2023 - Catalogue

# Energy Efficient Manufacturing

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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.

# DENiM - Digital Intelligence for Collaborative energy management in manufacturing

IIOT - Smart sensors & meters

Data Analytics - ML workflows

Digital Twin - Simulation based, physical models, data driven

Dynamic LCA/LCCA

Fault Detection & Diagnosis

Sustainable Production Planning

Renewable Energy/ Flexibility

Data Visualisation

Training & upskilling

## General Project Info

| | |
|---|---|
| Website | https://denim-fof.eu/ |
| Coordinator | Munster Technological University (Alan McGibney, Susan Rea) |
| Consortium List (Country, Partner) | DePuy (Ireland) Unlimited, Ireland<br>Sidenor aceros especiales SL, Spain<br>SCM Group SPA, Italy<br>Gorenje, Slovenia<br>R2M Solution SRL, Italy<br>IDENER Research & Development, Spain<br>MET SNC, Italy<br>BAG-ERA, France<br>Erre Quadro SRL, Italy<br>VTT, Finland<br>Universidad De Sevilla, Spain<br>SUPSI, Switzerland<br>Tecnalia, Spain<br>University College Cork, Ireland<br>Universite De Namur ASBL, Belgium<br>K-Loops SRL, Italy<br>CIE Galfor SA, Spain |
| Start Date | 1 November 2020 |
| Duration | 48 Months (End date 31 October 2024) |
| Total Budget | €11,007,262.30 - EU contribution €9,685,107.99 |
| Project Acknowledgement | This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement N 958339. |

## Brief Description

The overarching objective of DENiM is the development of an interoperable digital intelligence platform to enable a collaborative approach to industrial energy management.

DENiM will provide an integrated toolchain to provision advanced digital services including secure edge connectivity leveraging IoT, data analytics, digital twin, energy modelling and automation culminating in the delivery of continuous energy impact assessment, together with energy control and optimisation across existing production facilities, processes and machines.

From a DENiM perspective, digital intelligence refers to the ability to transform digital data extracted from heterogenous sources (shop floor, machines, planning, quality, maintenance) into real-time, actionable, energy-centric insights. This will enable industry to take advantage of digital technologies to improve their energy efficiency and competitiveness by gaining better knowledge of the actual energy demand of their machines/systems/plants as well as further automating production processes.

This in turn provides opportunities for developing human competences in terms of digital skills in synergy with technological progress. This will allow the manufacturing sector to maximise the potential promised by Industry 4.0 (and towards Industry 5.0 paradigm), by reducing the gap between the technological capabilities (e.g. Digital Twin, Big Data Analytics) and achievable impact (energy reduction, cost reduction, sustainability). DENiM will leverage the convergence of innovative digital technologies including Digital Twin, IoT, Cloud/ Edge Computing, Machine Learning, Modelling and Simulation to provide advanced services, which enables more sophisticated business practices and data processes, thus improving the understanding, capacity and efficiency of the manufacturing processes.

linkedin.com

youtube.com

@DENiM_fof

Countries involved:

Demo site:

Medical device manufacturing

Steel components

Composite Parts

Tools production

## Objectives and Targets

The key objectives of DENiM are categorised across the four collaborative pillars:

**Enabling Technologies:** DENiM will leverage the convergence of innovative digital technologies including Digital Twin, IoT, Cloud/Edge Computing, Machine learning and Modeling and Simulation, to provide advances services towards energy reduction, cost reduction and sustainability improvements.

**Objective 1:** Enable sharing of energy and environmental data across sectors

**Objective 2:** Digitisation framework for secure data and system integration for energy management

Digital Services: Tools and mechanisms will be developed to transform digital data extracted from heterogenous sources (shop floor, machines, planning, quality, maintenance) into real-time, actionable, energy- centric insights

**Objective 3:** Holistic Modelling for Continuous Performance Assessment

**Objective 4:** Continuous event-driven Planning and Decision Making

**Workforce Development:** new digital skills will be developed to enable industry to take advantage of digital services and technologies, gaining a better knowledge of the actual energy demand of machines/systems/plants as well as automating production processes.

**Objective 5:** Digital Maturity, Skills & Training

**Business Practices:** DENiM will showcase advanced digital technologies for energy management and will adopt energy related standards, contributing to working groups for the enhancement of current standards and the uptake of these across DENiM pilots sectors.

**Objective 6:** Cross-Sector evaluation of Energy Management Technologies

**Objective 7:** Promote Best Practices for Sustainable\Energy Efficient Manufacturing

**Objective 8:** Standardisation and Certification for Energy Performance Monitoring and Auditing

**Objective 9:** Data Protection, Legal & Ethical Framework

## Expected Impacts

Energy Reduction/Savings

- Significant reduction of energy across four different industrial sectors (30-40%)

Lifecycle Cost Reduction

- Substantial cost savings (15-20%) from optimised operation.

Scrap\Waste Reduction

- Reduction of scrap, waste (5-10%) improved environmental performance of involved products

Digital Services

- Map energy flows across the complete manufacturing value chain (50-100% increased monitoring).
- Integrate energy efficiency into existing business processes through digitalisation (2-5 new digital workflows)

Digital Skills

- Digital skills assessment & training across 4 industry sectors

## Pilot Summary

Through the DENiM pilots the project is applying design-based research using a "communities of practice" approach to enable the collaborative development and validation of new digital technologies and practices in conjunction with diverse pilot partners.

There are 4 pilot sites including three large industry players in their respective sectors (medical device, steel making and tool manufacturing) delivering significant scope to replicate and scale up the solution across other EU and global sites. The fourth pilot is an SME (composite part machining) starting with low digital maturity level but a strong ambition to improve energy efficiency, which will provide an opportunity to demonstrate the flexibility of DENiM to scale to smaller sites and make significant impact. Each site will leverage the DENiM enabling technologies to address site specific challenges and provide new opportunities to increase digitialisation across the value chain and decision support for energy, cost and waste reduction.

# ECOFACT - ECO-innovative Energy FACTory Management System based on enhanced LCA and LCCA towards resource-efficient manufacturing

IIOT - Smart sensors & meters
Data Analytics - ML workflows
Digital Twin - Simulation based, physical models, data driven
Dynamic LCA/LCCA
Fault Detection & Diagnosis
Sustainable Production Planning
Renewable Energy/ Flexibility
Data Visualisation
Training & upskilling

## General Project Info

| | |
|---|---|
| Website | https://ecofact-project.eu/ |
| Coordinator | Fundacion CARTIF (Francisco Morentin) |
| Consortium List (Country, Partner) | FUNDACION CARTIF, Spain<br>RINA CONSULTING SPA , Italy<br>FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY, Italy<br>ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS , Greece<br>FUNDACION CIRCE CENTRO DE INVESTIGACION DE RECURSOS Y CONSUMOS ENERGETICOS, Spain<br>SCHNEIDER ELECTRIC SPA , Italy<br>ONE TEAM SRL, Italy<br>PRE CONSULTANTS BV, Netherlands<br>IRISH MANUFACTURING RESEARCH COMPANY LIMITED BY GUARANTEE (IMR), Ireland<br>FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, Germany<br>ASOCIACION ESPANOLA DE NORMALIZACION, Spain<br>AENOR INTERNACIONAL SA, Spain<br>WINGS ICT SOLUTIONS INFORMATION & COMMUNICATION TECHNOLOGIES IKE, Greece<br>ATHENIAN BREWERY SA, Greece<br>ARCELIK A.S., Turkey<br>TOFAS TURK OTOMOBIL FABRIKASI ANONIM SIRKETI, Turkey<br>GALLETAS GULLON SA, Spain<br>Competence Industry Manufacturing 4.0, Italy<br>SMARKIA ENERGY .S.L. , Spain<br>VEOLIA SERVICIOS LECAM SOCIEDAD ANONIMA UNIPERSONAL, Spain |
| Start Date | 1 October 2020 |
| Duration | 48 Months (End date 30 September 2024) |
| Total Budget | €12.314.473,75, EU contribution €9.893.318,13 |
| Project Acknowledgement | This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement N 958373. |

## Brief Description

ECOFACT will put particular focus on (i) the development of an adapted methodology and high level platform enabling manufacturing industries to optimize the energy performance of their production systems in line with their relevant constraints (time and resources), while at the same time (ii) introducing a novel green marketing approach through the concept of energy and environmental signature of the manufactured products from a life-cycle perspective. These results will be achieved thanks to (i) the integration of energy-related information through the uptake of advanced ICT and digital solutions, while (ii) contributing to reduced environmental footprint and (iii) enhanced integral sustainability in manufacturing management. Specific platform modules and use case validations will also allow for the particularities of advanced manufacturing processes and flexible production, while facilitating supply chain collaborations through dedicated services.

The main objective of ECOFACT is to develop and demonstrate up to TRL 7 an ECO-innovative Energy FACTory Management platform based on improved dynamic LCA and LCCA towards holistic manufacturing sustainability. Focus is on the effective combination of ICTs for advanced data collection and processing, which enables a streamlined decision-making process within the production chain, also enhancing interoperability and flexibility to maximize the replication, upscaling and standardization potential within different plant sizes and manufacturing sectors.

ECOFACT will gather cutting-edge knowledge and experience from production processes, professional simulation tools as well as energy and resource planning standards, to develop and demonstrate an integrated approach, methodology and platform for boosting efficiency of both energy and material resources (linked as an Energy and Resources Management System tool) at factory level while the impact on the whole value chain is considered. The project will be industry-driven and focus on the development of a single, flexible high-level platform for holistic management and decision support.

linkedin.com
youtube.com
@Ecofact_Project

Countries involved:

Demo site:

Washing machines/fridges

Brewery

Biscuit factory

Car manufacturer

## Objectives and Targets

5 Scientific and Technological Objectives (STO), together with 3 Non-Technological Objectives (NTO), have been identified for the ECOFACT project:

[STO1] - Enabling the integration of massive energy data into production management systems thanks to improved connectivity between the Information Technology and Operations Technology domains.

[STO2] - Helping manufacturing operations and maintenance (O&M) staff to forecast problems, do better planning and improve performance in the use of (energy and material) resources thanks to a prognosis based Energy and Resource Management System (ERMS).

[STO3] - Contributing to better control the environmental signature of manufacturing processes and supply chains, enabling green production and product design as a cost-saver and marketing tool for manufacturing businesses.

[STO4] - Development of practical guidelines (ECOFACT methodology) and user-centric tool (ECOFACT software platform) for holistic (process, energy, environment) sustainable manufacturing management supported by the combination of enabling smart ICTs.

[STO5] - Demonstration of ECOFACT methodology and platform at TRL7 in 4 case studies across different manufacturing sectors.

[NTO1] - Providing inputs to new standardization, certification and regulation schemes on integrated, sustainable manufacturing management.

[NTO2] - Development of exploitation strategies for the validated ECOFACT approach and platform creating attractive business cases and fostering early replication

[NTO3] - Dissemination, communication and capacity building.

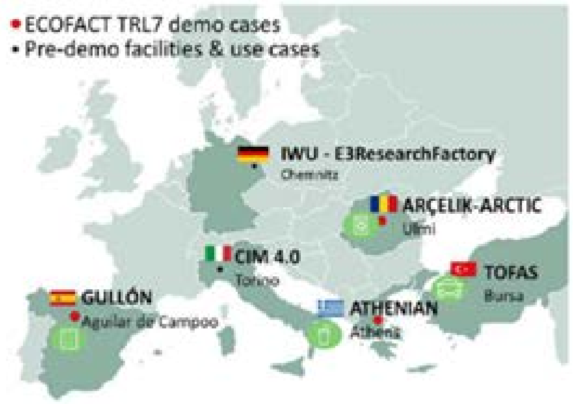
## Expected Impacts

- Energy consumption reduction for the selected and improved production process of at least 25%
- Life Cycle Cost reduction of at least 15%
- Improved environmental performance of the involved products
- Development of standardised European energy-efficient best practices to overcome the barriers limiting their application in the manufacturing sectors

## Pilot Summary

2 TRL6 validation sites and 4 TRL7 demonstration case studies are included in ECOFACT, as indicated in Figure 1. ECOFACT is a "demonstration-to-market" project aiming to identify the ultimate technical and non-technical barriers to overcome before full marketability of the holistic sustainable manufacturing concept and platform by 2028-2030.

| # | TRL | DEMO (Sector) |
|---|---|---|
| PD1 | TRL6 | CIM4.0 (Additive Manufacturing Lab) |
| PD2 | TRL6 | IWU (E3 Research Pilot Factory) |
| D1 | TRL7 | ARÇELIK-ARTIC (White Goods) |
| D2 | TRL7 | ATHENIAN BREWERY (Beverage) |
| D3 | TRL7 | GULLON (Food) |
| D4 | TRL7 | TOFAS (Automotive) |



EnerMan

# ENERMAN - Energy Efficient Manufacturing System Management

IIOT - Smart sensors & meters

Data Analytics - ML workflows

Digital Twin - Simulation based, physical models, data driven

Dynamic LCA/LCCA

Fault Detection & Diagnosis

Sustainable Production Planning

Renewable Energy/ Flexibility

Data Visualisation

Training & upskilling

## General Project Info

| | |
|---|---|
| Website | https://enerman-h2020.eu/ |
| Coordinator | Centro Ricerche FIAT SCPA (CRF) - Italy |
| Consortium List (Country, Partner) | AVL List GmbH (AVL) – Austria<br>FH OO Forschungs & Entwicklungs Gmbh (FHOOE) – Austria<br>Stomana Industry SA (STN) – Bulgaria<br>Internet of Things Applications and Multi-Layer Development (ITMLCY) – Cyprus<br>University of Cyprus (UCY) – Cyprus<br>ISAE-Supméca – Institut Supérieur de Mécanique de Paris (SUPM) – France<br>AEGIS IT Research GmbH (AEGIS) – Germany<br>Infineon Technologies AG (IFAG) – Germany<br>SimPlan AG (SIMPLAN) - Germany<br>Telecommunication Systems Institute (TSI) – Greece<br>Yiotis Anonimos Emporiki & Viomixaniki Etaireia (YIOTIS) – Greece<br>Industrial Systems Institute, Athena Research Center (ISI) – Greece<br>University of Patras (UOP) – Greece<br>Johnson & Johnson Depuy Synthes (DPS) – Ireland<br>Università degli Studi di Napoli Federico II (UNINA) – Italy<br>Maggioli SPA (MAG) – Italy<br>Prima Electro S.p.A. (PE) - Italy<br>3DNew Technologies (3DNT) – Italy<br>Sphynx Technology Solutions AG (STS) – Switzerland<br>ASAS Aluminyum Sanayi Ve Ticaret AS (ASAS) – Turkey<br>Intract Inovasyon Danismanlik Limited Sirketi (INTRACT) - Turkey |
| Start Date | 1 January 2021 |
| Duration | 36 Month |
| Total Budget | €12 202 500 |
| Project Acknowledgement | This project received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement n° 958478 |

## Brief Description

EnerMan envisions the factory as a living organism that can manage its energy consumption in an autonomous way. It will create an energy sustainability management framework collecting data from the factory and holistically process them to create dedicated energy sustainability metrics. These values will be used to predict energy trends using industrial processes, equipment, and energy cost models.

EnerMan will deliver an autonomous, intelligent decision support engine that will evaluate the predicted trends and access if they match predefined energy consumption sustainability KPIs. If the KPIs are not met, EnerMan will suggest and implement changes in energy affected production lines control processes.

The EnerMan administrators will be able to use the above mechanisms in order to identify how future changes in the production lines can impact energy sustainability using the EnerMan prediction engine to visualize possible sustainability results when in-factory changes are made in equipment, production line.

The EnerMan digital twin will predict the economic cost of the consumed energy based on the collected and predicted Energy Peak load tariff, Renewable Energy System self-production, the variations in demand response, possible virtual generation, and prosumer aggregation.

Finally, EnerMan considers the operators actions within the production chain as part of a factory's energy fingerprint since their activity within the factory impacts the various production lines.

Current and predicted energy consumption/ sustainability trends on specific assets of the factory are collected and visualized in a virtual, extended reality model of the factory to enhance the situational energy awareness of the factory personnel.

linkedin.com

youtube.com

@EnerManH2020

Countries involved:

Demo site:

Automotive

Food

Metal

Medical

## Objectives and Targets

**Objective 1:** Intelligent, autonomous, flexible and reconfigurable energy sustainability manufacturing closed control loop manager.

**Objective 2:** An intelligent, holistic, secure and trusted sensor data collection and analysis mechanism.

**Objective 3:** Digital twin for all energy operations

**Objective 4:** User experience analysis

**Objective 5:** Demonstrations in 8 use cases

**Objective 6:** Contributing new energy standards

**Objective 7:** Business and financing models for project results

## Expected Impacts

ENERMAN energy sustainability aware Digital Twin, which facilitates the simulation of possible scenarios and predicts possible outcomes on energy consumption, environmental impact and energy cost, allowing one to try new strategies without impacting the actual manufacturing production.

In ENERMAN, production scheduling and production process variations data will be collected in real-time and will be included in the holistic pre-processing to extract energy sustainability metrics/features.

Machine functionality status: estimation of the level of operability in the industrial equipment in order to predict possible long-term malfunctions that will impact energy consumption/sustainability. Short term energy consumption predictions: Using production line variations, conditions within the manufacturing process, supply chain variations we can observe how changes in these variations and conditions will impact energy consumption in the immediate future.

Environmental impact: Predict how the factory energy consumption impacts the physical environment though $CO_2$ emissions.

It also enables the administrators to evaluate various test scenarios in a virtual environment that helps them assess their factory energy sustainability impact in the future without disturbing the actual factory manufacturing.

## Use Cases

Automotive manufacturing the painting process

Engineering: A testing facility for vehicles

Semiconductor manufacturing: An energy optimized global supply chain

Food Industry: Chocolate processing and manufacturing

Metal manufacturing: Autonomous trigeneration facility for aluminium industry

Medical device industry: Titanium and CoCr alloys manufacturing

Metal manufacturing: Energy consumption in iron and steel manufacturing

Additive manufacturing: Processing metal components

# E2COMATION - Life-cycle optimization of industrial energy efficiency by a distributed control and decision-making automation platform

IIOT - Smart sensors & meters

Data Analytics - ML workflows

Digital Twin - Simulation based, physical models, data driven

Dynamic LCA/LCCA

Fault Detection & Diagnosis

Sustainable Production Planning

Renewable Energy/ Flexibility

Data Visualisation

Training & upskilling

## General Project Info

Website: https://e2comation.eu/

Coordinator: Consiglio Nazionale Delle Ricerche - CNR STIIMA (Andrea Ballerino)

Consortium List (Country, Partner): NXTCONTROL GMBH - Austria, SYNESIS-SOCIETA CONSORTILE A RESPONSABILITA LIMITATA - Italy, SIMPLAN AG - Germany, ACT OPERATIONS RESEARCH IT SRL - Italy, SIGMATOOLS GMBH - Switzerland, KATHOLIEKE UNIVERSITEIT LEUVEN - Belgium, SOFTWARE AG - Germany, THINKING ADDITIVE LTD - United Kingdom, ATHENS TECHNOLOGY CENTER ANONYMI VIOMICHANIKI EMPORIKI KAI TECHNIKI ETAIREIA EFARMOGON YPSILIS TECHNOLOGIAS - Greece, INSTITUTO TECNOLOGICO METALMECANICO, MUEBLE, MADERA, EMBALAJE Y AFINES-AIDIMME - Spain, SCUOLA UNIVERSITARIA PROFESSIONALE DELLA SVIZZERA ITALIANA - Switzerland, OCME SRL - Italy, MAHOU SA - Spain, CONDIS SUPERMERCATS SA - Spain, KASTAMONU ENTEGRE AGAC SANAYI VE TICARET ANONIM SIRKETI - Turkey, ROYO SPAIN SL - Spain, SCM GROUP SPA - Italy DESIGNO - Italy

Start Date: November 1st 2020

Duration: 48 Months

Total Budget: €10,560,000 EU contribution €8,105,775

Project Acknowledgement: This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement N 958410

## Brief Description

Improving industrial energy efficiency at European Manufacturing level requires the integration of energy data with advanced optimization techniques to guide a company decision making.

E2COMATION intends to address the optimization of energy usage, at multiple hierarchical layers of a manufacturing process as well as considering the whole life-cycle perspective across the value chain.

E2COMATION's envisioned model of a factory embraces the capability to be:

- Self-conscious, in the sense of being able to perceive, monitor and analyse the whole set of energy and material flows characterizing the production environment, and the ensemble of events which change their normal patterns;
- Predictive, in order to detect/adapt/optimize its management and control strategy under productivity and ecofriendliness constraints;
- Adaptable at multiple levels to enable the responsiveness to unforeseen occurrences;
- Scalable, so as to be replicable and easily expandable or upgraded in different application contexts;
- Sustainable under a life-cycle perspective, through the adoption of newly conceived methodological approaches.

To this purpose, E2COMATION aims at providing a cross-sectorial methodological framework and a modular technological platform to monitor, predict, evaluate impact of the behaviour of a factory across energy and the life-cycle assessment dimensions, in order to adapt and optimize dynamically not only its real-time behaviour over different time-scales, but also its strategic and sustainable positioning with respect to the complex supply and value chain it belongs to.

For E2COMATION to be successful, it is fundamental that the effectiveness of its methodological approach and technological framework is proved in complex industrial scenarios, involving several factories of different sectors. This will be achieved by implementing the project platform in 2 completely different value chains, the food and drink one and the woodworking one, with 4 concurrent industrial use-cases.

linkedIn.com

youtube.com

twitter/E2COMATION

Countries involved:

Demo site:

Wood production

Furniture production

Beer production

Food production

## Objectives and Targets

E2COMATION major objectives are:

**1. Holistic analysis of energy-related data streams for production performance forecasting:** data stream handling for extracting reliable statistics for factory parameters , and data analytics at the higher knowledge layer for monitoring the behaviour of processes and products and for the extraction of more elaborate "cause-effect" performance indicators;

**2. Life-cycle conceptual paradigm applied to digital twinning of factory assets:** digital twin of the specific asset developed at shop-floor level, where energy and production dimensions will be correlated at runtime and corresponding models will be made available;

**3. Factory-level integrated multi-objective optimization architecture:** a unique optimization solution, where multi-objective optimization will jointly consider the dimensions of production, of energy, and the LCSA KPI models in a unique problem;

**4. Modular and scalable automation platform for distributed monitoring and supervision:** A scalable automation solution to seamlessly move across the automation pyramid from machine, to cell, to line, till plant level, as well as to enable the action of E2COMATION high level optimization and LCSA tools through dedicated cloud technologies for communication;

**5. Comprehensive simulation environment enhanced with energy and environmental performance:** Evolving "what-if scenario" simulation and virtual performance assessment runtime energy and LCA models at shop-floor level, whose parameters/models can be fetched and updated by data collection, analytics and IoT mechanisms to empower decision making;

**6. Energy Aware Planning and Scheduling tool (EAP&S):** real time scheduling and optimization of production, conjugating production efficiency and energy saving, by using flexibility in energy contracts based on real time exploitation of energy hourly price and leveraging on available degrees of freedom in production process;

**7. Life Cycle Assessment and Costing tool (LCAC):** a modular and dynamic tool to assess Life Cycle Assessment and Costing at factory/value chain levels against PEF/OEF, and also to predict environmental footprint based on advanced learning technique;

**8. Sustainable Computer Aided Process Planning (s-CAPP):** Dynamic CAPP including energy and lifecycle criteria as drivers in the multidimensional equations of CAPP activities, as well as correlating CAPP output with LCA oriented information, so as to endow new product/modified processes with precertification typical of PEF/OEF schemes;

**9. LCA-driven supply chain management (SCM) and business ecosystem:** Cloud-based solution for SCM to conceive an energy aware and sustainability driven tools that enable cooperation and optimization across the value chain.

**10. E2COMATION decision support platform for energy optimization and life-cycle management:** A Cloud based solution aimed at integrating in fact all tools and modules into one robust platform, enabling the seamless communication of tools towards orchestrating the collaboration of information, knowledge, and decisions to the plant floor and across the value chain, and facilitating the operations of E2COMATION by handling the interaction of the different modules, appropriately responding to expected and unexpected events or user-triggered actions.

## Expected Impacts

Energy consumption reduction of at least 25%

- Energy consumption reduction via Advanced control and supervisory management: by EAPS: 15%, by energy sources unit commitment: 5%, and by optimal supply chain management: 5%
- In-depth monitoring of energy performance: Percentage of plant's energy streams monitored: > 90%, with a percentage of monitoring of identified major energy consuming assets:> 95%

Life cycle cost reduction of at least 15%

- Reduction of investment costs: 5%
- Operations and maintenance costs: Reduction of energy costs: 15%
- Increase of production assets' useful life: 10%
- Indirect reduction of operation costs due to overall plant optimization: 5%
- Reduction of supply and logistics costs: 10%
- Reduction of downtime costs: 15%

Improved environmental performance of the involved products – food and drink value chain

- Reduction of energy usage: 25%.
- Reduction of water usage: 10%
- Reduction of transportation footprint: 15%

Improved environmental performance of the involved products – woodworking and furniture value chain

- Reduction of energy usage: 15-20%.
- Reduction of water usage: 10%

## Pilot Summary

Validation of E2COMATION tools and technologies will consider four industrial sites across two different values chains. Woodworking and furniture sector will be addressed with digital twin and through process optimization of MDF board production at KEAS plant in Gebze (Turkey), as well as energy aware scheduling and simulation tools with smart thermal energy grid management of ROYO furniture production facility in Valencia (Spain). Food & Beverage sector will encompass performance optimization of high speed bottling line in Mahou San Miguel Brewery in Alovera (Spain), as well as LCA-driven supply chain management applied to CONDIS SUPERMERCATS distribution center in Montcada (Spain). All involved industrial cases will validate advanced LCA & Costing tool, and benefit from scalable E2COMATION (energy) data gathering and stream analytics solutions.

# Conclusion

Improving industrial energy efficiency is a critical contribution towards achieving a sustainable future in the manufacturing domain. This requires new innovation to apply existing and investigate new techniques, tools, methods and approaches in the context of real-world environments. The role of the four funded DT-FOF-09-2020 projects (namely DENIM, ECOFACT, ENERMAN and E2COMATION) is thus to collectively contribute solutions to an energy efficient pathway, providing new innovative solutions that are evaluated and validated across different industrial sectors, promote best practice and share knowledge and lessons learned to help accelerate the digital and green transition for the manufacturing industry.

This catalogue provided an overview of the ongoing efforts of these EU Innovation actions, that are addressing the complexity of the energy efficient management of manufacturing systems.

Together these projects are developing best practices to overcome current barriers that limit the application of advanced digital solutions that can tackle energy efficiency in the manufacturing sector. The combination of ICT, such as digital twin, big data analysis, internet of things, cloud technologies and artificial intelligence, will lead to a shift from diagnosis to prognosis in controlling the consumption and cost of energy in manufacturing. In addition, the projects will provide actionable insights to link the environmental footprint of a given manufacturing process/plant from the equipment component to the whole facility and the entire value chain. The demonstration of these approaches and technologies, through a broad range of complex industrial case studies allows the projects to create new pathways to energy efficiency for industry.