



**KYUSHU**  
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Technology



# Evolution and Revolution – I4.0 part II

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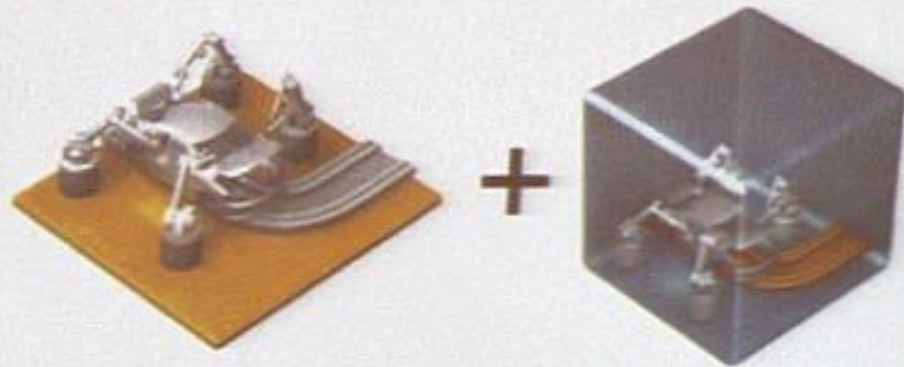
Mendelova  
univerzita  
v Brně



Agronomická  
fakulta

# Cyber-Physical Systems have all the information as a digital model

## Cyber-Physical System (CPS)



Physical production facility

Digital model

## Contains all the information on ...

- Software / Informatics
- Mechanics
- Electrics, Electronics
- Automation, HMI
- Safety, security
- Maintenance
- Location, identity...
- Status
- SW version
- Interfaces
- ...

The digital model is always up-to-date and is extended over the entire lifecycle



Product  
design

Production  
planning

Production  
engineering

Production  
execution

Services



# Many CPS - Multiagent Systems

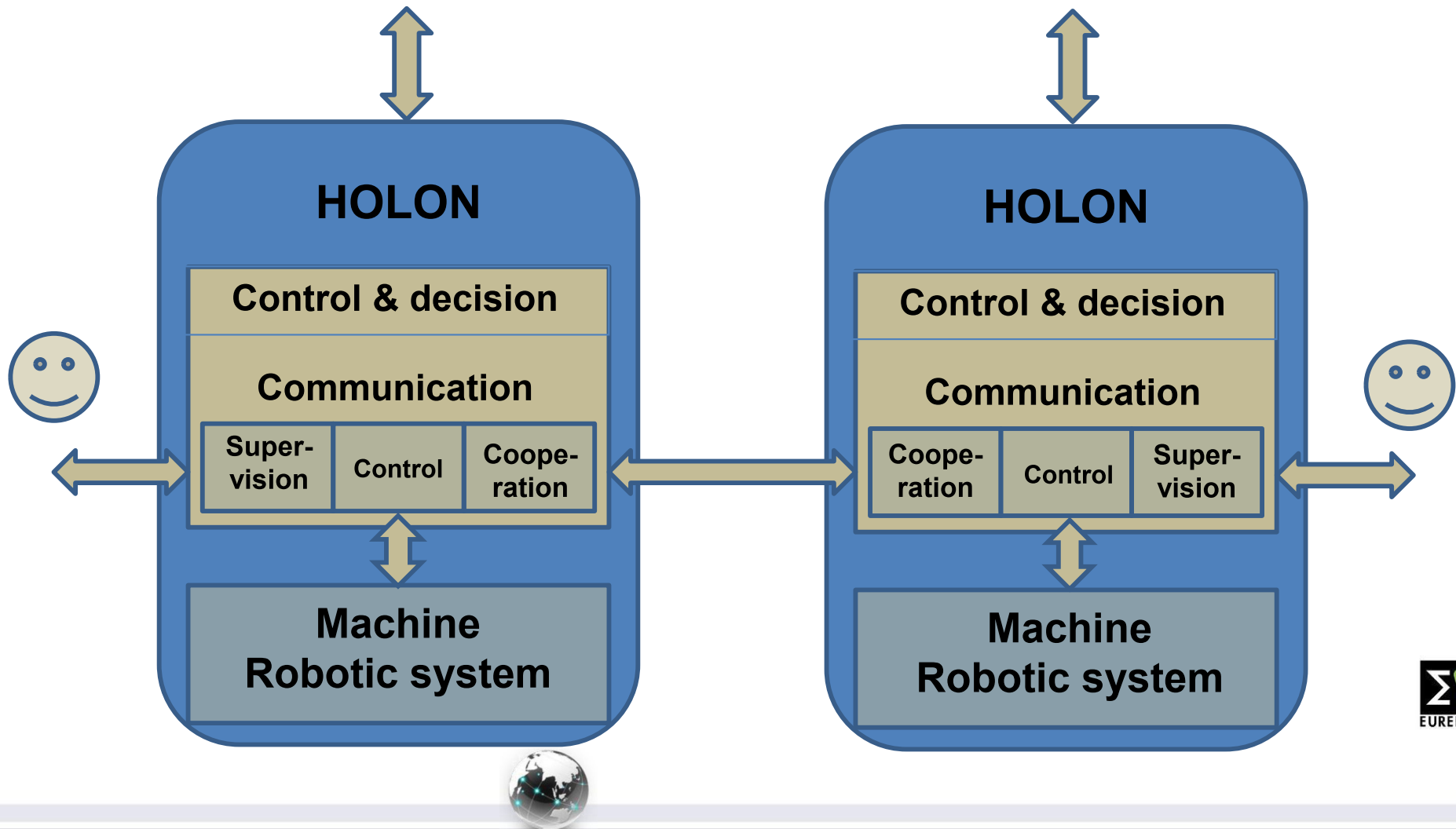
1. Industry production system control structure - holarchy
2. basic level - machinery represented by autonomous units – holons X CPS
3. second level – CPS x holonic swarms represented by multiribotic systems
4. number of autonomous and flexible multirobotic units





# Basic unit - HOLON

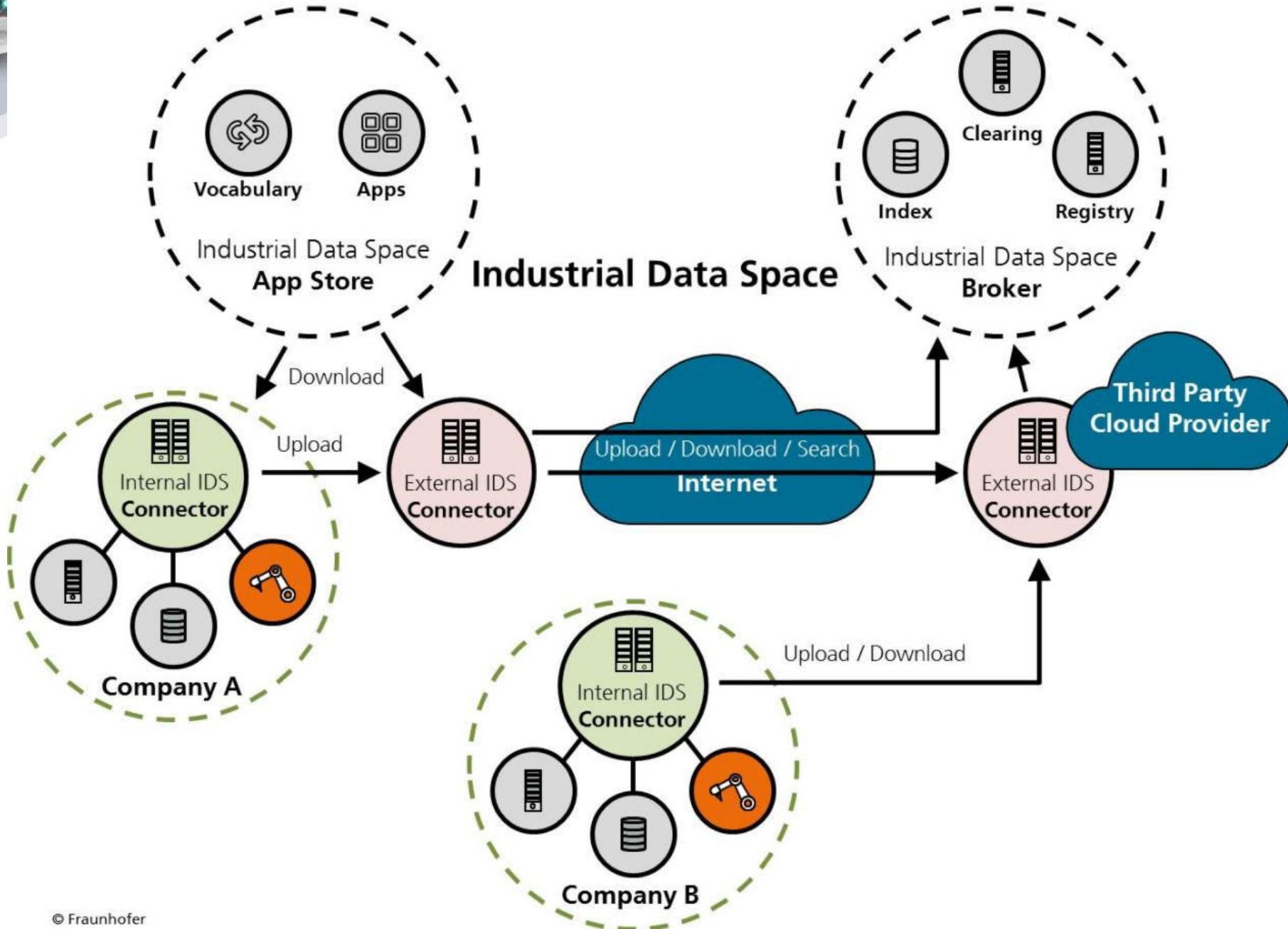
Upper level of Control – complex goals







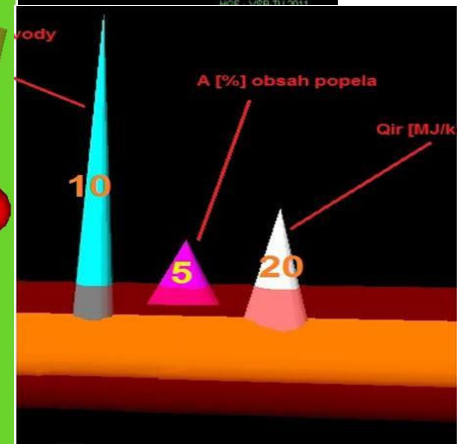
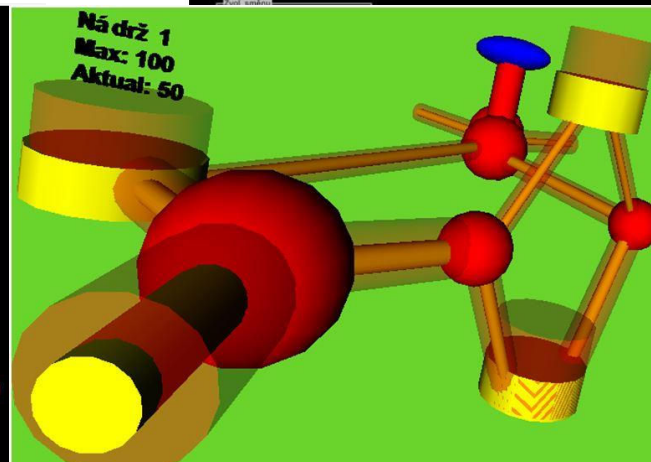
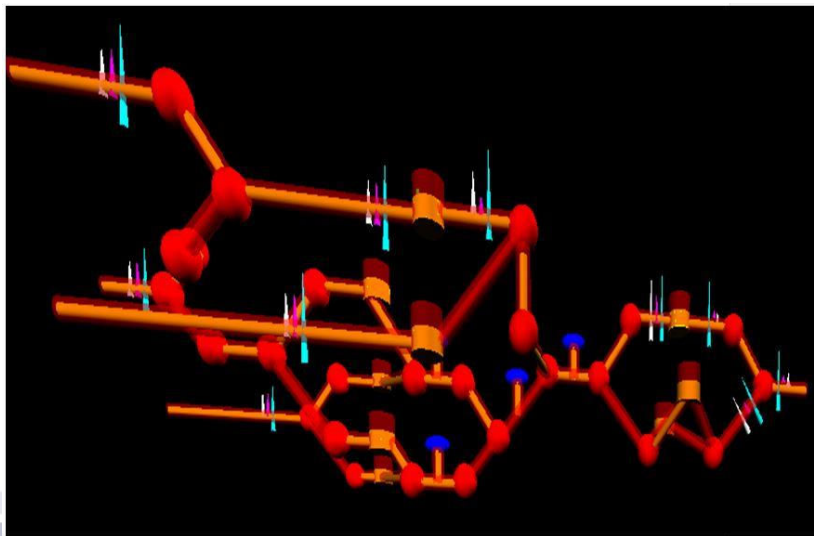
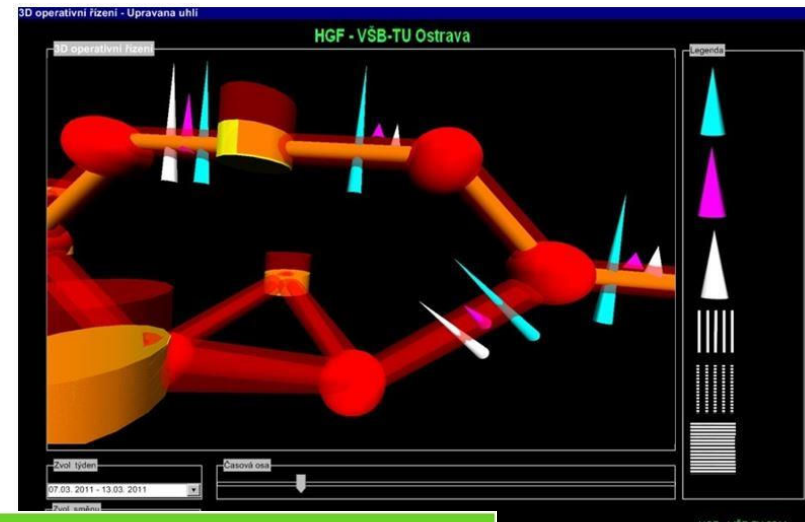
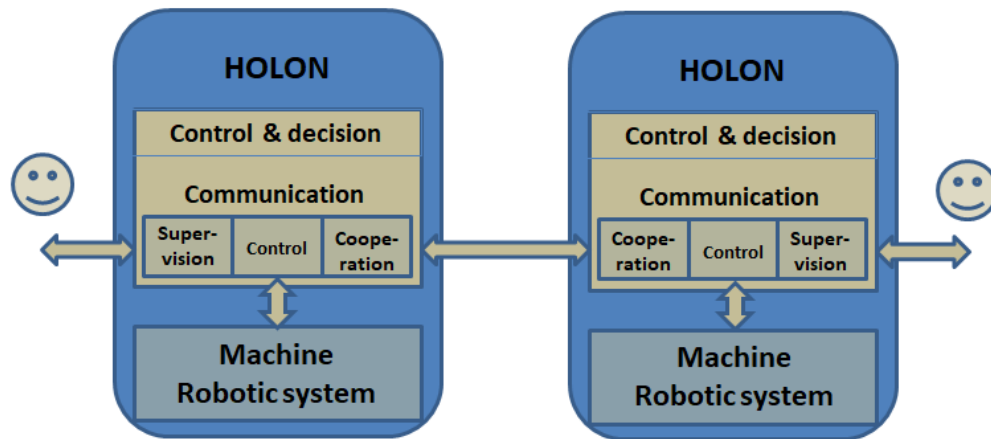
# Industrial Data Space





# Holon and Virtual representation

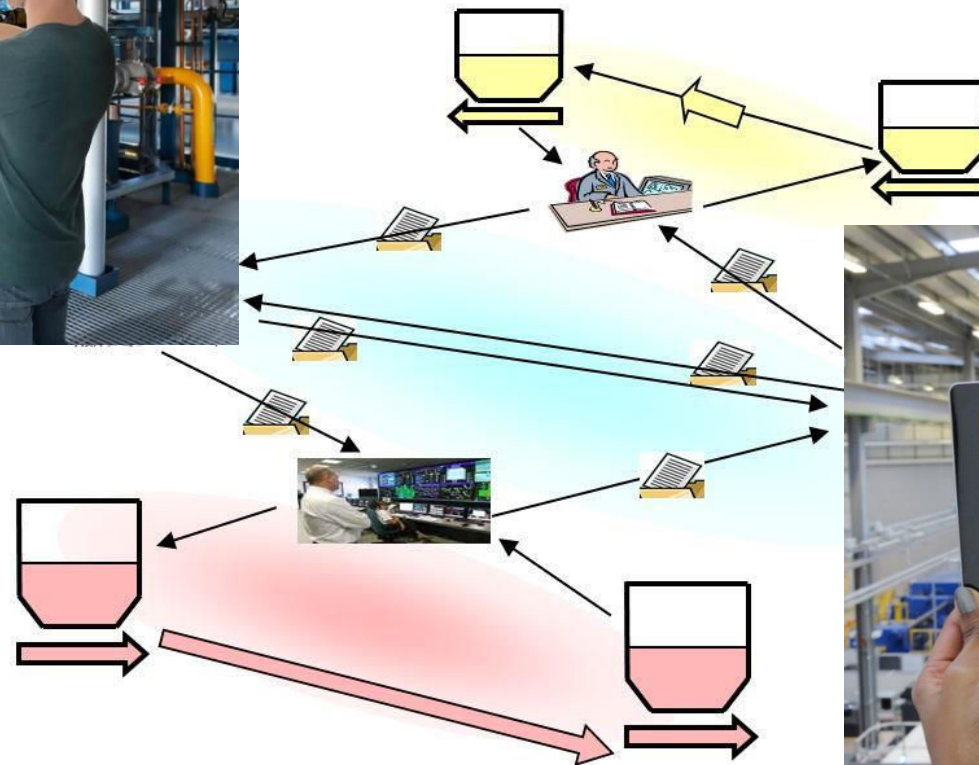
- CPS – cybernetics physical systems, digital twins
- Communication of holons, agents straight connected to machinery – goal orientation





# Virtual and Augmented reality

- CPS – visual models of digital twins
- Communication of agents - straight connected multilevel agents systems – visualization







# MAS Advantages

1. Parallelism – some production/transportation activities can be realized in parallel that reduces the time of operation execution.
2. Robustness – in the case of failure of one production unit next one unit with the same functionality can take over original function.
3. Scalability – in the case of changed production parameters, it can be changed the number of units used for the task execution.
4. Reconfigurations – there can be changed the role of separate units in production system according the changes of production goals







# CPS in Industry - Summary

- CPS is the basic part of I4.0 systems
- Autonomous activity
- Communication ability
- Negotiation to production goals
- Digital twins
- Cooperative behavior
- Real time problem solving
- Value chain creation





# Summary I - Sources of information

## Integration in Digital Supply Chain

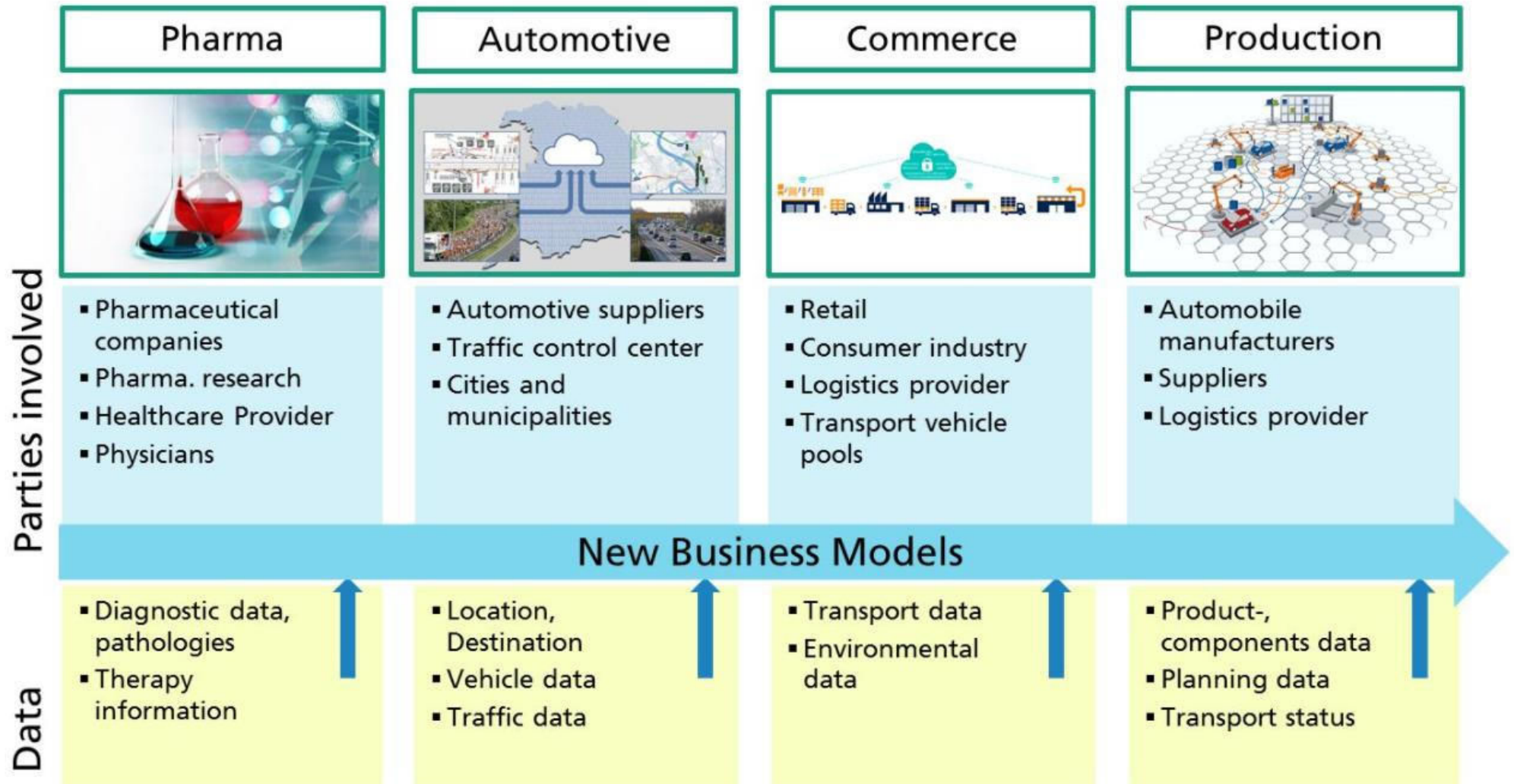
- Smart sensors – autonomous wireless communication,
- Smart industrial robots – holonic agents x CPS,
- Artificial intelligence includes Holo MAS -
  - Holonic Multi Agent Systems
- Smart Machines share distributed Control model – distribution of control x edge computing,
- CPS – share the model of surrounding world
- Digital twins - materials, products and smart machines communicate to each other in RT
- Standards, **standards, standards, ...**





# Economy 4.0

## New Business Models Based on Different Data Sources





# Integration of real and virtual world

- New principles of **Control model** – distribution of control, **systems in systems**
- Digital factories are **on-line connected to global business chains**
- Industry 4.0 – **total digital interconnection** of all levels of production at added value creation – from product design to product logistic
- New technology for – **3D printing**, M2M (machine-to-machine), M2P (machine-to-person),
- Digital Factory, Digital Supply Chain, Cloud computing, **everything is DIGITAL**
- Internet of Things, Big Data, Smart industrial robots,
- **Artificial intelligence** includes P2P, etc.







# Human Integration

## Developing Industrie 4.0 competencies

### Challenges:

Utilization of Industrie 4.0 applications for competence development and real-life learning environments

### Requirements

- **Process understanding**, integration and **real-time synchronization** of **processes** throughout the product lifecycle
- **Transversal skills development** and training (IT, electronics, mechanics etc.)
- **Generic competences** about organization, communication and cooperation
- **High flexibility** and **decision-making** capability

**Solutions for competence development: Fraunhofer »FUTURE WORK LAB«**

### Project work, simulations



### Learning factories 4.0



### Participation ramp-up





# Asistive technology

## Intelligent IT-Assistance for everyday life

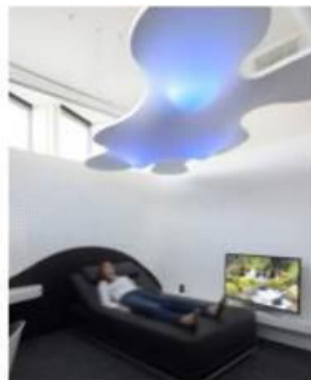
### ■ Iris-Scan

- replaces access card (ATM, hotel, apartment)
- ergonomic adjustment (hotel, workplace, ...)

### ■ Interactive, collaborative Virtual Reality Conference

### ■ Smart Energy Control

### ■ Synchronization of private media library with external media systems





# Industry 4.0 – New Societal Challenges - reflection in – Society 4.0

- **IoT** – new way of life– interconnection of smart sensors networks and ICT, ability to share models, resources and data at human movement in the space – Augmented reality.
- **I4.0** Hybrid technology: **Human – Machine** → Introduction of intelligent interconnected systems, cross connection through production chains **IIoT (IoP) – security - standards.**
- **IoT** – platform for intelligent technology for **Society 4.0** – **but there is a lot of questions:**
  - User - privacy protection,
  - Standards and technology limits,
  - Redundancy/reliability of information ...





# Interconnection of Physical and Virtual world

- Horizontal integration in entire life cycle
- Vertical integration of control hierarchy
- Engineering processes integration (idea – product)
- Communication standards and semantic problem
- Integration protocols – reference architectures
- Platforms for Service Oriented Architecture
- Tools for subsystems login, authorization, ...
- Interoperability in production systems







## Conclusion

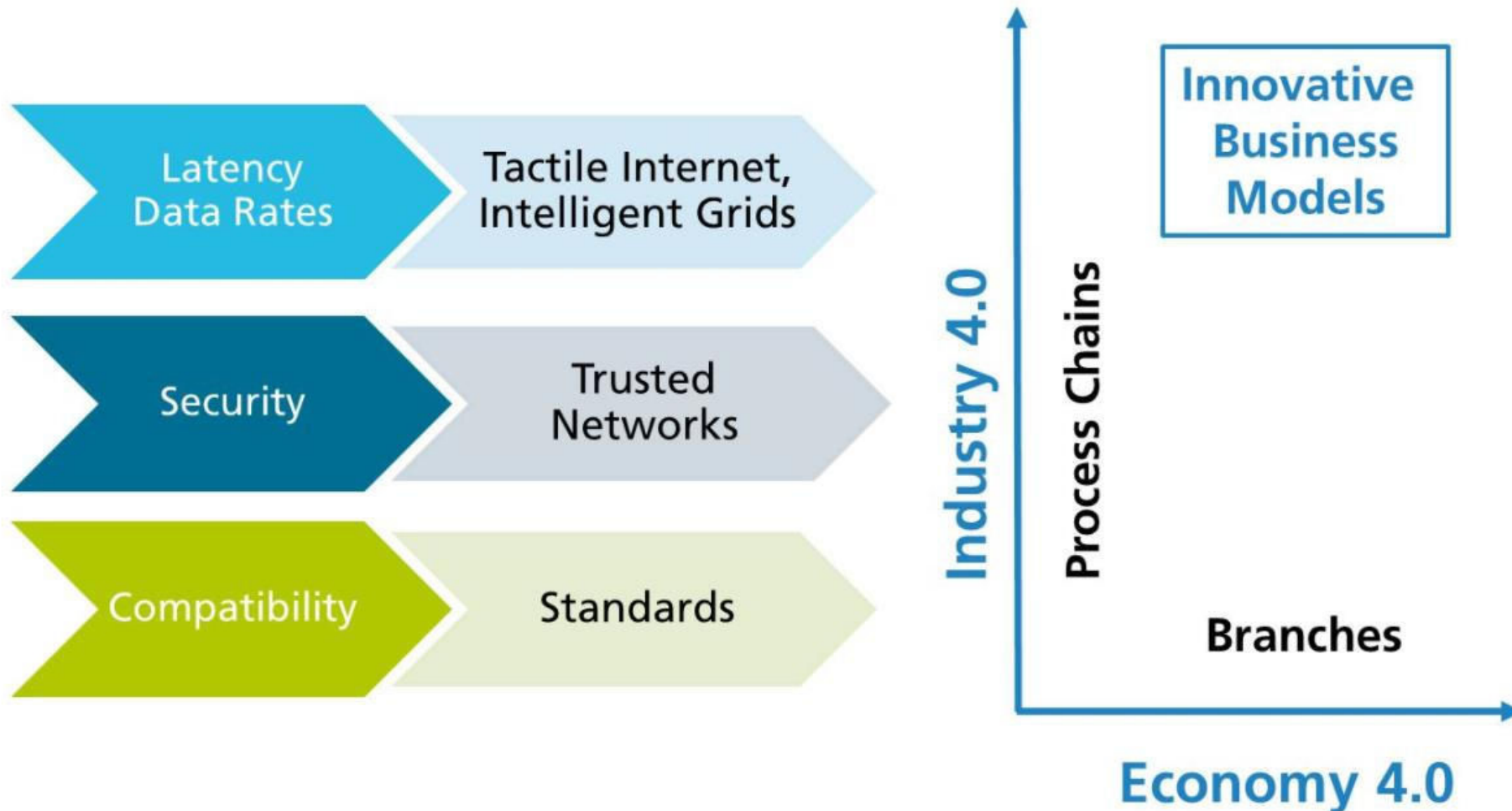
1. CPS as key elements IIoT – I4.0
2. Connection of real and virtual world
3. RT communication and integration
4. Understanding of knowledge – semantics
5. Sharing of the models - skills, ontology
6. Security of the information, knowledge ...
7. Real agents in virtual world - created by artificial agents in real world





# Society 4.0 Outlook

## Challenges and Chances for Implementation of Economy and Industry 4.0





# New Societal Challenges– Industry 5.0? - Japan S&T plan – Society 5.0

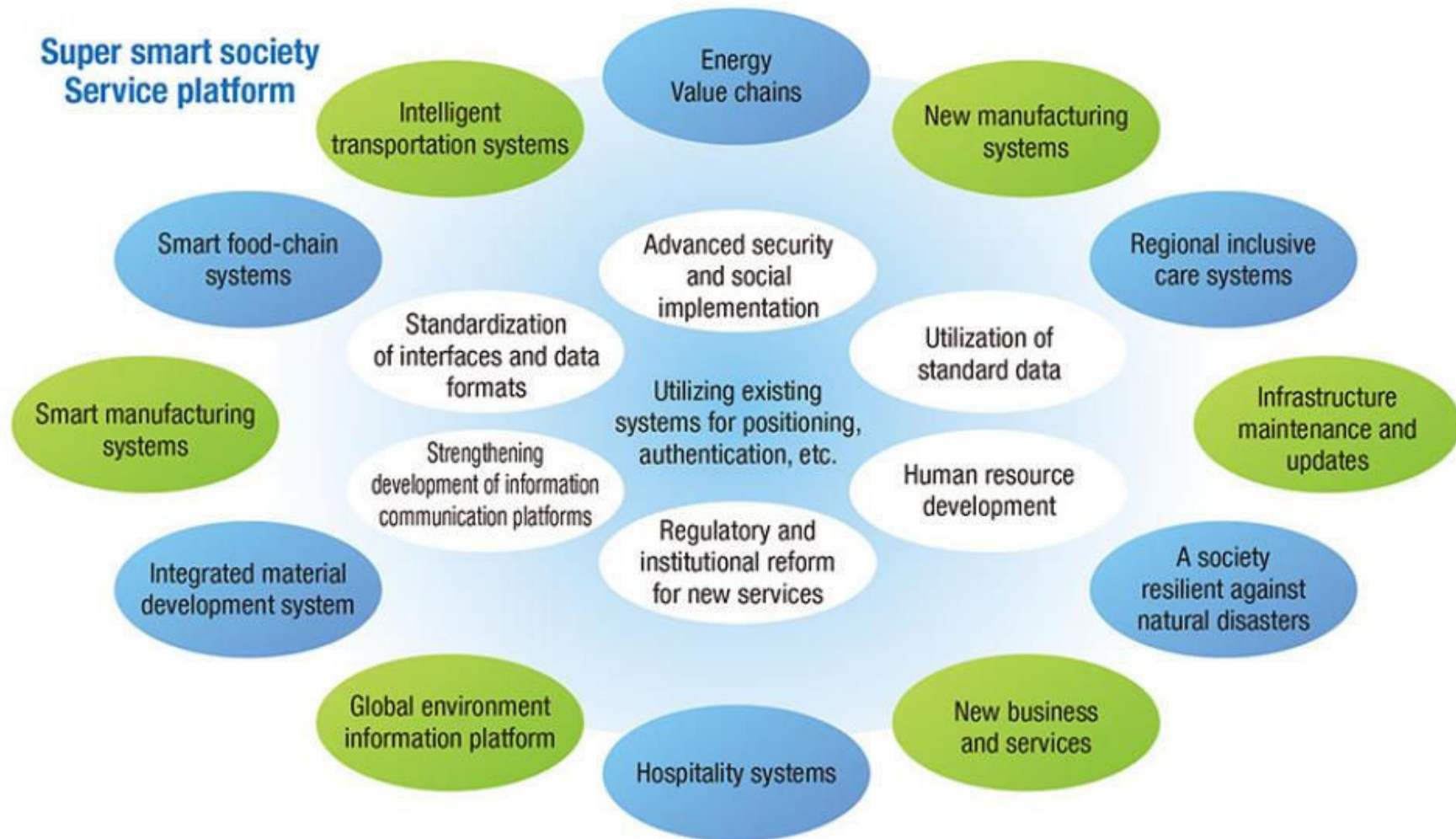
- **Society 5.0** – new way of life – strong role of R&D and human resources – strong societal transformation
- Innovation connected to accumulation, processing and distribution of data from internet, edge computing
- Focusing to R&D, new challenges in economy and business services
- Responsible to the actual societal challenges and needs Top quality services to all citizens without selection
  - Age – population aging
  - Gender
  - Society position
  - Region and language





# Japan S&T plan – Society 5.0 Super Smart Society

Strongly promoted by Council for Science, Technology and Innovation; Cabinet Office, Government of Japan





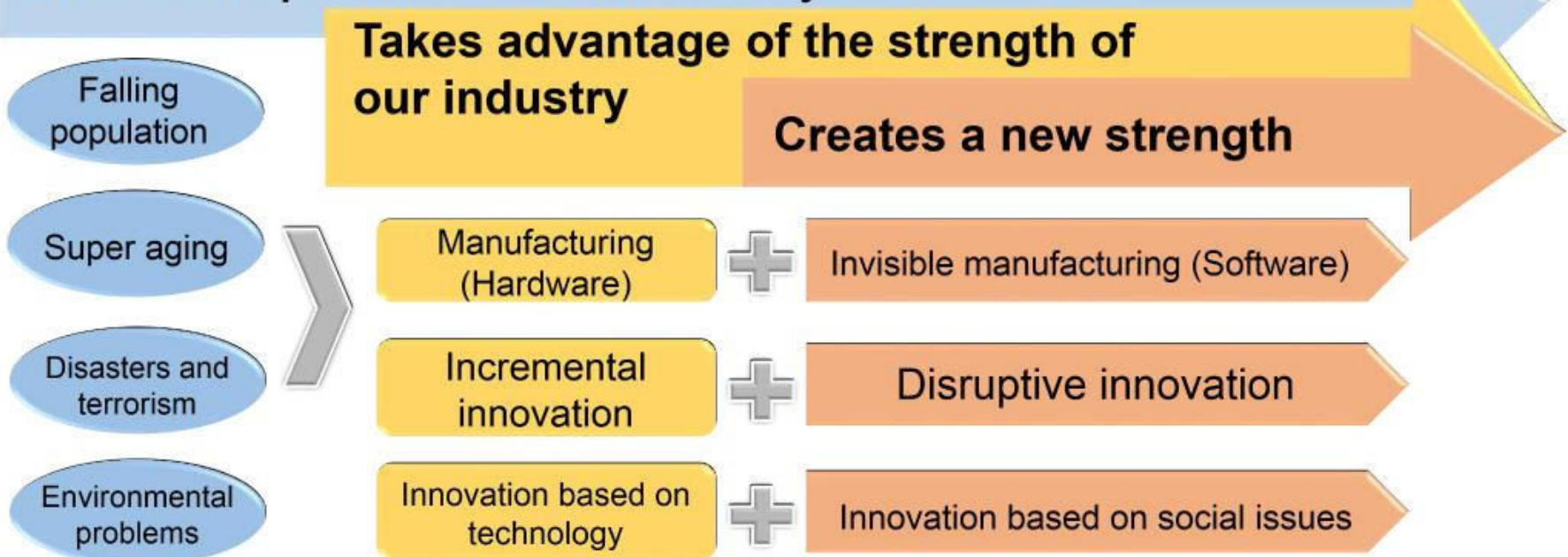


# Japan S&T plan – Society 5.0 Super Smart Society

**Keidanren**  
Policy & Action

- To provide new values and services through reforms with needs arising from national challenges as a momentum.
- To utilize strength of physical space in the competition of CPS,
- To capitalize on 1) creative capability of “disruptive innovation” and “innovation based on social issues”, and 2) “invisible manufacturing” (software).

**Starts from problems of our country**

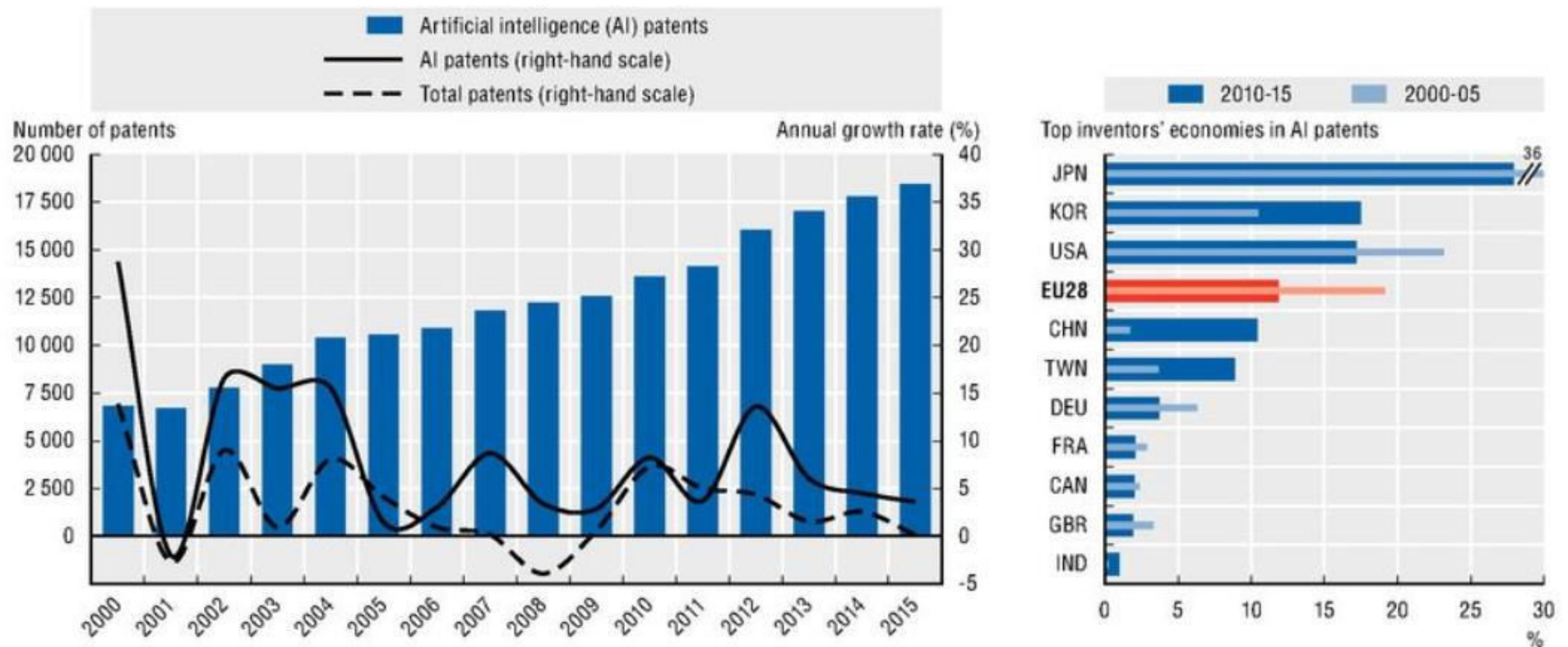




# Artificial Intelligence – OECD Science, Technology and Industry Scoreboard 2017

## 7. Patents in artificial intelligence technologies, 2000-15

Number of IP5 patent families, annual growth rates and top inventors' economies



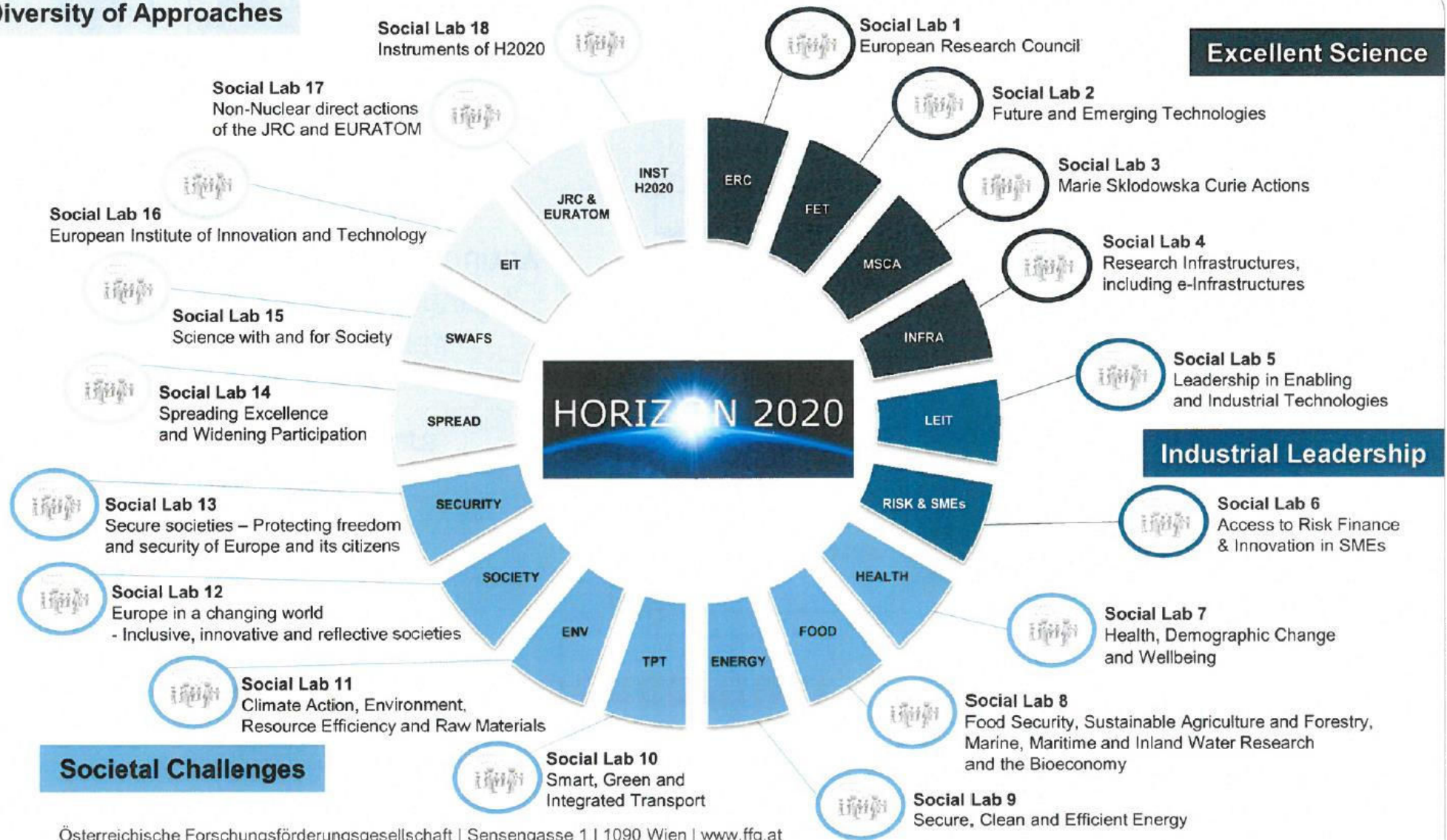
Source: OECD, STI Micro-data Lab: Intellectual Property Database, <http://oe.cd/ipstats> June 2017. StatLink contains more data. See chapter notes.

StatLink <http://dx.doi.org/10.1787/888933616978>





## Diversity of Approaches





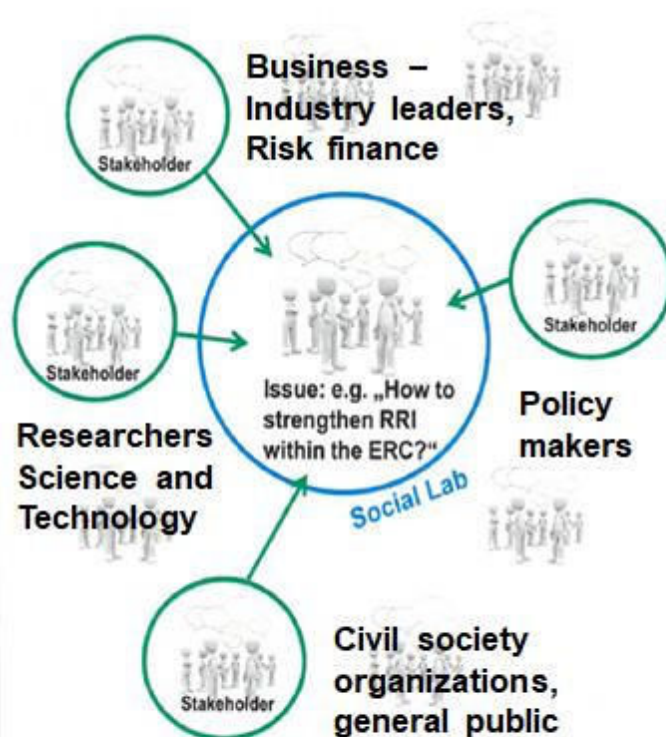
# Social Laboratory

## What's a Social Lab?

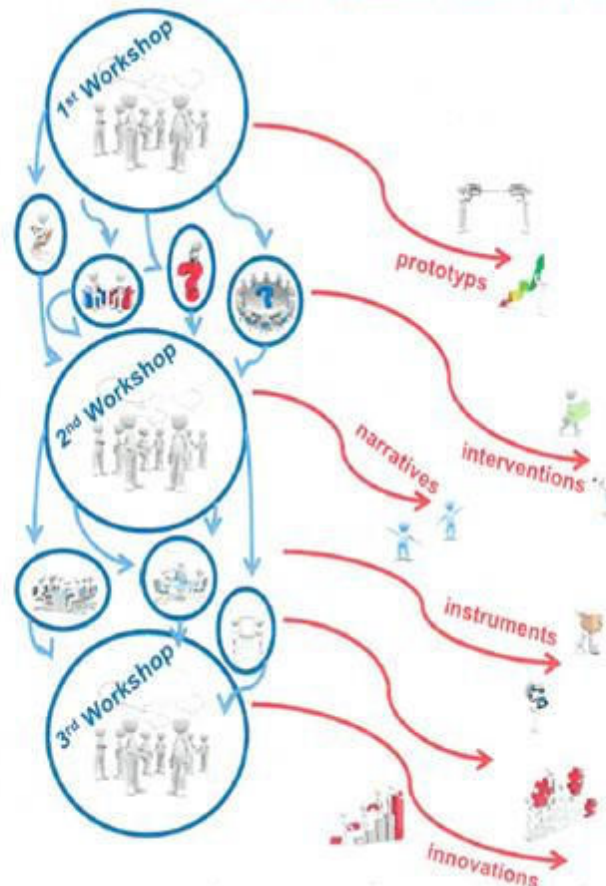
How to start it and how it works!

**N** ■ NEW  
■ HORIZON

### How to start a Social Lab?



### How does a Social Lab work?



The Social Labs will involve a wide-ranging group of R&I stakeholders who will co-create tailor-made pilot actions to stimulate an increased use and acceptance of Responsible Research and Innovation (RRI) across H2020 and each of its parts.

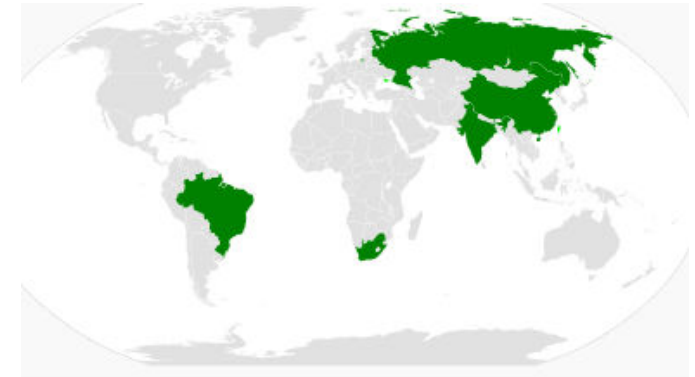
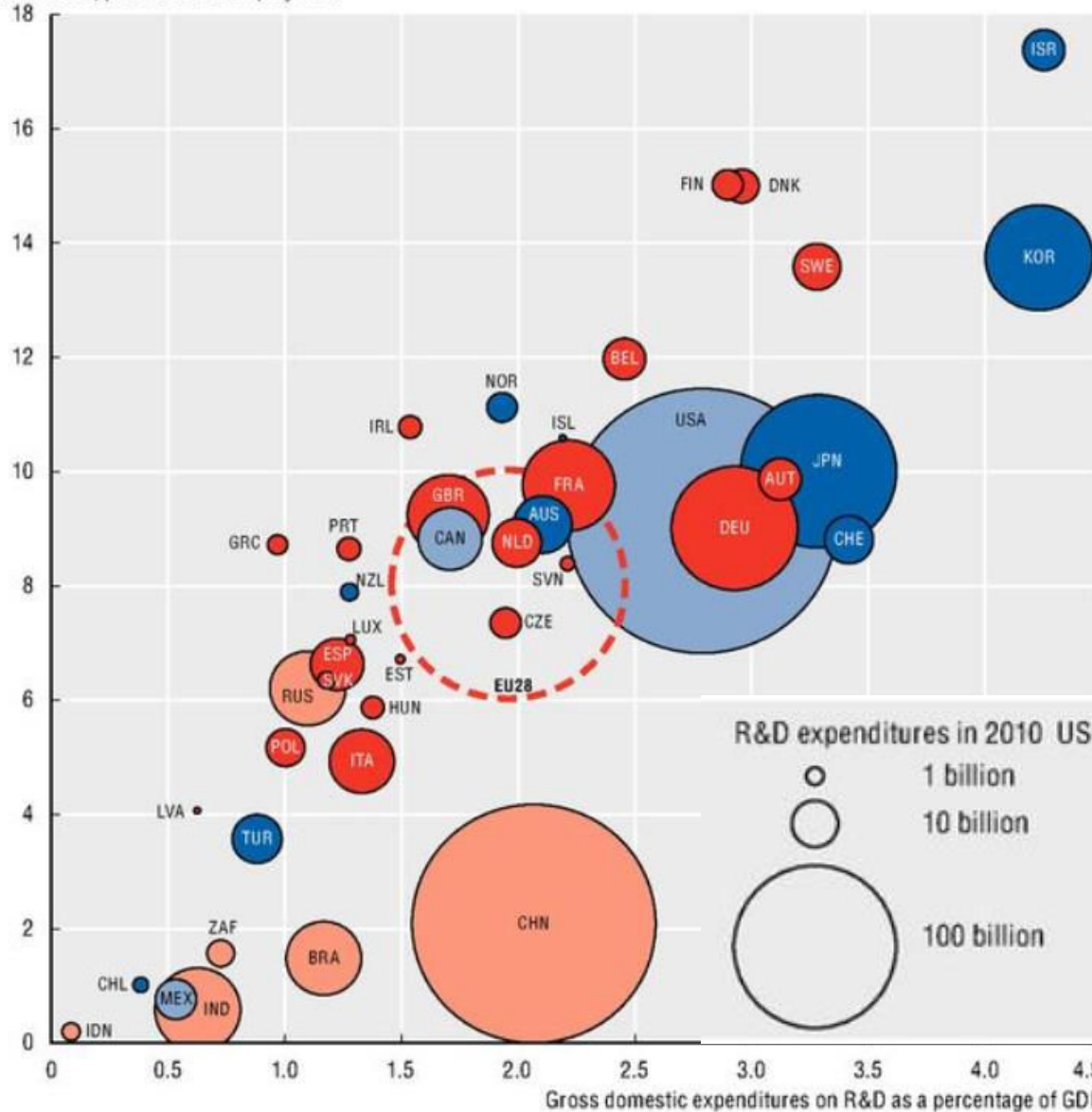
Each Social Lab will involve 15 to 25 participants and will have a lifetime of 32 months (November 2017 to May 2020). There will be a total of three consecutive RRI stakeholder workshops in European capitals.





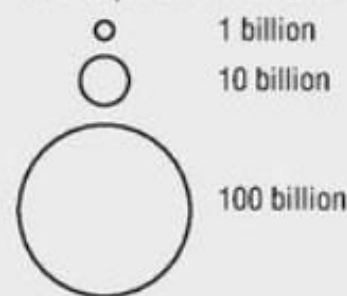
# World R&D performance - OECD Science, Technology and Industry Scoreboard 2017

Researchers, per thousand employment



- Brazil** (Federative Republic of Brazil)
- Russia** (Russian Federation)
- India** (Republic of India)
- China** (People's Republic of China)
- South Africa** (Republic of South Africa)

R&D expenditures in 2010 USD constant prices and PPP



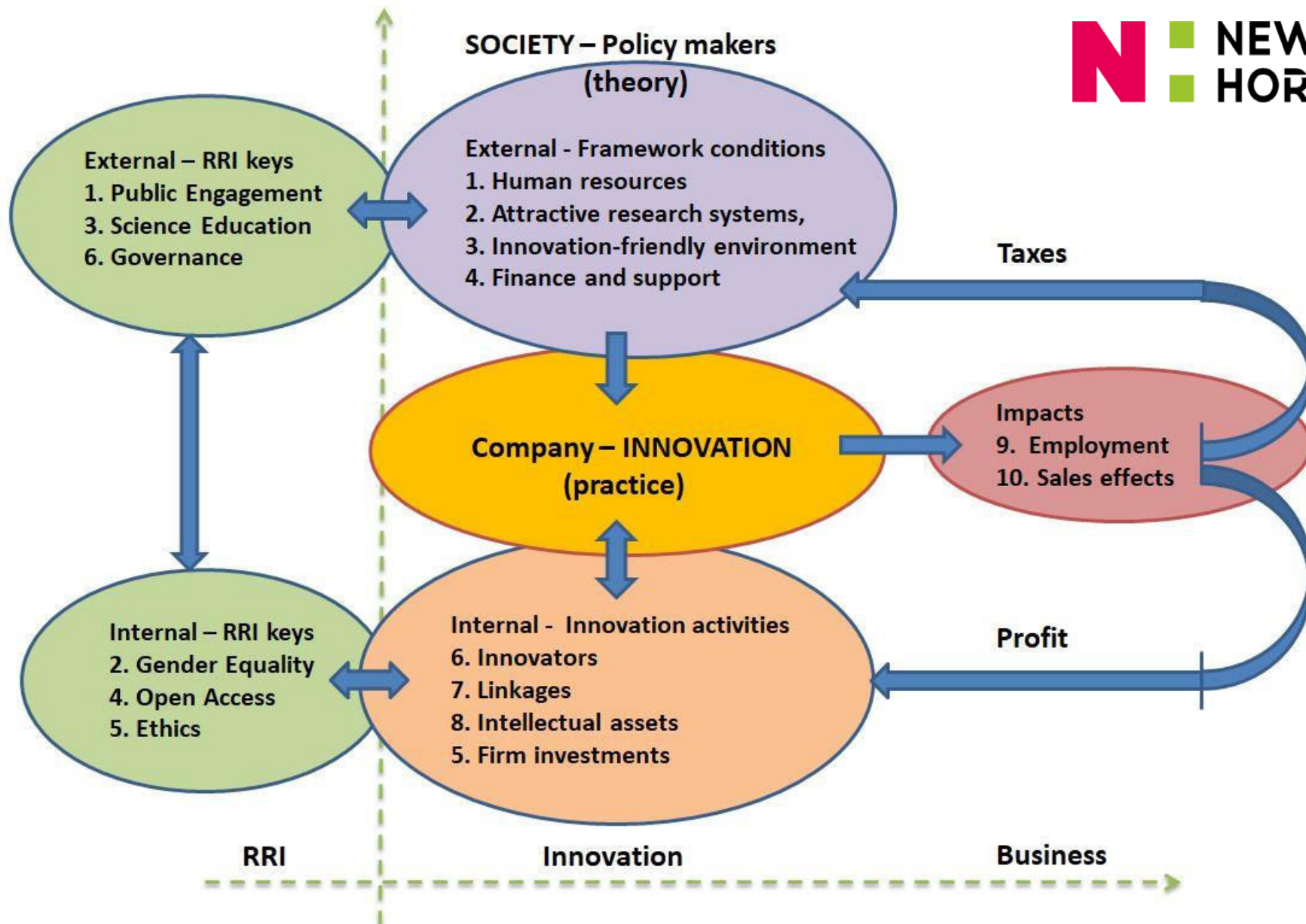
- BRICS**
- North America**
- European Union**
- Other OECD members**

EUREKA



# The landscape of RRI and Innovation

**N** ■ **NEW**  
■ **HORIZON**





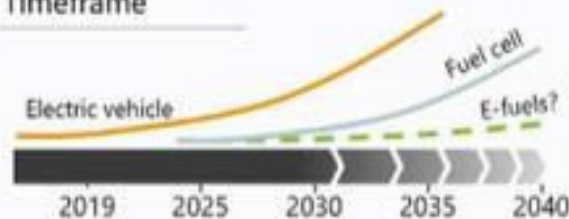
# Hannover Messe 2021

## Automotiv advancements

### Focus of the study

FEV  
CONSULTING

#### Timeframe



- Focus of the study: 2040 timeframe
- Until 2030, we expect a strong phase of "battery push" with rapidly increasing battery electric vehicle sales which is extended by the introduction of fuel cell vehicles especially after 2030
- Further technology trends could have an additional impact on the automotive supply chain, however, were not investigated in detail:
  - Alternative fuels might play a role, depending on legislative boundary conditions
  - Services & infrastructure are expected to generate new business potentials

#### Vehicle systems



- Focus of the study: Powertrain system
- Further vehicle systems such as Chassis, Body in White, Interior and Exterior are expected to change with future vehicle technology trends and the influence of new mobility solutions
- Key trends: Autonomous driving, weight reduction, safety, new features

#### Market regions



- Focus of the study: Europe (EU-27 + 3), USA, China
- Further markets are expected to transition towards electrified powertrains
- Emerging market such as India are expected to become more relevant
- Japan potentially leads the fuel cell development pursuing a "hydrogen society"





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## Automotiv advancements

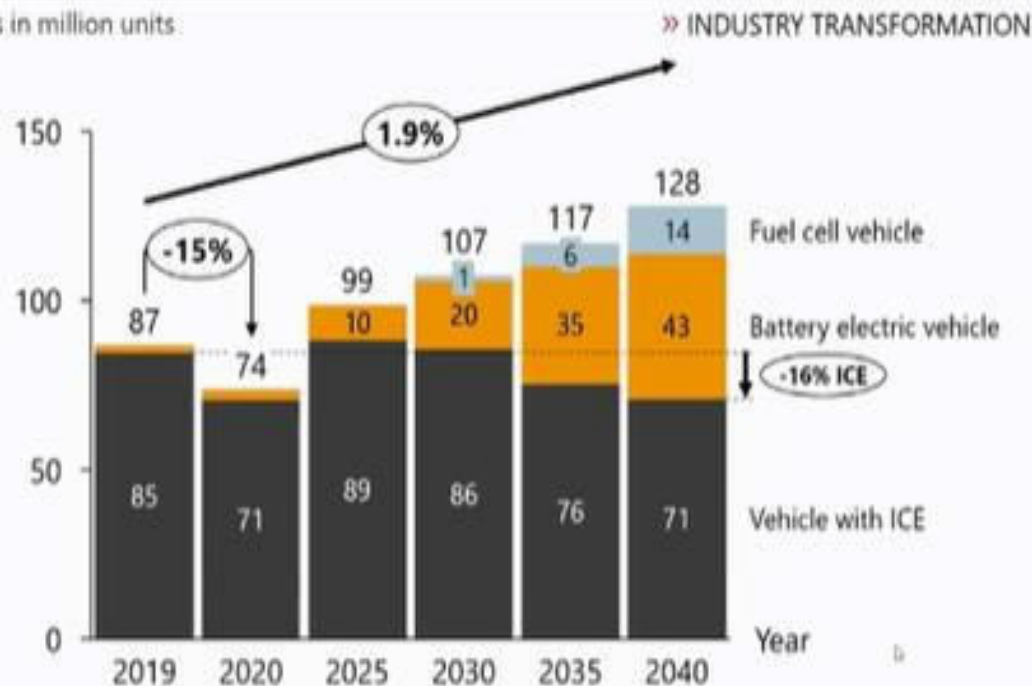
By 2040, over 40% of world-wide light duty vehicle sales will be using an all-electric powertrain

FEV  
CONSULTING

WORLD-WIDE LIGHT DUTY<sup>1)</sup> MARKET

### VEHICLE SALES FORECAST

Sales in million units



- Total market is expected to recover after 2020
  - Constant market volumes in Europe, US, Japan and South Korea market regions after 2025
  - Increasing market size for China, India and rest-of-world markets at different growth rates
- Reduction of global combustion engine-based powertrains by 16% until 2040
- Strong growth of battery electric vehicles
  - Until 2030 mainly driven by China and Europe
- Fuel cell vehicle sales will increase after 2030
  - Until 2030 growth driven by Japan and South Korea, limited by total market size
  - From 2030 onwards strong growth in China, Europe and the USA

<sup>1)</sup> including passenger cars and light commercial vehicles up to 3.5t gross vehicle weight  
Source: FEV





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## Automotiv advancements

Globally, we expect 44% pure electric vehicle in 2040 – largest market for battery electric vehicle is China with approx. 13 million units

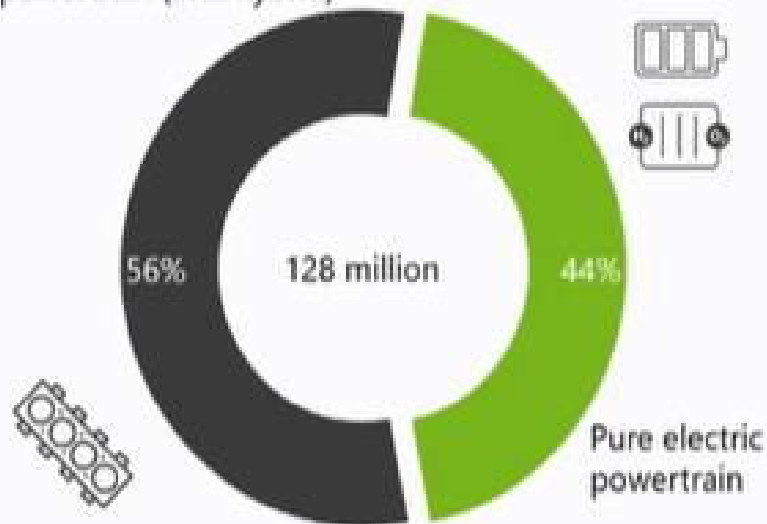
FEV  
CONSULTING

MARKET SNAPSHOT 2040

### WORLD-WIDE SALES<sup>1)</sup> VOLUME

Combustion engine based  
powertrain (incl. hybrid)

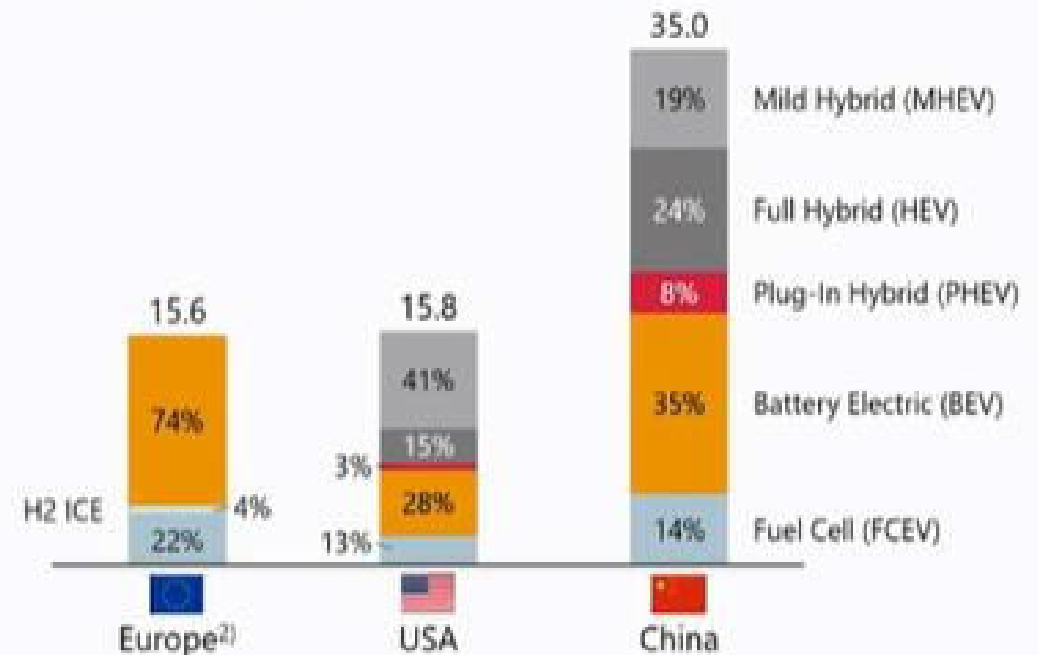
» INDUSTRY TRANSFORMATION



### PASSENGER CAR POWERTRAIN TYPE FORECAST

Total sales in million units

» INDUSTRY TRANSFORMATION



1) Vehicle sales include passenger cars and light commercial vehicles up to 3.5 tons  
2) EU27+3  
Source: FEV



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## Industry transformation – Automotiv impact

Negative business potential impact due to industry transformation on all mature technology groups beside thermal management is expected

FEV  
CONSULTING

BUSINESS POTENTIAL IMPACT

» INDUSTRY TRANSFORMATION



1) Market size in billion EUR  
2) Compound annual growth rate  
Legend indicates shrinking markets, markets with below-average performance and market with above-average performance  
Source: FEV



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## Automotiv transformation

### Example:

- 10.000 km/y
- 7 l Diesel / 100 km
- 25 kWh / 100 km

- Coal: 0,35 kg CO<sub>2</sub>/kWh
- Efficiency powerplant: 35%
- Diesel: 10 kWh/l
- Diesel: 0,27 kg CO<sub>2</sub>/kWh



1890 kg CO<sub>2</sub> / y



CO<sub>2</sub>



2500 kg CO<sub>2</sub> / y



Designed by Ergle / Freytag



0 kg CO<sub>2</sub> / y



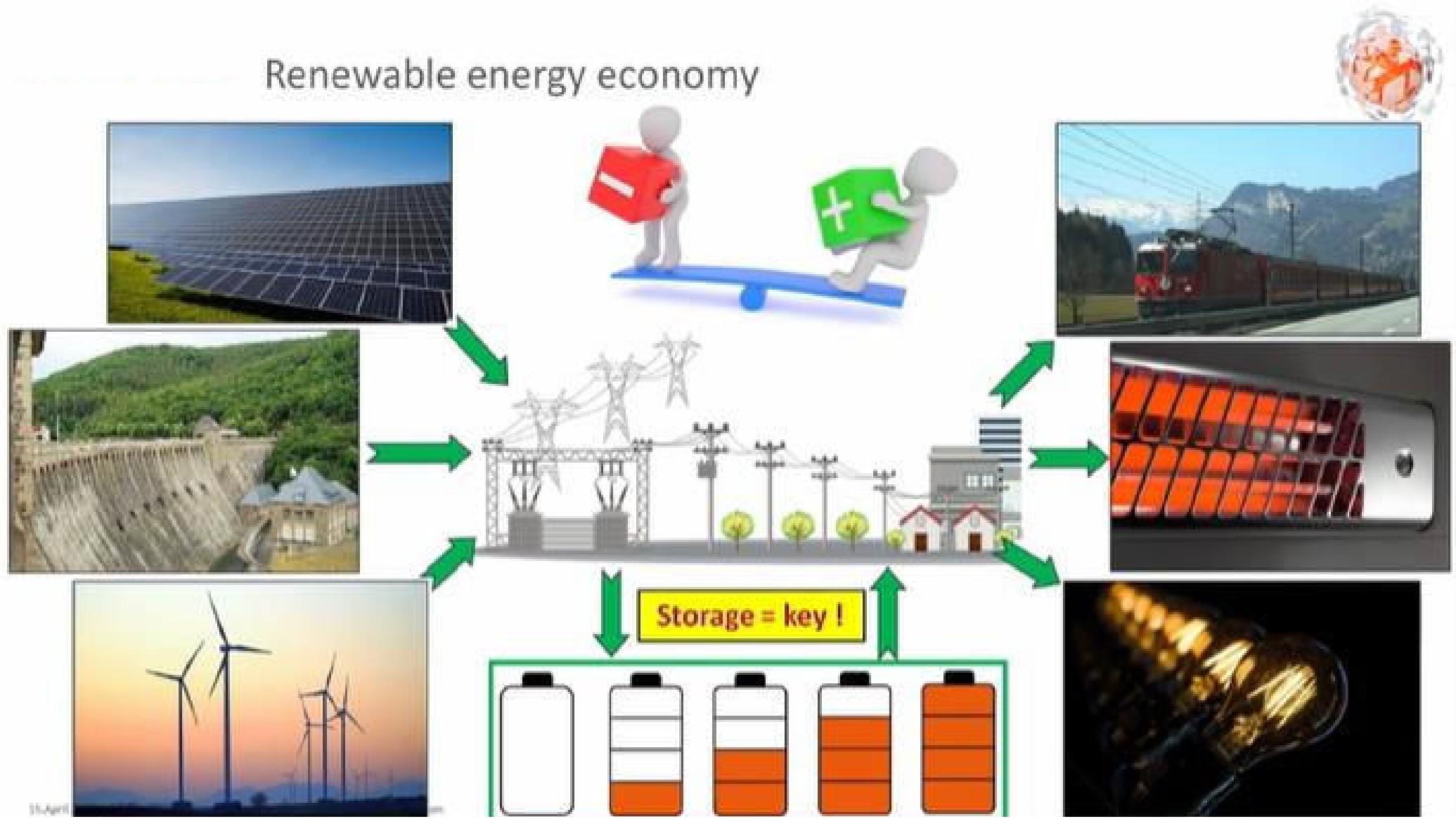
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## Energy transformation

### Renewable energy economy







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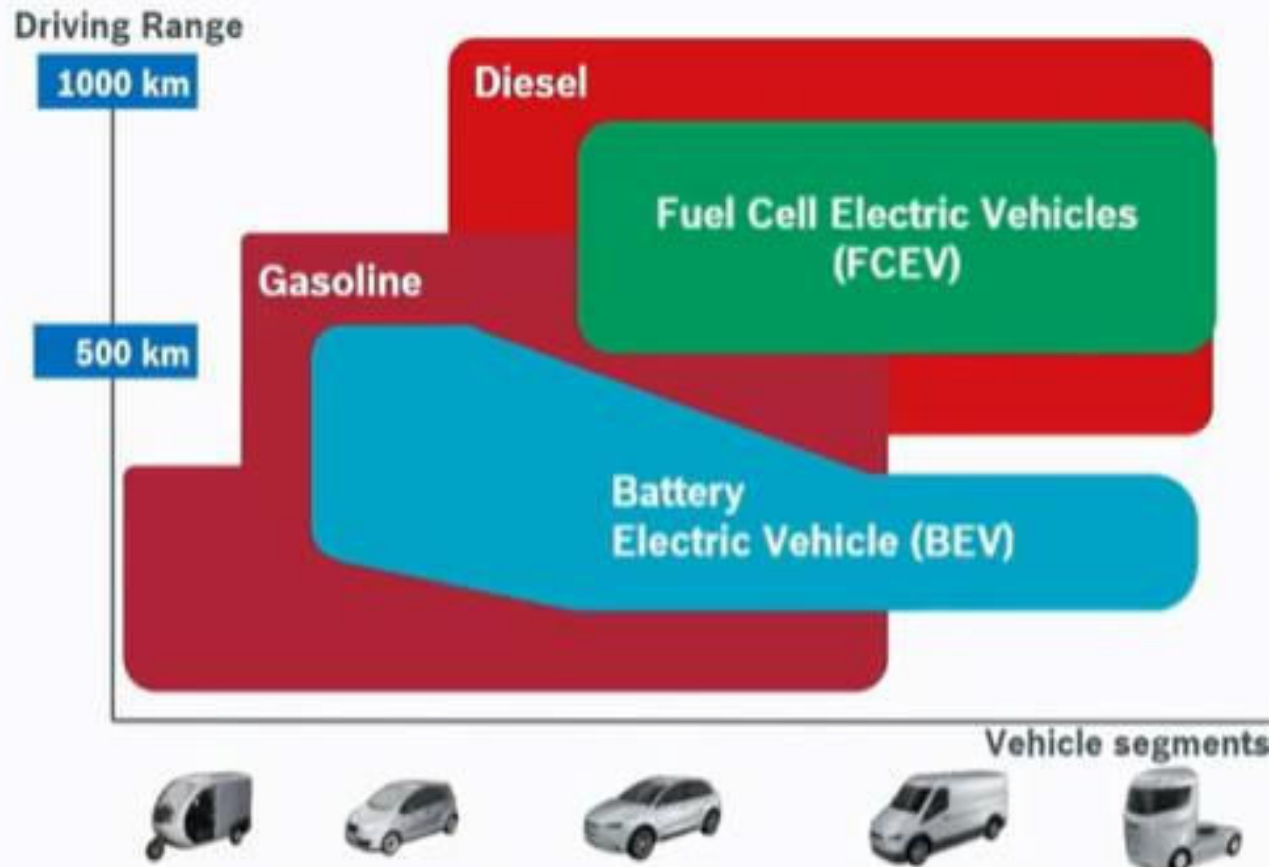
## Automotiv advancements FCEV

### Mobile Fuel Cells Fuel Cell Electric Vehicles - Motivation

#### Fuel Cell Electric Vehicles

(FCEV) complements portfolio of Electric Vehicles (EVV) and

- ☐ offer ultimate solution for zero tail-pipe emissions in applications for long distance transportation of heavy goods and/or many people.
- ☐ remove range anxiety barrier in all e-mobility applications (refueling time in 3 min, driving range above 500 km)



Vehicle segments

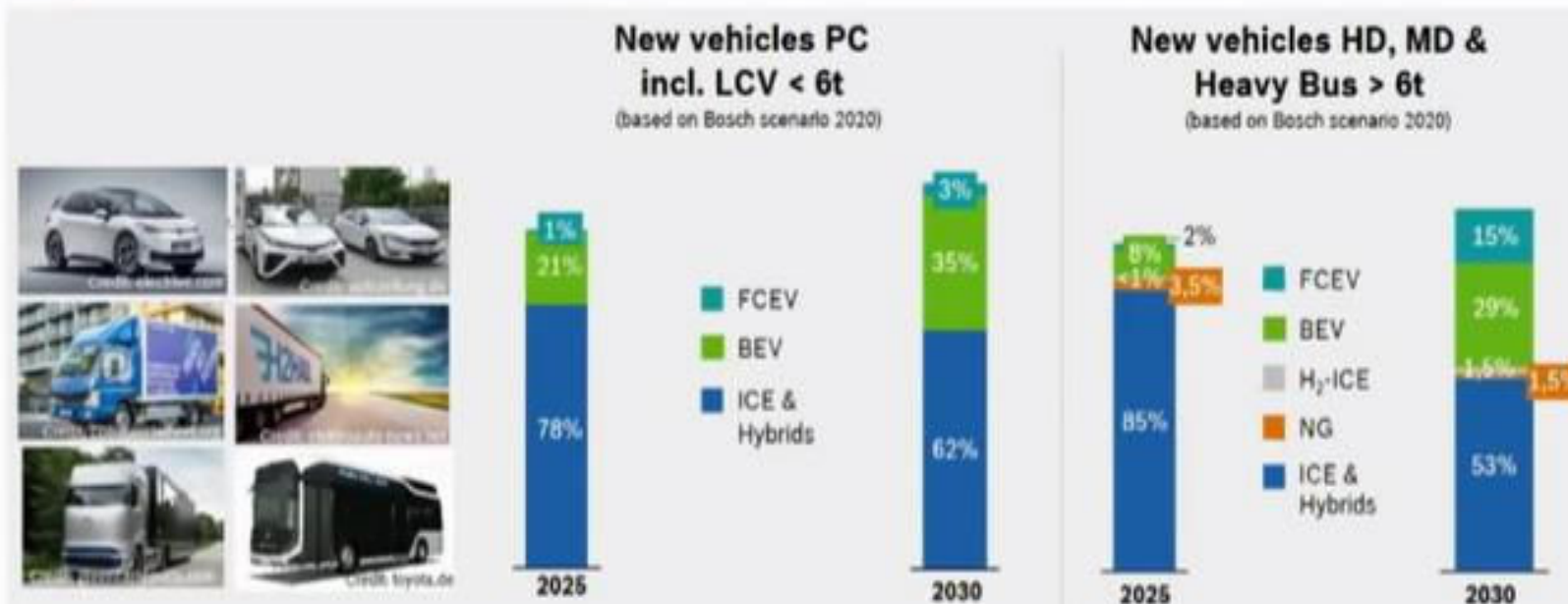


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## Automotiv advancements

### Mobile Fuel Cells

### Expected market shares 2025-30 for Fuel Cell Electric Vehicles



**Powertrain Portfolio in 2030**  
(new vehicles, worldwide)

Passenger Cars + Light Comm. Vehicle:  
>1/3 fully electric t/o 8% FCEV

Comm. Vehicles Medium-/ Heavy Duty:  
15% with FCEV powertrain

**ICE shares shrinking - fuel cell with growth potential**

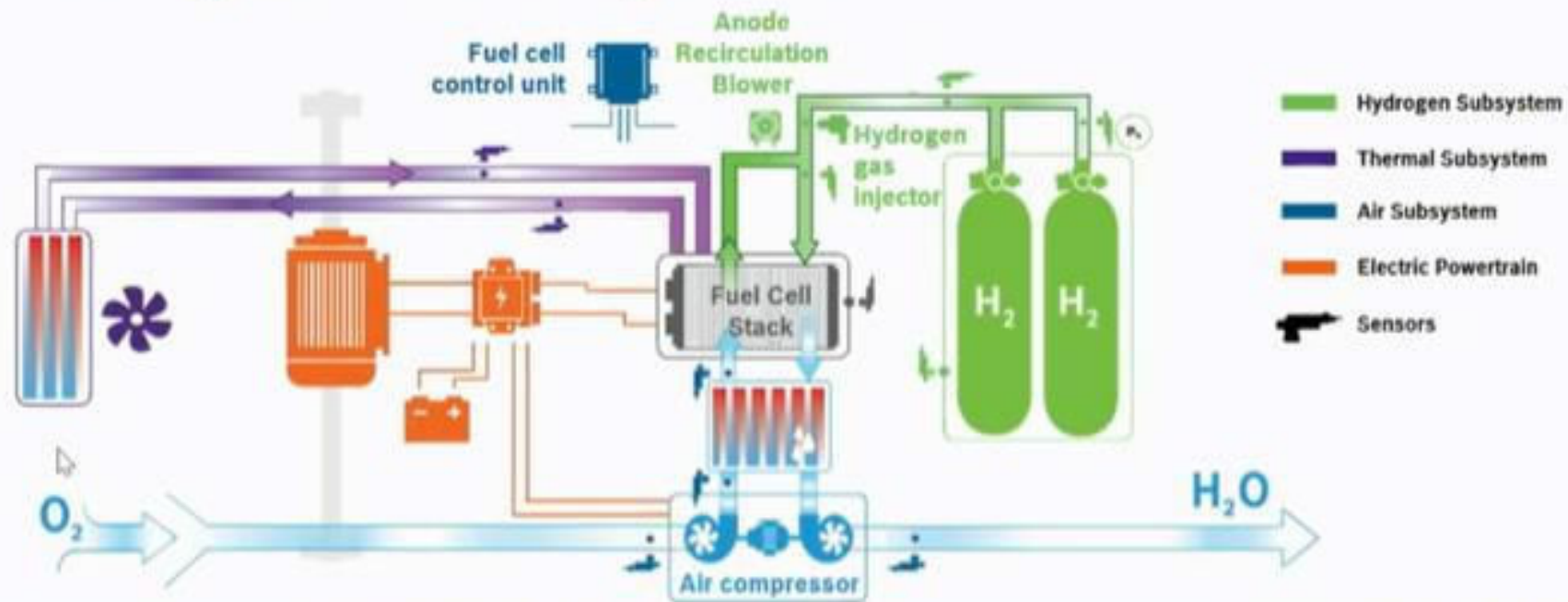
In 2030  
based on  
Bosch  
Scenarios  
more than 3  
mio Fuel Cell  
Vehicles will  
be sold.



# Hannover Messe 2021

## Mobile fuel cell system and components

### Mobile Fuel Cells Fuel Cell System and components



#### COMPONENTS FOR FUEL CELL SYSTEM



#### MODULES AND KITS





<https://www.youtube.com/watch?v=wCj1kJ1Fyk4&t=16s>

<https://www.youtube.com/watch?v=rVlhMGQgDkY>

***Will you be the intelligent agent or Biorobot?***

**THANK YOU FOR  
THE ATTENTION**



**Vladimír Kebo**



<https://www.youtube.com/watch?v=voNBzul7IJ4>







# International RFID lab VŠB-TUO

## Ph.D. students with Sanjay E. Sarma (2012)

