DENiM
Digital intelligence for collaborative ENergy management in Manufacturing

Nimbus Research Centre

DENIM: DIGITAL INTELLIGENCE FOR ENERGY EFFICIENT MANUFACTURING

PATHWAYS TO PRACTICE

DR. ALAN MCGIBNEY
NIMBUS CENTRE, MTU

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 958339

ICT Research & Innovation Ecosystem

MTU

Nimbus Research Centre

Research & Training

Technology Development

TECHNOLOGY GATEWAYS
delivering solutions for industry
NIMBUS - Embedded Computing & Software Systems
an Enterprise Ireland network

Rubicon

Commercialisation

- Approx 40 Staff: (researchers, engineers, admin, students)
- 4.5 M€/annum,
- Working with 200 companies in Ireland & EU, > 60 projects per year

Science Foundation Ireland sfi For what's next

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

ENTERPRISE IRELAND
where innovation means business

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Research Areas

Nimbus Research Centre

Digital Platforms

Architecture design and engineering; Smart systems integration; Open and scalable IoT platform for data integration, visualisation, fusion and distribution.

Advanced Digital Skills

Educational approaches based on Communities of Practice, Supporting digital transformation through a new education and training framework.

Future Networks

Lifecycle management for reliable embedded networks; QoX provisioning for reliable, low latency wireless networks (WSN, LPWAN, 4G/5G).

Cyber Secure Systems

Secure digital value chains: Distributed Ledger Technology for secure trusted interaction between "things". Secure Services for IoT-driven control.

Transforming Industries - Make things connected, secure and smart

Smart Energy

Smart Buildings & Construction

Sustainable Manufacturing

Smart Communities

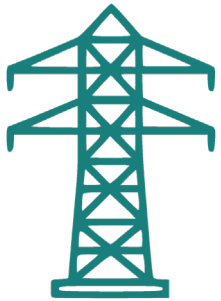
CURRENT CHALLENGES

Disparate Data Sets across Systems & Roles

Energy Efficiency Independent of Production Process

Manual "what-if" Scenario Creation and Analysis

Cadence-based Planning and Decision making



Limited interaction with Grid

Digital Skills Gap between Energy, IT & Data Experts

DENiM
Digital intelligence for collaborative ENergy management in Manufacturing

Academia

MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

Scuola universitaria professionale della Svizzera italiana SUPSI

Universidad de Sevilla

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

Université de Namur

Technology Providers

R2M Research to Market Solution

ERREQUADRO Research over Research

tecnalia MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

K-LOOPS

idener SCIENTIFIC COMPUTING

BAG-ERA

scmgroup Industrial Machinery and Components

VTT

CONSORTIUM: USE CASES

Sustainable production planning & maximising the use of renewable energy (Ireland)

Energy-efficient steelmaking and forging processes management (Spain)

Edge Intelligence for continuous energy optimisation of industrial machines (Italy)

Digital Twin of machining processes for production planning (Slovenia)

KEY STRATEGIES

Systems need to collaborate across technologies, industries, and responsibilities to uncover energy flows and unlock energy efficiencies.

Continuous performance assessment is essential to ensure precise predictions and efficient energy target management.

Manufacturing systems must evolve and adapt to changing operation conditions, requirements & system configurations to support & promote sustainability.

INNOVATION PILLARS

Business practices

Best Practice

Enabling Technologies

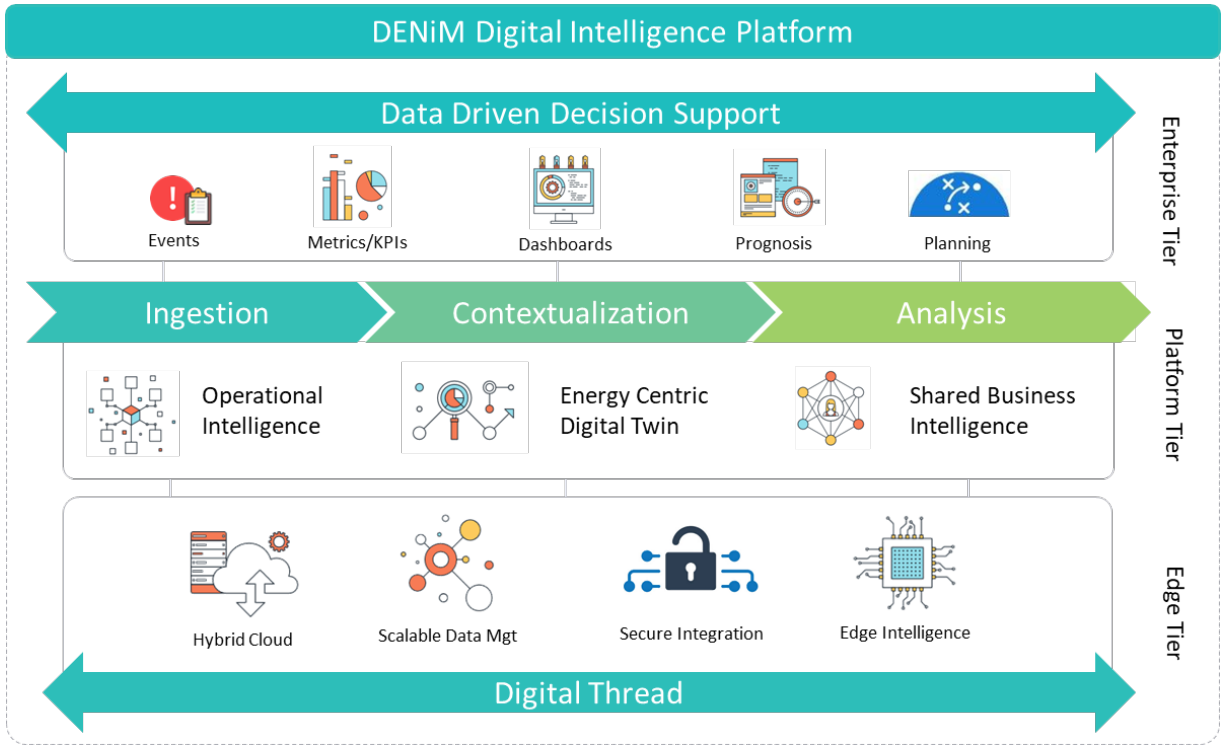
Workforce Development

Key Objectives

Digital Services

SOLUTION AT A GLANCE

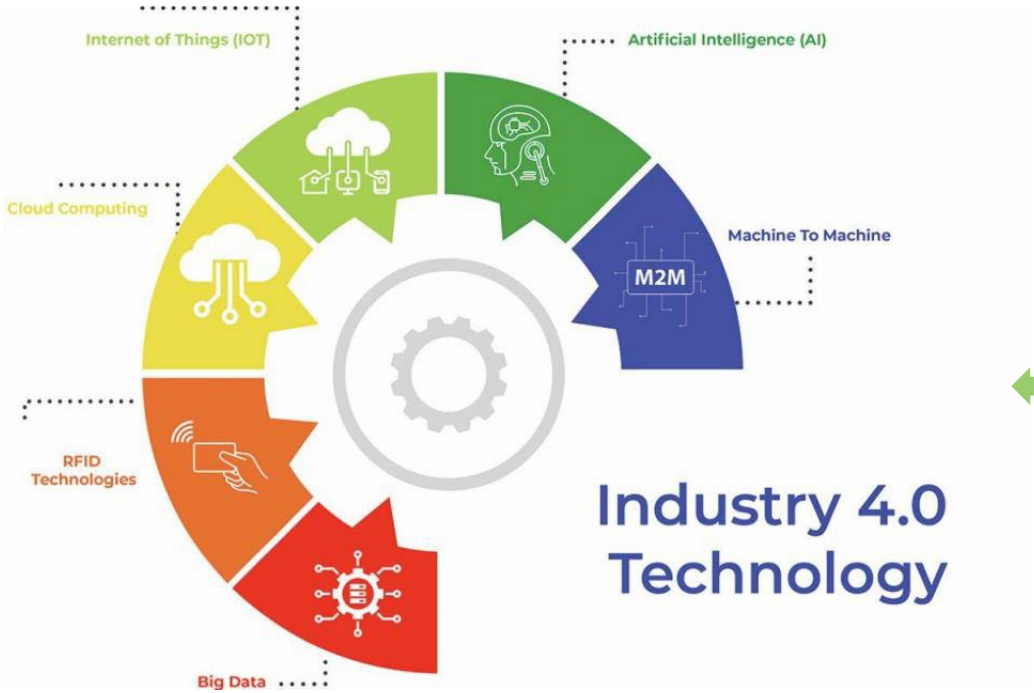
- Secure and real-time data collection, aggregation and processing
- Holistic Approach to Energy Efficiency
- Continuous Event-Driven Analysis based on Accurate Models
- Digitalisation Supporting Collaborative Decision Making
- Integration of Renewables with Production Process
- Assessment of soft skills, upskilling & improved awareness



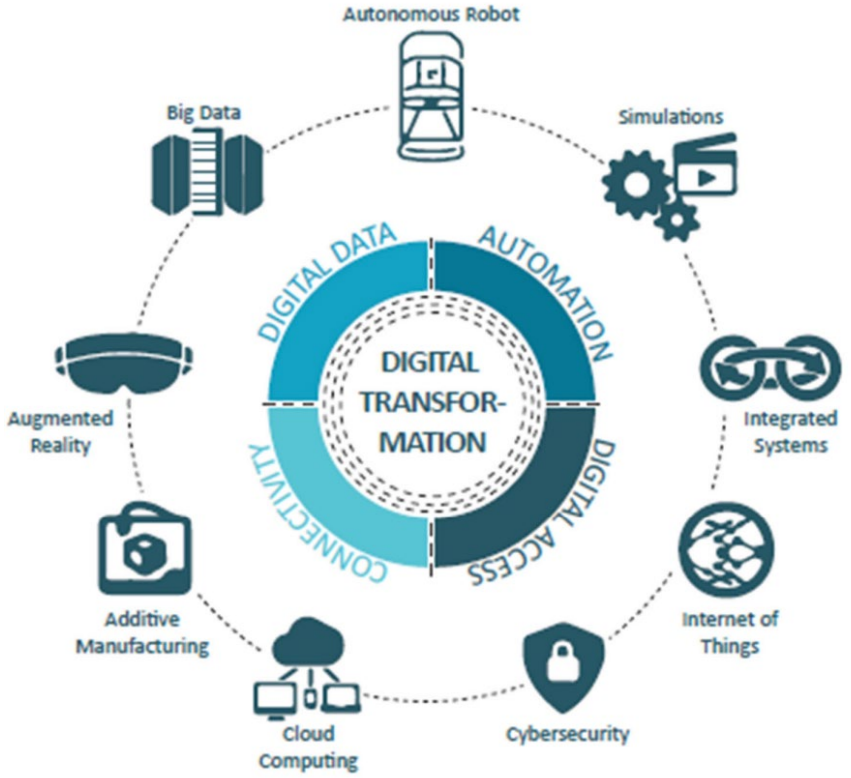
PATHWAYS TO PRACTICE

HOW DO WE MAKE THE DENIM AMBITION A REALITY

DIGITAL TRANSFORMATION IN MANUFACTURING



Enabling



Source: https://timesofmalta.com/articles/view/industry-40s-myriad-of-opportunities.906232

Vite, Clara & Morbiducci, Renata. (2021). Optimizing the Sustainable Aspects of the Design Process through Building Information Modeling. Sustainability. 13. 3041. 10.3390/su13063041.

PATHWAY FOR ENERGY EFFICIENCY

A pathway is made up of different levels or milestones that represent the evolving steps towards the most advanced situation

For DENiM it is about defining the pathway for energy efficiency using digital technologies

Benefit of pathways?

- Can facilitate and stimulate the discussion and identification of innovation strategies for company/sector-specific scenarios (and replication!).
- Allow us to demonstrate how R&D projects are contributing solutions for future smart manufacturing
- Pathways are supported by cross-cutting aspects that enable progress along the pathways, e.g. tools, skills, training, infrastructure, cyber security etc.

PATHWAY DESIGN

Readiness Assessment	Milestone Definition	Key Enablers	Pathway Definition
Step 1	Step 2	Step 3	Step 4

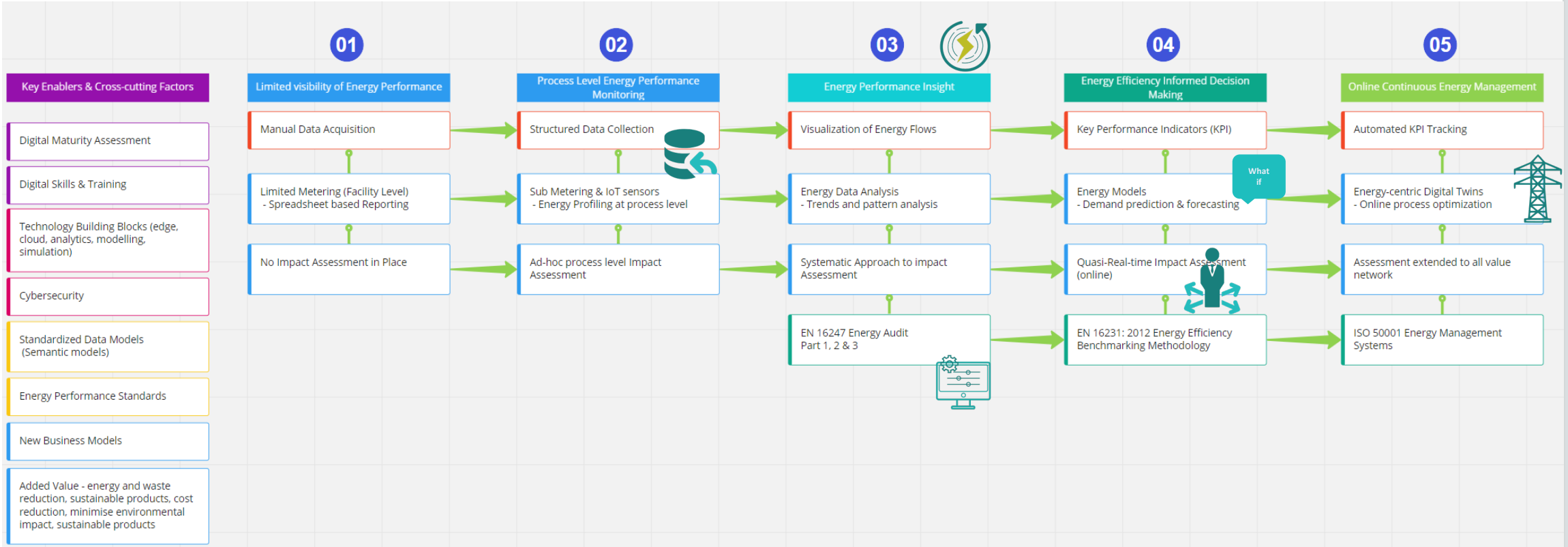
DENiM

ECOFACT

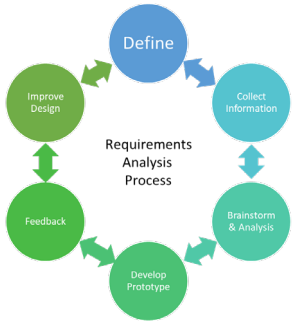
E2CO

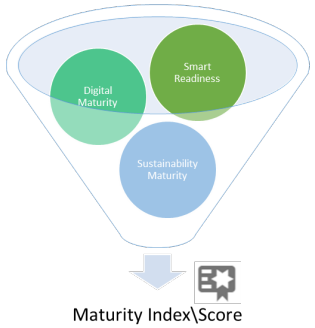
EnerMan

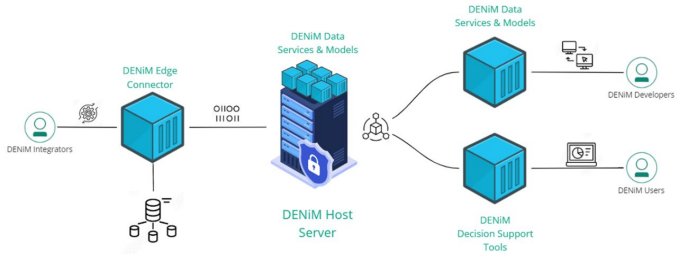
1ST ENERGY EFFICIENCY PATHWAY

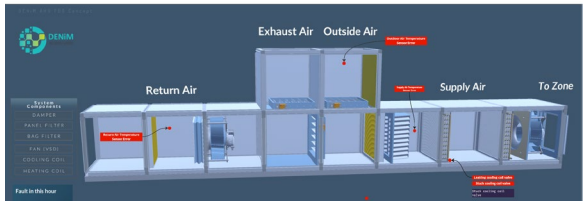


DESIGN LED APPROACH





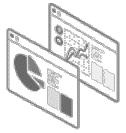




M12

Implementation planning established baseline, roadmap and pathway setting

M18



P0 – Lab Prototype:
Integration Readiness

M24

P1 – First prototype:
Integrated Prototype Deployed

M36

Prototype Evaluation:
Refinement of DENiM Solution – Decision Support Tools

M42

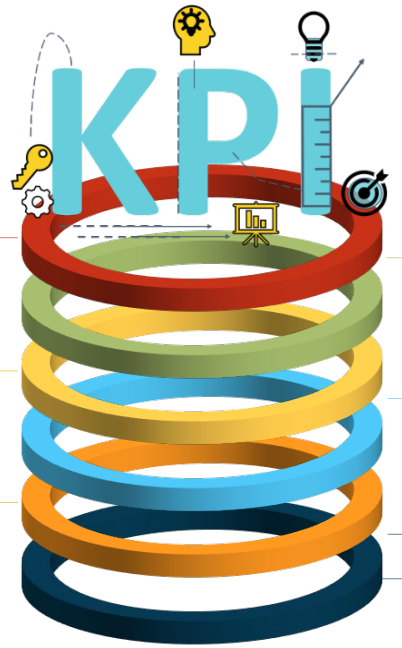
P2 - Final Prototype:
Full Digital Intelligence Platform

Goal Setting

Implementation Planning

DENIM HOLISTIC ASSESSMENT FRAMEWORK

- Environmental Indicators
  - Inventory
    - waste, emissions, material, water, energy
  - Impact
    - Product Environmental Footprint (PEF) & Organisation Environmental Footprint (OEF)
- Economic & Cost Indicators
  - CAPEX
    - Ownership costs
  - OPEX
    - Direct & Indirect operational and maintenance costs



KPI-P3-1: REDUCTION OF ELECTRICAL ENERGY
Reduction of energy consumption e.g. minimising idling time (5%), cutting air of machines.

KPI-P3-2: REDUCTION OF OVERALL ENERGY
Optimise production planning and scheduling to reduce energy consumption

KPI-P3-3: COST REDUCTION PER PRODUCT AND PROCESS
Optimise production planning and scheduling to reduce operational cost

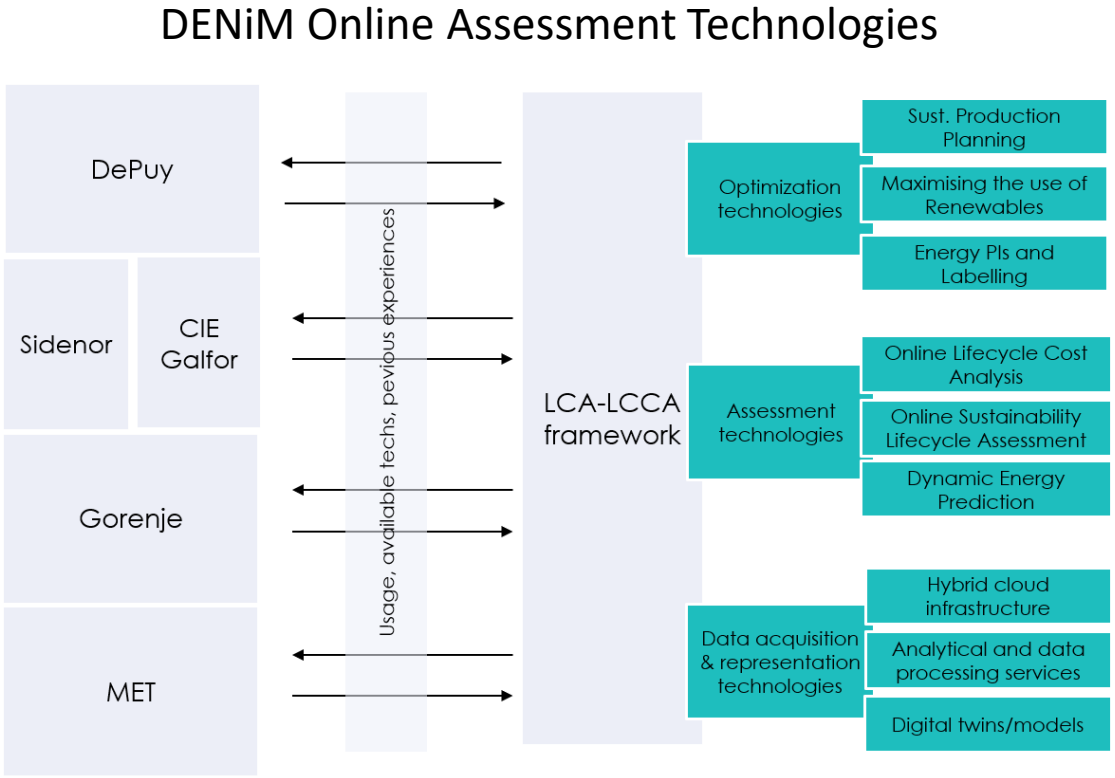
KPI-P3-4: SCRAP REDUCTION ACROSS PROCESS
Optimised operation and quality controls through digitalization will allow to reduce production scrap

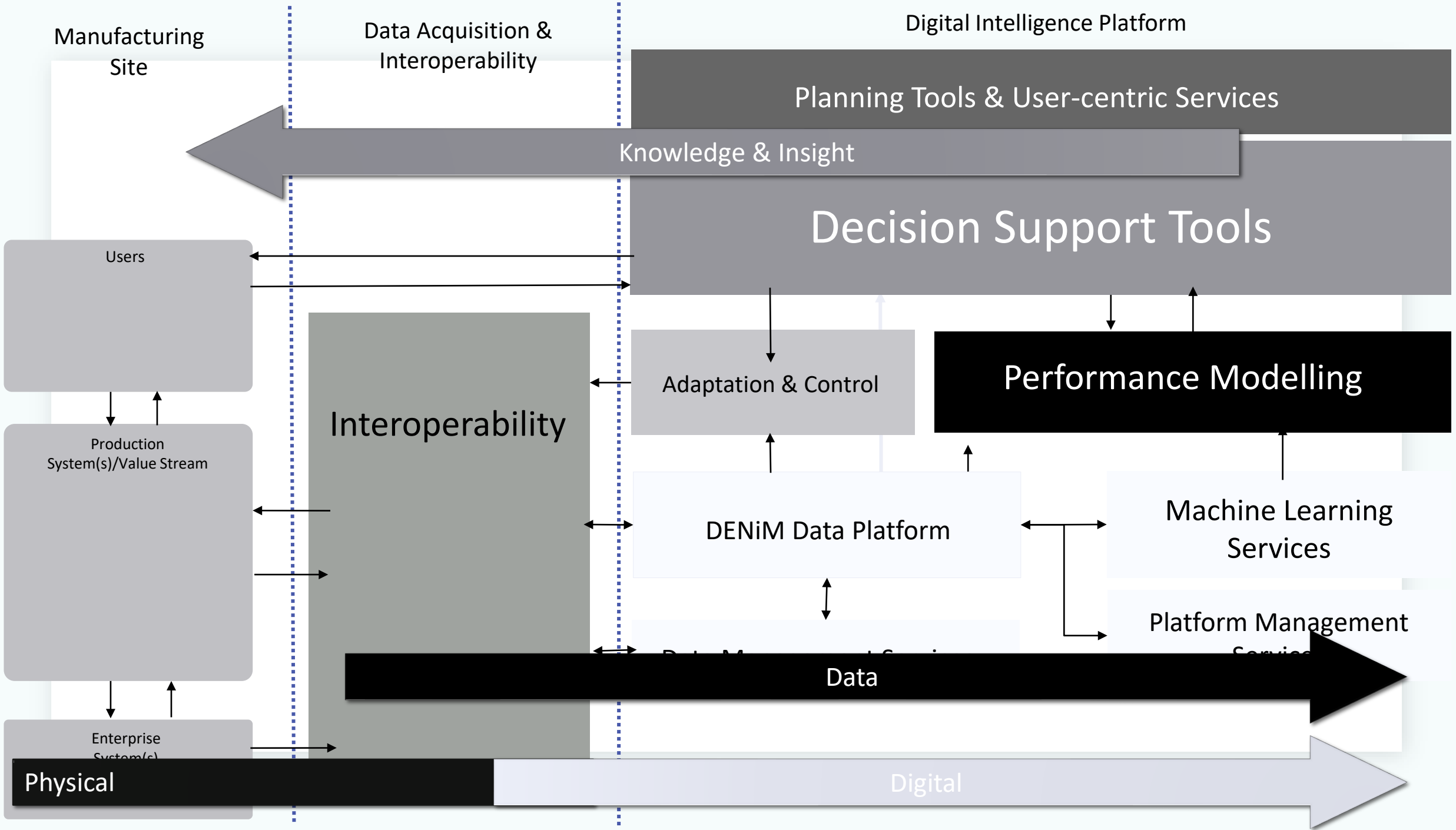
KPI-P3-5: REDUCTION OF TOOL WEAR
Optimised operation and quality controls through digitalization will allow to reduce the tool wear.

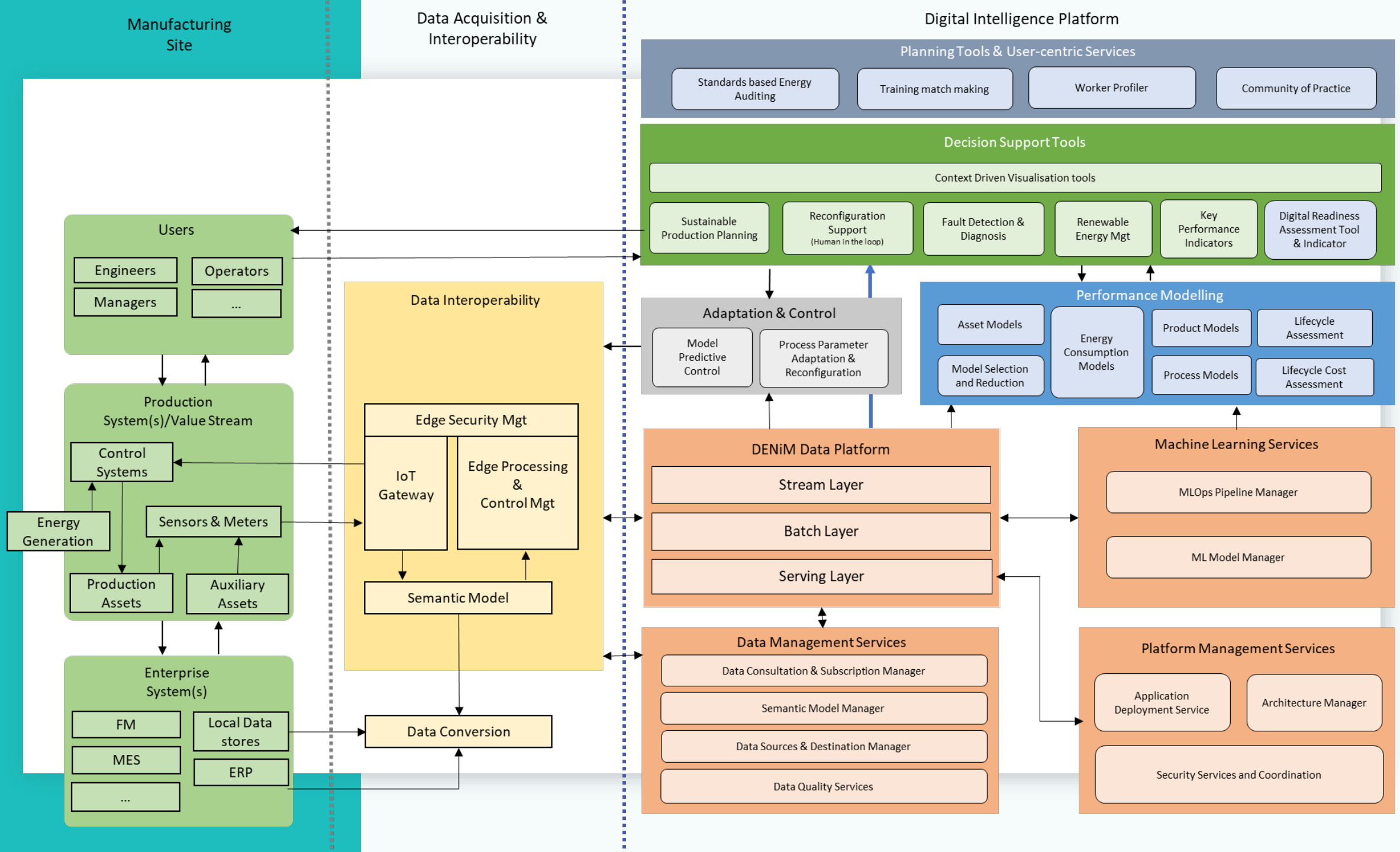
KPI-P3-6: ENERGY-INTENSIVE MACHINES MONITORED
The number of machines e.g. milling, grinding, pressings to be improved with monitoring systems in real time.

KPI-P3-7: DIGITAL SUPPORTED WORKFLOWS
Number of digital services involved in new approach created within DENIM project e.g. monitoring and optimization of machines.

DENIM HOLISTIC ASSESSMENT FRAMEWORK




Manufacturing Site
Data Acquisition & Interoperability
Digital Intelligence Platform
Planning Tools & User-centric Services
Knowledge & Insight
Decision Support Tools
Users
Interoperability
Adaptation & Control
Performance Modelling
Production System(s)/Value Stream
DENiM Data Platform
Machine Learning Services
Platform Management
Data
Enterprise
Physical
Digital

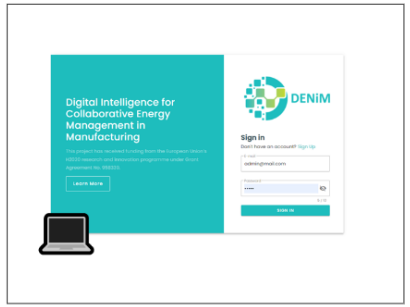

Manufacturing Site
Data Acquisition & Interoperability
Digital Intelligence Platform
Planning Tools & User-centric Services
Standards based Energy Auditing
Training match making
Worker Profiler
Community of Practice
Decision Support Tools
Context Driven Visualisation tools
Sustainable Production Planning
Reconfiguration Support (Human in the loop)
Fault Detection & Diagnosis
Renewable Energy Mgt
Key Performance Indicators
Digital Readiness Assessment Tool & Indicator
Users
Engineers
Operators
Managers
...
Data Interoperability
Adaptation & Control
Model Predictive Control
Process Parameter Adaptation & Reconfiguration
Performance Modelling
Asset Models
Energy Consumption Models
Product Models
Lifecycle Assessment
Model Selection and Reduction
Process Models
Lifecycle Cost Assessment
Production System(s)/Value Stream
Control Systems
Energy Generation
Sensors & Meters
Production Assets
Auxiliary Assets
Edge Security Mgt
IoT Gateway
Edge Processing & Control Mgt
Semantic Model
DENiM Data Platform
Stream Layer
Batch Layer
Serving Layer
Machine Learning Services
MLOps Pipeline Manager
ML Model Manager
Enterprise System(s)
FM
MES
...
Local Data stores
ERP
Data Conversion
Data Management Services
Data Consultation & Subscription Manager
Semantic Model Manager
Data Sources & Destination Manager
Data Quality Services
Platform Management Services
Application Deployment Service
Architecture Manager
Security Services and Coordination

Digitisation to support sustainable production planning and maximising the use of renewable energy in Medical Device Manufacturing

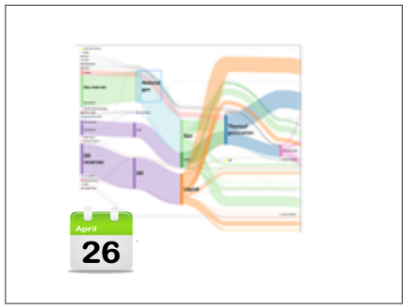
DePuy Synthes
THE ORTHOPAEDICS COMPANY OF Johnson&Johnson

Target Benefits	DPS Cork Opportunity
Energy reduction	DPS energy cost **30-35%**
Wastage / Scrap	Poly scrap value 2019 **5-10%**
Cost reduction	DPS Cork CIP target of approx. **10 -20%**
Digital service	85% of all production and facilities equipment will be metered

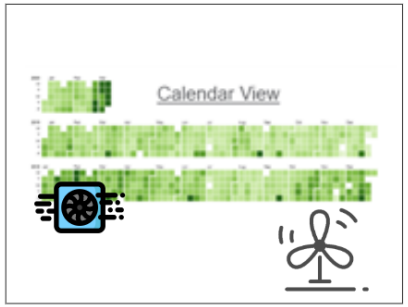
PILOT SCENARIO – CUSTOMER JOURNEY



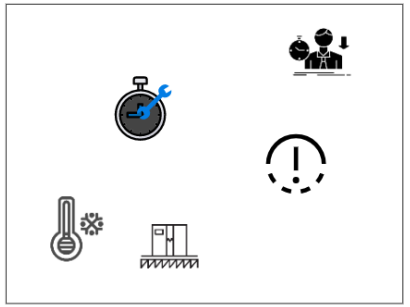
Trigger **Action**	
Julie opens her web browser and types in the URL to access the DENiM HMI	
Who	Operations team lead
Where	• On site
What	• Access DENiM via URL • Login to system using credentials



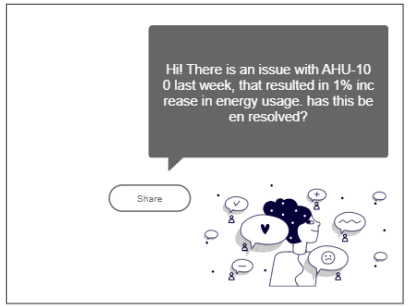
Discovery **Looking for inspiration**	
Julie gets presented with the site level dashboard showing performance metrics and related data. Julie selects "Process view" and selects the Poly Stream and selects analysis period	
Who	Operations team lead
Where	• DENiM HMI Process View
What	• Select Process View from list • Select time frame for analysis • Select baseline time period • Select Metrics e.g. energy flow, waste/scrap



Analysis **Digging Deeper**	
Julie wants to understand more on where most energy is being consumed, she therefore looks at the list of assets and their associated energy consumption	
Who	Operations team lead
Where	• DENiM HMI - Asset View
What	• Views list of assets relating to poly stream • Loads energy for given asset • A heatmap is generated on a daily representation of energy

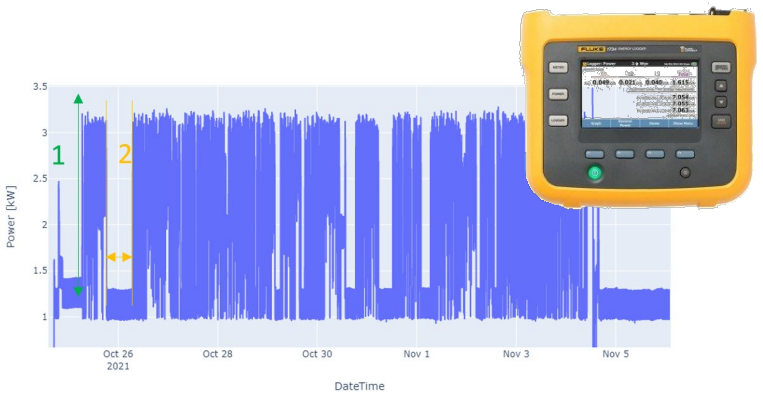


Target Areas **Cause and effect**	
Julie wants to see why auxiliary services have consumed so much during this period, therefore she selects auxiliary asset (e.g. AHU) and sees a timeline of activities over the period	
Who	Operations team lead
Where	• DENiM HMI - Activity View
What	• Selects view activities and events • timeline is shown with events • detected faults and issues are highlighted • it is seen that the machine was operational outside of manufacturing time period



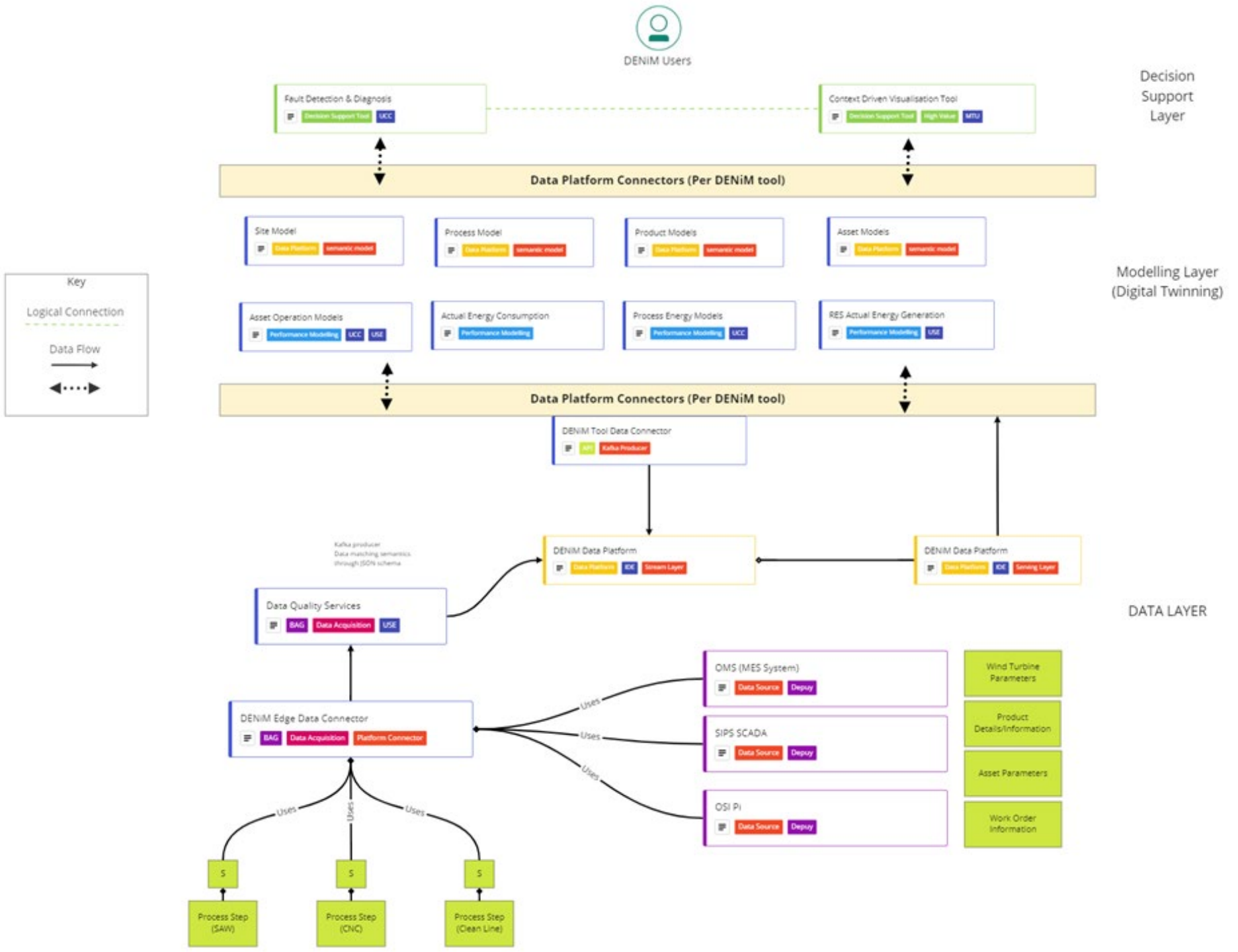
Report **Final Conclusions**	
Julie records the difference from the baseline and that energy has increased by 1%. this is due to auxiliary services fault. Julie contacts maintenance to understand if issues have been resolved	
Who	Operations Team Lead, Maintenance Team
Where	• DENiM HMI - Collaboration Message
What	• Generates report from findings • Baseline performance for poly stream is provided • a message is generated and sent to the Maintenance Team & Julies Manager

DEPUY PROTOTYPE

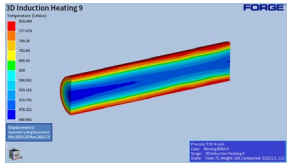


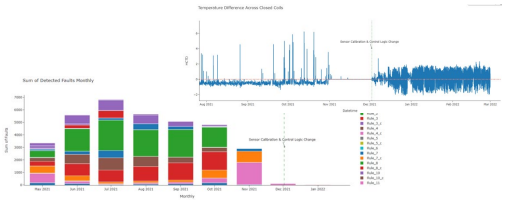
DEPUY ARCHITECTURE PATTERN

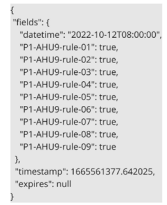
DENiM On Premise Deployment

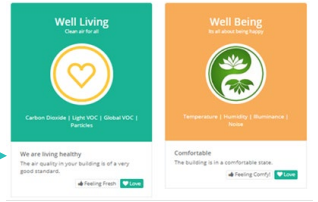


FAULT DETECTION & DIAGNOSIS









DENiM Data Platform
Data Platform | IDE | Stream Layer

Asset Operation Models
Performance Modelling | UCC | USE

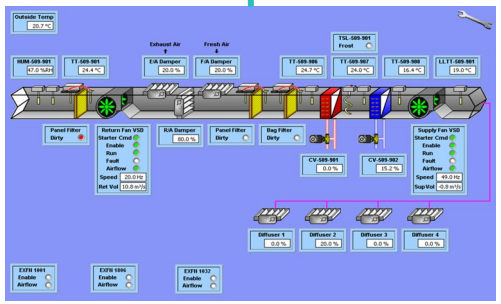
DENiM Edge Data Connector
BAG | Data Acquisition | Platform Connector

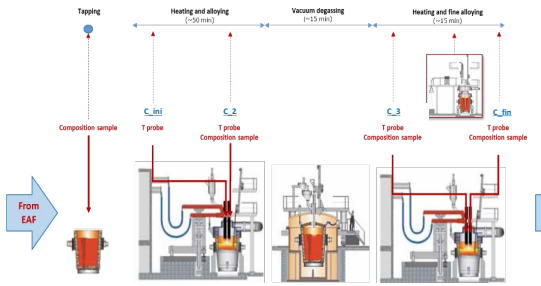
OSI-PI

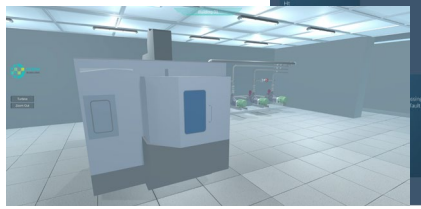
Kafka Stream

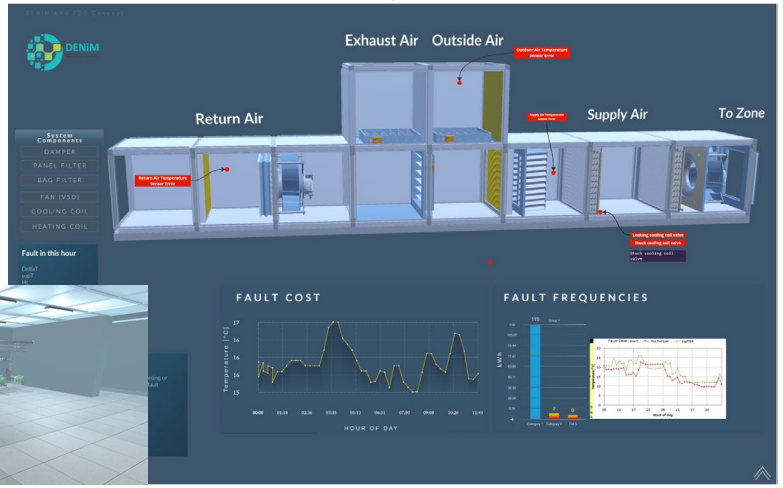
Kafka Stream

DENiM Data Platform
Data Platform | IDE | Stream Layer









WHAT WE HAVE LEARNED

1. Lack of a Digital Transformation Strategy
2. Lack of relevant expertise & skills in-house
3. Complexity of Software & Technology integration
4. Refence Architecture & Common Information Model
5. Driving Adoption of New Tools & Processes (culture & change management)
6. Common assessment frame – baselining & benchmarking
7. Cyber security concerns – reluctance to share data
8. Budget Constraints

OPPORTUNITIES FOR KNOWLEDGE SHARING

Technical

- Common Requirements
- DENiM Reference Architecture could inform DiCIM platform definition
- Digital Maturity & Skills Assessment
- Promotion of best practice, standards

Dissemination & Communications

- Workshops, dissemination events & sharing of best practice
- Publication Opportunities
- Engine Initiative – Create Working Group with sister projects

Join the community

Informed Stakeholder

Stay informed about all project developments, events and meetings by subscribing to the newsletter.

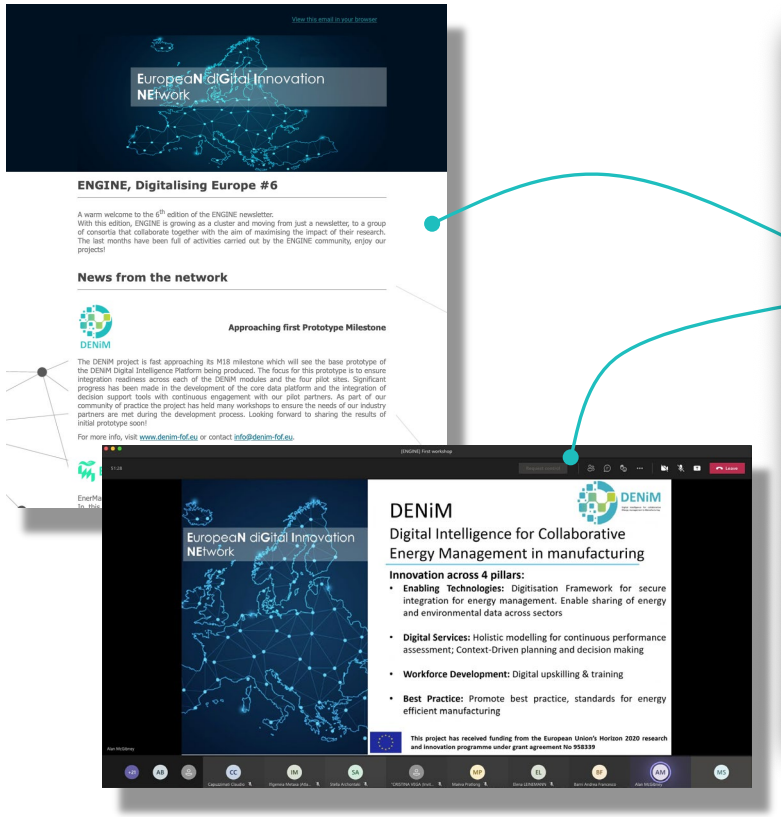
Subscription will also give you the opportunity to follow the developments of DENiM's sister projects thanks to the collaboration with the European project aggregator ENGINE.

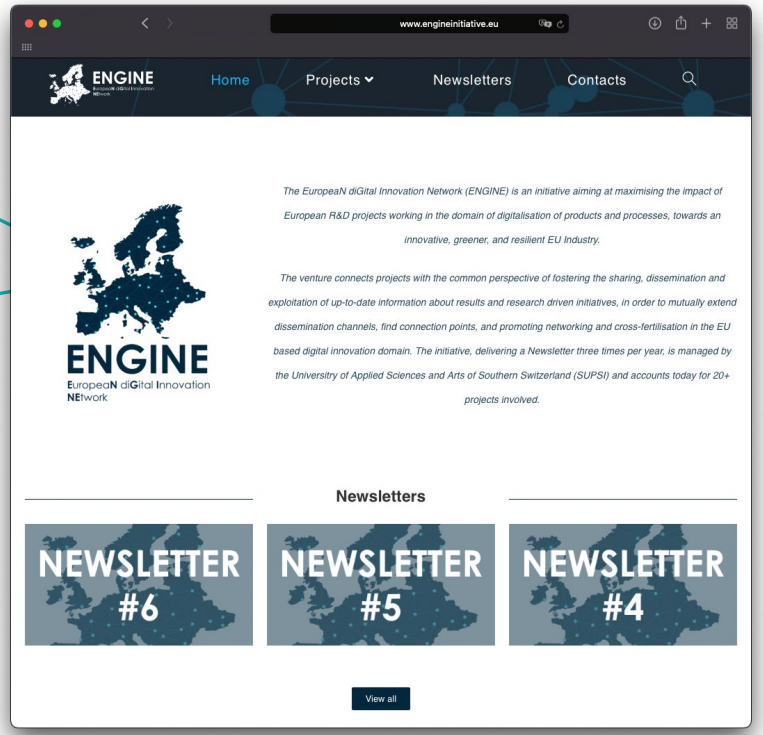
Involved Stakeholder

Participate in our events and workshops by subscribing as involved stakeholders!

In addition to periodic updates, you will have the opportunity to participate in the development and learn more about the activities carried out in the project (such as meetings, workshops, events and more recent developments).

JOINT ACTION - ENGINE INITIATIVE





ENGINE
EuropeaN diGital Innovation NEtwork

engineinitiative.eu

Collaboration across European projects for knowledge sharing and maximizing exploitation effort

Workshops, collaborative newsletters

20+ EU project involved

FoF-09 Project Catalogue

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Introduction

All projects mentioned in this brochure; DENIM, ECOFACT, ENERMAN and E2COMATION are funded by Horizon 2020 and are grouped together under the call DT-FOF-09-2020 - Energy-efficient manufacturing system management (IA).

The specific objective of advanced manufacturing and processing research and innovation is to transform today's manufacturing enterprises, systems and processes. This will be done by leveraging key enabling technologies in order to achieve more knowledge-intensive, sustainable, resource- and energy-efficient trans-sectoral manufacturing and processing technologies, resulting in more innovative products, processes and services. Enabling new, sustainable products, processes and services and their competitive deployment, as well as advanced manufacturing and processing is also essential for achieving the objectives of the priority 'Societal challenges.'

To answer the specific problem for this call and to improve industrial energy efficiency requires the integration of energy data, such as historical data, real-time data and real-time predicted energy cost, into the production management systems. Manufacturing systems are complex because many parameters, related to environment, components, usage of materials, machines, cells, lines and supply chains, collectively influence the energy performance of production processes.

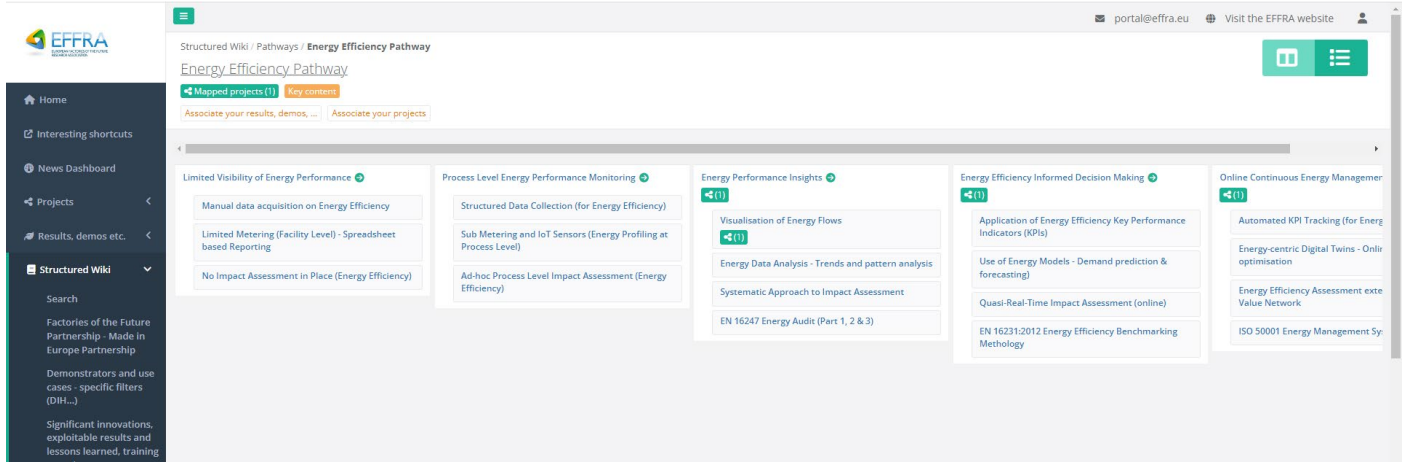
Different technologies of energy-efficient manufacturing have already been studied in the past. However, the challenge is now to combine all these technologies in a holistic, intelligent and interoperable approach to ensure a comprehensive implementation, providing significant energy savings. Collectively these projects will develop energy-efficient best practices to overcome the barriers limiting their application in the manufacturing sectors.

The following brochure contributes to identify innovation leaders, demonstrating new technologies and approaches, bringing down barriers or sharing good practices among recent EU funded projects.

Energy Efficiency Pathway for Manufacturing: White Paper

SCAN ME

SCAN ME



Pathways to Energy Efficient Manufacturing through Digitisation

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Abstract

This article presents the outcomes of a collaborative activity across four EU funded projects, under DT-FOF-09-2020 - Energy-efficient manufacturing system management, focused on establishing innovative ways and best practice for leveraging digital technologies to implement more energy efficient manufacturing systems. The outcome of this work is the definition of a pathway towards energy efficiency that allows industry to understand their current situation and to stimulate the definition of a strategic road map to incorporate energy efficiency as a key criteria in operational and organisational decision making. This research presents the findings and the design of such a pathway.

Keywords

Digitisation; Energy Efficient Manufacturing; Pathways; Energy Management

Plain Language Summary

Manufacturing is one of the largest energy-consuming sectors and responsible for approximately a third of the global energy demand. Therefore, energy management is key to ensuring that manufacturing remains competitive as well as being sustainable as part of the global energy transition. Digital technologies will play a significant role in helping the manufacturing industry by providing the ability to automatically monitor and optimise energy usage, while continuously informing stakeholders with regard to the environmental and economic impact of the decisions made at all stages of the manufacturing process. This involves the integration and embedding of advanced digital services including secure-edge connectivity, the Internet of Things (IoT), data analytics, digital twin and automation within existing business roles such as process optimisation, production planning, facilities and energy management. However, this combined green and digital transition is a multi-faceted and complex task for any organisation as such this article explores approaches to reduce the barriers and minimise risk of making this transition. This results in the definition of an innovation pathway for energy efficiency through digitisation.

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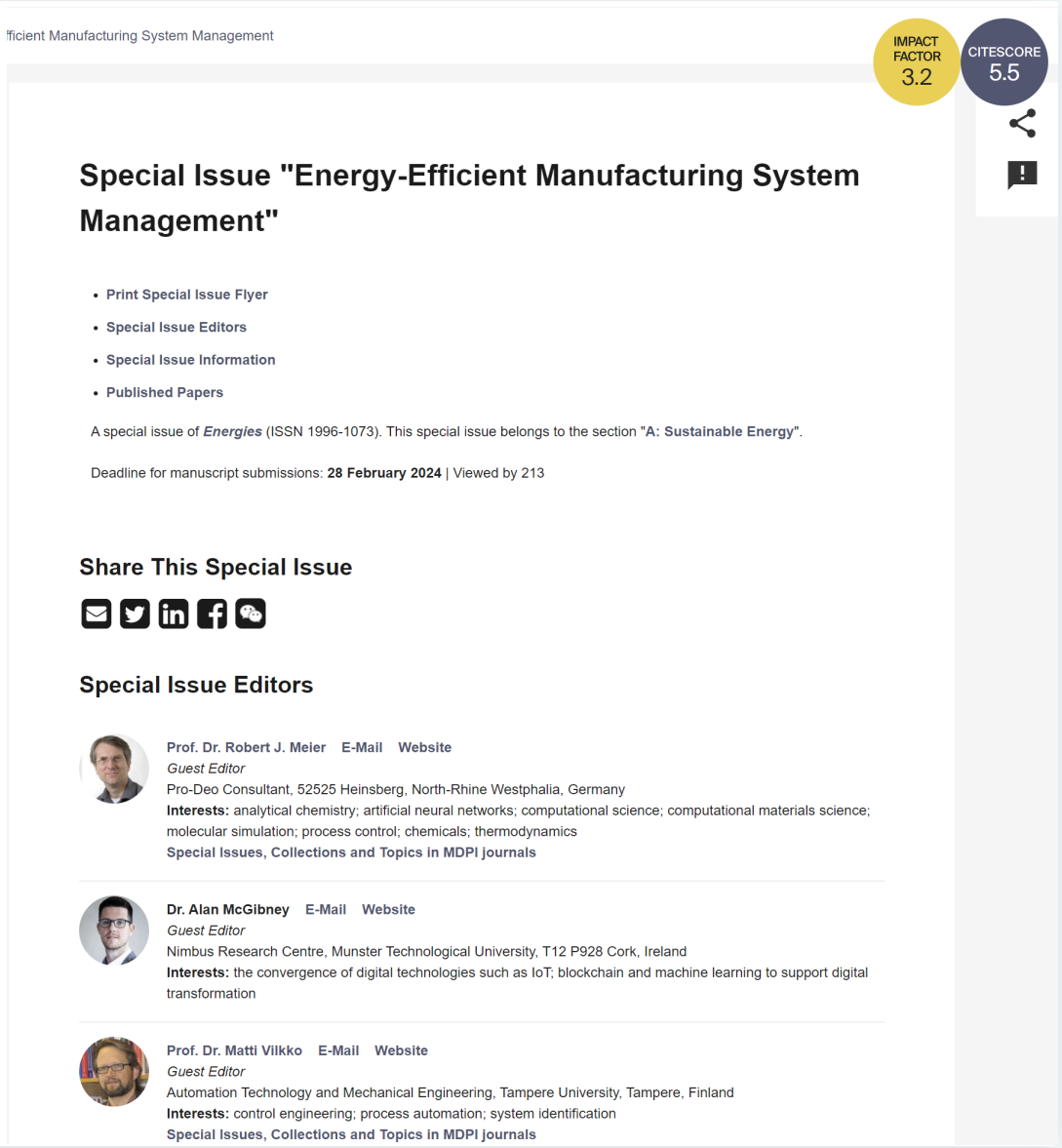

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