



Agri-food Efficiency with New Energy Audit Measures

D2.4 – Survey of digital technologies

Responsible author(s): CSMT



**Co-funded by
the European Union**

Grant Agreement N° 101120618

Document: Deliverable D2.4 – Survey of digital technologies

Due delivery date: M22

WP2 – Acceleration Programme (EE Network): Capacity building and advisory to company staff

Project title: Agri-food Efficiency with New Energy Audit Measures

Project acronym: AENEAM

The AENEAM project aims to accelerate the transition of the EU agri-food industry towards a sustainable growth model by increasing the uptake of recommended measures from energy audits. The project will encourage companies, mainly SMEs, to undergo energy audits and subsequently implement the recommendations from these audits, promoting digital solutions.

This report is part of the project N°101120618 / AENEAM which has received funding from the European Union's LIFE program (2021-2027).

Call identifier: LIFE-2022-CET

Topic: LIFE-2022-CET-BUSINESS

Type of action: LIFE-PJG

Grant agreement: 101120618

Lead contractor for this deliverable: CSMT Gestione S.c.a.r.l.

Dissemination Level		
PU	Public – Fully open	x
SE	Sensitive – Limited under the conditions of the Grant Agreement	

Disclaimer

Co-funded by the European Union. The content of this report represents the views of the author only and his/her sole responsibility; it cannot be considered to reflect the views of the European Commission and/or the European Climate, Infrastructure and Environment Executive Agency or any other body of the European Union. The European Commission and the Agency do not accept any responsibility for use that may be made of the information it contains.

Authors	
Name	Partner Name
Gina Ambrosio	CSMT
Andrea Pasotti	CSMT
Alberto Bonetti	CSMT

Document versions		
Version	Date	Change editors
V.0	10.12.2024	First Draft
V.1	17.10.2025	Added section 2.3

Validation of final version		
Role	Person	Partner name
Work Package Leader	Gina Ambrosio	CSMT
Project Coordinator	Irene Eslava Lecumberri	AIN
Internal Quality Control	WP Managers	ALL

Table of Contents

1. Introduction.....	7
1.1. Characteristics of Digital Technologies for Energy Management (DTEM)	8
1.1.1. Type of digital technologies	8
1.1.2. Automatic Monitoring and Targeting Systems (aM&T)	9
1.1.3. Supervisory Control and Data Acquisition (SCADA)	10
1.1.4. Energy Management Systems (EMS)	11
2. Survey Methodology and Database Overview	13
2.1. Methodology	13
2.2. The Digital Technologies Database	13
2.3. Key Findings from the Database	14
3. Objectives and Benefits of Using DTEM	18
3.1. Benefits of Using DTEM	18
3.1.1. When to Install/Update/Replace?	20
3.1.2. Comparison websites	20
4. Success Stories: Practical Applications from Case Studies in the Agri-food Sector	21
4.1. Energy Optimization and Uptime in a Flour and Oil Producer	21
4.2. Service Continuity and Power Quality in a Coffee Roasting Company	22
4.3. Comprehensive Digitization and Monitoring in a Fish Farm	22
4.4. Energy optimization and implementation of monitoring system in a winery	23
5. Conclusions	23
6. Annexes	24

Index of figures

Figure 1: Input used to fill the excel database.	14
Figure 2: Solutions type in Excel Database. Last updating October 2025.....	15
Figure 3: Number of solutions within the Excel Database per key benefits. Last updating October 2025.....	16
Figure 4: Overview of surveyed DTEM solutions, illustrating the enabling technologies behind key benefits (top) and the widespread availability of scalability and integration features (bottom).....	17
Figure 5: Analysis of cost models for DTEM solutions, highlighting the prevalence of one-time activation and maintenance costs over subscription-based fees.....	18

Index of tables

Table 1: Feature of Automatic Monitoring and Targeting Systems (aM&T or AMyT)	10
Table 2: Feature of Supervisory Control and Data Acquisition (SCADA).	11
Table 3: Feature of Energy Management Systems (EMS).	12

List of acronyms

AENEAM: Agri-food Efficiency with New Energy Audit Measures
AI: Artificial Intelligence
AIN: (Partner Name - Acronym stands for Asociación de la Industria Navarra)
aM&T: Automatic Monitoring and Targeting Systems
BDA: Big Data Analytics
BEMS: Building Energy Management Systems
CO₂: Carbon Dioxide
CSR: Corporate Social Responsibility
CSRD: Corporate Sustainability Reporting Directive
CSMT: (Lead Contractor Name - Centro Servizi Multisetoriale e Tecnologico)
DTEM: Digital Technologies for Energy Management
EMS: Energy Management Systems
EU: European Union
HVAC: Heating, Ventilation, and Air Conditioning
HMI: Human-Machine Interface
IoT: Internet of Things
ISO: International Organization for Standardization
KPI: Key Performance Indicator
LIFE: (EU Funding Programme for Environment and Climate Action)
MES: Manufacturing Execution System

OPC UA: OPC Unified Architecture (A machine-to-machine communication protocol for industrial automation)

OT/IT: Operational Technology / Information Technology

PLC: Programmable Logic Controller

PME: Power Monitoring Expert (Specific software name example)

PU: Public (Dissemination Level)

SCADA: Supervisory Control and Data Acquisition

SE: Sensitive (Dissemination Level)

SMEs: Small and Medium-sized Enterprises

UPS: Uninterruptible Power Supplies

1. Introduction

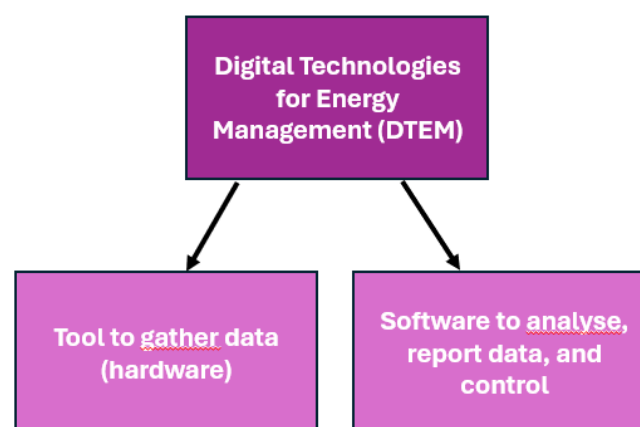
The food industry faces growing pressure to minimize its environmental impact, driven by climate change and resource scarcity. As one of the most energy-intensive sectors, representing approximately 37% of global industrial energy consumption (IEA data reference), it is imperative for the industry to adopt innovative solutions to enhance energy efficiency throughout the production process. Boosting energy efficiency is not just a response to global environmental challenges but also a strategic necessity for maintaining competitiveness. Food companies must sustainably meet the rising global demand for food while addressing these critical issues. Achieving energy efficiency goals often involves a virtuous cycle strongly linked with Digitalization.

The aim of this document is to facilitate the understanding and selection of various digital technologies that promote energy efficiency. It explores the range of available monitoring and control solutions (like smart meters and real-time data analysis) used to identify inefficiencies and optimize operations, illustrated through practical examples. Complementing this report, an Excel database catalogues specific digital technologies identified during our survey activities.

Despite the evident benefits, the implementation of energy efficiency initiatives in the food industry is not without challenges. Key obstacles include limited awareness, resource constraints, and competing business priorities. However, these barriers can be addressed through targeted strategies, such as active organizational involvement, access to dedicated funding, and fostering collaboration between companies.

The adoption of digital technologies, combined with a structured approach to energy management, can yield substantial advantages. These include cost savings, enhanced operational performance, and a reduced environmental footprint, laying the groundwork for a more sustainable and competitive future in the food industry.

To this deliverable, we used the definition of carbon trust Digital Technologies for Energy Management (DTEM) to include smart energy meters, and tools that gather data from energy meters or sub-meters and use software to report and/or analyse that data, as well and using information collected to automatically control the building/process. They include both the software itself and the physical infrastructure (e.g. sensors) that enable management.



1.1. Characteristics of Digital Technologies for Energy Management (DTEM)

DTEM are advanced tools that gather data from energy meters, building management systems, and process controls. Through specialized software, they analyse, report, and, in some cases, regulate energy-consuming equipment to optimize energy usage. Typically, these technologies operate across different hierarchical levels within a facility, often visualized as a pyramid structure:

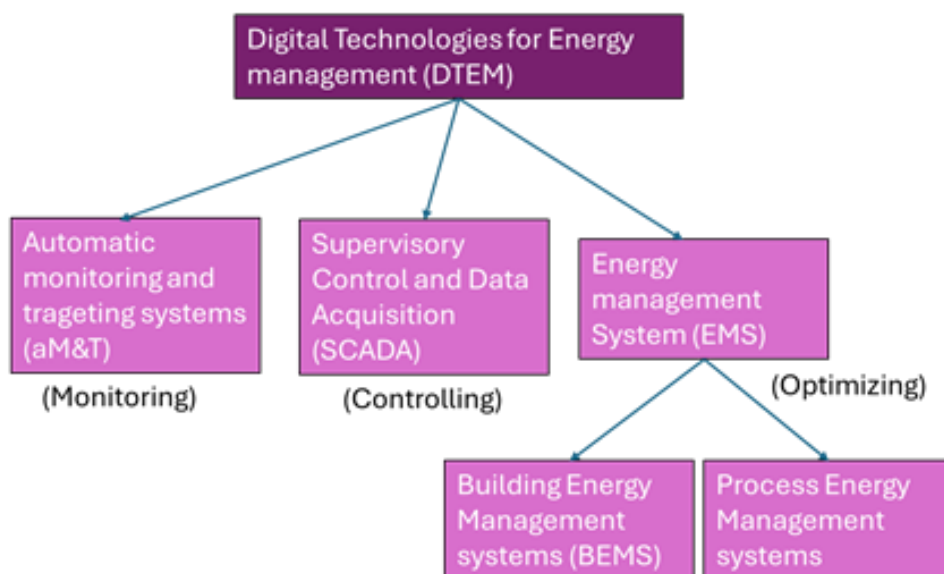
- **Field Level:** Data acquisition directly from machines and electrical distribution (sensors, meters).
- **Production/Control Level:** Process monitoring and control (PLCs, HMIs, SCADA).
- **Management Level:** Site-wide analysis, reporting, and strategic decision-making (EMS, Cloud platforms).

Effectively utilizing DTEM enhances an organization's energy management by enabling the following capabilities:

- Monitoring energy consumption to detect and eliminate avoidable energy waste.
- Identifying unexpected energy usage and triggering timely corrective actions.
- Providing real-time adjustments based on system parameters.
- Quantifying achieved savings and uncovering opportunities for further improvements.
- Supporting benchmarking activities for meaningful performance comparisons.
- Enhancing budget planning with data-driven insights.
- Raising staff awareness through actionable feedback.

By simplifying and accelerating energy management processes, DTEM revolutionizes the way energy is measured, monitored, and conserved. Advances in data analytics, real-time connectivity, and user-friendly interfaces are driving greater digitalization, making these tools more accessible and effective while maximizing their potential benefits.

1.1.1. Type of digital technologies



Three primary types of digital technologies have been identified (often deployed within the hierarchical structure mentioned above):

1. **Automatic Monitoring and Targeting Systems (aM&T or AMyT):** *These are monitoring technologies* designed specifically for tracking and measuring performance, with no direct control over the process. They primarily operate at the Field and Management levels.
2. **Supervisory Control and Data Acquisition (SCADA):** *These are control technologies* that not only monitor the process but also act upon it, making adjustments to optimize performance or respond to changes. Typically operate at the Production/Control level, bridging Field and Management.
3. **Energy Management Systems (EMS):** *These are optimization technologies* that aim to improve energy efficiency by monitoring, controlling, and optimizing systems within buildings (BEMS) and enterprises (EMS). Primarily operate at the Management level, utilizing data from lower levels, but can include control functions. A relevant implementation trend is the use of Edge Computing platforms, which bring data processing and application execution closer to the field level.

The following sections provide a detailed description of each of these technologies.

1.1.2. Automatic Monitoring and Targeting Systems (aM&T)

aM&T or AMyT systems play a critical role in energy management by collecting, processing, and analyzing energy consumption data. These systems provide clear, actionable reports and visualizations that support strategic energy management decisions. By offering insights into energy usage patterns, identifying inefficiencies, and highlighting opportunities for improvement, aM&T systems help organizations reduce costs and enhance energy efficiency.

Characteristics: The effectiveness of aM&T systems depends on the availability and quality of energy consumption data, which is influenced by the type of meter and supply contract. Hardware components at the Field level are crucial for data acquisition. While energy suppliers may provide this data, delays in access or difficulties in integrating the data into software tools can arise. To address this, some suppliers offer online analysis platforms, providing an accessible, cost-effective entry point for identifying energy-saving opportunities and supporting further investments in DTEM.

At a basic level, aM&T systems rely on data from supply meters, such as Half-Hourly Data meters or Smart meters. However, this data often lacks granularity and typically reflects only site-wide consumption. More advanced systems integrate sub-metering, using specific hardware like panel-mounted power analyzers, modular energy meters integrated into I/O systems or communicating circuit breakers, to improve data detail and coverage, enabling in-depth insights into energy consumption at a process or utility level.

Examples of sub-metering applications include:

- Buildings: Sub-metering for boilers, lighting, HVAC systems, and energy consumption on individual floors.
- Industrial/Manufacturing: Sub-metering for hot water and steam boilers, condensate return systems, thermal oil boilers, compressed air systems, ventilation, cooling systems, and specific production lines or individual machines.

- **Multi-Site Control:** DTEM enables centralized monitoring and control of building systems across multiple locations. This functionality is typically accessible through web-based interfaces, allowing real-time oversight and management across sites.

By delivering detailed, accurate, and actionable data, aM&T systems empower organizations to identify energy waste, prioritize efficiency measures, and justify further investments in energy-saving technologies.

Table 1: Feature of Automatic Monitoring and Targeting Systems (aM&T or AMyT)

Feature	Justification
Real-Time Energy Monitoring	aM&T systems monitor energy consumption in real time or near real time, depending on the availability of metering data.
Optimization of machinery efficiency	They provide actionable insights to improve machinery efficiency by identifying energy waste and inefficiencies.
Reduction of energy losses unrelated to production facilities	Sub-metering allows for detailed monitoring of specific systems like boilers and lighting, addressing non-production energy losses.
Optimization of climate control in production environments	Sub-metering and detailed data analysis can optimize HVAC systems and other climate-related controls.
Reduction of direct energy expenses	Insightful energy reports and patterns help reduce costs through efficient usage.
Reduction of CO₂ emissions	By improving energy efficiency, aM&T systems indirectly contribute to reducing emissions.
Integration with management systems	Advanced aM&T systems support integration with enterprise management platforms and other tools.
Solution scalability	The modular nature of sub-metering and digital platforms allows aM&T systems to scale across sites.
Costs	These systems incur initial setup, maintenance, and subscription costs for software platforms or advanced functionalities

1.1.3. Supervisory Control and Data Acquisition (SCADA)

SCADA systems are designed to minimize variations in industrial processes and maintain optimal operating conditions. These systems utilize network communications and intuitive graphical interfaces to provide high-level management and control of processes. By offering real-time monitoring and control, SCADA systems ensure that operations remain within predefined parameters, enhancing efficiency and reliability. In the context of energy management, SCADA systems not only monitor energy usage but also integrate crucial process data allowing for contextual energy analysis.

Characteristics:

- **Customizable Dashboards and Graphical Interface:** Standard functionality that allows users to focus on critical processes and visualize key performance indicators (KPIs) clearly. Modern HMIs often feature vector graphics and web-based access.

- **Real-Time Device and Set Point Monitoring:** A fundamental feature that continuously monitors system operations to identify deviations from standard parameters and detect inefficiencies.
- **Process Set Point Configuration:** Enables operators to adjust and optimize process settings to maintain desired performance levels.
- **Exception/Fault Alarms and Reporting:** A background feature that ensures constant monitoring, automatically generating alerts and reports when anomalies or system failures occur. Advanced systems may include "smart alarms" or grouping functionalities.
- **Preventive Maintenance Scheduling:** Essential for identifying early signs of parameter drift caused by equipment wear, helping to optimize energy usage and avoid unexpected downtime.
- **On-Machine Energy Analysis:** SCADA systems integrated with machine HMIs can enable direct visualization and analysis of machine-specific energy efficiency (e.g., correlating kWh consumption with production units like pieces produced), potentially following standards like VDMA 34179 / ISO 14955.

By integrating these features, SCADA systems provide a robust framework for monitoring, controlling, and optimizing industrial processes. Their ability to deliver real-time insights, customizable interfaces, and automated alerts enables organizations to reduce operational inefficiencies, enhance system performance, and plan proactive maintenance strategies.

Table 2: Feature of Supervisory Control and Data Acquisition (SCADA).

Feature	Justification
Real-Time Energy Monitoring	SCADA provides real-time monitoring as a core feature.
Optimization of machinery efficiency	SCADA optimizes processes and equipment settings.
Extension of machinery lifespan	Preventive maintenance scheduling helps prolong the life of machinery.
Reduction of direct energy expenses	Enhanced operational efficiency and maintenance reduce energy costs.
Integration with management systems:	SCADA systems are designed for integration with higher-level systems.
Solution scalability	SCADA systems are customizable and scalable for different process sizes.
Costs	SCADA typically incurs one-time activation costs and periodic maintenance costs but not subscription costs.

1.1.4. Energy Management Systems (EMS)

EMS are advanced computer-based tools designed to monitor, control, and optimize energy consumption within buildings (BEMS) or enterprises. They are particularly effective for managing devices like lighting and HVAC (heating, ventilation, and air conditioning) systems.

A typical EMS integrates aM&T functions with real-time monitoring and control of building/enterprises services. While data recording capabilities are a core feature, specific configurations may need to be tailored with the supplier to meet organizational needs. Advanced EMS often include functionalities like KPI definition, energy forecasting, compliance

reporting (e.g., for ISO 50001), and detailed consumption analysis correlated with production parameters (e.g., energy per batch or recipe).

EMS provide flexible operating modes to address seasonal variations, comfort requirements, and energy optimization. These systems continuously monitor both internal and external environmental conditions to maximize efficiency and performance. Key parameters—such as temperature set points, valve positions, occupancy schedules, and airflow—are carefully tracked and adjusted, allowing for advanced control and significant energy savings. They typically interface with a wide range of devices and protocols (e.g., Modbus, OPC UA, specific PLC protocols).

Additionally, EMS can identify anomalies in energy consumption or detect equipment faults. This enables organizations to address issues early, facilitating proactive maintenance planning and reducing downtime. Systems with integrated aM&T capabilities also enhance reporting and benchmarking, allowing performance comparisons between buildings or across multiple sites to identify further improvement opportunities. Some EMS platforms can be deployed as applications on Edge Computing devices, allowing for localized data processing and faster response times.

Characteristics:

Table 3. *Feature of Energy Management Systems (EMS).*

Feature	Application
Real-time monitoring of consumption	Enables continuous tracking of energy usage to detect inefficiencies.
Optimization of machinery efficiency	EMS can optimize HVAC and lighting systems for energy efficiency and, in industrial settings, analyse energy use correlated to production.
Optimization of climate control in production environments	Environmental set-point adjustments and HVAC control ensure climate optimization.
Extension of machinery lifespan	Energy optimization translates into cost savings.
Reduction of direct energy expenses	Provides automated alerts and diagnostics for faults or irregularities. Supports cost allocation and identifies saving opportunities.
Reduction of CO₂ emissions	Enhanced energy efficiency indirectly reduces carbon emissions.
Integration with management systems:	EMS integrate with other building energy management systems, and potentially ERP/MES via standard protocols (Modbus, OPC UA etc.).
Solution scalability	Customizable dashboards and interfaces make EMS scalable for various building sizes and needs.
Costs	One-time activation, maintenance, and subscription costs (especially for SaaS/Edge models or cloud services) apply, as these systems often involve software licensing and updates.

EMS continuously monitor real-time data and system set points within HVAC and other control systems. By doing so, they can detect and highlight equipment faults or irregularities in

operation, ensuring that issues are quickly identified and addressed. A key advantage of EMS is their ability to automatically adjust control parameters in response to real-time conditions. By adapting to changing demands, these systems minimize inefficiencies, optimize performance, and contribute to overall energy savings.

2. Survey Methodology and Database Overview

To effectively support the AENEAM project's objective of promoting the adoption of digital solutions alongside energy audit recommendations, a dedicated survey of existing DTEM was conducted. This survey aimed to identify and catalogue a range of relevant technologies applicable to the agri-food sector, particularly targeting the needs and capabilities of Small and Medium-sized Enterprises (SMEs). **It is important to clarify that the intent of this survey is not commercial; rather, it seeks to provide an overview of the DTEM options currently available.**

2.1. Methodology

The compilation of the DTEM list involved a multi-faceted approach aiming to cover technologies across the different operational levels (Field, Production/Control, Management):

Desk Research: Online research was performed utilizing search engines, technology vendor websites, publications, and specialized comparison platforms (such as those mentioned in Section 3.1.2).

Partner Expertise: Input and knowledge from AENEAM project partners, leveraging their experience with agri-food companies and energy efficiency solutions, were incorporated.

Stakeholder Input Integration: Incorporated insights, needs, and feedback gathered directly from participating companies (stakeholders) throughout the AENEAM acceleration programme, ensuring practical relevance.

Market Analysis: Review of existing market reports and databases focusing on energy management software, IoT solutions for industry, and building automation systems.

Criteria for Inclusion: Technologies were selected based on their primary function related to energy monitoring, control, or optimization. The classification into aM&T, SCADA, and EMS/BEMS (as defined in Section 1.1) was applied.

2.2. The Digital Technologies Database

The results of this survey have been compiled into a structured **Excel database (Annex 1)**. This database serves as the practical output of the survey component of Task 2.6 and acts as an internal reference tool. The database catalogues the identified technologies and includes key information relevant to their potential application for energy savings, structured under fields such as:

- **Unic ID:** Project-internal identifier.
- **Technology/Solution Name:** Name of the product/service.
- **Type of digital technology:** Classification (aM&T, SCADA, EMS, etc.).

- **Solution description:** Summary of functionality, highlighting its role in data gathering, analysis, or control.
- **Component:** Hardware/Software classification.
- **Key Benefit:** Mapping capabilities against energy-saving goals (e.g., real-time monitoring, process optimization, cost reduction). *[The subsequent columns in the database use binary indicators (1/0 or Yes/No) to denote the presence or absence of specific features/objectives].*
- **Technologies Enablers:** Specifies if IoT or AI (or Machine Learning) are core components.
- **Cost Structure:** Notes on typical cost elements (activation, subscription, maintenance).
- **Integration & Scalability:** Information on compatibility with other systems and potential for expansion.
- **Other Info/Link to website:** References for further investigation.

		COMPONENTS		
Type_of_digital_tecnology▼	AMyT▼	SCADA▼	BEMS▼	EMS▼
AMyT	Sensor	Actuators	Software	Software
SCADA	Data acquisition and communication	PLCs / Controllers		
BEMS	Power supply	Software		
EMS	Visualization			
Other	Software			
	Others			

COMPONENTS		
AMyT		
	SCADA	
		EMS

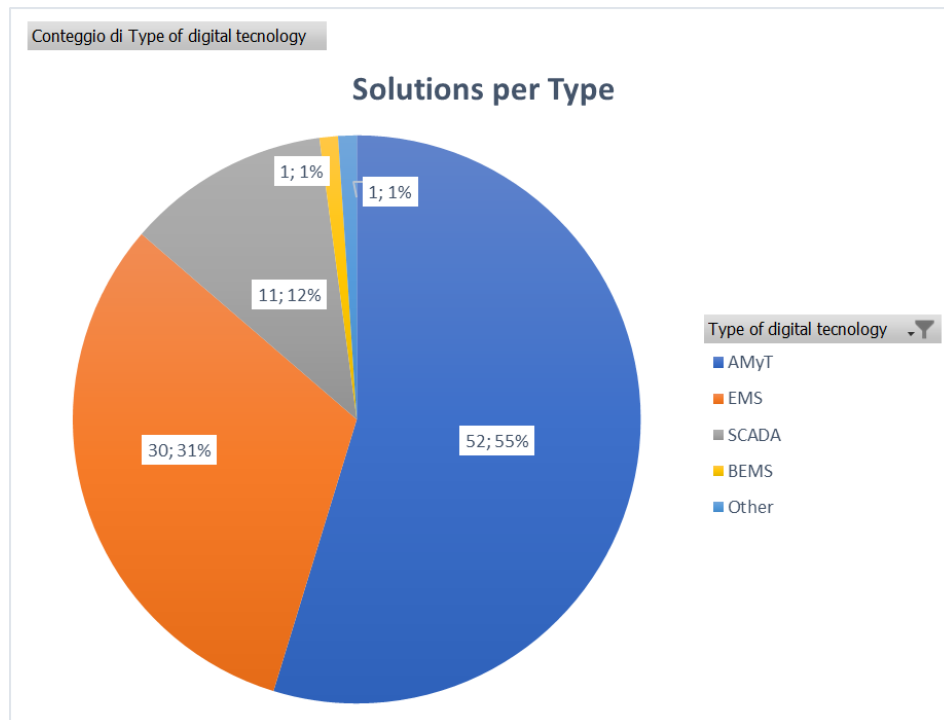
SCADA system requires some AMyT componets, and BEM system requires SCADA system

The analysis of DTEM catalogued in the Excel database has revealed several recurring trends and key characteristics. **The findings presented in this section are based on information collected by the project partners up to the end of October 2025. As such, they represent a snapshot of the market at that time and, while intended to be representative, this overview may not be fully exhaustive.** This section summarizes the main findings from the survey, providing a quantitative overview of the current landscape of solutions available to the agri-food sector.

The survey highlights a clear prevalence of **aM&T systems** (in database AMyT), which constitute **55%** of the identified solutions. This indicates that real-time data collection and performance tracking are considered the foundational step for energy management. **EMS** follow with 31%, and **SCADA** systems with 12%, representing more advanced control and optimization layers. The other 2% is related with **BEMS** and **Other**.

AENEAM

Figure 2: Solutions type in Excel Database. Last updating October 2025.



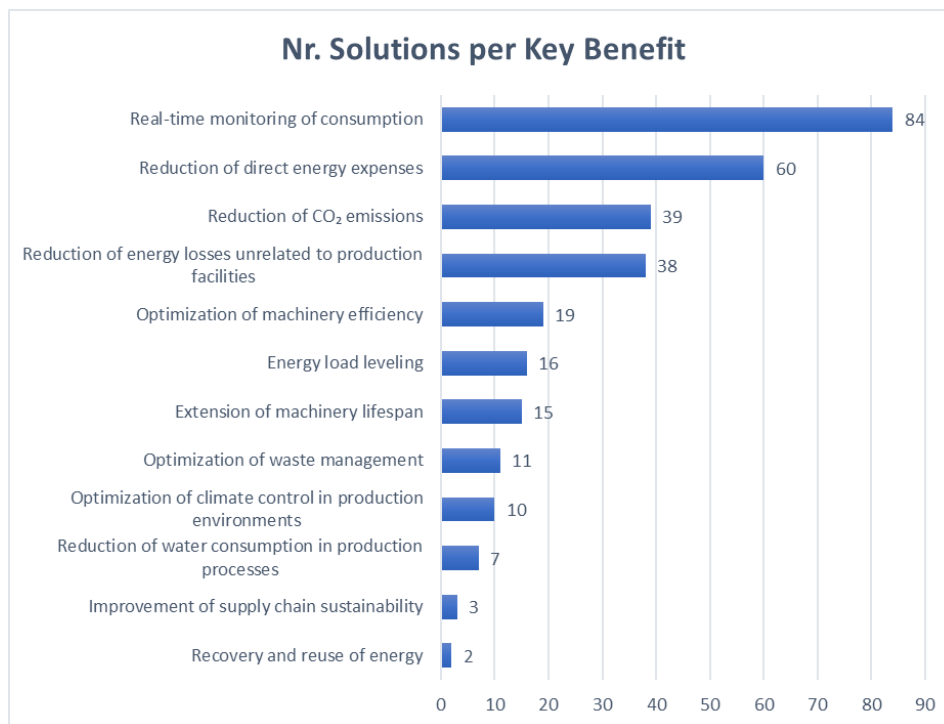
Key Benefits Offered

The primary drivers for adopting DTEM solutions are strongly linked to efficiency and cost reduction. As shown in the chart below, the most frequently cited benefits are:

- **Real-time monitoring of consumption** (offered by 88% of solutions).
- **Reduction of direct energy expenses** (63%).
- **Reduction of CO₂ emissions** (41%).
- **Optimization of machinery efficiency** (20%).

These findings confirm that DTEM are perceived primarily as tools for achieving tangible economic and environmental savings.

Figure 3: Number of solutions within the Excel Database per key benefits. Last updating October 2025.



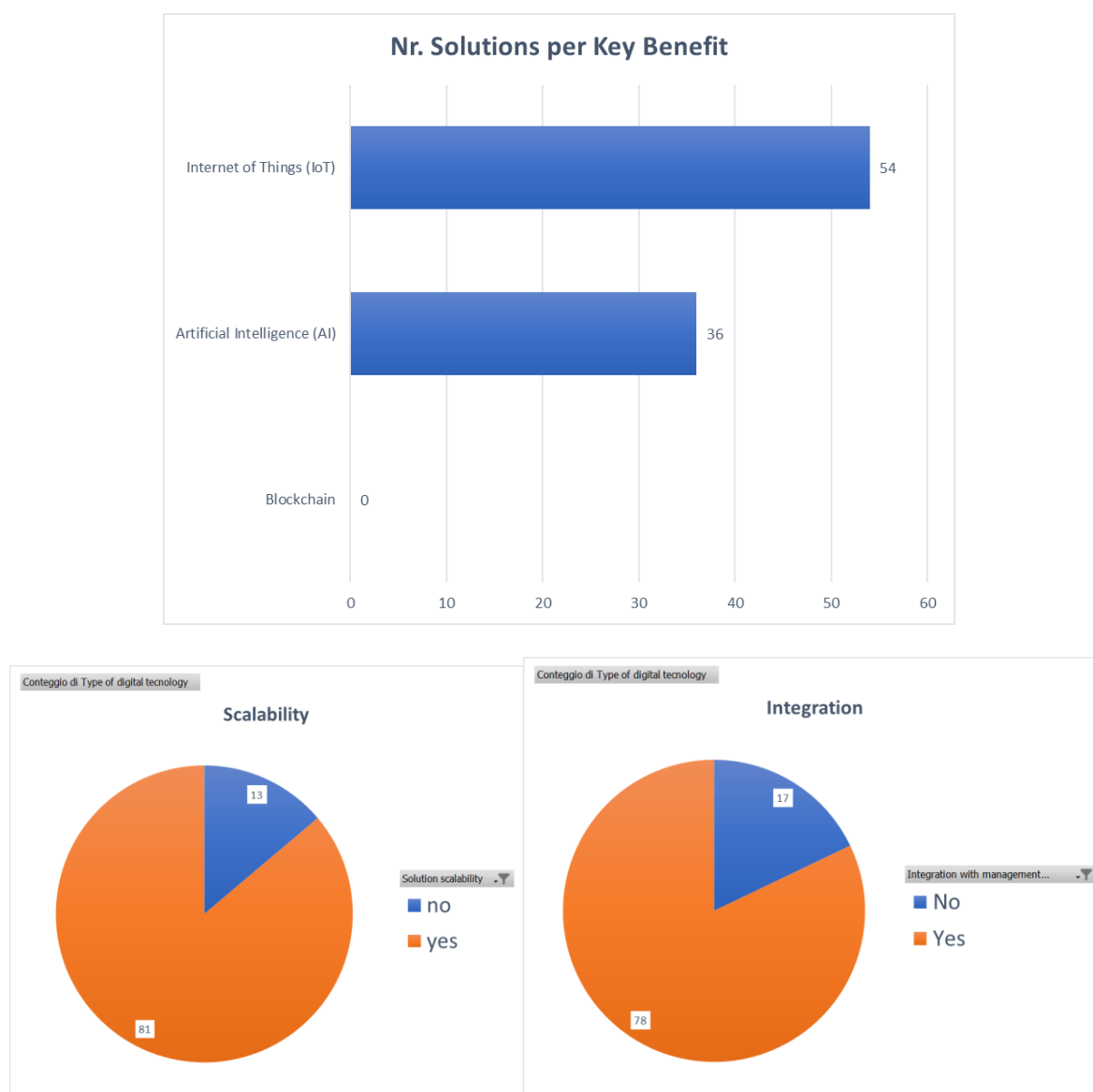
Enabling Technologies and Core Features

From a technological standpoint, the **Internet of Things (IoT)** emerges as the dominant enabling technology, featured in **54%** of the catalogued solutions. This underscores the importance of sensorization and connectivity for modern energy management. **Artificial Intelligence (AI)** is also a significant component, present in 36% of cases, highlighting a trend towards predictive analytics and process automation.

Furthermore, two features are nearly universal across the surveyed technologies:

- **Scalability:** Over 86% (81 out of 94) of the solutions are designed to be scalable. This high percentage indicates that most providers allow companies to start with a pilot project and expand their energy management system over time as their needs grow.
- **Integration:** Similarly, over 82% (78 out of 95) of the technologies offer capabilities for integration with existing management systems (e.g., ERP, MES). This is a crucial feature, as it ensures that new DTEM can fit within a company's established digital ecosystem without creating data silos.

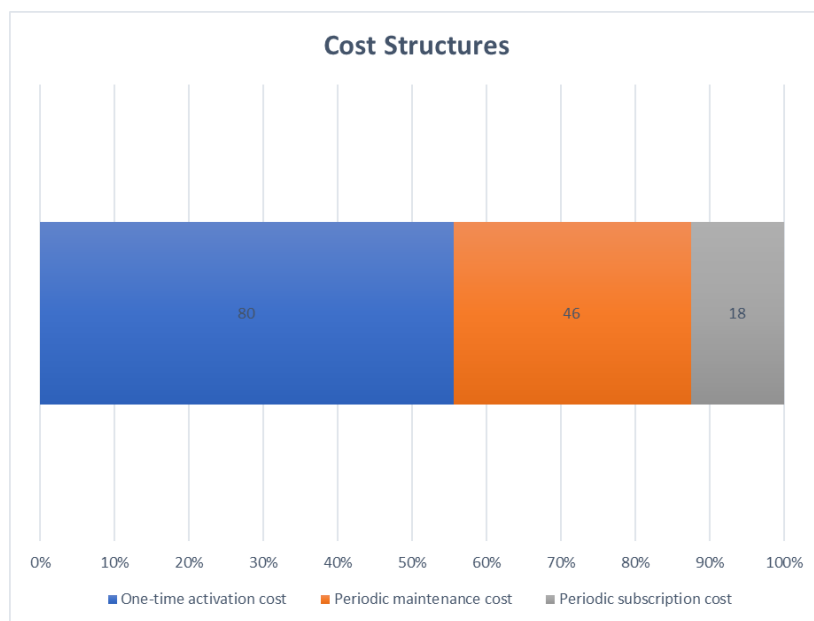
Figure 4: Overview of surveyed DTEM solutions, illustrating the enabling technologies behind key benefits (top) and the widespread availability of scalability and integration features (bottom).



Cost Structures

The analysis of cost models reveals that most solutions involve an **one-time activation cost** combined with **periodic maintenance costs**. Subscription-based models (SaaS), while less common, are also present in the market, offering an alternative with lower initial investment. This variety allows companies to choose a financial model that best suits their budget and strategic planning.

Figure 5: Analysis of cost models for DTEM solutions, highlighting the prevalence of one-time activation and maintenance costs over subscription-based fees.



3. Objectives and Benefits of Using DTEM

3.1. Benefits of Using DTEM

DTEM provide numerous advantages, both measurable and intangible, that can greatly enhance an organization's energy efficiency and overall operational performance. While the extent of savings depends on the specific setup and conditions, suppliers can help estimate the potential benefits of implementing these solutions. **Academic research confirms the benefits. For instance, a study on Italian SMEs demonstrated that adopting Industry 4.0 technologies led to a 7% average increase in labor productivity, with gains persisting for up to two years (Springer, 2023, as cited in Bernedo, 2025).**

Adopting DTEM is a strategic move that enables organizations to increase efficiency, reduce costs, and advance their sustainability objectives. Utilizing tools such as BEMS, aM&T systems, and SCADA systems allows businesses to gain detailed insights into energy consumption patterns, streamline processes, and meet high standards of operational and environmental performance.

The key benefits of DTEM are outlined below:

Verification and Monitoring of Energy Consumption. One of the most immediate advantages of DTEM is the ability to verify energy bills. Any billing errors can be detected and quantified, helping to estimate past costs and justify the adoption of new technologies. For example, addressing billing discrepancies can save staff time and reduce administrative costs.

Reporting and Key Performance Indicator (KPI) Development. DTEM systems simplify the generation of energy reports and carbon footprint reports, often automating data collection and analysis. These tools support the definition of sector-specific KPIs (e.g., kWh/m² or kWh/kg of product), enabling comparisons with industry standards and benchmarks to identify

further opportunities for energy savings. Advanced sub-metering, a key feature of systems like aM&T or SCADA, provides highly detailed data, enhancing the accuracy of carbon footprint calculations for individual processes or products.

Preventive Maintenance and Optimized Scheduling. By monitoring typical energy consumption patterns and other operational parameters (e.g., temperature, vibration) across production lines over time, DTEM helps identify equipment faults or wear and tear. Anomalous increases in energy consumption can signal malfunctions or maintenance needs. This information enables targeted maintenance scheduling, improving operational efficiency and minimizing the costs associated with unplanned downtime. **The power of these analytical capabilities is confirmed by academic research, which shows that the adoption of AI and Big Data Analytics (BDA) is consistently linked to enhanced firm productivity, improved decision-making, and greater supply chain agility (ZEW, 2022; Nature, 2024, as cited in Bernedo, 2025).**

Identification and Verification of Efficiency Projects. aM&T and SCADA systems provide granular data that is crucial for identifying energy waste, estimating potential savings, and verifying the effectiveness of energy-efficiency projects. Once savings are quantified and validated, they build confidence for future investments and can be used to support funding applications or incentive programs.

Support for Corporate Social Responsibility (CSR). DTEM systems play a critical role in sustainability reporting. Tools like SCADA and EMS provide the data granularity needed to monitor and quantify CSR goals, such as energy consumption, water usage, or carbon emissions reduction. This type of reporting is increasingly important for corporate clients, stakeholders, and end consumers, especially considering regulations like the Corporate Sustainability Reporting Directive (CSRD).

Process Optimization and Staff Training. Through sub-metering of production lines and correlation with production data, DTEM enables comparisons of energy efficiency across similar shifts or processes and allows for calculation of metrics like specific energy consumption (e.g., kWh per unit produced). Significant disparities in energy use may indicate opportunities to optimize operations or implement targeted training programs. Providing clear, building- or process-specific energy data also enhances staff awareness and training, demonstrating the tangible impact of their actions.

Improvement of Productivity and Workplace Comfort. Studies show that elevated CO₂ levels caused by inadequate ventilation can reduce productivity and lead to “sick building syndrome”. BEMS) automatically regulate airflow to maintain optimal CO₂ levels, improving occupant comfort and reducing unnecessary energy consumption due to over-ventilation.

Achieving Performance Standards. DTEM systems support compliance with internationally recognized standards, such as ISO 50001, ISO 14001, and the Carbon Trust Standard. These technologies simplify the collection, analysis, and reporting of the data required to demonstrate compliance with sustainability goals and regulatory requirements including potentially aspects of the CSRD and national regulations (like Italy's D.Lgs 102/2014 requirements).

Optimization of Controls and Systems. Traditional manual controls for schedules and temperature settings often fail to meet the needs of multi-occupant or multi-function buildings, leading to inefficiencies such as heating or cooling during non-operational hours. BEMS

systems automate these controls based on occupancy and temperature requirements, significantly reducing energy consumption.

For instance, a BEMS can optimize boiler operation by automatically adjusting start-up and shutdown times to reach desired temperatures based on occupancy schedules, while also adapting to external temperature variations to avoid unnecessary heating. Similarly, SCADA systems enhance process efficiency by providing real-time feedback and automatically adjusting operational parameters to maintain optimal performance.

3.1.1. When to Install/Update/Replace?

Determining the right time to install, update, or replace energy management systems is crucial for maintaining optimal performance and efficiency. The decision largely depends on the current system's age, functionality, and the specific needs of the building or facility. Below are the general guidelines for when each action is most appropriate:

No system installed: If there is no existing energy management system, it is essential to install a new one to begin monitoring and optimizing energy use. This is the first step in improving energy efficiency and reducing costs.

Obsolete system: For systems that have become outdated and are no longer effective or supported, installation of a new system or a full replacement is necessary. Upgrading to newer technology can provide better performance and additional functionalities.

Older operating system: If an older system is still functional but not performing at its best, it may be time to either replace or renew it to enhance its capabilities or consider updating to incorporate newer features and improvements.

Recently installed system: For newer systems that are still in operation, a simple upgrade can ensure they remain up to date with the latest technology, enhancing efficiency and providing ongoing support for energy management goals.

New buildings/major renovations: When constructing new buildings or undergoing extensive renovations, it is essential to install or replace the energy management system to ensure that energy use is monitored and optimized from the outset, contributing to both sustainability and cost savings.

3.1.2. Comparison websites

There are several comparison sites available that can help you identify the most suitable energy management software systems for your needs. These platforms offer valuable insights, including reviews, price comparisons, and feature breakdowns, to guide your decision-making process. Some examples include:

- Capterra: [link](#)
- GetApp: [link](#)
- Software Advice: [link](#)

These third-party comparison sites are provided for informational purposes only. Their inclusion in this guide does not imply any endorsement or recommendation from us. The use of comparison websites is an excellent way for organizations to explore different energy management software options, enabling them to make well-informed decisions based on

features, pricing, and user feedback. These platforms can also highlight differences between various tools, allowing for a clearer understanding of which system best meets the organization's specific energy management goals.

4. Success Stories: Practical Applications from Case Studies in the Agri-food Sector

Digital technologies offer concrete solutions to improve efficiency, sustainability, and resilience in the agri-food sector. Below are three examples, based on real case studies presented within the project acceleration programme in Italy, illustrating the application of various digital architectures (such as DTEM.89, DTEM.90 in Excel database) to meet specific business needs.

An example is also shown on a real case study presented in the Spanish webinars within the acceleration programme.

The information will not have a commercial purpose, but it represents an example.

4.1. Energy Optimization and Uptime in a Flour and Oil Producer

Company: A processing industry specializing in the production of flour, oils, and lecithins from oilseeds and cereals.

Challenge: The need to optimize key processes such as weighing, ensure maximum operational continuity (plant active 24/7) essential for production, improve traceability and safety, and pay closer attention to energy consumption to reduce costs.

Implemented Solution: Adoption of an integrated digital architecture for energy and process management (EcoStruxure™ Power Operation). The solution includes:

- **Connected Products:** Sensors and smart devices on the electrical distribution network.
- **Edge Control:** SCADA system focused on energy supervision and control (Power SCADA Operation).
- **Apps, Analytics & Services:** Advanced software (e.g., Power Advisor / Power Monitoring Expert) for consumption analysis, power quality monitoring, and predictive diagnostics of electrical assets.

Key Results:

- **Increased Power Availability:** Reduction of unplanned downtime thanks to advanced monitoring and diagnostics of the electrical network.
- **Operational Efficiency:** Optimization of plant performance through more accurate data and improved control.
- **Energy Cost Reduction:** Identification and quantification of consumption by area and process, enabling targeted efficiency measures and better cost allocation.

4.2. Service Continuity and Power Quality in a Coffee Roasting Company

Company: A company specializing in the production of coffee blends.

Challenge: To streamline the production process (e.g., weighing), increase traceability and safety along the supply chain, but primarily to guarantee service continuity and resolve issues related to poor power quality that negatively impacted operations.

Implemented Solution: Implementation of a digital automation architecture (EcoStruxure™ Automation Expert) combined with specific Power Quality solutions:

- **Connected Products:** Process sensors, PLCs (e.g., M241), and installation of UPS (Uninterruptible Power Supplies) in a redundant configuration to ensure stable power.
- **Edge Control:** Automation platform (Automation Expert) for process control.
- **Apps, Analytics & Services:** Tools for remote monitoring and secure management (e.g., Secure Connect Advisor).

Key Results:

- **Traceability and Safety:** Precise tracking and monitoring of each batch (bag) throughout the process up to shipment.
- **Reliability and Continuity:** Effective resolution of power quality issues (micro-interruptions, fluctuations), ensuring more stable and continuous operation of production lines thanks to UPS and integrated control.

4.3. Comprehensive Digitization and Monitoring in a Fish Farm

Company: An aquaculture company specializing in sturgeon farming (Agro Ittica).

Challenge: To monitor the status of a wide range of equipment (electrical, electronic, mechanical) distributed over a large area in real-time; digitize field data collection replacing paper-based processes; implement rigorous product traceability; ensure swift and effective interventions on critical infrastructure (pumps, oxygenators, etc.).

Implemented Solution: Development of a tailored "Industry 4.0 Suite," integrating various technologies:

- **OT/IT Integration:** Interfacing existing equipment (chemical/physical sensors, electrical panels, PLCs with various protocols - OPC UA, Modbus, Profinet, etc.) with specific applications.
- **Dedicated Software:** Use of software platforms for fish farm management (ECERTUS), data analysis (SMART INDUSTRY), space management (A SPACE), and machine management (eMACCHINA).
- **Dematerialization:** Digitization of key processes (egg staging, loading/sales, quality checks, feeding, census, movements) using mobile devices and software.
- **Cloud and Connectivity:** Use of Cloud platforms (Apogeo, John Deere) for data management and integration (e.g., tractors).

Key Results:

- **Full Traceability:** Monitoring of the sturgeon at every stage, from arrival to maturation/sexing.

- **Proactive Monitoring:** Centralized control of environmental conditions (water) and systems (pumps, oxygenators, consumption), with timely detection of anomalies for targeted interventions, crucial for fish health and operational efficiency (including energy efficiency related to pumps and aerators).
- **Management Efficiency:** Elimination of paper, quick access to information, improved planning, and overall operational management.

4.4. Energy optimization and implementation of monitoring system in a winery

Company: Winery company.

Challenge: Need to optimize the company's energy costs and monitor the different production lines within the factory.

Implemented solution: Adoption of an integrated digital architecture for energy and process management (MILUZ). The solution includes:

- **Connected Products:** Energy sensors and meters in panels and subpanels for production processes and other plant consumption.
- **Applications, Analytics, and Services:** Advanced software (MILUZ) for consumption analysis, power quality monitoring, predictive diagnostics of electricity consumption, and integration of the plant's photovoltaic generation, in addition to personalized technical assistance.

Key Results:

- **Contracted power comparator:** Reduction of contracted power. This resulted in an estimated annual savings of 1,500€ per year, 15% of the power cost.
- **Energy Cost Reduction:** Identification and quantification of consumption by area and process. High consumption was observed in the cold storage units, with an estimated annual cost of 16,000€ per year. This enabled an analysis for the replacement of units with higher performance and improved energy efficiency
- **Cost Allocation by Product:** By identifying consumption by product line, product sales prices were reviewed to enhance market competitiveness.

5. Conclusions

This report has provided a comprehensive survey of DTEM and underscored their critical role in advancing energy efficiency within the demanding context of the EU agri-food sector. As highlighted throughout this document, the strategic adoption of DTEM is fundamental to achieving the AENEAM project's goals of promoting the uptake of energy audit recommendations and fostering a transition towards more sustainable operations, particularly among SMEs.

The survey revealed a diverse landscape of DTEM solutions, operating across different functional levels. The findings quantitatively confirmed a market focus on foundational data collection, with aM&T systems constituting 55% of the identified solutions, followed by more advanced EMS and SCADA platforms. This hierarchical approach, from essential data acquisition at the Field Level to sophisticated site-wide optimization at the Management Level, is key to transforming raw data into actionable insights for energy savings.

The benefits derived from implementing DTEM are multifaceted and were clearly substantiated by the survey results. Beyond the primary objective of reducing direct energy costs, the analysis confirmed that the most compelling drivers for adoption are real-time consumption monitoring (offered by 88% of solutions), direct energy expense reduction (63%), and CO₂ emissions reduction (41%). Furthermore, these technologies are instrumental in enhancing operational efficiency, enabling predictive maintenance, and facilitating compliance with crucial standards like ISO 50001 and the sustainability reporting frameworks of the CSRD.

The methodology employed, combining desk research with partner and stakeholder input, aimed to create a relevant, though non-exhaustive, overview. The survey profiled the typical modern DTEM solution as a scalable, integrable, and IoT-enabled platform (54 of cases), often enhanced with Artificial Intelligence (36). The near-universal availability of scalability (81) and integration capabilities (78) is a particularly crucial finding, as it underscores their adaptability for SMEs, which can start with pilot projects and expand over time without creating data silos. The accompanying Excel database serves as a practical resource for the AENEAM consortium to identify solutions tailored to specific company needs.

In conclusion, understanding the capabilities, market trends, and applications of DTEM, as presented in this report and illustrated through the case studies, is essential for effectively guiding agri-food SMEs. While large-scale econometric studies sometimes struggle to demonstrate a clear causal link between technology adoption and financial performance due to reliance on aggregated data (Bernedo, 2025), the AENEAM project's hands-on approach overcomes this limitation. By working directly with SMEs through energy audits and tailored advisory activities, we can identify and verify efficiency gains at a firm-specific level, bridging the gap between theoretical benefits and practical implementation. This confirms that a granular, company-level approach is essential to unlock and measure the true potential of digitalization in the agri-food sector. DTEM are powerful enablers for implementing energy audit recommendations and driving meaningful efficiency gains. Embracing digitalization through the appropriate selection and integration of these data-driven technologies is a strategic imperative for companies seeking competitiveness, resilience, and long-term sustainability in the evolving energy landscape.

6. Annexes

Annex 1 - Survey of digital technologies