented and highly skilled jobs)

Knowledge Generation on KETs is in EU but …

- SMEs are a key driver of innovation:

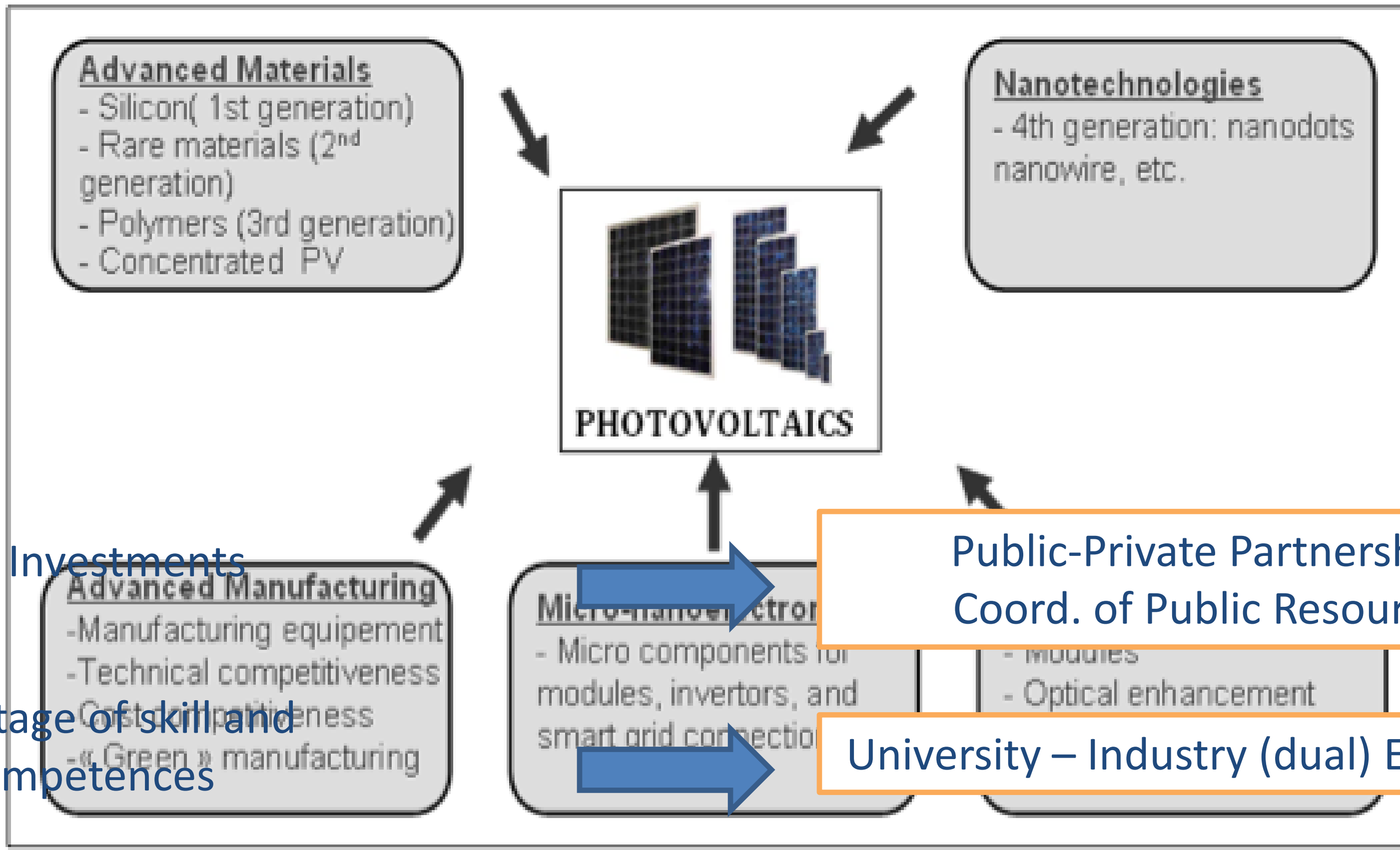
  in the photonics sector 5.000 European companies are SMEs; in Germany, about 80 % of the nanotechnology companies are small or medium sized.

Knowledge Exploitation is outside EU !

- Global Market Potential (2015) of KETS: around 1300 bn US $

Industrial Challenges

Causes



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i. Lacki
industr

ain

ii. High Investments

Public-Private Partnerships
Coord. of Public Resources

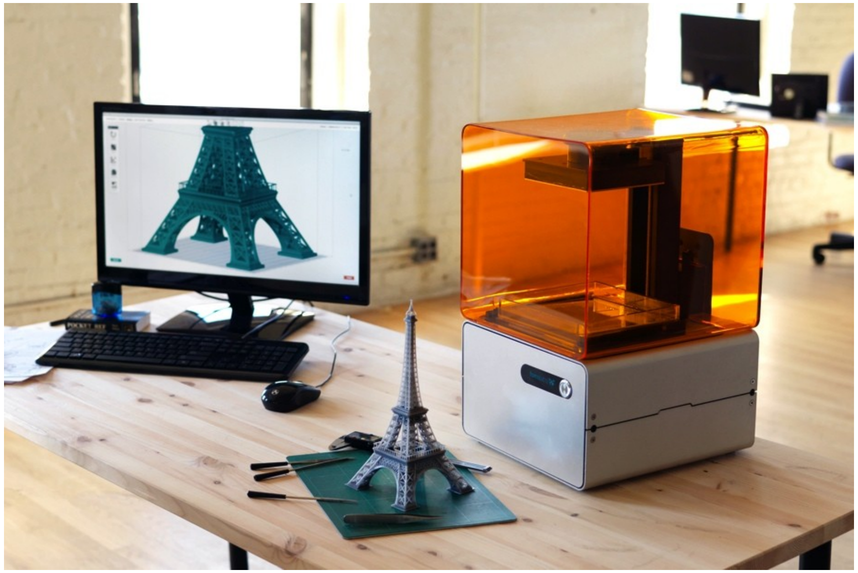
iii. Shortage of skill and competences

University – Industry (dual) Education

Curitiba (Brazil)
7-10 October 2014

Industrial Challenges

3D Low Cost Printers

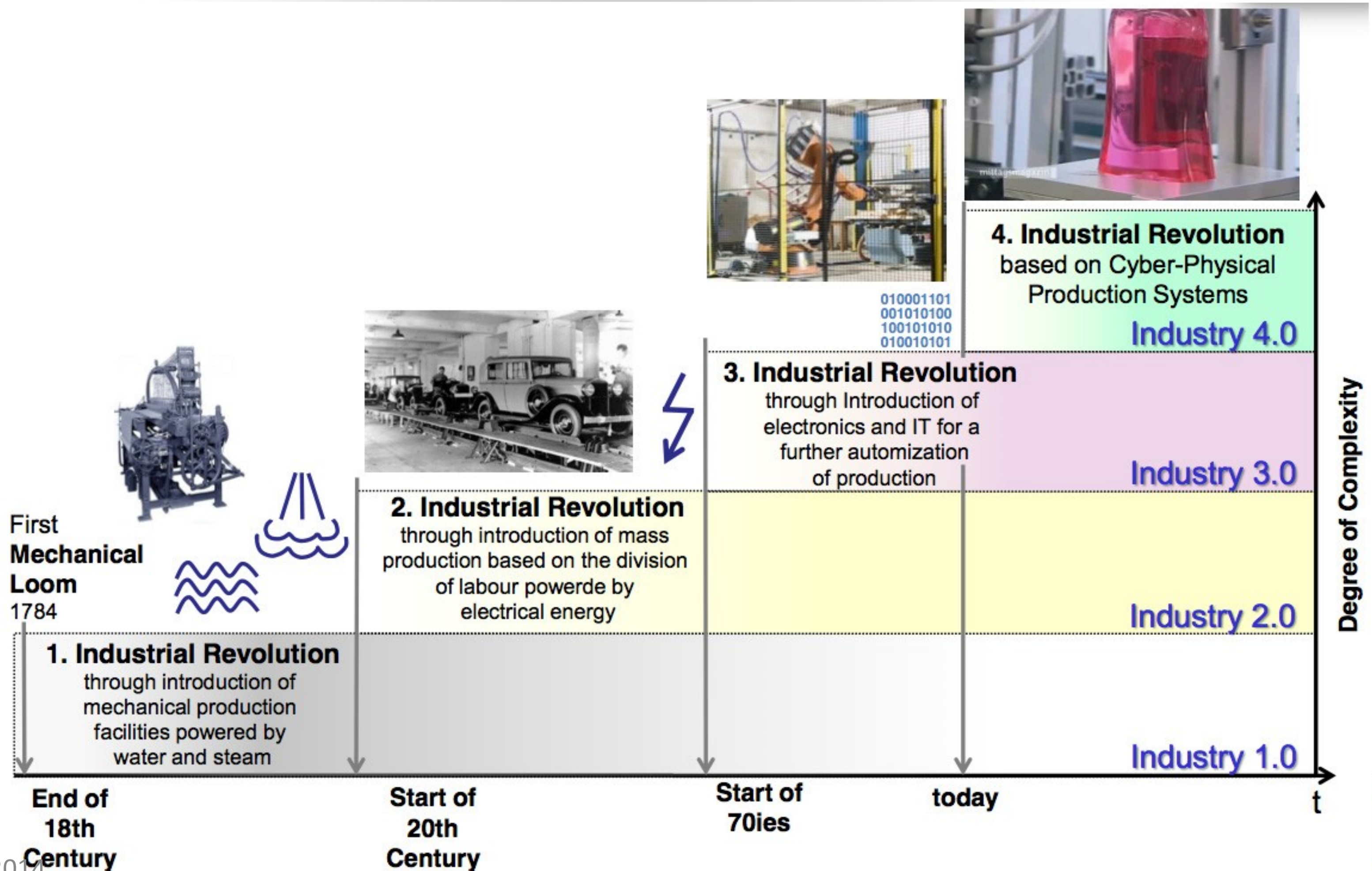


- Economic / Low Volume Productions
- Final products assembled in production districts close to final consumers
- Lower needs of transport: economic and environmental savings

Considered a disruptive technology like the first printing machine (1450), steam engine (1750) and transistor (1950).

What's is going on ….

… from Industry 1.0 to Industry 4.0



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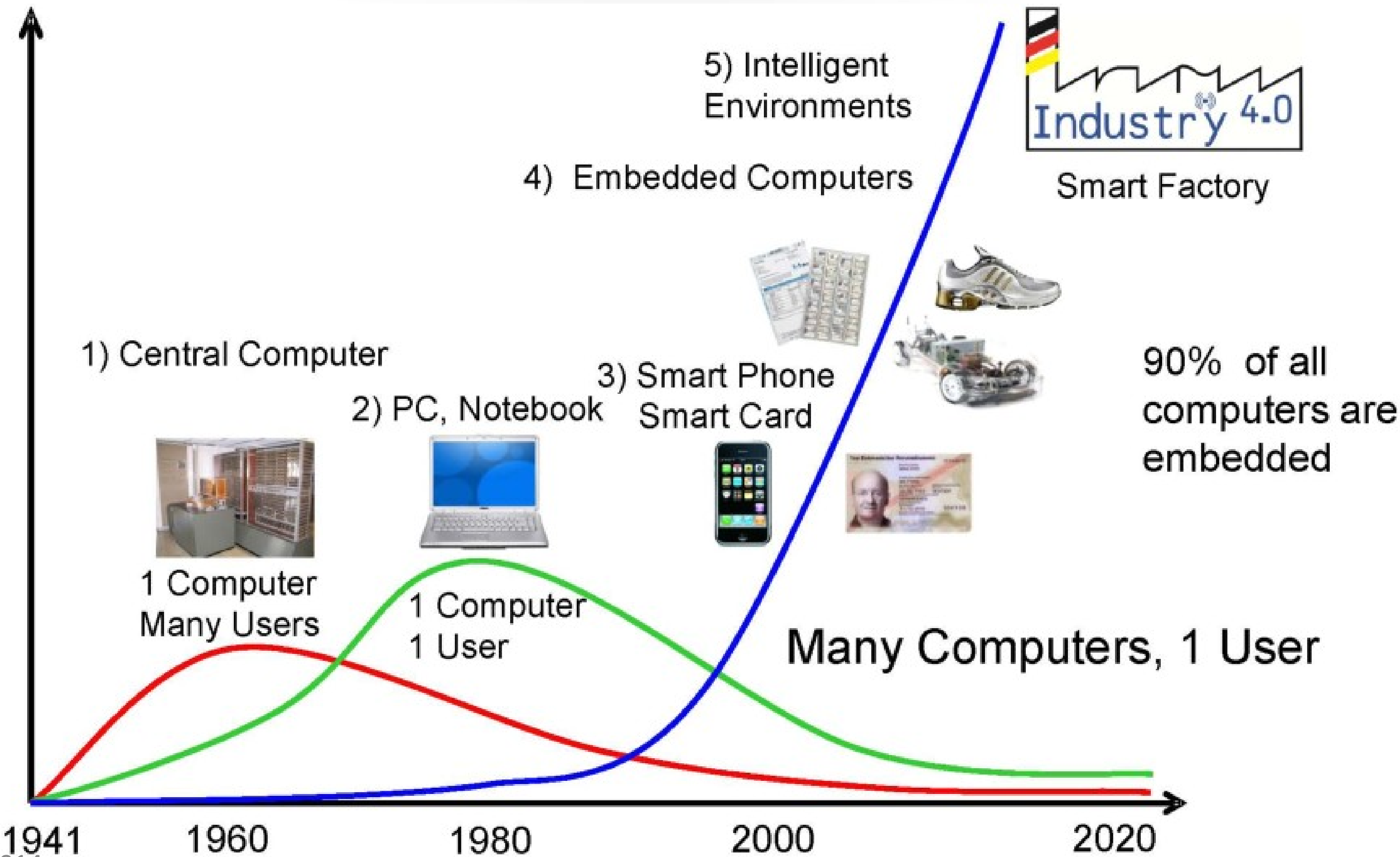
TOWARDS FUTURE INTERNET INTERNATIONAL COLLABORATIONS, ESPOO, FINLAND,
31.05.2012 - ***Prof. Dr. Dr. h.c. mult. Wolfgang Wahlster***

Towards Intelligent Environments based on the Internet of People, Things and Services.



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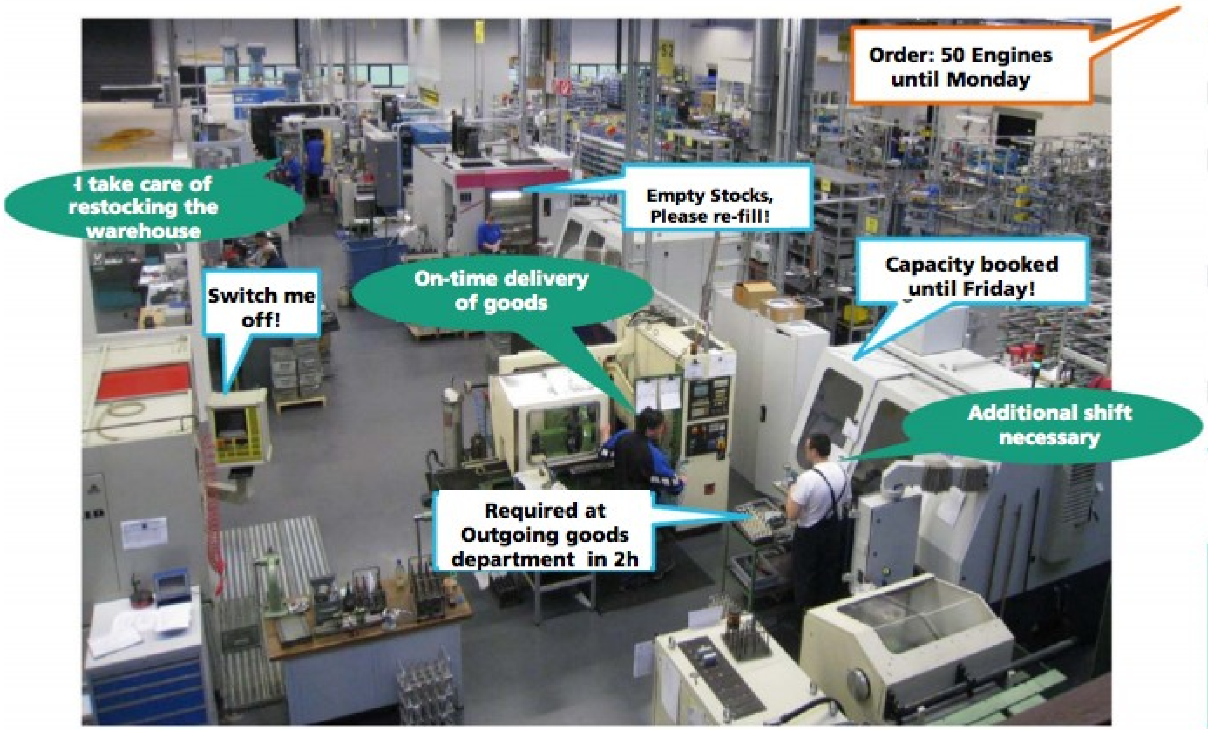
How can we imagine a Smart Factory according to Industry 4.0 ?

Smart means: Adapt, Communicate and Interact

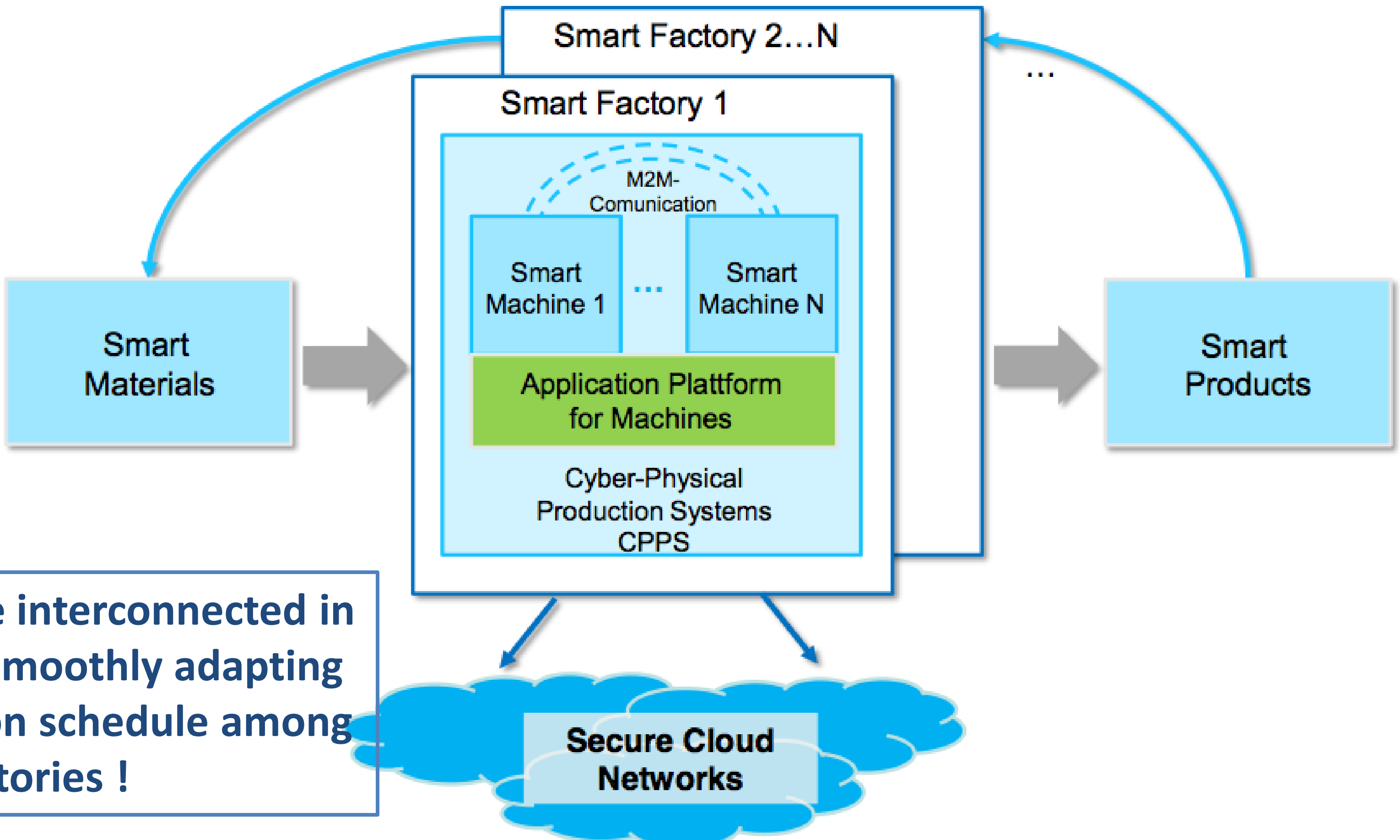


Cyber-Physical Systems

- Are communicating with each other and with the environment
- Are configuring themselves (Plug and Produce)
- Are storing information

De-centralized self-organization in real-time

Pipelines of Smart Factories for Industry 4.0 based on Secure Networks of Clouds



Plants are interconnected in order to smoothly adapting production schedule among smart factories !

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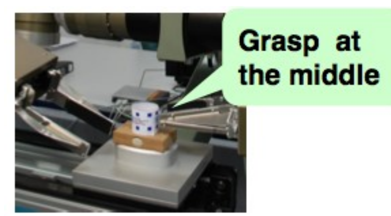
Products with Integrated Dynamic Digital Storage, Sensing and Wireless Communication Capabilities

The product as an information container

- The product carries information across the complete supply chain and its lifecycle

The product as an agent

- The product carries affects its environment



The product as an observer

- The product monitors itself and its environment

Adaptive Grasping and Smart Product Assembly

Stereo Cameras in the Head and a 3D Camera on the Torso for Approaching an Object

Reading Size, Weight and Lifting Points from the Product Memory with an antenna in the left hand – The Robot gets instructions from the product being produced in the CPPS

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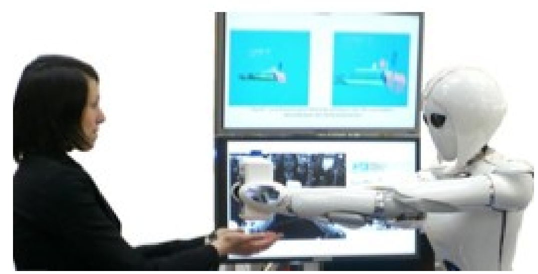
Industry 4.0: Robots are no Longer Locked in Safety Work Cells but Cooperate with Human Workers

Today

Tomorrow



A new generation of light-weight, flexible robots collaborate with humans in the smart factory

Human-Centered CPS-based Assistance Systems for the Smart Factory

Physical Assistance by Exoskeletons

Context-adaptive Assistance for Fault Diagnosis

Mobile, Personalized, Situation-Adaptive, Tutoring Systems

AR/VR/DR-Assistance in Complex Work Processes

Multimodal Human-Machine Interaction

Location-based Maintenance and Planning Assistance

EU Industrial Challenges

NON Technological Issues	Image of Manufacturing Holistic approach in R&D and industry transformation Sustainability Issues **Innovation and Project Fin.** **Teaching Factory** **University / Industry Education**

(*)

(*) Survey on 23 National Technological Platforms of ManuFuture

EU Societal Challenges in 'Horizon 2020'

Ethic Commitments and Opportunity of Growth

Healthly Aging Society
- Workforce Aging
- Health-care Systems

Sustainable Urban Development
- Future Energy Networks
- Urban and Industrial Symbiosis
- Global Security

Industrial Engineering could play a central role to tackle Societal Challenges !

EU Societal Challenges

Population Aging in the EU

	Nawadays		2060	
	Male	Female	Male	Female
MLE [years]	75.7	82.1	84.5	89.0
ODR	25,40%		53,50%	
MLE: Mean Life Expectancy				
ODR: Old age Dependency Ratio				
ODR = (people ≥ 65 years) / (people 15÷64 years)				

- **IE for Health-care Systems:**

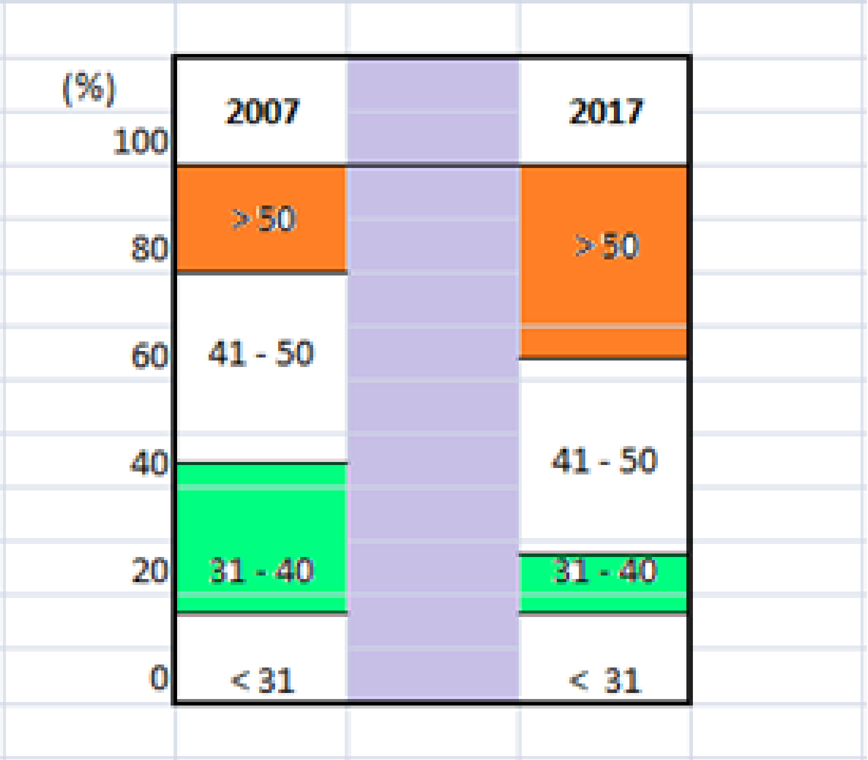
- Analyzing Hospital Processes
- Drug Logistics
- De-Hospitalization Process
- Remote Control and Diagnosis of Patients by IoTs
- Long care assistance for aged and disabled people
- ...

Work Force Aging in the EU

IE new models for aged workers:

- WTMs for Aged Workers
- Job Rotation Policy
- OR & Ergonomics

New Ergonomic Standards
(in the view of Workforce Aging)



The '2007' vs. '2017' distributions of workers' age at the BMW plant in Dingolfing (G)

EU Societal Challenges

Sustainable Urban Development
Future Energy Networks
Urban and Industrial Symbiosis
Global Security

World market of clean production technologies is expected to grow:

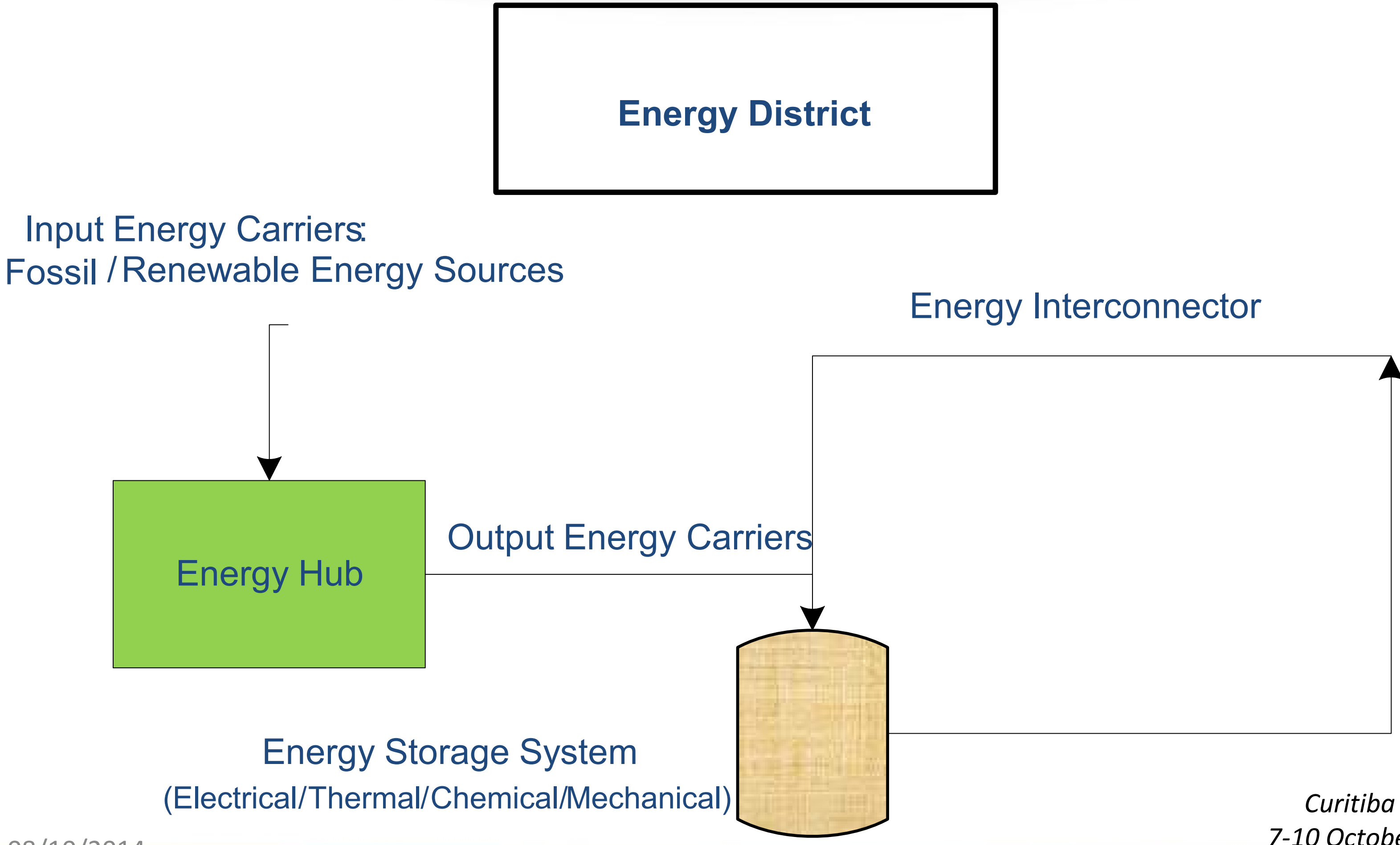
from 380 bn euro (2007 estimate) 765 bn euro (2020 estimate)
(EU Commission, 2012)

Future Energy Networks

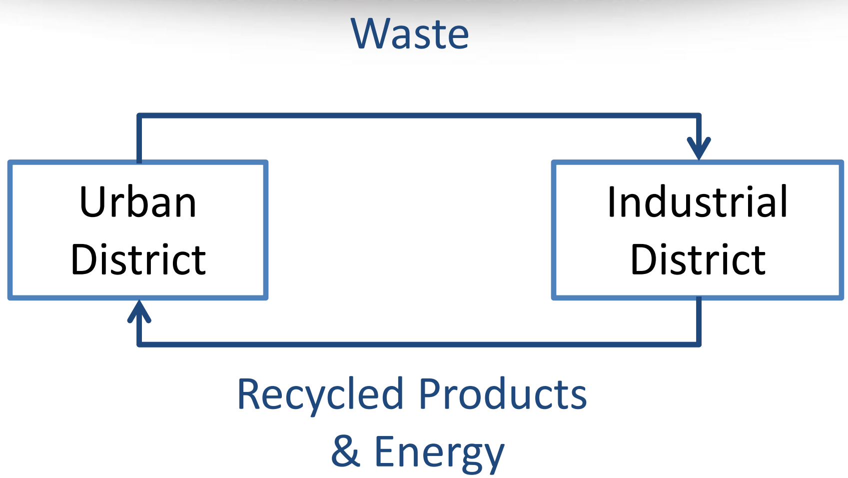
- Todays' energy infrastructures are approaching their expected life.
- Over 60 % of energy demand is concentrated in Cities (*).
- Around 75 % of EU population lives in urban areas responsible for 80 % of energy consumptions and global warming gas emissions (**).

(*) International Energy Agency, 2012
(**) Antonio Tajani, vice-President 2012 of the European Commission, Responsible for Industry and Entrepreneurship

Future Energy Networks



Urban and Industrial Symbiosis



Eco-town program in Japan:

- 26 eco-towns
- 61 new recycling projects
- 107 new recycling facilities
- 1.65 bn euros

Industry 4.0: Smart, Green, and Urban Production

Smart Production

High-precision, superior quality production of high-mix, low volume smart products

Green Production

Clean, resource-efficient, and sustainable

Urban Production

Smart Factories in the city close to the employees' homes

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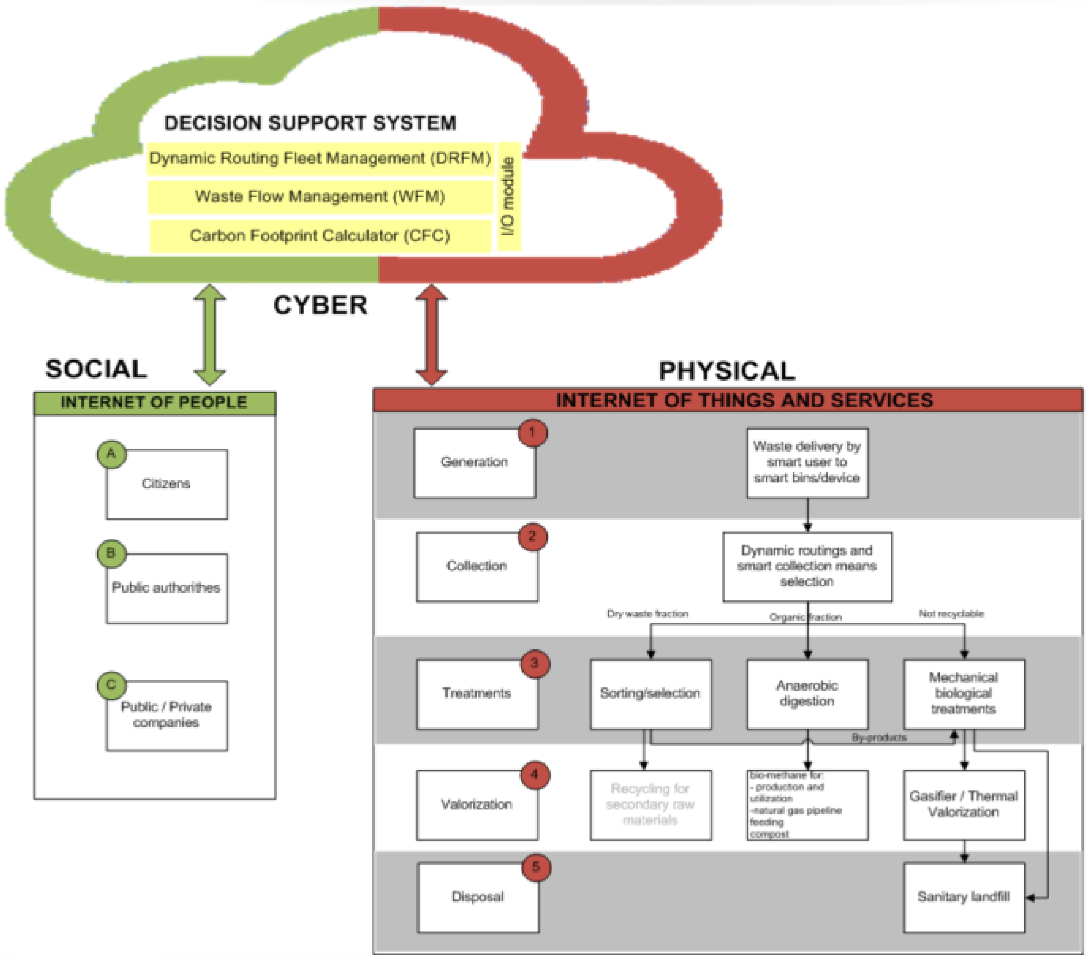
Research Award to:
Minimizing Carbon-footprint of Municipal Waste Separate Collection Systems

- *Giovanni Mummolo*
- *Giorgio Mossa*
- *Salvatore Digiesi*
- *Giancarlo Caponio*
- *Rossella Verriello*

Department of Mechanics, Mathematics and Management –
Politecnico di Bari

Social-Cyber-Physical System for Planning and Managing an Integrated Municipal Solid Waste in a Smart City

(Waste 4.0 Life Project under submission)



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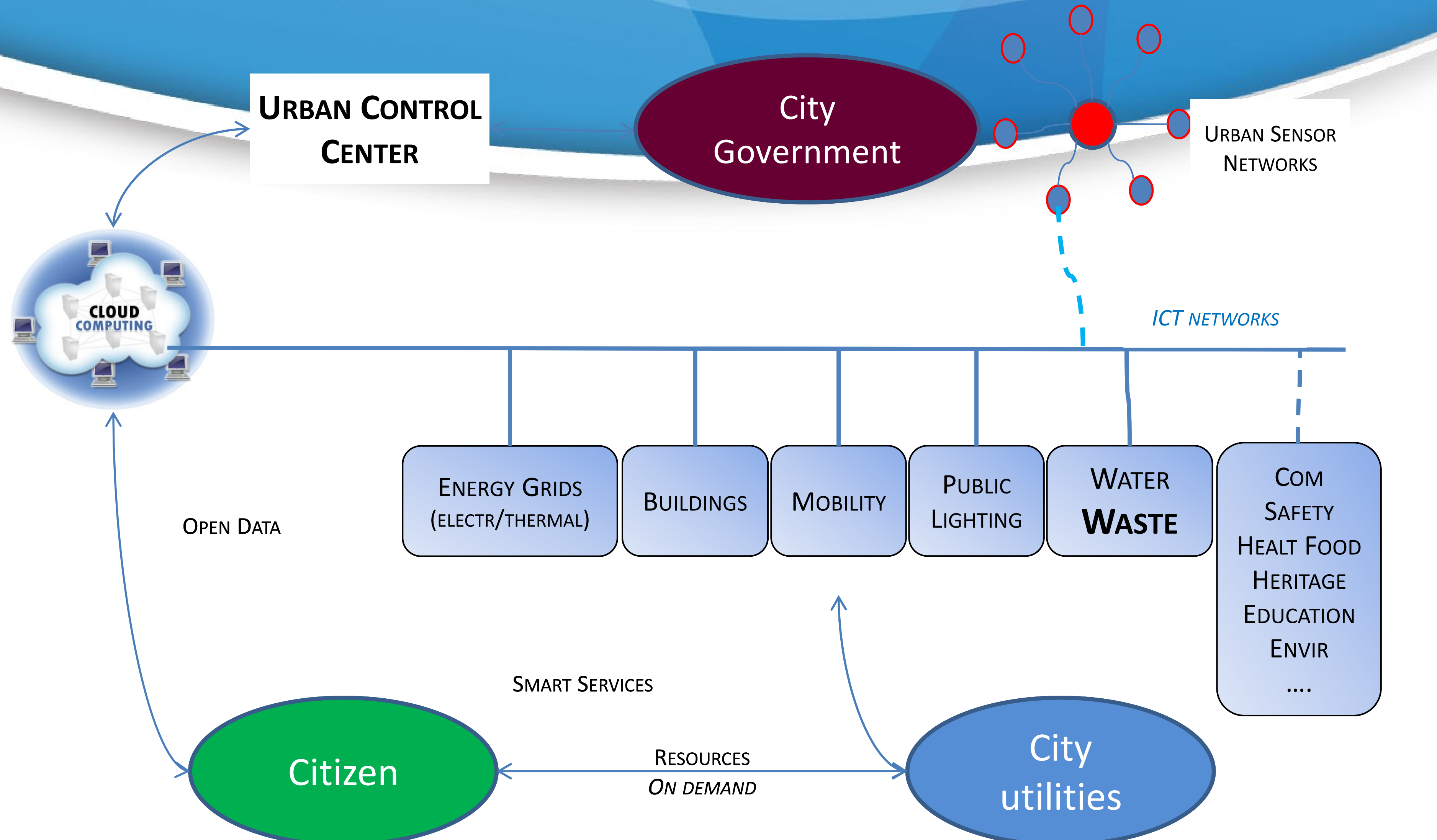
The smart city model



RES NOVAE Research Project (Italian Ministry of University and Research)

Global Security

- Intentional and Unintentional Events

- Industrial Sites
- Gas / Oil Pipelines
- …
- Urban Infrastructures: ports, airports, railway stations
- Cultural Heritage Assets: Museums, churches, archeological sites,…

- New Professionals: Data scientist; Cyber Safety Guards.
- High demand of Cyber-based Security Systems.

A Survey on Industry Needs vs. University Curricula

Industrial Engineering Competence

The Institute of Industrial Engineers (IIE) [http://www.iienet2.org/]:
"Industrial engineering is concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems."

IESE project (Industrial Engineering Standards in Europe) [http://www.iestandards.eu/]:
"The branch of engineering that engages in the study of how to describe, evaluate, design, modify, control and improve the performance of complex systems, viewed over time and within their relative context."

Industrial Engineering Educational Programme (IEEP)

ILO: International Labor Organization

Operations Research:

- Modeling Techniques
- Mathematical Programming
- Algorithms
- Statistics
- …

IE Fundamentals:

- Engineering Basics: (maths, physics, statistics & prob)
- IT Basics
- Work Measurement
- Processes
- Workplace Evaluation
- Logistics
- Organization Developments

Mftg System Eng.:

- Mass - Batch – Job production / FMSs / GT
- Lean Production
- Automation
- Maintenance
- …

Human Factors Eng.:

- Ergonomics
- Human Interface Eng.
- Behavioural Science

Mgmt System Eng.:

- Quality Management
- Project Management
- Mgmt Information Systems
- Contract Management
- Health & Safety Management
- Business Ethics
- Cross Cultural Management

Industrial Engineering Standard in Europe (IESE) Project

ILO: International Labor Organization

Operations Research:
- Modeling Techniques
- Mathematical Programming
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- Statistics
- …

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- Maintenance
- …

Innovation & Tech :
- Innov. Process & Life Cycle
- Speed of Tech. Develop.
- Mftg. Technologies
- Information Technology
- Nano / Bio Technology

Human Factors Eng.:
- Ergonomics
- Human Interface Eng.
- Behavioural Science

Environment & Sustainability:
- Policies & Standards
- Energy Mgmt and Auditing
- Sustainable Tech. (solar, …)
- Building Mgmt Systems
- Lighting / HVAC
- …

Major Educational Gap (Survey on Industry)

Industry 4.0 vs. CIM 2.0: new IT competence required

CIM

Main idea:
- Holistic consideration of a company's value creation processes and support by integrated IT-systems;
- Continuous computer-aided information processing, based on an inter-departimental data base (CAD/CAM; flexible manufacturing systems).

Goal: unmanned factory
Human Role: planning and monitoring

"The perspective of a completely automated and unmanned factory cannon represent a realistic perspective because of technological and economical reasons." *Prof. Dr. Hirsch-Kreinsen*

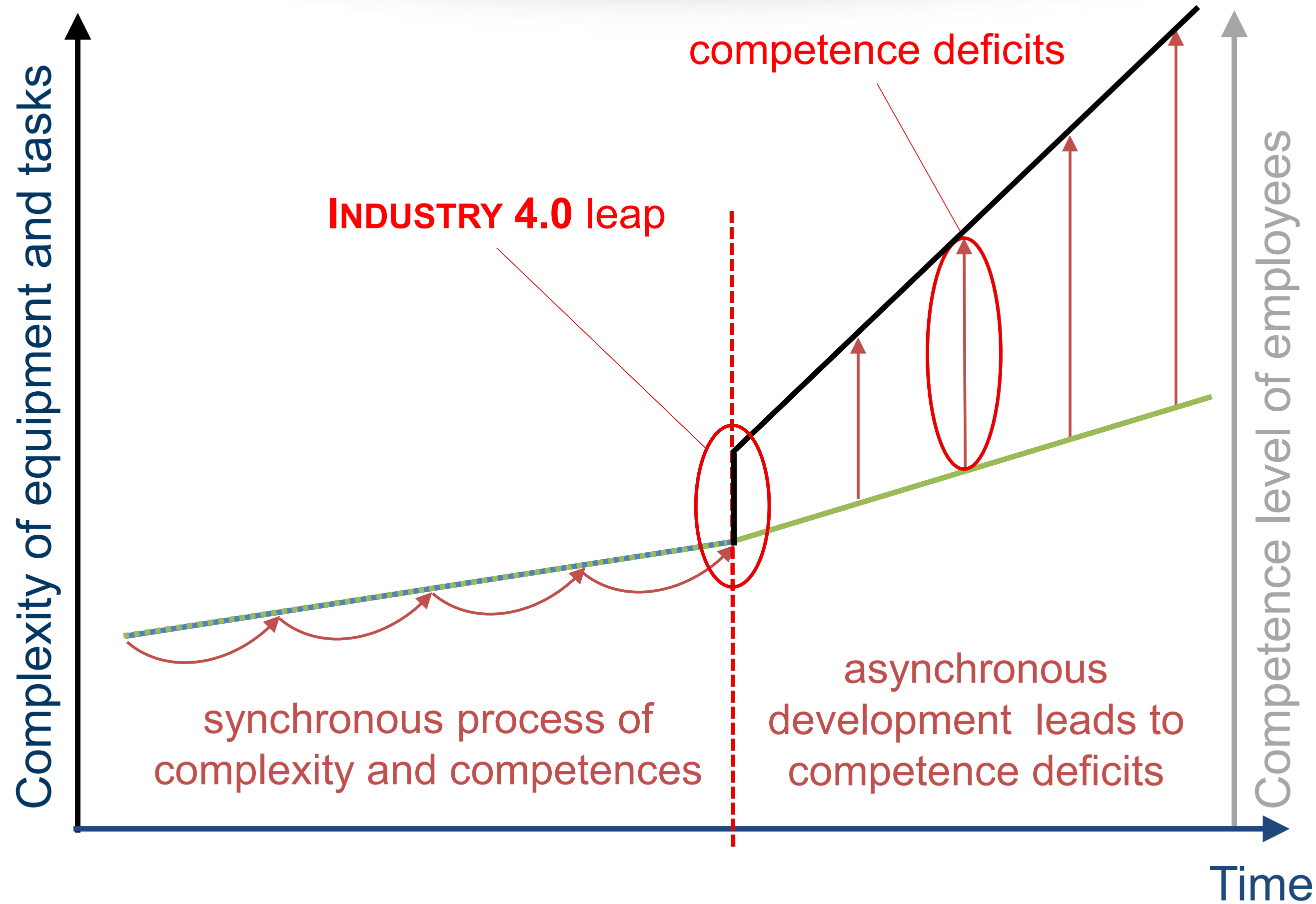
Industry 4.0

New enablers and New Competence required:
Internet technology, data collection storage and processing

Technical innovations shall not be considered isolated. A more integrated view of technical, organizational and personal aspects has to be considered as a socio

The human role within the production is still very important!

Competence deficit



Reduction of PhD Workforce:

The Negative Loop Phenomenon in Knowledge Generation / Exploitation

Issue:
Skill Gap of Science, Technology, Engineering, and Maths (STEM) Workers

- 67 % of US Manufacturers suffers from moderate- … Skilled …

Recession and R&D Funding Cut → PhDs tend to leave University and search for industry positions → PhDs over-qualification and de-motivation → Expected Reduction in Talented Research People → Quality Reduction of R&D and HE Ss.

- Reduction of …
- Skill Obsolescence due to Workforce Aging and Changing Nature of Work
- Educational Gap: Mismatch between Institutional Education and Industry Needs

… Economist Intelligent Unit, 2012)

A New Model of Doctoral Education in Industrial Engineering

Solutions for EU from the Salzburg Principles I, II (2005 – 2010), (EUA, Council for Doctoral Education)

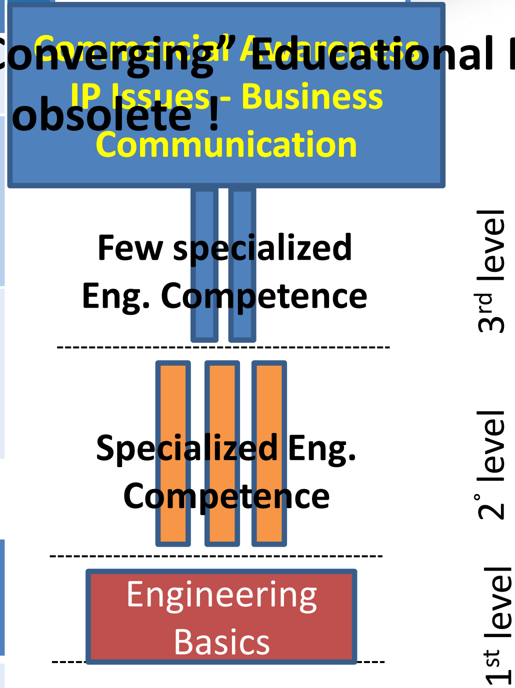
Main outcome of doctoral education (Guidelines):

The ‘T-shaped’ 3rd Level educational model
‘Early stage Researcher’ with Knowledge Exploitation Capability.
Less interest in PhD thesis results (expertise in very few domains).

Knowledge Exploitation & Transfer require:
Acquire/Synthesize Knowledge. Awareness of Commercial Value of K. IP - Business topics / Communication Capabilities.

The current “Converging” Educational Model is evaluated as obsolete !

The ‘T’-shaped phD Ed. Model



Forward an Holistic view of the R&D and Education: The ‘University / Industry’ System

The Role of the **European Academy on Industrial Management** in conceiving a new BoK of IE (Master on ‘Advanced IE & M’, Summer School on IE & M, …)

The **‘European School of Industrial Engineering’** as an European Multi-University Collaborative Network.

	(%) Researchers in Business Sectors	# Researchers/1000 x labor force
EU 27	**46**	**6**
Japan	**68**	**9**
US	**79**	**11**

- More Industry PhDs in EU
- Stimulate demand for high-skilled jobs (KETs)

AIM: European Academy for Industrial Management

- **Origin and Evolution**

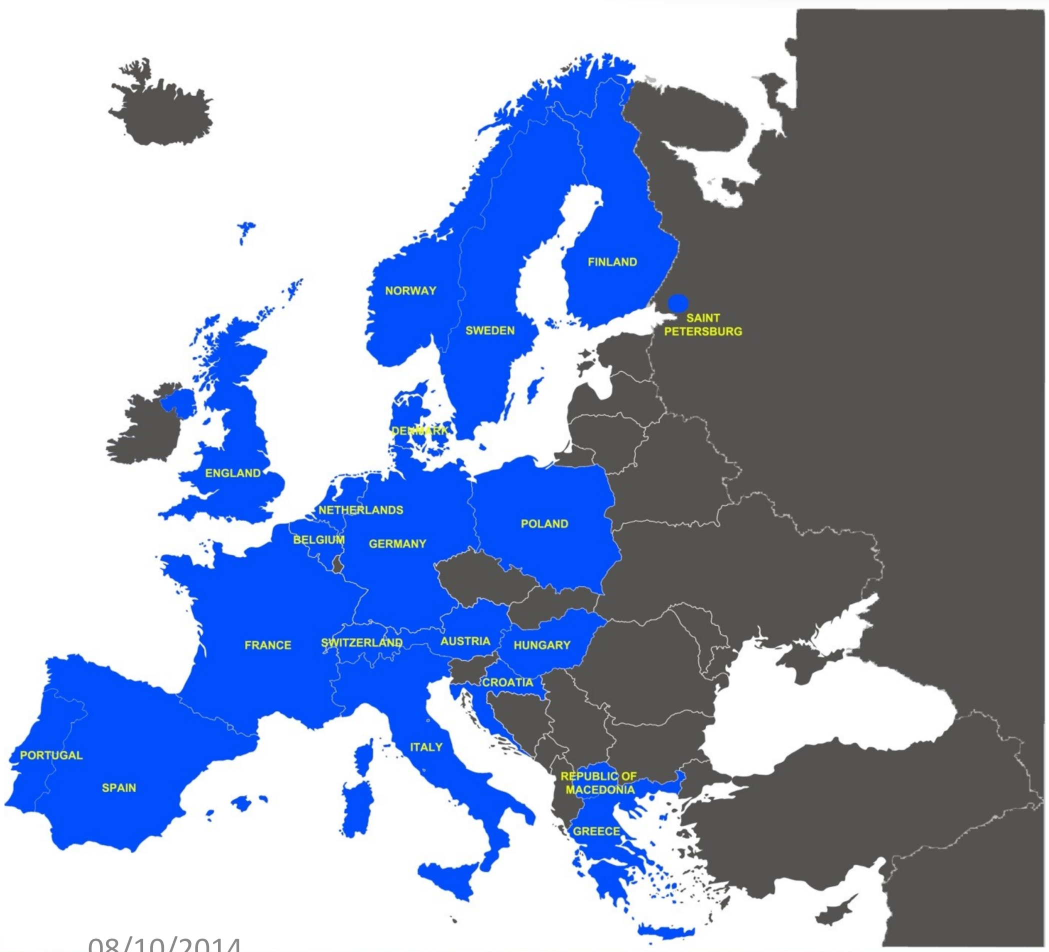
- 1982: Technical Faculties of German Universities agreed on the need of updating IE competence.

- 1984: First nucleus of AIM consisted of 14 EU Universities: European Academy for Technical Plant Management (EHTB).

- Nowadays: Representatives of 34 Universities of 22 European Countries of EHEA.

http://www.europe-aim.eu/

AIM: European Academy for Industrial Management



http://www.europe-aim.eu/

Map of European Countries (blue colored) represented in the European Academy for Industrial Management

Curitiba (Brazil)
7-10 October 2014

Vision of AIM

- AIM pursues to be the leading **European Academy developing and promoting education and research in the field of Industrial Engineering and Management (IE&M).**
- As such, it endeavors to gather full professors in this field from all corners of the European Higher Education Area (EHEA).
- IE&M education is promoted by classical and modern approaches including problem solving, case study as well as co-creative education. Active learning, instead of teaching, is the preferred point of view of AIM.

http://www.europe-aim.eu/

IE&M Educational Activities by AIM

Recent Activities of the European Academy for Industrial Management (AIM)

- *Special Issue on: 'Sustainable Manufacturing' published in 4th number in 2013 of "Management and Production Engineering Review"*

- *36th AIM Annual Conference on "Advances in Cyber-Physical Systems", S. Petersburg, 18-21 September 2014*

- *Special Issue (2015) on:* 'Industrial Cyber-Mechanical Systems' *to be published in "Management and Production Engineering Review", Quaterly of Polish Academy of Sciences, http://www.review.univtech.eu/, call for contributions*

- *37th AIM Annual Conference on "Human Centered Production in Cyber-Physical Production Systems for Industry 4.0"Vienna, 17-20 September 2015*

http://www.europe-aim.eu/

IE&M Educational Activities by AIM

Recent Activities of the European Academy for Industrial Management (AIM)

- AIM Master on 'Advanced Industrial Engineering and Management':
To be jointly designed and offered by EU Universities and Companies
(“Erasmus +” Program, deadline April 2015)

- European School of Industrial Engineering: A New Model for the European University (MoU between EU Universities and Companies)

- MoU between AIM and ABEPRO (Malaga, 23 July 2014)

- MoU between AIM and The Institute of Industrial Engineers (IIE), preliminary phase.

http://www.europe-aim.eu/

Memorandum of Understanding

Malaga, July 23, 2014
Signing the AIM – ABEPRO Memorandum of Understanding

President Milton Vieria Junior for ABEPRO

and

President Giovanni Mummolo for AIM

Article 1. Purpose of the Memorandum of Understanding
AIM and ABEPRO cooperate in scientific and educational activities for knowledge development in the fields of Industrial Engineering, including Industrial Management and Production Engineering, by international mobility projects for students and professors, research projects, and any other similar initiatives jointly or independently proposed and developed by both AIM and ABEPRO on the basis of specific agreements.

Forward the European School of Industrial Engineering

Vision

- A Multi-University System promoted by European Academic Institutions of the EHEA and Industry to bridge the gap between IE academic competence and industry needs with the common aim of preparing skilled and creative workforce providing effective answers to major grand challenges of the EU.

Mission

- MS and PhD courses with specialty on different IE subjects
- Academic and Executive IE Curricula conceived by U & I
- Scientific Symposia and Executive Workshops

by

- Coupling Theoretical and Experiential Learning Approaches
- Sharing Educational Materials and Best Practice
- Privileging the Learning instead of the Teaching point of view

Forward the European School of Industrial Engineering and Management: The Basic Reference Model

AIM

European Academy for Industrial Management
Schools of Engineering of 34 European Universities of 22 European Countries

European Industrial stakeholders
- Companies
- Industry Associations
- Unions
- Technical Associations
- Other Stakeholders

european school of Industrial Engineering and Management
ESIEM

Certified Curricula and Modules to integrate (not substitute) 2nd and 3rd level **University curricula on** Industrial Engineering & Mgmt.

Body of Knowledge on **Industrial Engineering and Management**

An European Reference for Schools of Engineering and Industry.

Certified Executive Curricula or Modules on Industrial Engineering & Mgmt.

EU University System
Recognition of curricula and/or modules offered by ESIEM as part of 2nd and 3rd Level University degrees delivered by EU Universities.

EU Industry System
Knowledge, Skill, and Competence updates in the view of workforce aging and skill gap. Life Long Learning.

enegep

Conclusions

1. **World Wide Competition should be more and more based on "Talents Driven Innovation"**

2. **Industrial and Societal Challenges in the EU will contribute on Economic Growth and Jobs' Creation**

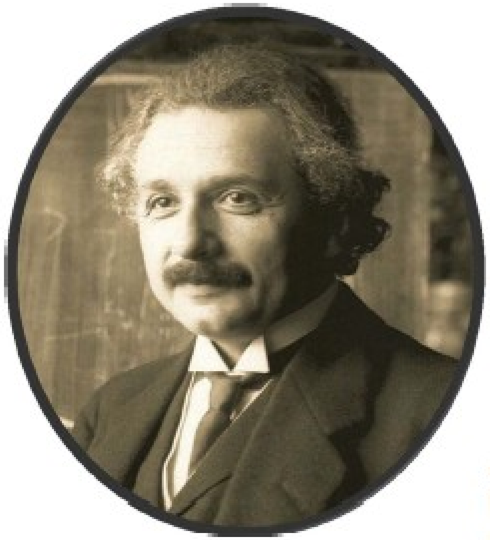
3. **IE Competence require to be updated with major focus on:**
   - I. Innovation Exploitation and Technology Management
   - II. Societal Challenges of interest for IE (e.g. Workforce Aging and Sustainable Urban Development)
   - III. IT for Implementing Social – Cyber Physical Systems in Smart Factories as well as in Smart Cities

4. **Education and Networking**
   - I. Dual University – Industry IE Education
   - II. Teaching Factory and Experiential Learning
   - III. European Multi-University Collaborative Network

5. **The Role of the European Academy for Industrial Management**
   - I. Educational projects as well as scientific activities are promoted.
   - II. Main focus on education of Industrial Engineers for Industry challenges; the Academy is being paid a growing attention also to societal challenges.
   - III. Multi-University Academy projected in the EHEA.

Building the future by innovation !

„Insanity is
to do the same things over and over
and expect different results ."



Albert Einstein,
Physiker
(1879 - 1955)