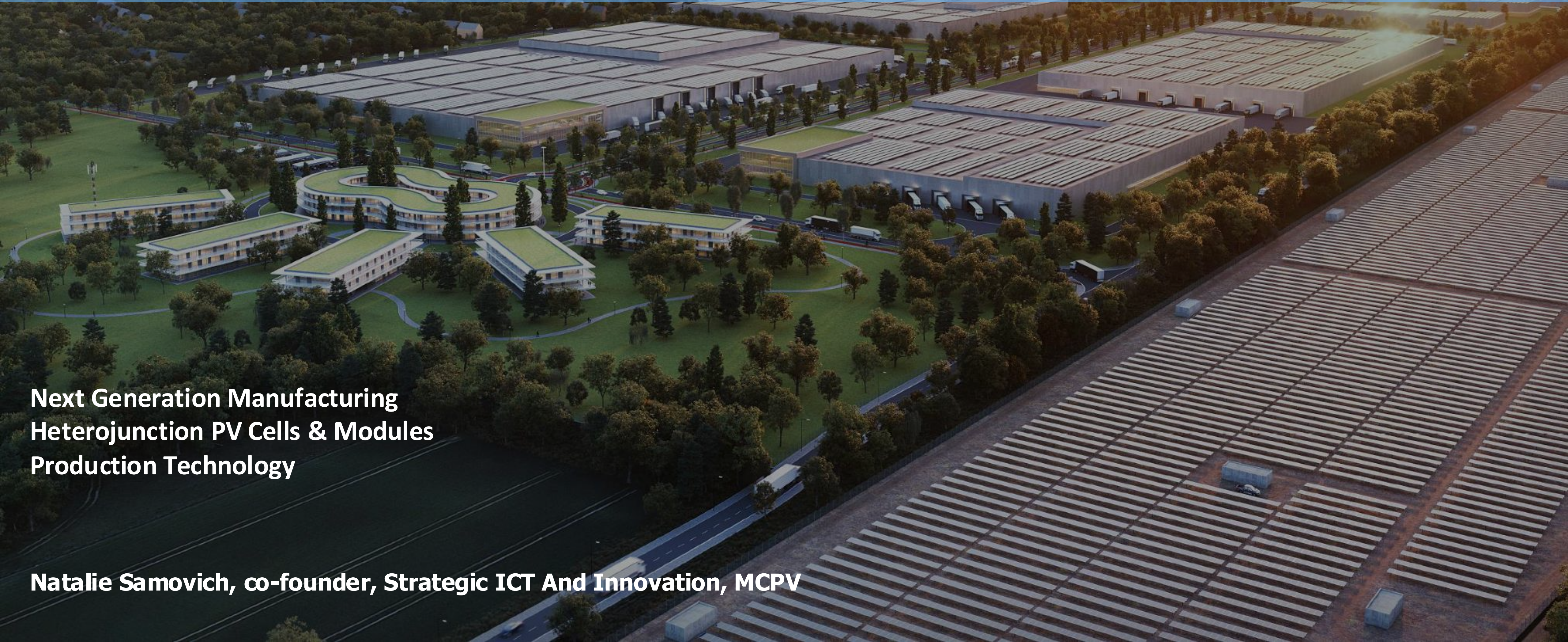
GREEN FIELD MANUFACTURING. ENERGY AND RESOURCES EFFICIENCY BY DESIGN, DEFAULT AND CARBON NEUTRALITY DRIVE TOWARDS ENSIA AND NZIA IMPLEMENTATION

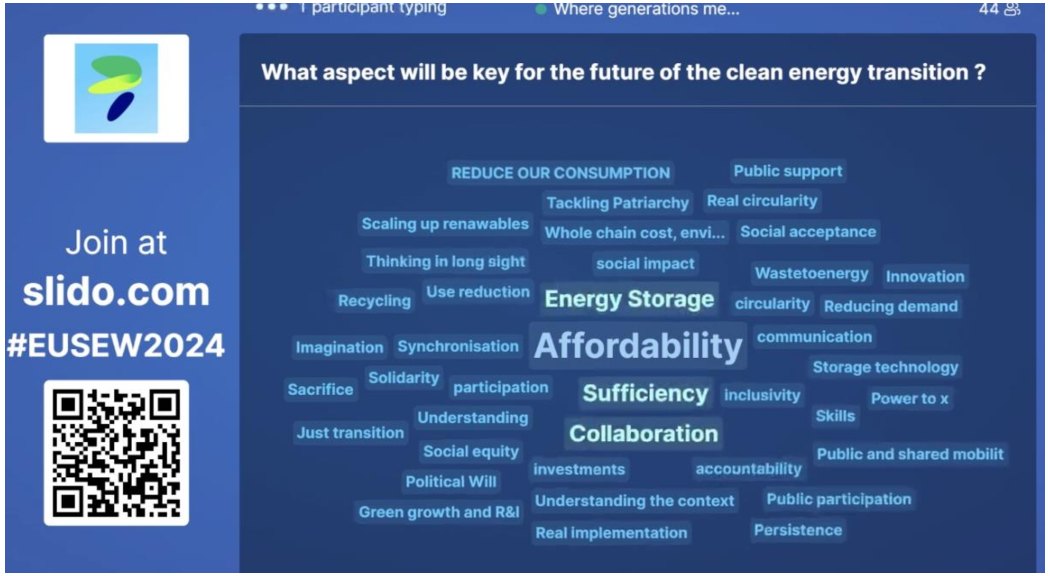
MCPV
connecting EU solar value chains



Next Generation Manufacturing
Heterojunction PV Cells & Modules
Production Technology

Natalie Samovich, co-founder, Strategic ICT And Innovation, MCPV

Competitiveness | Sustainability by Design



Source: EIT Manufacturing report: (https://www.eitmanufacturing.eu/wp-content/uploads/2023/05/ems-future-manufacturing-system-final.pdf)

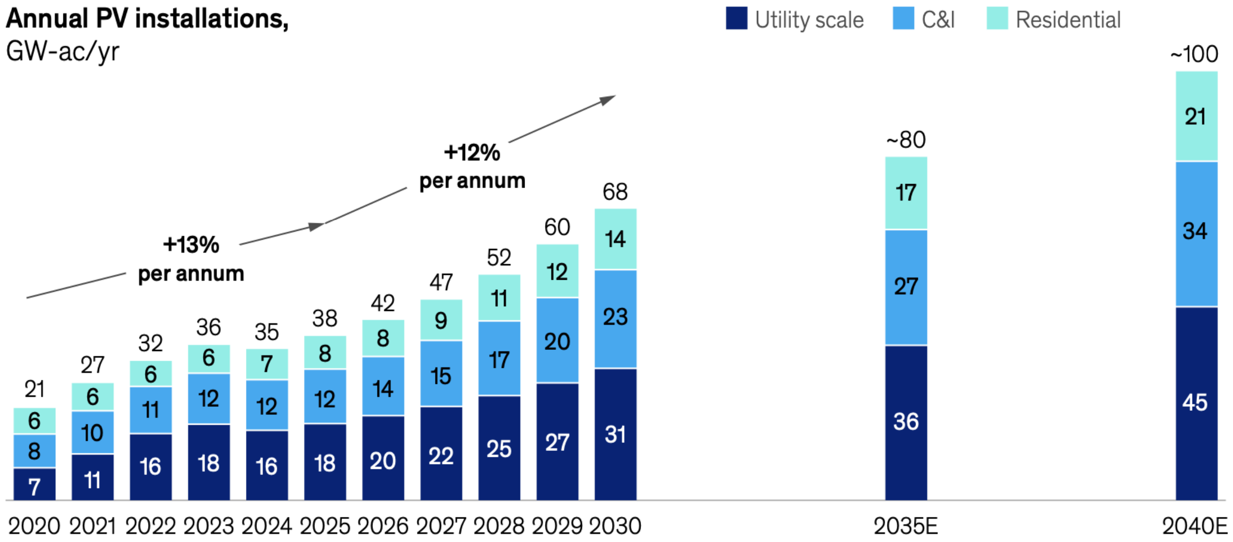
Green field GW scale manufacturing enabled by Digital Technologies

Source: EIT Manufacturing report: (https://www.eitmanufacturing.eu/wp-content/uploads/2023/05/ems-future-manufacturing-system-final.pdf)

- **New resources management practices** based on the circular economy principles minimise the impact of finite resource consumption and create truly sustainable business models and value propositions;
- **New activities optimisation** efforts enhance efficiency, boost productivity, minimise waste, reduce costs, and improve product quality;
- **New partnership schemes based** on collaborations with other manufacturers, suppliers, or even competitors create synergies and unlock new value propositions by integrating complementary products and/or services;
- **New cost structures** analyse and better manage the various costs incurred in the design, manufacturing, and delivery of products and services to enhance profitability.

GREENFIELD Manufacturing

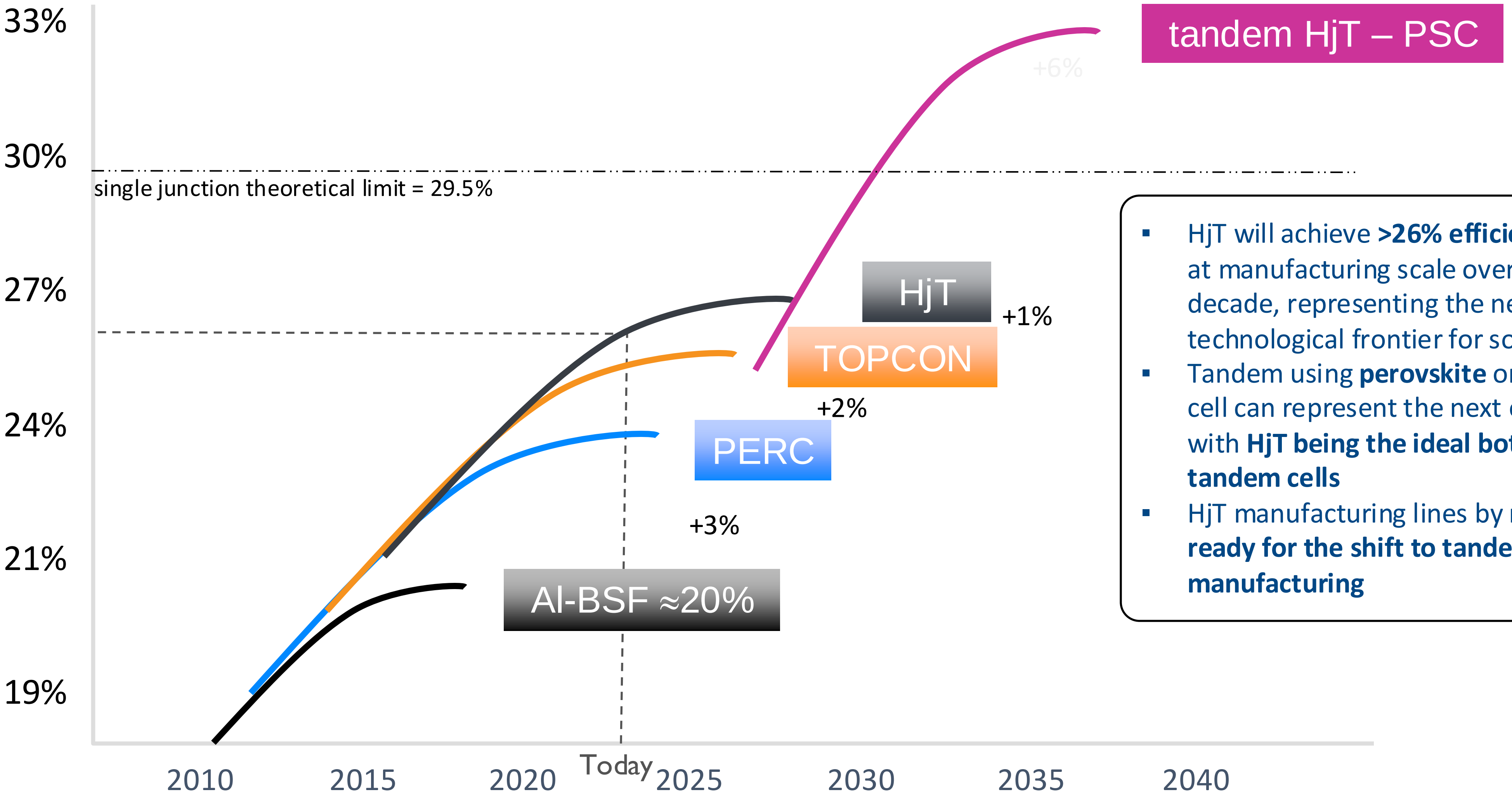
Large unmet demand for "Made-in-Europe" solar cells and modules



Source: McKinsey report

- European cumulative installed capacity forecasted to grow 3x by 2030 (vs. 2022) to deliver the 750 GW REPowerEU target.
- EU has a formal 2030 target of at least 30 GW of "Made-in-Europe" PV manufacturing capacity, opening a significant opportunity for greenfield first-movers like MCPV.
- Managed growth from 400MW to 3,9GW and beyond.

HjT represents the next frontier in solar cell manufacturing



- HjT will achieve **>26% efficiency levels** at manufacturing scale over the next decade, representing the next technological frontier for solar PV
- Tandem using **perovskite** or other top cell can represent the next evolution, with **HjT being the ideal bottom cell for tandem cells**
- HjT manufacturing lines by nature **ready for the shift to tandem cell manufacturing**

Clean Tech Energy and Solar Manufacturing Valley

- Maximising solar and wind resources connection to the plants for clean electricity production and grid sourcing plan, as well as optimisation of related energy infrastructures plans
- Self-generation, energy storage, grid sourced electricity and power purchase contracting
- Circular water utilisation
- Circular heat utilisation
- Materials and gases supply and consumption optimisation

Clean Tech Energy and Solar Manufacturing Valley

- Electricity sourcing roadmap towards 100% renewable energy mix facilitated by electricity procurement and onsite management;
- 360 degrees approach towards manufacturing line, facilities and logistics carbon footprint roadmap planning;
- Fully integrated HJQ campus approach for resources management and optimisation through microgrids and circular resources management;
- Product level design and development considerations in addition to ECO design targets.

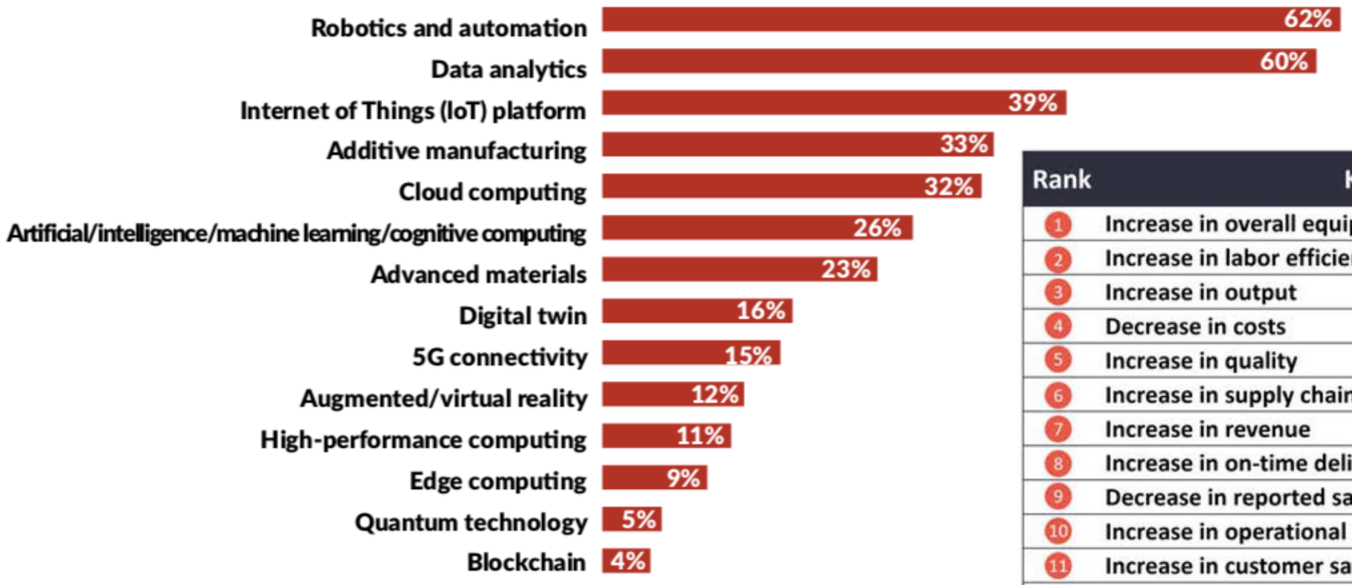
Materials Hub, Enabling Infrastructures, on site H2 production, Advanced Wearhouse

Enabling Digital Technologies

- 5-6G CONNECTIVITY
- EDGE IIOT, CONTEXTUAL ENERGY
- DIGITAL PLATFORMS / MARKETPLACES
- DATA SPACES
- AI (GENERATIVE AI)
- EDGE TO CLOUD COMPUTING CONTINUUM
- DIGITAL PRODUCTS PASSPORTS
- GW BLUEPRINT
- INDUSTRIAL METAVERSES AND DIGITAL TWINS

Focus on current investments in manufacturing technologies

(Source: Deloitte 2023)

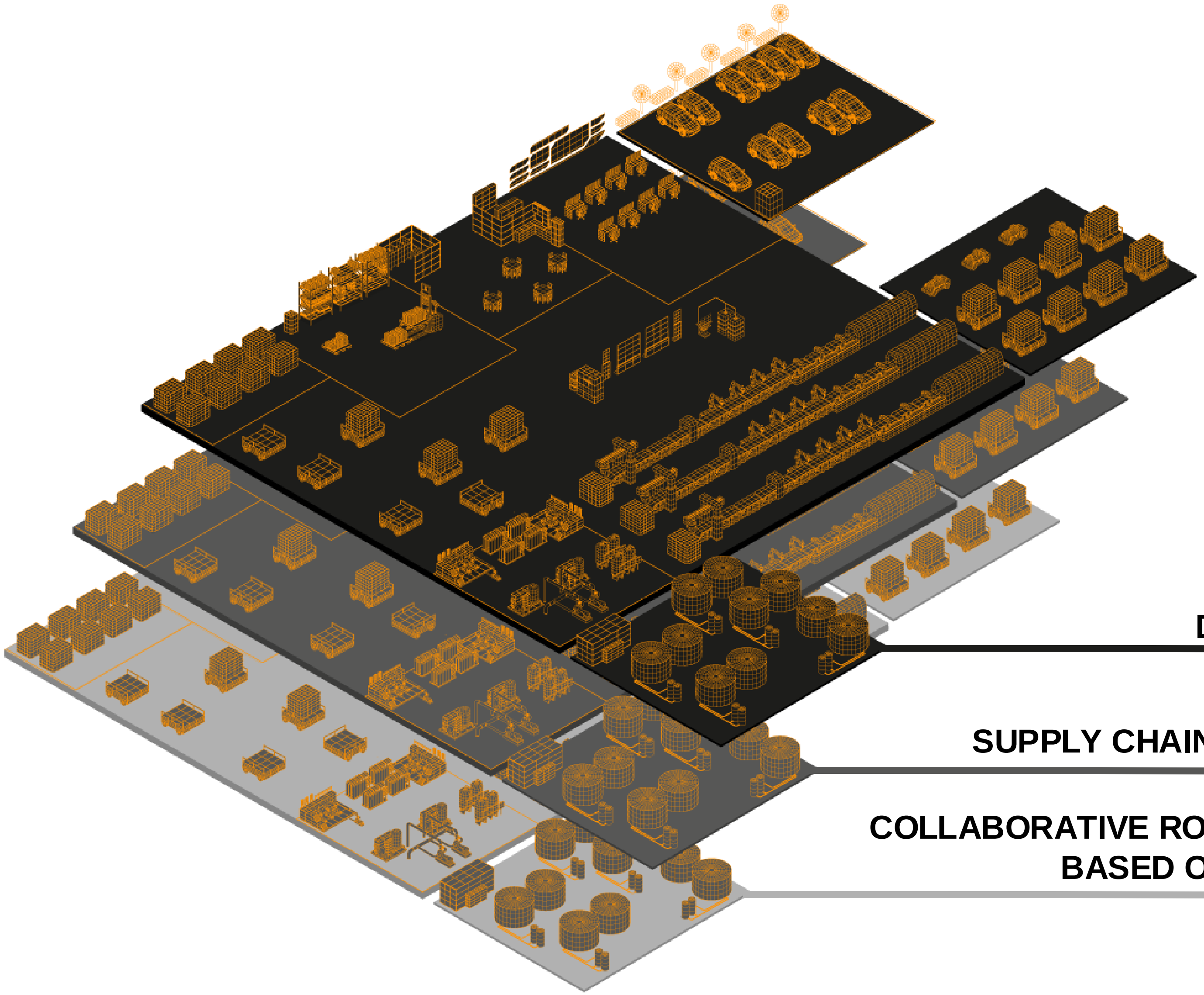


Rank	KPI	Group	Importance[1]	Ambition[2]
1	Increase in overall equipment effectiveness (OEE)	Operational	86%	★★★
2	Increase in labor efficiency	Operational	79%	★★★
3	Increase in output	Operational	78%	★★
4	Decrease in costs	Operational	77%	★
5	Increase in quality	Operational	76%	★★★
6	Increase in supply chain resiliency	Supply Chain	73%	★★★
7	Increase in revenue	Marketing & Sales	69%	★★
8	Increase in on-time delivery	Operational	69%	★★
9	Decrease in reported safety incidents	Safety	67%	★★★★
10	Increase in operational resiliency	Operational	64%	★★
11	Increase in customer satisfaction	Marketing & Sales	63%	★★★★
12	Decrease of waste	Sustainability	63%	★★★★
13	Increase in ROE/ROCE	Finance	63%	★
14	Increase in market share / market penetration	Marketing & Sales	59%	★
15	Decrease in inventory levels	Finance	57%	★★
	... of 27 measured KPIs in total		Very important / Important	

Ambition (based on % of KPI improvement planned in next 3 years): ★ :<25% ★★ :25% - 27% ★★★ :27% - 29% ★★★★ :>=29%

Note: 1: Share of companies that regard the respective KPI as very important or important for measuring the success of the smart factory strategy 2: Improvement (in percentage) of KPI planned from now (2022) to 2025 (next 3 years). N= 500 **Source**: IoT Analytics Research 2022, IoT Signals Manufacturing Spotlight 2022(https://aka.ms/IoTAnalytics-SignalsReportMnf)

Enabling Digital Technologies |GW scale



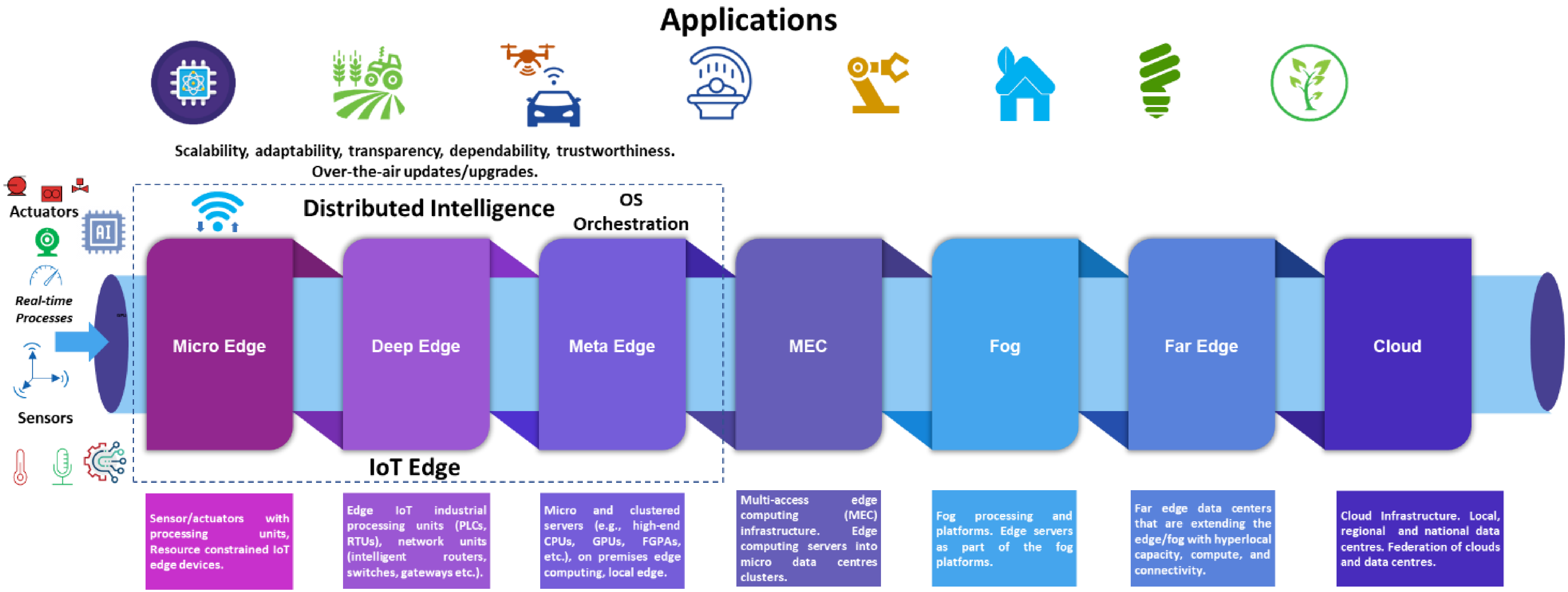
DIGITAL TWINS/ AI ENABLED MANUFACTURING

SUPPLY CHAIN DATA SPACES/ HUMAN CENTRIC TRUSTED AI

COLLABORATIVE ROBOTICS / A PATHWAY TO NET SUSTAINABILITY BASED ON TRUSTED AI IN ADVANCED MANUFACTURING

Variety of generation sources in size, both centralised and decentralised, fully or largely circular

Edge IoT Continuum



Edge IoT Trends / IIoT

- The emergence of integrated IoT + edge + AI solutions with AI, ML and automation innovations for the development of new autonomous IoT systems and the integration of IoT digital twins.
- The emergence of edge IoT swarm systems and the integration of neuromorphic computing.
- Pervasive AI and ubiquitous context-aware edge IoT autonomous systems integrated with swarm and neuromorphic computing.
- Edge AI embedded across the micro-, deep-, meta-edge continuum with the development of new techniques for federated ML and self-training.

EDGE in Energy management - Evolving?

Edge Intelligence for energy efficiency

Edge analytics for predictive maintenance

Edge computing for smart grids

Edge driven models process time-sensitive data, while Cloud computing focuses on more asynchronous processes based on data

Edge computing is used to process time-sensitive data, while cloud computing is used to process data that is not time-driven

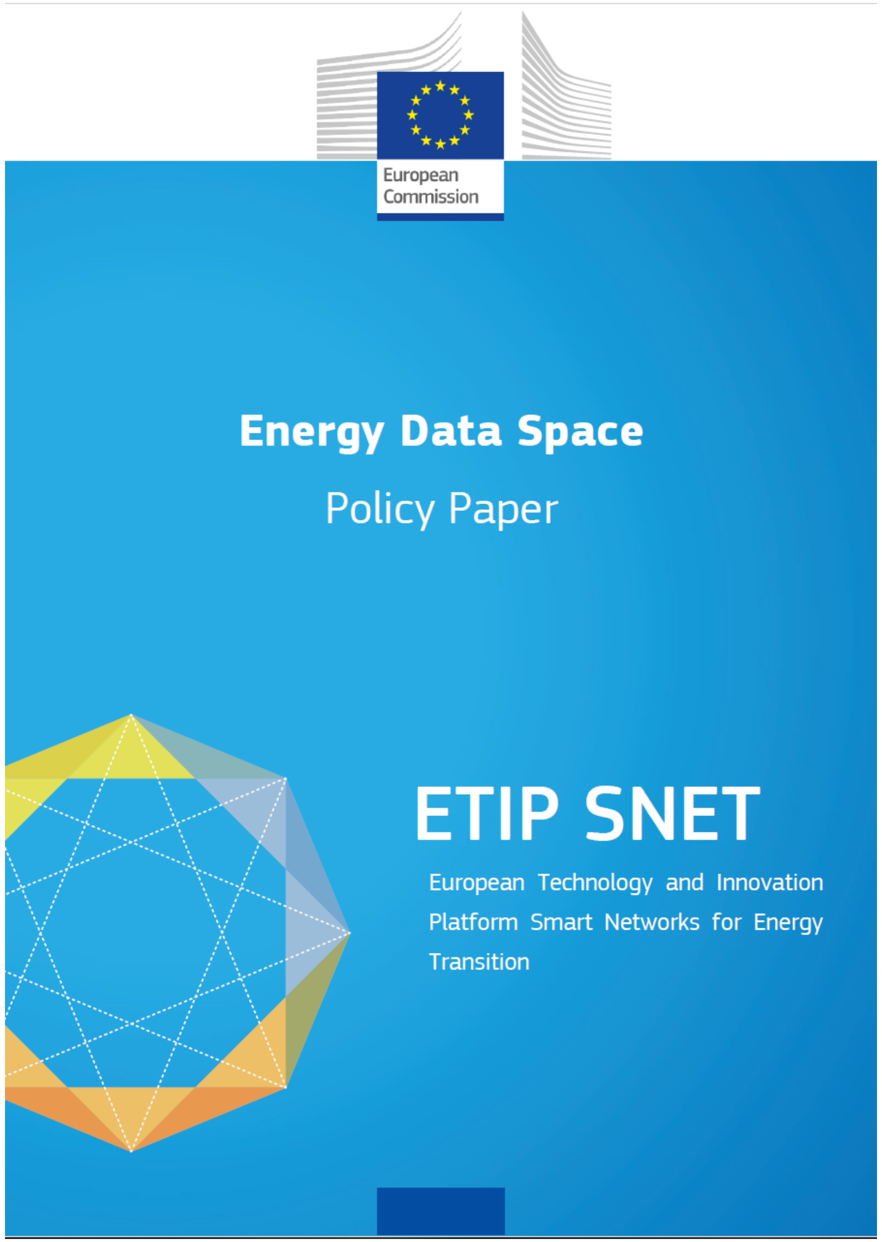
Edge devices for worker safety and enablement

Demand Response Flexibility of Demand, VPPs

Digital Twins and advances analytics towards Data Spaces

ETIP SNET policy paper on Energy Data Spaces

- Led by the ETIP SNET Working Group 4 “Digitalization of the electricity system and customer participation”
- Scopes of the policy paper are:
  - To assess the current status and evolution of energy data spaces
  - To provide suggestions, in terms of policy and regulation, to facilitate the large deployments in Europe
- int:net coordinated the Energy Data Spaces HEU projects to collect the **key challenges, policy and regulation recommendations**
  - Including feedbacks from industry stakeholders
- Published in December 2023



Data Spaces

- A data space, is a **framework that supports data sharing** within a data ecosystem. It is **constituted by a clear structure in which the participants collaborate on data assets**; in particular, they agree to trade and share data in a way that is compliant with the agreed data values and relevant regulations (e.g., security and privacy, quality and integrity).

- Data spaces deployment is characterised with respect to the following **five categories**:
  - Business
  - Legal
  - Functional
  - Operation
  - Technology

Data management strategies, the 3 main architectural approaches

1 Decentralized model

Market actors work together to develop standardized market communication and exchange data either based on explicit consent of the data subject or under the umbrella of clearly defined business processes (e.g. EDA in Austria).

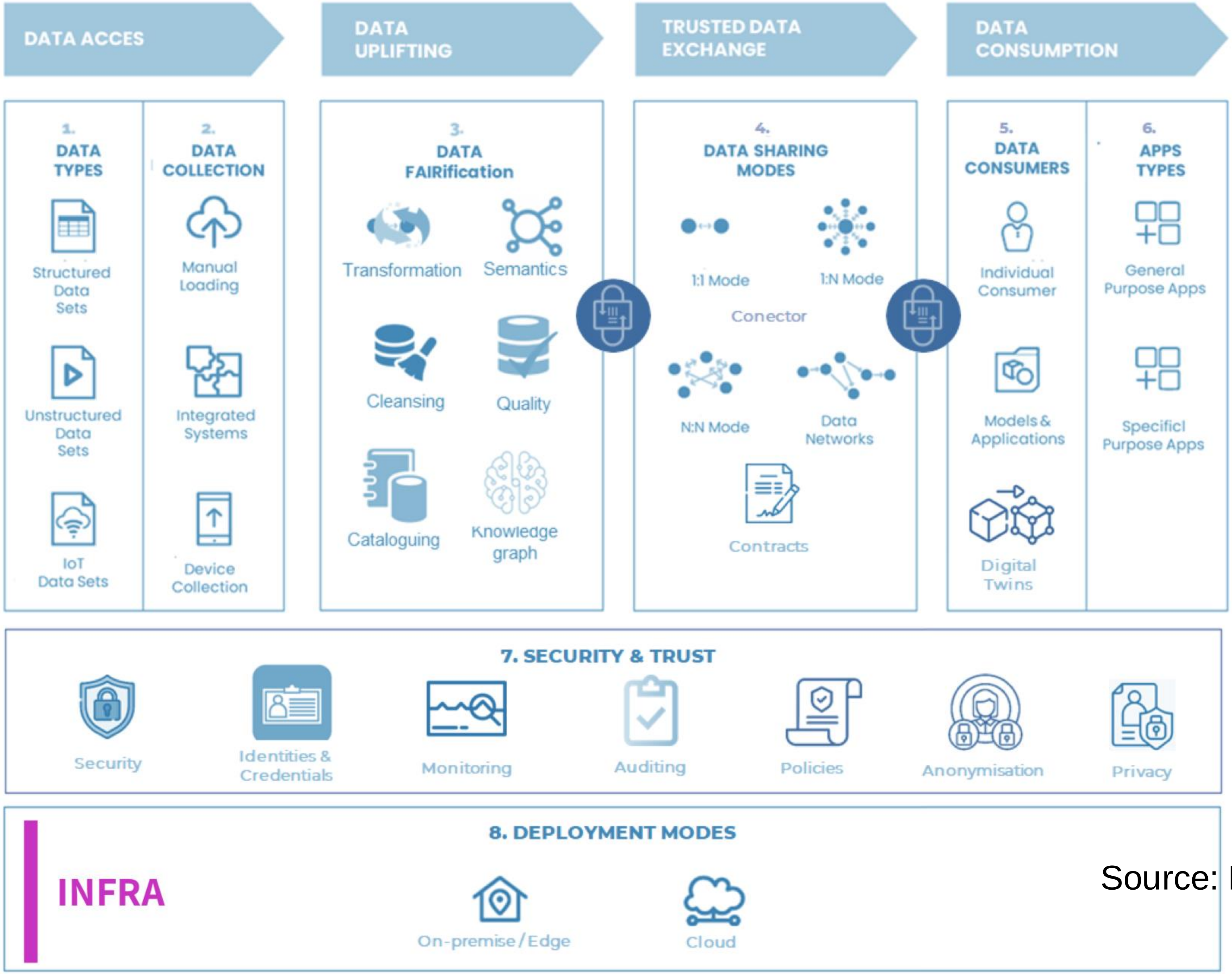
2 Centralized model

Data is sent to a data hub where it is managed and stored by a specific party. All business processes run on that hub and results are sent back to its clients. Market participants use its functionalities. Deployed in Finland and Estonia.

3 Hybrid model

Combination of the two previous models. All market participants can communicate in a decentralized manner, but in some use cases, there are task-specific central structures.

AI FOR DATA SPACES



DATA SPACES FOR AI

Source: Data Space 4.0

Increased complexity in infrastructural and computational environments

Manufacturing Use Cases

Product Innovation Collaboration

- Digital Name Plate
- Digital Product Passport
- Change Notification
- Collaborative Innovation Tools
- Digital Twin for Collaborative Engineering
- . . .

Production Optimization / Autonomous Factory

- Collaborative Condition Monitoring
- Federated Learning
- Collaborative Quality Management
- Modular Manufacturing
- Digital Twin for Process Simulation
- Self Configuration of Components
- . . .

Supply Chain

- Material Traceability
- Synchronous Planning for Production
- Demand & Capacity Management
- . . .

Energy & CO2-Management

- Energy Efficiency & Load Balancing
- Dynamic CO2 Tracking & Management
- Energy Load Management
- Circularity
- . . .

Source: Data Space 4.0

Cloud-Edge-IoT Continuum: opportunities and challenges for the Manufacturing Industry

AIOTI WG Manufacturing

Alliance for IoT and Edge Computing Innovation

V3.1 – 09.06.2024

Cloud-Edge-IoT Continuum: opportunities and challenges for the Manufacturing Industry

Release 1.0

AIOTI WG Manufacturing

2024

AIOTI

Leveraging IoT and Edge Computing Infrastructures to foster Energy Flexibilities through next energy sectorial integration

AIOTI WG Energy

Alliance for IoT and Edge Computing Innovation

Leveraging IoT and Edge Computing Infrastructures to foster Energy Flexibilities through next energy sectorial integration

Release 1.0

AIOTI WG Energy

19 December 2022

Edge driven Digital Twins in distributed energy systems:

Role and opportunities for hybrid data driven solutions.

The integration of Digital Twins at the grid edge is positioned as a key enabler for developing a more efficient energy ecosystem with the evolving business models.

The devices at the edges of electricity grids serve as physical infrastructure for sector integration, connecting with transport sector (electromobility) and heating & cooling along with dynamic buildings components.
Digital Twins driven by edge computing are also expected to provide essential data for infrastructure planning across sectors, fostering the development of cross-sectoral business use cases.

Aspect	Description	Benefits
Advanced Predictive Maintenance	AI-powered digital twins support predictive maintenance in distributed energy systems by monitoring assets in real-time, predicting failures, and optimizing maintenance schedules.	Minimizes downtime and extends the lifespan of energy assets.
Grid Integration of Distributed Assets	Digital twins' model Distributed Energy Resources (DERs) like solar panels, wind turbines, and battery storage. AI optimizes the integration of these resources into the grid.	Enhances grid stability, reduces energy wastage, ensures reliable energy supply.
Demand Response Optimisation	AI-driven digital twins model energy consumption patterns, assisting grid operators and [illegible] responding to real-time demand ne[illegible] demand-response programs.	Reduces energy costs and [illegible] grid reliability.

Alliance for IoT and Edge Computing Innovation

Edge driven Digital Twins in distributed energy systems

Role and opportunities for hybrid data driven solutions

Release 1.0

AIOTI WG Energy

January 2024

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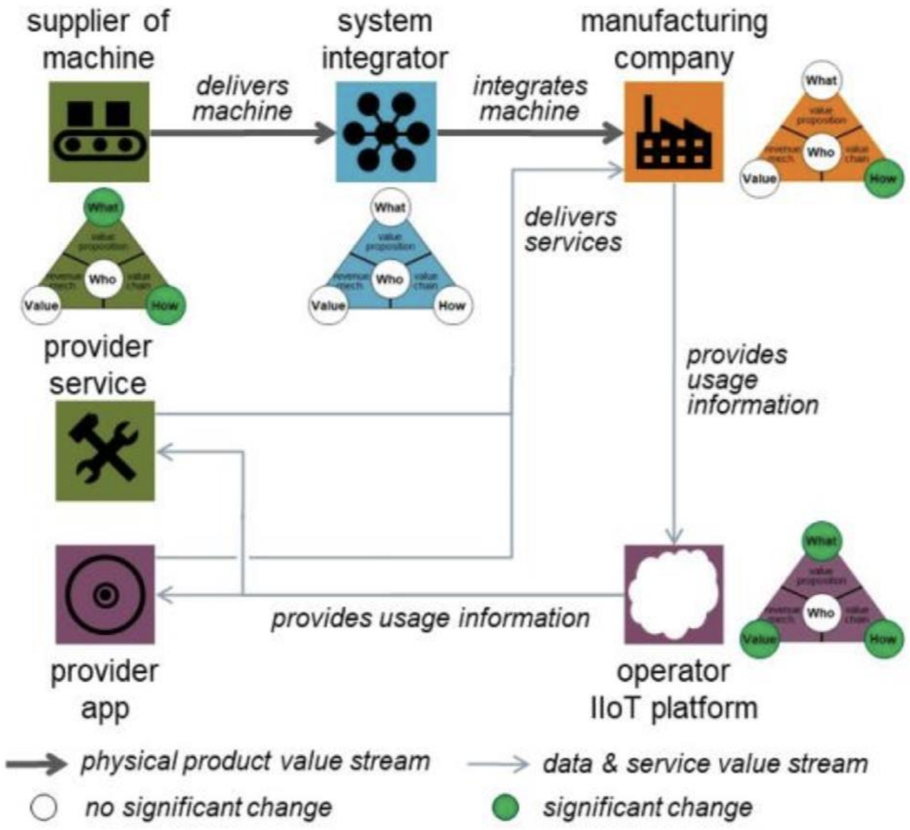


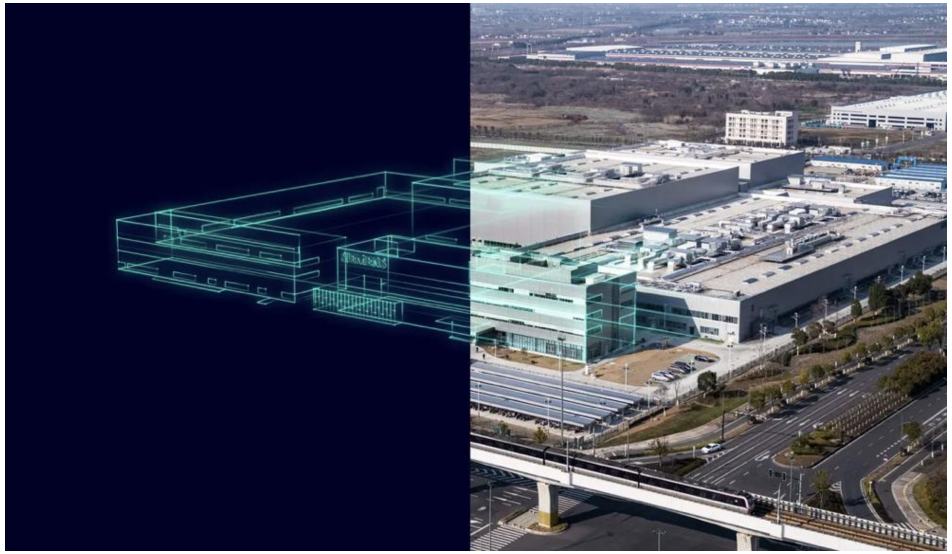
White Paper: Business Impact of IoT in Manufacturing Industries

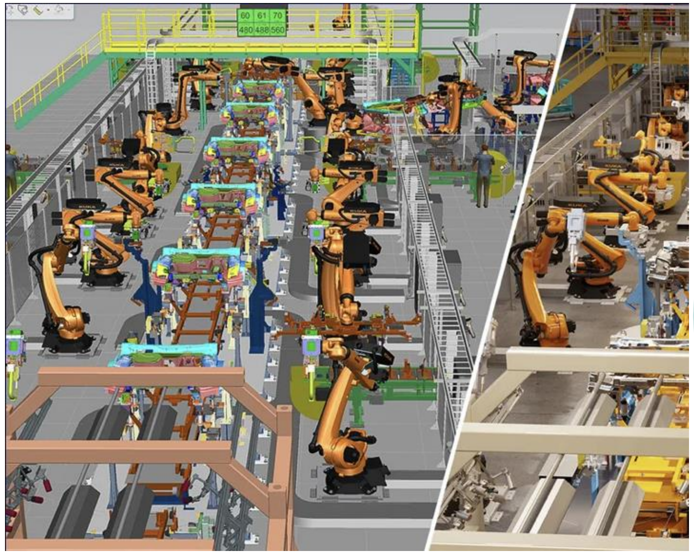
Release 1.1

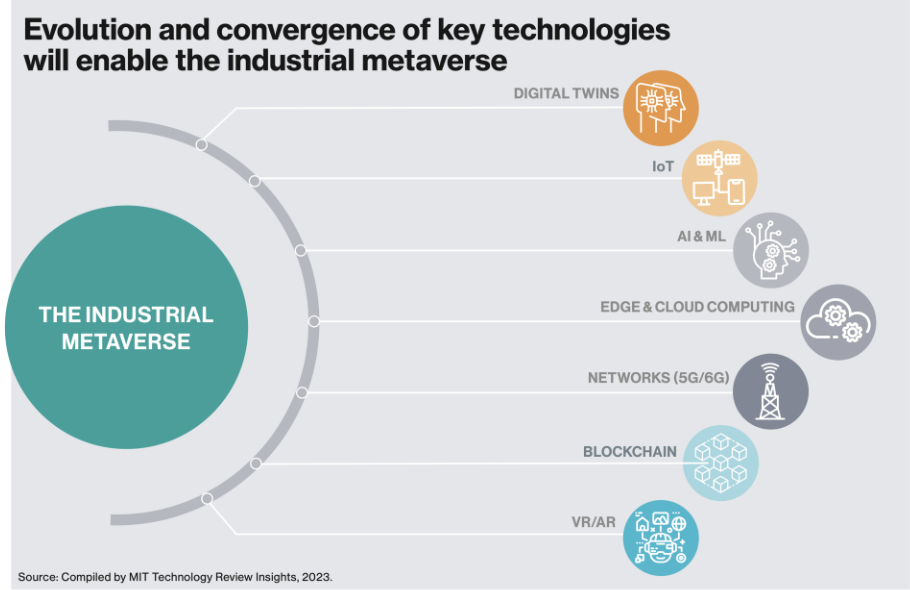
AIOTI WG Smart Manufacturing

December 2022

Rise of Industrial Metaverse







Source: Siemens

- Combining and connecting the real and digital worlds to improve operations over the entire life cycle.
- Key technology of the Industrial Metaverse - Digital Twins already combine the real and the digital worlds to fast track planning of factories.

connecting EU
solar value chains

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HPE's approach to sustainable IT

Equipment efficiency

- Balance resiliency, efficiency, workloads and capacity
- Eliminate zombie equipment
- Increase computex/storage utilization
- Use application optimized equipment where possible
- Take advantage of monitoring and optimization software
- Understand the implications of various workloads

Energy efficiency

- Power management tools
- Specify efficient technology solutions idle consumption
- Consider the implications of rising processor power consumption
- Develop formal refresh cycles based on performance improvements
- Monitor energy/carbon of technology infrastructure
- Consider both power and thermal implications when optimizing

Resource efficiency

- Optimize facilities and IT infrastructure, operations, procedures, training
- Deliver efficient cooling and power conversion/backup systems
- Implement a water efficiency strategy
- Integrate data center infrastructure, IT infrastructure monitoring, and efficiency monitoring tools

Software efficiency

- Select energy efficient software
- Standardize on efficient languages and performance engineering practices
- Leverage CPU/GPU architectural efficiency features
- Take advantage of new algorithmic advances
- Use automated optimization applications

Data efficiency

- Analyze data collection frequency
- Deliver actionable and high-impact insights
- Optimize environmental impact and cost of data movement
- Evaluate use of data retention
- Drive efficiency in data storage media