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ECOFACT (ECO-innovative Energy FACTory Management System)

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Learning Objectives

- Learn about EU-funded R&D projects within the Horizon 2020 (H2020) program.
- Learn about ECOFACT targets and demonstration environments for the continuous and discrete manufacturing.
- Learn about the ECOFACT platform, in which an Energy and Resource Management System (ERMS) is combined with a dynamic LCA/LCC approach.
- Learn about the Autodesk Forge-based Digital Twin Platform (DTP) and its functionalities.

Description

ECOFACT is a 12M € Horizon 2020 EU-funded project made up of 20 consortium members from several European countries aiming at developing an ECO-innovative Energy FACTory Management platform using improved dynamic LCA/LCCA towards holistic manufacturing sustainability. The platform will be deployed in four different demo-sites: a biscuits factory (Gullón), an automotive factory of the Stellantis group (Tofaş), a brewery of the Heineken group (Athenian Brewery) and a white goods factory (Arçelik). One Team is leading the development of the Digital Twin Platform (DTP), based on Autodesk Forge and composed of production lines 3D models and different applications (material-flow simulations, energy simulations, production planning and scheduling, industrial energy disaggregation, industrial energy flexibility). The DTP will display simulation results and real-time IoT data alongside the 3D models leveraging Forge functionalities.

Speaker(s)



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Andrea Perego is a Management Engineer graduated with full marks at Politecnico di Milano who firmly believes in the power of ideas supported by sweat and tears.

Currently in One Team Andrea leads the business unit dealing with the scouting and management of value-added projects, including Research & Innovation projects funded by the European Union, mainly in the field of BIM and Digital Twins. Andrea and One Team's goal is to create value through innovation, fostering by the way the compliance with current sustainability paradigms.

Recently Andrea and his team have been working at three Horizon 2020 projects:

- www.bim4eeb-project.eu (7M € budget);
- www.infinitebuildingrenovation.eu (10M € budget);
- www.ecofact-project.eu (12M € budget).

Furthermore, as a Board Member of the company, Andrea is also in charge of managing strategic alliances with existing partners and scouting new ones.

In closing, as Marketing Director, Andrea has helped his team to manage the rebranding of the company, including the development of One Team's new website (www.oneteam.it).



[LinkedIn](#) 

Alder Moriggi is an analyst and software developer engineer at One Team, which is an Italian System Integrator company and Autodesk Platinum Partner.

As Senior Analyst, Alder works close to customers on many projects, covering different industries.

Alder has always worked in CAD & GIS fields, since 2012 with Autodesk software. In 2019 he started developing Forge Platform solutions.

About One Team

One Team Srl is a leading high technology SME with more than 30 years of experience in providing consultancy and end-to-end software and hardware solutions for Architecture, Engineering, Construction, Manufacturing, Owner/Operators (AECO) and GIS firms facing the challenges of implementing design, construction and geospatial digital tools. One Team has strong relationships with industry leading software manufacturers, for which it holds the top qualifications (Autodesk Platinum Partner, ESRI Silver Partner, HP Gold Partner...) and is a member of Autodesk, ESRI and Microsoft Developer Networks and, hence, is specialized in the integration of CAD / BIM / GIS / ERP systems.

For more information visit www.oneteam.it.



one team

Introduction

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

The project started in October 2020 with a €12 million budget almost entirely covered by the European Commission through its Horizon 2020 (H2020) program. With 20 consortium members coordinated by CARTIF, a Spanish research institution, the R&D work is expected to finish in September 2024. This means the project is currently in the middle of its four-year development.

The result will be a holistic and sustainable platform for the manufacturing environment, which will become fully marketable in 2028-2030.

One Team's role within ECOFACT is the creation of the Autodesk Forge-based Digital Twin Platform (DTP), which will act as an Energy and Resource Management System (ERMS).

Horizon 2020 (H2020)

H2020 was the EU's research and innovation funding program for the 2014-2020 period with a budget of nearly €80 billion.

As key H2020 objectives, climate action and sustainable development are relevant to all areas of the program. About 35 % of H2020's total budget addressed climate action, while about 60% involved sustainable development. H2020 provided grants to research and innovation projects through open and competitive calls for proposals. The program has been succeeded by Horizon Europe.

Among the numerous H2020's calls for proposals, ECOFACT is part of the energy-efficient manufacturing system management topic.

Project overview

ECOFACT partners are spread across seven different countries (Italy, Greece, Germany, Spain, Ireland, Netherlands and Turkey) and account for five research institutions, eight large industries, five SMEs and two associations.

The project's targets are well described by five Scientific Technological Objectives (STOs) and three Non-Technological Objectives (NTOs).

Targets

STO1 | Enabling the integration of massive energy data into production management systems thanks to improved connectivity between the Information Technology and Operations Technology domains. Target: developing one plug-and-play solution consisting of a hardware Smart Box for interoperable connection of different energy sensors compliant with the connectivity requirements of smart connection to distributed IIoT networks; a reduction of network resources and costs by 20% is targeted.

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). Target: controlling consumption and cost of energy addressing a cut on the factory energy bill by average of 25%.

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. Target: reducing environmental footprint of manufacturing processes by average of 4-8%.

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. Target: TRL7 validation of the ECOFACT platform in 4 complex case studies demonstrating a 25% reduction in the energy consumption and a 15% reduction in the LCC of the production processes.

NTO1 | Providing inputs to new standardization, certification and regulation schemes on integrated, sustainable manufacturing management. Target: ECOFACT will lead the elaboration of one CWA (CEN-CENELEC Workshop Agreement) as a pre-normative standard derived from the project results.

NTO2 | Development of exploitation strategies for the validated ECOFACT approach and platform creating attractive business cases and fostering early replication. Target: to conduct 5 feasibility studies towards reduced energy use and Life-Cycle Costs and improved product environmental performance.

NTO3 | Dissemination, communication and capacity building. Target: to engage at least 50 institutions (research, educational and EU) via additional Letters of Support (LoS) and 8,000 EU citizens in its communication campaign via demo-site visits, webinars, YouTube project videos, website, social media etc.

Demonstration environments

The ECOFACT platform and methodology is tested in four different demo sites at Technology Readiness Level 7 (TRL 7) or, in other words, as a system prototype in operational environment. Athenian Brewery and Gullón were chosen to validate the ECOFACT solution in the continuous manufacturing field. The first company, based in Greece, is part of Heineken and produces beer bottles, cans and kegs. The second, located in Spain, is one of the largest biscuit factories in Europe. The discrete manufacturing environment is instead represented by Tofaş (Turkey) and Arçelik (Romania). While the first plant is dedicated to the body painting of Stellantis' commercial vehicles, the second produces white goods (washing machines).

The ECOFACT concept is also pre-tested in two pre-demo facilities at TRL 6: the Italian CIM4.0 in its Additive Manufacturing (AM) production line and the German E³-Research Factory, which consists of pilot plant for digitalization and resource-efficient manufacturing.



Figure 1a, 1b, 1c & 1d: ECOFACT demo sites; from left to right Arçelik, Tofaş, Athenian Brewery and Gullón.



Figure 2: ECOFACT demo sites and pre-demos are located in Greece, Spain, Turkey, Romania, Italy and Germany.

ECOFACT platform

Three action pillars distinguish ECOFACT: (i) combination of cutting-edge ICTs (i.e. IIoT, ML, AI and digital twin) as enablers for data collection & processing and advanced decision-making; (ii) integration of energy and environmental data as well as assessments into production and business decision-making (sustainability awareness); (iii) demonstration and planning for replication of the ECOFACT concept to make a real impact in the EU industry.

In order to undertake the first two pillars, a single and integrated software platform is being developed: the ECOFACT platform.

The ECOFACT approach (figure 3) comprises a multi-scale structure of four innovation levels: (i) a field level with connected products and infrastructure for field data monitoring; (ii) an edge control layer for 24/7 real-time data acquisition and visibility; (iii) a Data Brokering Layer (DBL) bridging site information and cloud data services; (iv) an Apps&Services layer to empower industries through advanced data analyses and service recommendations.

The latter two innovation levels are also included in the ECOFACT platform (figure 3).

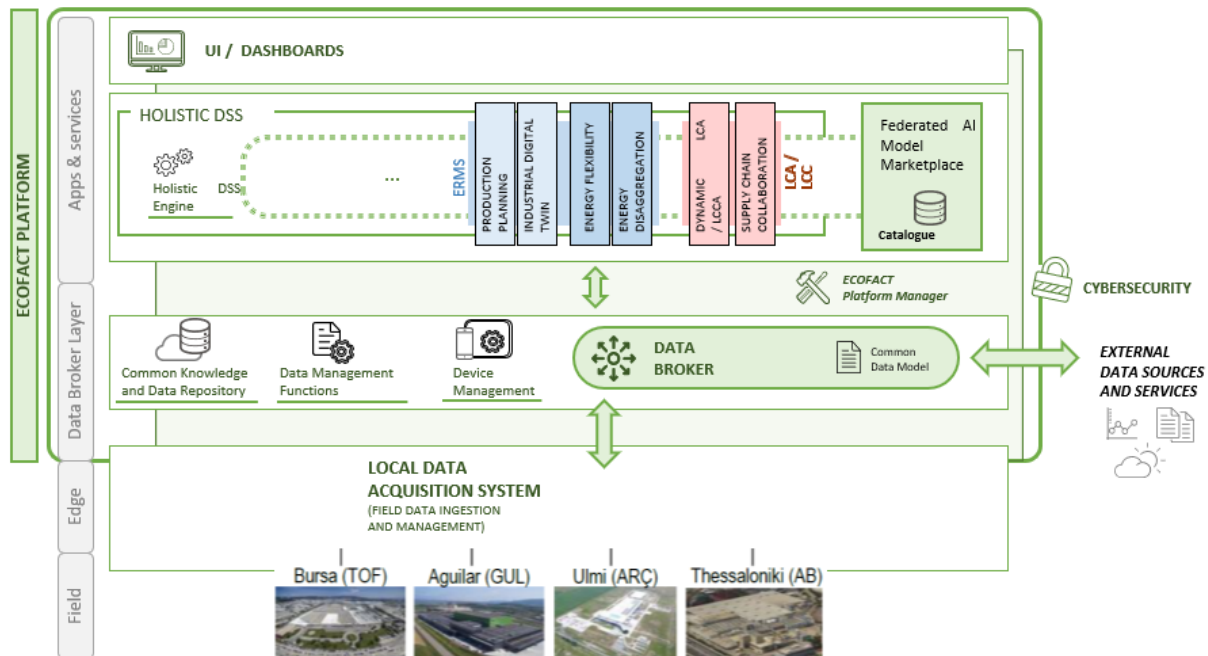


Figure 3: ECOFACT approach and platform; two out of four layers are included in the ECOFACT platform.

Focusing on the field level, a holistic energy and production monitoring is guaranteed through hardware boxes solutions integrating different sensors (temperature, power etc.) and connection standards and protocols. The edge control layer is instead useful to homogenize real-time data from the IIoT network, combining all levels of the automation pyramid in the field (sensors, PLC, SCADA, etc.) and creating a data stream channeling to higher-level layers.

Within the ECOFACT platform the DBL, which is responsible to aggregate data, accounts for a Data Broker, a common ECOFACT data model, a common knowledge & data repository and a device management. The Data Broker manages information streams accessible through a series of APIs by data producers, consumers or stream processors; it is based on an open-source stream-processing software platform (Kafka) enhanced with other functionalities. The common ECOFACT data model structures and organizes data elements at runtime and standardizes how they interact, guaranteeing interoperability among the edge control and App&Services levels. The common knowledge & data repository acts as an information storage that can be subscribed in real-time by data consumers – historical data are also served by this repository and transferred to the App&Services through the Data Broker. In closing the device management allows production managers to give new configurations to the edge control layer (through a specific UI contained in the App&Services).

In the context of the ECOFACT platform the App&Services level consists of a holistic Decision Support System (DSS) and a user-friendly UI/dashboard. Numerous data are incorporated into the DSS: outputs coming from a prognosis-based Energy and Resource Managements System (ERMS) and the dynamic LCA/LCC services, data collected by the field monitoring network and by external sources (e.g. energy pricing, weather forecasting etc.) and inputs from end-users (in terms of user knowledge from past decisions). Data-driven and business-centric views are

implemented for the UI, helping production managers to interact with the DSS and access historical and real-time data at different granularity.

As figure 3 properly shows, four components are identified within the ERMS: industrial digital twins, production planning, energy flexibility and energy disaggregation. The dynamic LCA/LCC services instead involve dynamic LCA/LCC models and a supply chain collaboration system. Currently One Team is integrating the ERMS components into a single and unified environment based on Autodesk Forge: the Digital Twin Platform (DTP). Therefore the digital twins of the four ECOFACT demo sites (set up by One Team) and their related data can be hosted alongside the energy and resource tools realized by other partners. At the same time another ECOFACT consortium member (PRé Sustainability) is arranging a dynamic environmental footprinting fed with real-time data and based on automated calculations over flexible parametrized LCA/LCCA models. SimaPro, one of the world's leading LCA and sustainability software, is being utilized for this purpose. The same partner oversees the implementation of the supply chain collaboration service for information sharing among different actors to enable precise LCA/LCC analyses along all the manufacturing steps.

In closing the whole ECOFACT platform ensures safe and reliable digital operations through authentication, encryption, security, inspection, privacy and audit mechanisms.

Digital Twin Platform (DTP)

As anticipated, the Autodesk Forge-based Digital Twin Platform (DTP) acts as the Energy and Resource Management System (ERMS) of the entire ECOFACT platform. Its development is led by One Team, which is integrating into a single environment the industrial digital twins of the demo sites, their related data and a set of energy and resource tools.

Although still under development the DTP is already online, with all its foreseen functionalities implemented at least at a preliminary stage. Among the Forge APIs the platform leverages Authentication APIs, Model Derivative APIs, Viewer APIs and Data Visualization APIs. When logged in the DTP, a user can navigate different ECOFACT sites depending on the authorization. This means for example that someone permitted to view Athenian Brewery's data is not allowed to consult information related to Gullón, Tofaş or Arçelik.

Three main sections compose the DTP, namely digital twins, tools and data-exchange layer.

Digital twins

In the first the digital twins uploaded on the platform are accessible through the Forge Viewer, also giving the end-user the possibility to consult real-time data alongside a specific line or machinery. Relevant documents of the factories are stored as well and can be downloaded or viewed directly on the platform.

Of note all the 3D models involving the four demo sites are realized using Autodesk Inventor, in which machineries and products are combined into an assembly to create the industrial lines. On-site measures of components are instead easily taken thanks to the Leica BLK3D device.

A couple of screenshots from the Forge-powered DTP are shown below for the Tofaş demo case, including the visualisation of temperature data from sensors.

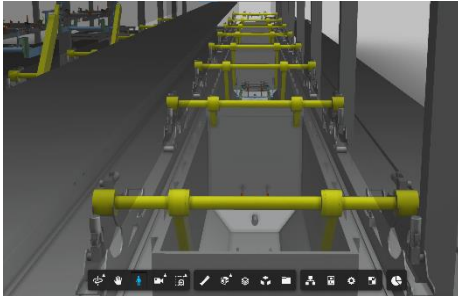


Figure 6: Eisenmann E-coat line.



Figure 5: Geico E-coat line.

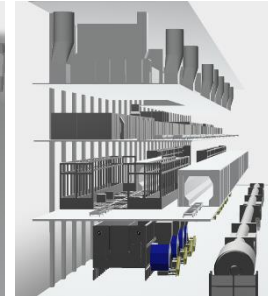


Figure 4: Water based Top-Coat Line.

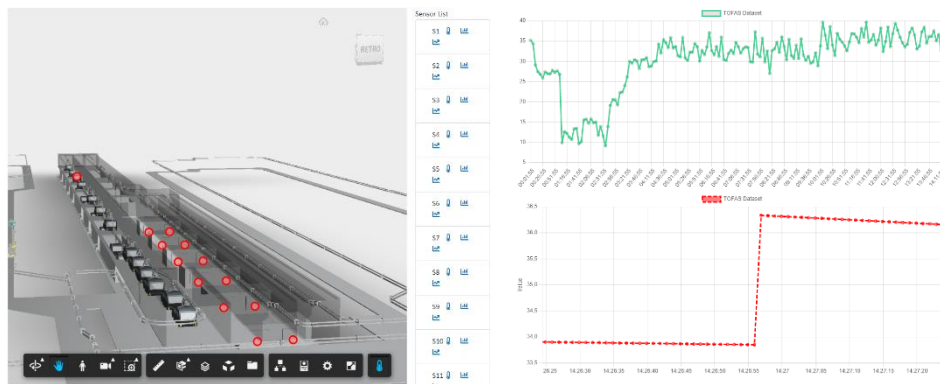


Figure 7a & 7b: from left to right Geico E-coat line with temperature sensors and two different visualisations of the temperature coming from one sensor (real-time in red).

Tools

The tools area includes the energy and resource applications elaborated by other partners. Although the section is evolving according to the project progress, the OptimiST tool developed by RINA-C is almost fully integrated into the DTP and can already run for the Athenian Brewery demo site.

OptimiST focuses on the industrial energy flexibility and optimized management of generation assets. It can be applied in three different ways: generation assets optimization with fixed demand profile (module A), flexibility management with variable demand profile (module B) and change overs optimization (module C).

While module C is enforced to reduce the change over time between one type of product and another in the packaging lines of the continuous manufacturing demo sites, Athenian Brewery and Gullón, module A is implemented to evaluate the techno-economic feasibility of a generation system composed by a PV and a CHP plant to produce electricity and thermal energy for the Tofaş facility. A mix of modules A and B is instead executed for the Arçelik factory, since the production profile is modified depending on the profile from the installed PV plant.

In order to run a simulation with OptimiST on the DTP, input data (XLSX files and values) are required in a specific GUI. Considering the Athenian Brewery demo case, three beer packaging lines are taken into account: one for the bottles, one for the cans and one for the kegs.

After running a simulation, the output is made available as an XLSX file to download or as an Excel-style page on the DTP (figure 8) and can also be viewed graphically (figure 9) alongside the industrial digital twins. It basically consists of a production scheduling for each line over a one-week time horizon. A preliminary result regarding the packaging line of the bottles shows that their makespan can be reduced by 20 % – from 102 to 82 hours. This means that the change over time between one type of bottle and the other can be decreased by 16 %, which is equivalent to 16 % less thermal energy consumption and 16 % less CO₂ emissions.

2022/03/02 10:03:47 ATHENIAN BREWERY - SIMULAZIONE DEMO

PACKAGING					
BOTTLE					
	hr	hrs	PLANNED Hls		
Monday	0	00:06	1,0		START
2021/05/17	100001				CO
	100001	01:06	2,24	94800	100.001
	100001		1,0		CO
	109136	04:30	7,36	303200	109.136
	109136		2,30		CO
	100601	14:36	9,24	376000	100.601

Figure 8: OptimiST demo simulation shown as an Excel-style page on the DTP for Athenian Brewery's bottles packaging line.

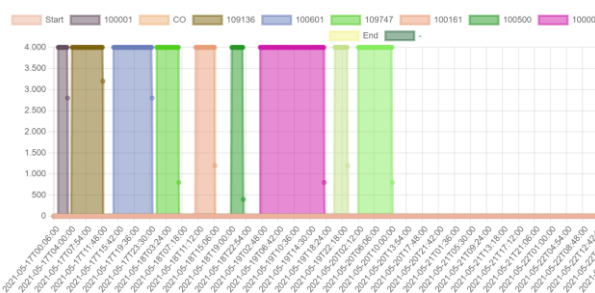


Figure 9: graphical output of an OptimiST demo simulation for Athenian Brewery's bottles packaging line.

In figure 8 the columns include the simulation days (over one week), the bottles codes, the hour when something happens (e.g. start or end of production and change of product), the hours occurred for an event (production or change over) and the beer volume produced (L*h). In figure 9 the horizontal and vertical axes are referred to the simulation time and beer volume respectively, with each color equivalent to a specific bottle code and the blank space to the change over time.

As previously explained, OptimiST is conceived for the other ECOFACT demo sites too. Similarly to Athenian Brewery the change over time is minimized for Gullón (module C), with a production scheduling of two packaging lines and three formation lines defined as output. A minimization of the energy bill managing the available energy assets takes place for Tofaş (module A); the outputs are the electrical and thermal energy assets management plan on one front and a set of economic parameters (NPV, PBP, IRR, CCF and ACF) on the other. A minimization of the energy bill concerns Arçelik (modules A and B) as well; in this case the outputs are the electrical energy assets management plan and the production scheduling for two assembly lines, two drum lines, two cabinet lines, a plastic injection section and buffers.

The other applications One Team is integrating into the DTP are the following: (i) material-flow simulation for predictive management of manufacturing process data (based on the Siemens Plant simulation tool); (ii) production planning and scheduling (based on the Gurobi solver); (iii) energy simulation for dynamic operations management and cost optimization (with the energy models built on TRNSYS) – predictive maintenance; and (iv) industrial energy disaggregation – by products. Their development is in the hands of Fraunhofer-IWU (i and ii), CERTH and CARTIF (iii) and LINKS Foundation (iv).

Data-exchange

A first layer of the DTP data-exchange is also accessible on a dedicated page.

A set of REST APIs ensures the platform's main functionalities. The authentication API guarantees an access token through client and secret IDs. The resource APIs are useful to get DTP files (i.e. factory models and documents). The user APIs get an access token for one or more demo sites.

Future developments

In the next months One Team will continue with its system integration activities. OptimisT is only the first of the energy and resource tools that will be part of the Autodesk Forge-powered Digital Twin Platform.

The material-flow simulation for predictive management of manufacturing process data application focuses on the interaction between energy consumption, power, production, storage and transport. It is based on the Siemens plant tool and already has a provisional GUI on the DTP. Further work is still needed to establish a connection with an external service. The same can be said for the production and planning optimization application that leverages the Gurobi solver. These two developments are proceeding in parallel for the two discrete manufacturing demo sites, Tofaş and Arçelik.

The tool related to the energy simulation for dynamic operations management and cost optimization – predictive maintenance – is dedicated to the predictive management of production operations with the dual aim of reducing manufacturing energy costs (with regard to maintenance programs) and increasing system robustness. From a practical point of view data are first collected from sensors and SCADA systems of each machinery. Then energy simulation algorithms are built to forecast abnormal behaviours (e.g. electricity and thermal energy losses or electricity excess/peak), followed by the development of a predictive maintenance model that leads to the most cost-effective and energy efficient operations. Of note the energy models are set up utilizing TRNSYS. The aim of the integration process is to give the end-user the possibility to visualise some information directly alongside the industrial digital twins.

The industrial energy disaggregation – by products – application is being developed as a web platform, which will be linked to the DTP through REST APIs. The Industrial Energy Disaggregation (IED) essentially separates different components from the energy signal(s). In ECOFACT the ED is being performed by products for forecast and wise long-term planning in terms of energy.

Considering other activities within the project, the coming two years will serve to integrate the Digital Twin Platform, based on Forge and built as an Energy and Resource Management System, and the dynamic LCA/LCC services, conceived taking advantage of the functionalities offered by the SimaPro software, into a holistic Decision Support System for the end-user. The ERMS and dynamic LCA/LCC services will rely on a single and unified UI/dashboard too.

Links and contacts



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