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Updated Market Analysis for the Considered CEI Use Cases

White paper

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Cloud, Edge, IoT, Demand landscape, Use case, Market segment, go-to-market, requirements, scenarios

Disclaimer

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Glossary of terms

AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AR/VR	Augmented Reality/Virtual Reality
CAGR	Compound Annual Growth Rate
CDN	Content Delivery Networks
CEE	Central and Eastern Europe
CEI	Cloud-Edge-IoT
CRM	Customer Relationship Management
DSL	Digital Subscriber Line
ERP	Enterprise Resource Planning
EU	European Union
GEO	Geostationary Equatorial Orbit
IaaS	Infrastructure as a Service
IED	Intelligent Electronic Devices
IoT	Internet of Things
IPA	Intelligent Process Automation
IT	Information Technology
LED	Light-Emitting Diode
LEO	Low Earth Orbit
LTE	Long-Term Evolution
LPWAN	Low-Power Wide-Area Networks
MEC	Multi-access Edge Computing
MPLS	Multiprotocol Label Switching
MVNO	Mobile Virtual Network Operator
NB-IoT	Narrowband IoT
PaaS	Platform as a Service
RFID	Radio-Frequency Identification
ROI	Return on Investment
RPA	Robotic Process Automation
RTU	Remote Terminal Unit
SaaS	Software as a Service
SD-WAN	Software-Defined Wide Area Network
SIM	Subscriber Identity Module
TF	Task Force
VNF	Virtual Network Functions
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless Local Area Network
WP	Work Package

Executive Summary

This document presents refined estimates of annual market opportunities in the European Union (EU) for 79 Use Case Solutions identified as significant and promising by the UNLOCK-CEI project. It builds on a detailed structural analysis methodology (presented in "*White Paper 2.1: Technology Implementation Model and Architectural Patterns for CEI Use Cases*"[1], including a common technology implementation model and estimated costing scheme, applied to detailed analysis of market factors (including statistics on enterprises, employment and value added) for the five sectors considered by this project: agriculture, energy, healthcare, manufacturing and transport.

While the 79 Considered Use Cases cover a wide range of applications of Cloud-Edge-IoT (CEI) technologies, they should not be regarded as exhaustive:

- Additional Use Cases of interest in these sectors have been identified by projects related to UNLOCK-CEI and through interactions with industry experts from each of these sectors, but these have not been analysed in detail.
- The broad focus of the Considered Use Cases from UNLOCK-CEI has been business-to-business (B2B) applications, rather than business-to-consumer (B2C).

Therefore, the results of this analysis are intended to identify broad characteristics of the evolving CEI market, rather than top level market forecasts. These results should help suppliers in the CEI ecosystem navigate the market and develop intelligent go-to-market business strategies. They also help identify patterns of development that will influence market segmentation, market pathways and possible alternative market scenarios.

In this document, the following definitions apply:

- **Market Segment**: a subset of a total market based on demographics, needs, priorities, common interests, and other psychographic or behavioural criteria used to better understand the target audience.
- **Market Pathway**: a subset of a market segment expected to develop and evolve in a certain way, based on the changing needs of customers, the changing capabilities of suppliers, as well as the dynamics of different suppliers entering and exiting the market over time.
- **Market Scenario**: alternative Market Pathways that might be expected to develop. Different Market Scenarios would reflect different development pathways that might be possible depending on future actions by market participants.

With this context, several results of this analysis can be highlighted:

The aggregate CEI market opportunity is projected at €26 billion per year. Across the five sectors examined in this project, estimated market opportunities vary widely, based on the structure of those sectors in the EU and the likely technology implementation approaches for possible Use Cases.

The Transportation sector represents the largest total market opportunity, estimated at almost €12 billion per year (45% of the total). Energy/Utilities and Manufacturing are each estimated at roughly 25% of the total, with €6.8 and €6.4 billion per year respectively. Agriculture and Healthcare make up the balance, with €0.8 and €0.4 billion per year respectively (3% and 1% of the total, respectively). Figure 1 compares the total annual market opportunity by sector.

1 https://zenodo.org/records/12544163

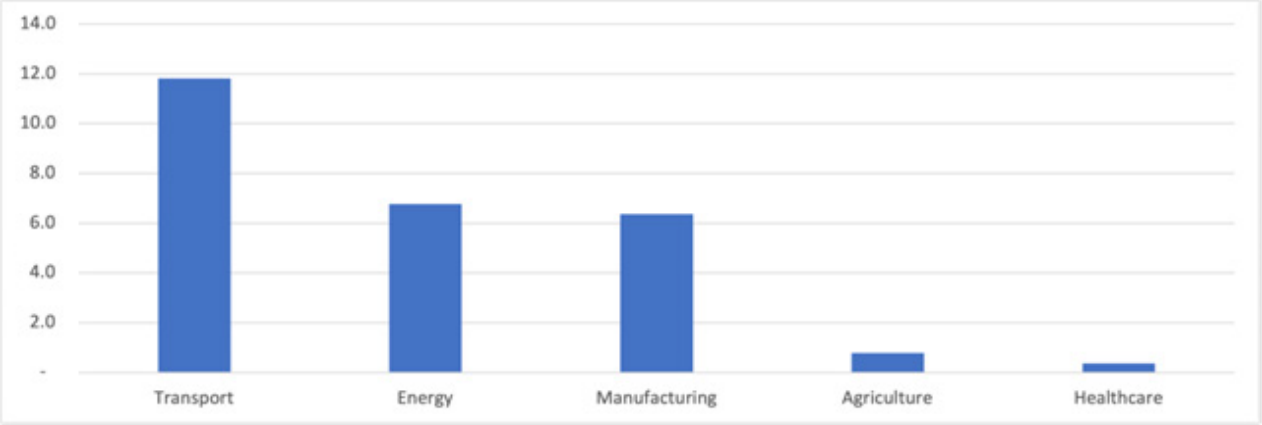

Figure 1: Total Annual Market Estimates for 5 sectors of interest (€ billions)

These market opportunities are very concentrated (Figure 2). The largest 24% of the 79 use cases (19 use cases) account for over 90% of the total annual market estimate. The largest 16.5% of the 79 use cases (13 use cases) account for over 80% of the total annual market. Addressing these top applications represents the most attractive way for suppliers to enter the European CEI market. The top 19 use cases are highlighted in light green in Table 5. Note that 18 of the 19 highest value use cases appear in the Energy/Utilities, Manufacturing and Transportation sectors, with only one appearing in the Agriculture sector.

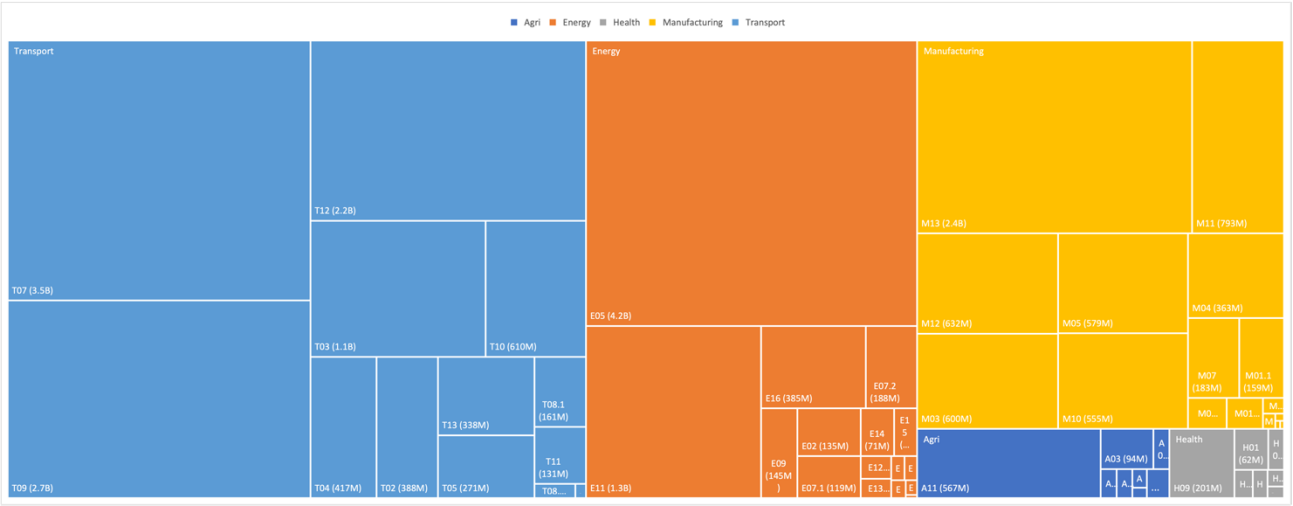

Figure 2: Annual Market Estimates for 79 Considered Use Cases (€ millions) ("treemap" format)

Based on the common technology implementation model developed for this project, the market estimates for individual Use Cases can be divided between IoT device spending and edge gateway spending. Figure 3 shows this breakdown for each Use Case, illustrating IoT device spending with the grey portion of each bar and edge gateway spending with the orange portion.

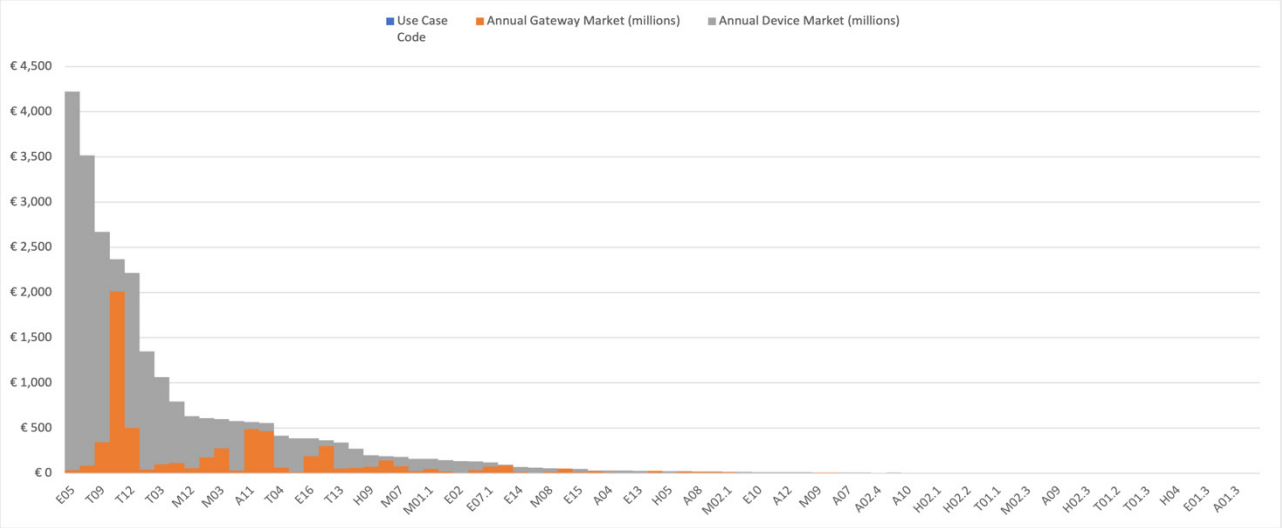

Figure 3: Annual Market Estimates for 79 Considered Use Cases (€ millions) (Gateway vs. Device estimates)

Overall, the IoT device market is expected to be much larger than the edge gateway market. Across the entire set of Considered Use Cases, the opportunity for IoT devices is estimated at close to €20 billion per year, compared to just over €6 billion/year for edge gateways (76% and 24%, respectively, of the total €26 billion CEI market estimate).

Recognizing that the market opportunities estimated in this report represent only a portion of the total market, forecasts of €6 billion per year for edge gateways system and €20 billion per year for IoT devices are consistent with the projections of both IDC and Decision Etudes & Conseil.

1. Introduction

This report responds to recommendation R3 from reviewers of the UNLOCK-CEI project:

> *"...indicate the sources used in the market studies and costs (e.g., D2.2 "Total addressable market analysis", p59, and in many other deliverables)".*

The analysis to which this recommendation refers is presented in Section 5 of Deliverable D2.2, entitled "Guiding Investments: Cross-Sector Strategic Insights". This report refreshes the project's complete analysis initially described in D2.2, including methodology, detailed sources, as well as assumptions included in the market estimates. In preparing this report, some assumptions used in the original D2.2 were made more conservative, cutting the projected annual market by roughly half – to €26 billion per year. Current sources and assumptions are fully described here, and the results presented have been used in all materials presented by the UNLOCK-CEI project since March 2024, including Deliverable D3.3, so no adjustments to these deliverables or presentations are needed.

1.1 Motivation

The UNLOCK-CEI team was originally motivated to conduct this detailed analysis to understand the current and future state of the market from the perspective of potential suppliers, potential architectures and business relationships in delivering CEI services to customers, and the alternative market scenarios that may develop as this market grows. Given the CEI market's evolving nature, understanding it at this level of detail is difficult.

- UNLOCK's own D1.1[2] ("Cloud-Edge-IoT Demand Landscape") and D1.2[3] ("Cloud-Edge-IoT Demand Landscape") deliverables present high-level market estimates for the respective cloud, edge and IoT segments of the overall market, and explore various structural aspects of the market, without quantifying them in detail.
- A recent study by DECISIONS Etudes et Conseils[4] explored the underlying technologies in detail, as well as selected sectoral requirements, offering glimpses into how, overall, the markets for different services and technologies may evolve over time. Aside from selected sectoral requirements, this report did not address the architectural choices that may be possible, or the service requirements that will limit the architectures that might be used to implement each use case.

No other market analyses have been found by the project team that address these topics in the required level of detail.

To fill this gap, the UNLOCK-CEI team analysed a large set (63) of use cases, in five major industry sectors, that appear promising for the Cloud-Edge-IoT market in Europe. This set of use cases (the "Considered Use Cases", see Table 1) was initially explored through a survey of approximately 700 industry respondents, the results of which can be found in D1.2 (Cloud-Edge-IoT Demand Landscape). In total the original 63 Use Cases presented by WP1 in D1.2 have been expanded to a list of 79 Use Case Solutions, which form the "Considered Use Cases" that are the foundation of this analysis.

2 https://doi.org/10.5281/zenodo.7821330

3 https://doi.org/10.5281/zenodo.8107103

4 https://op.europa.eu/en/publication-detail/-/publication/ff35c457-8f3b-11ee-8aa6-01aa75ed71a1

Table 1: Considered Use Cases with Assigned Use Case Codes

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
Agriculture		
A01.1	Employee safety monitoring	Track Employees in Hazardous Environments
A01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
A01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
A02.1	Asset condition monitoring	Monitor the Condition of Key Fixed Equipment
A02.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment
A02.3	Asset condition monitoring	Monitor the Condition of Key Mobile Equipment (e.g. tractors, trucks, harvesters)
A02.4	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. tractors, harvesters)
A03	Visual inspection - quality/ integrity	Inspect agricultural products (e.g. at harvesters, and grading stations) for quality control
A04	Video security & surveillance	Visual monitoring of fields and buildings
A05	Asset command & control	Command & Control of Key Assets (e.g. processing machines)
A06	Agriculture Field Monitoring	Monitor the Condition of Farm Fields, Paddocks and Pasture areas
A07	Asset location tracking	Track and Optimise Key Mobile Assets (e.g. tractors, harvesters)
A08	Process automation & optimization	Manage & Optimise precision agriculture systems
A09	Livestock monitoring	Collect Livestock health Data from "wearable" devices
A10	Agriculture Animal Tagging	Track Livestock locations from "wearable" devices
A11	Autonomous Vehicles	Enhancing and optimising the production
A12	Smart building	Smart Building Management
Energy		
E01.1	Employee safety monitoring	Track Employees in Hazardous Environments
E01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
E01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
E02	Asset location tracking	Track the Location of Key Movable (portable) Assets (e.g. high-value test equipment and tools
E03	Asset monitoring & maintenance	Monitor the Condition of Key Fixed Equipment
E04	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. repair trucks)

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
E05	Smart meters	Smart Meters: Load Management, Theft Prevention
E06	Regulatory compliance	Operational Reporting for Regulatory Compliance
E07.1	Remote network mgmt (e.g. fault detection)	Enhanced Grid Monitoring
E07.2	Remote network mgmt (e.g. fault detection)	Diagnostics, Incident detection from Enhanced Grid Monitoring
E08	Sensor-based diagnostics & maintenance	Predictive Maintenance for Key Fixed Equipment (e.g. transformers, circuit breakers)
E09	Video security & surveillance	Intrusion Detection & Access Control
E10	Asset command & control	Asset Dispatch of Generation Assets, Command & Control of Key Assets
E11	Process automation & optimization	Smart Grid: Real-Time Analytics and Dynamic Grids Optimisation
E12	Drone-based observation	Drone-based Inspection (e.g. remote generation, transmission assets)
E13	Field service technician monitoring	Technician Performance and Work Order Optimisation
E14	Connected drilling & extraction	Optimised Gas & Petroleum Exploration and Production
E15	Smart building	Smart Building Management
E16	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Special Environments (switchyards, substations)
Healthcare		
H01	Remote Health Monitoring	Collect Patent Health Data from remote devices (e.g. in patients' homes)
H02.1	Hospital Asset Tracking - dumb assets	Track Location of portable Assets (e.g. wheelchairs, hospital beds)
H02.2	Hospital Asset Tracking - patient monitors	Track Location of smart Assets (e.g. bedside monitors)
H02.3	Hospital Asset Tracking - other high-value assets	Track Location of other high-value portable Assets (e.g. dialysis machines, imaging machines)
H03	Video security & surveillance	Intrusion Detection & Access Control
H04	Regulatory compliance	Operational Reporting for Regulatory Compliance
H05	Bedside Telemetry	Collect Patent Health Data from distributed devices in the hospital
H06	AI-enabled Diagnosis & Treatment	Collect data about pathologies and symptoms to analyse and leverage cures.
H07	Robots or augmented-reality-assisted surgery	Routine surgical procedures are assisted by robots and/or AR tools for surgeons
H08	Smart building	Smart Building Management
H09	Automated guided vehicles (AGVs)	Automated Guided Vehicles (medical supplies, specimens) in hospitals

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
Manufacturing		
M01.1	Asset monitoring & maintenance	Monitor Condition of Key Fixed Equipment
M01.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment
M02.1	Employee safety monitoring	Track Employees in Hazardous Environment
M02.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
M02.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
M03	Visual inspection - quality/ integrity	Inspect manufactured products at various stages of production for quality control
M04	Manufacturing operations/ automation	Manage & Optimise Smart manufacturing at a single facility
M05	Video security & surveillance	Intrusion Detection & Access Control
M06	Food traceability	Track flow of food products through the agricultural food chain
M07	Asset command & control	Command & Control of Key Assets (e.g. conveyor belts)
M08	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. forklifts)
M09	Regulatory compliance	Operational Reporting for Regulatory Compliance
M10	Process automation & optimization	Manage & Optimise Smart manufacturing across the enterprise
M11	Smart building	Smart Building Management
M12	Asset location tracking	Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)
M13	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Factories, Warehouses
Transportation		
T01.1	Employee safety monitoring	Track Employees in Hazardous Environment
T01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments
T01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations
T02	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)
T03	Passenger traffic flow	Track passenger flow across the transport network to manage capacity and congestion
T04	Video security & surveillance	Intrusion Detection & Access Control
T05	Vehicle & infrastructure inspection	Drone-based Inspection (e.g. railroad rights of way, switchyards)

Use Case Code	Use Case (from D1.2 Section 4)	Explanatory title
T06	Regulatory compliance	Operational Reporting for Regulatory Compliance
T07	Freight monitoring	Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)
T08.1	Asset monitoring & maintenance	Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)
T08.2	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)
T09	Autonomous Vehicles	Autonomous vehicles leveraging security in a controlled system
T10	Quality of shipment conditions	Inspect shipping units (containers, pallets, crates, boxes) to detect damage and ensure proper routing
T11	Asset command & control	Command & Control of Key Assets (e.g. close/open doors to warehouses for truck access)
T12	Automated guided vehicles (AGVs)	Automated Guided Vehicles in railyards, ports, warehouses
T13	Smart building	Smart Building Management

In this report [D2.2 (R3)] the UNLOCK-CEI team examines each of the Considered Use Cases through a detailed structural analysis methodology. Each use case is categorised according to its possible architectural approaches for implementation, costs are estimated for such implementations, and these cost estimates are translated into market size estimates based on assumptions about the adoption of the use cases within the examined economic sectors.

As a general check, the market projections developed through this process can be validated against estimates from other sources (including those mentioned above), however the value of these estimates is not in their absolute magnitude but in their composition and the relative magnitude of their components. This allows the use cases, technologies and architectures to be differentiated in terms of the speed and scale of adoption – which in turn points to possible pathways for market development.

1.2 Methodology: Structural Analysis Assumptions and Approach

The structural analysis approach taken here begins with several key framing assumptions, which in turn support the step-by-step methodology employed. These framing assumptions are:

1. The enterprise and its facilities are the units of analysis for each use case.
2. For each use case at each facility, the implemented solution must connect with specific target objects at the facility (e.g. animals on a farm, packages in a logistics facility, power transformers in an electrical grid).
3. There is a common technical approach that can be used to model the economics of all the use cases.
4. There are common patterns for architecture and physical scope for use case implementation.
5. Capital costs can be estimated for the components in the common technical approach.
6. Potential total capital invested in each use case can be analysed to develop insights into possible market pathways and market scenarios.

7. Adoption rates are based on the results of the survey conducted by WP1, specifically the proportion of respondents indicating that they are planning to implement the use case within the next 2 years.

Assumptions 1 through 5 are examined in detail in *"White Paper 2.1: Technology Implementation Model and Architectural Patterns for CEI Use Cases" [1]*.

1.3 Structure of this Report

Section 2 quantifies the number of adopting enterprises and facilities for each use case.

Section 3 estimates the number of target objects that need to be connected in each implemented solution.

Section 4 combines this information with the estimated component cost information presented in [4] to calculate the potential market opportunity associated with each of the Considered Use Cases.

Conclusions based on this analysis can be found in Deliverable D3.3.

2. Estimating the Number of Adopting Enterprises and Facilities

The UNLOCK-CEI project focuses on the following five industry sectors:

- Agriculture
- Healthcare
- Manufacturing
- Energy
- Transportation.

In each of these sectors, public statistics are available to help quantify the population of enterprises that might adopt each of the use cases under consideration. The guiding principle for this quantification is to consider each enterprise's ability to pay for the use case implementation. The survey of industry participants conducted by WP1 is then used to estimate what proportion of this population might make this investment in the next 2 years for each use case.

These sectors are considered below.

2.1 Manufacturing, Energy and Transportation

For these three sectors (as well as others), Eurostat's recently published Structural Business Statistics (SBS)[5] provides data on three key variables (number of enterprises, employment, value-added), broken down by employment size classes.

This analysis considers statistics for the following industry categories (category codes are from the SBS):

- C: Manufacturing
- D: Electricity, gas, steam, air conditioning
- E: Water, sewer, waste management
- H: Transportation and storage
- R: Human health and social work.

Category E is included since it is like other utility-type organisations considered in the Energy category (D). Finally, Category R is included for consideration as part of the healthcare market analysis. Note that this statistics series does not include data on agricultural establishments – a different source is used for this sector.

In each category, the following data are available:

- Number of enterprises
- Number of employees
- Value added (million Euros).

This data is broken down by ranges of employees:

- >250
- 50-249
- 20-49
- 10-19
- 0-9.

5 https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20221220-4. The specific dataset is "Enterprise statistics by size class and NACE Rev.2 activity (from 2021 onwards)" (https://ec.europa.eu/eurostat/databrowser/view/SBS_SC_OVW/default/table?lang=en)

Table 2: Average Value Added Per Enterprise by Employee Size Range (million Euros per Employee) presents the calculated average economic value added per enterprise in Million Euros in each of the industry categories listed above:

Table 2: Average Value Added Per Enterprise by Employee Size Range (million Euros per Employee)

Industry Category		Number of Employees per Enterprise				
		0-9	10-19	20-49	50-249	>250
C	Manufacturing	0.1	0.6	1.5	6.2	84.8
D	Electricity, gas, steam, AC	0.2	3.2	6.8	21.4	299.8
E	Water, sewer, waste management	0.1	0.9	2.2	6.6	51.6
F	Construction	3.0	0.5	1.5	5.7	50.7
H	Transportation and storage	2.2	0.6	1.4	5.3	88.7
R	Human health and social work	7.3	0.4	1.0	5.7	64.3

Cells are highlighted yellow where the average value added is greater than 5 million Euros per enterprise, and tan for average value added between 1 and 5 million Euros. These amounts are chosen arbitrarily to establish the primary and secondary populations of enterprises that might adopt various use cases.

In this analysis, for each use case, the primary population of enterprises is assumed to adopt the use case at the rate determined by WP1's survey of industry participants (dividing by 2 to establish the annual rate), while the secondary population is assumed to adopt the use case at 50% of this rate.

Table 3 maps these criteria onto the number of enterprises in each cell:

Table 3: Number of Enterprises by Employee Size Range, with assigned Primary and Secondary population totals

Industry Category 0-9		Number of Employees per Enterprise					Total Adopting Enterprises	
		10-19	20-49	50-249	>250	Primary	Secondary	
C	Manufacturing	1,808,982	163,570	102,508	63,292	15,794	79,086	102,508
D	Electricity, gas, steam, AC	169,248	1,999	1,592	1,291	562	3,445	1,999
E	Water, sewer, waste management	65,185	6,057	4,938	3,601	882	4,483	4,938
H	Transportation and storage	31,060	57,696	36,952	16,483	3,316	19,799	68,012
R	Human health and social work	3,370	14,105	7,369	2,846	463	6,679	7,369

This data source does not indicate the number of facilities per establishment. Given the number of involved employees, the primary population of enterprises is generally assumed to have an average of 3 facilities per enterprise, while the secondary population is assumed to have a single facility.

The number of employees per facility represents the population of target "objects" for several use cases, so Table 4 presents total employment in each cell:

Table 4: Number of Employees by Employee Size Range, with assigned Primary and Secondary employee totals

Industry Category		Number of Employees per Enterprise					Adopting Employees	
		0-9	10-19	20-49	50-249	>250	Primary	Secondary
C	Manufacturing	3,754,239	2,252,349	3,181,884	6,586,360	14,392,643	20,979,003	3,181,884
D	Electricity, gas, steam, AC	181,216	25,553	50,376	132,175	939,528	1,122,079	25,553
E	Water, sewer, waste management	132,290	76,152	152,545	368,081	677,050	1,045,131	152,545
H	Transportation & storage	47,594	1,567,008	1,110,014	1,622,422	4,717,741	6,340,163	1,157,608
R	Human health and social work	4,038	197,251	237,276	278,236	335,190	617,464	237,276

2.1.1 Refined Adopting Population Estimates for Specific Use Cases

In general, use cases for the manufacturing, energy and transportation sectors do not require further differentiation within each industrial category. However, there are a few exceptions:

- "Agricultural Food Traceability" (M06) in the manufacturing sector. Here it is estimated that there are 300 enterprises and 400 enterprises, respectively, in the primary and secondary adopting populations in Europe, of sufficient economic size to invest in CEI applications, based on rough estimates from the Structural Business Statistics data.
- "Process Optimization" (E14) for oil and gas exploration and production enterprises. Here it is estimated that there are 500 enterprises and 200 enterprises, respectively, in the primary and secondary adopting populations in Europe, based on rough estimates from the Structural Business Statistics data.

In addition, "employee safety monitoring" use cases in all sectors consider both the incidence of "accident-prone" facilities and the number of employees at risk of accidents at those facilities. These populations are detailed together in section 3.1 below.

2.2 Agriculture

Eurostat's Structural Business Statistics (SBS) do not include statistics on agricultural enterprises or facilities. Instead, Eurostat provides "Farm Structure" statistics[6], which allow adopting populations to be estimated for each use case in this sector. For the purposes of this analysis, these statistics identify, for each distinct "farm holding" (considered a facility in this analysis):

- the farm type (a standardised list that indicates the principal agricultural output(s) of the farm),
- The number of agricultural workers (AWUs) at each farm holding,
- The total livestock "units" (LSUs) at each farm holding, where different species of livestock translate into LSUs at different rates,
- the size of the farm (utilised agricultural area) in hectares, and
- the standard output of the farm in Euros (gross economic output of each farm, based on a standardised list of crop or output types and associated productivity assumptions).

Older statistics presented standardised gross margin, but current statistics provide only estimated

6 "Farm indicators by legal status of the holding, utilised agricultural area, type and economic size of the farm and NUTS2 region" (https://ec.europa.eu/eurostat/databrowser/view/ef_m_farmleg/default/table?lang=en)

gross values of output.

The question of a farm's "willingness to pay" for the implementation of a use case can be addressed similarly to the sectors presented above, identifying primary and secondary adopting populations based on their economic size, and applying the adoption rates determined by the survey of industry participants reported in Deliverable D1.2. However, unlike the Structural Business Statistics, which identify economic value-added broken down by employment size range, Farm Structure statistics present "standard output" values for each type of farm and size range. As a proxy for the value-added statistic from the Structural Business Statistics, standard output per hectare can be calculated, and only farm facilities with a minimum level of standard output per hectare are included; this analysis assumes 15,000 Euros per hectare as the minimum. From this subset of farm holdings, farms with more than 500,000 Euros of aggregate standard output per year are categorised as the primary adopting population, while farms with between 100,000 and 500,000 Euros of aggregate standard output are categorised as the secondary adopting population. For agriculture, the primary and secondary adopting populations of facilities are determined to be 48,730 and 84,600, respectively.

2.2.1 Refined Adopting Population Estimates for Specific Agricultural Use Cases

Many agricultural use cases are more specific to the type of agricultural enterprise or facility in question. For example, the "Smart Building" use case assumes the presence of a more significant "building" to be automated, such as greenhouses or poultry facilities. For simplicity the adopting facility populations for only the "Livestock Monitoring" and "Agricultural Animal Tagging" use cases are refined beyond the overall figures above. Although there are many millions of livestock in EU farms[7], these use cases are assumed to only apply to cattle-related farm types, given the greater economic value of each animal, where the farm establishment is sufficiently large and profitable to afford the required investment. This limits the potential adoption of these use cases to farm types FT45 ("specialist dairying"), FT46 ("specialist cattle -- rearing and fattening"), and FT47 ("cattle - dairying, rearing and fattening combined"). For these use cases, the primary and secondary adopting populations of facilities are determined to be 3,220 and 5,670, respectively, and the corresponding numbers of cattle are 1,447,430 and 772,620, respectively.

2.3 Healthcare

The analysis in section 2.2.1 suggests that the primary population of healthcare enterprises is approximately 6,700, half of which fall in the 0-9 person employment range, plus an additional 7,400 establishments in the secondary population. As an alternative baseline for this analysis, the World Health Organisation[8] indicates that the total number of hospitals in the European Union (EU-27) is 12,752. This figure is comparable to the statistics identified in the Structural Business Statistics but is more directly applicable to the use cases defined by WP1, so it is taken as the baseline for the structural analysis of healthcare CEI use cases.

The total of 12,752 is arbitrarily divided in half to represent the primary and secondary adopting populations (6,376 each, respectively). Adoption rates are established in the same way as for the other sectors.

7 https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220517-2#:~:text=The%20EU%20has%20a%20sizeable,million%20goats%20in%20December%202021. Across the EU27 there are approximately 77 million cows and 143 million pigs.

8 https://gateway.euro.who.int/en/indicators/hfa_471-5011-number-of-hospitals/

3. Estimating the Population of Distributed Devices for Each Use Case and Corresponding Market Opportunities

Assessing the scale of market opportunity for each Use Case requires estimating both the number of facilities that adopt that Use Case, as well as the population of "target objects" involved in each use case. Depending on the Use Case, target objects at a facility could range from the number of animals on a farm, the number of packages present in a logistics facility, to the number of power transformers in an electrical grid. This section provides rationales for estimating the size of these target object populations at each "average" facility, supporting the calculations required to estimate the annual market opportunity for each Use Case.

3.1 Employee Safety Monitoring Use Cases

The incidence of work-related accidents is addressed by certain data sets contained in Eurostat's European statistics on accidents at work (ESAW)[9]. Overall, 2.3% of employees across the EU27 reported accidents in a 12-month period (reported in 2020). By contrast with the overall average, several sectors show accidents reported at rates in excess of the average:

- Agriculture, forestry, fishing – 2.8%
- Industrial (manufacturing, but not including construction) – 2.6%
- Construction – 4.1%

Other sectors did not report accident rates higher than the overall average.

These statistics allow the potential investment in employee safety monitoring to be quantified.

- 0.5% of the agricultural workforce experience "excess" accidents (2.8% minus the average of 2.3%). Assuming 1 worker experiences an accident among 10 workers working in accident-prone circumstances, this means that 5% of workers (10 times 0.5%) at an agricultural facility might benefit from the Employee Safety Monitoring use case. An agricultural facility would need at least 20 workers to be a candidate for this use case.
- In industrial sectors (including manufacturing and energy), an excess accident rate of 0.3% would translate into 3% of workers benefiting from Employee Safety Monitoring. Enterprises in these sectors would need at least 33 employees to benefit from this use case.
- Although the transportation sector did not report excess accidents, the same 3% of workers might be assumed to benefit from Employee Safety Monitoring. Enterprises in these sectors would also need at least 33 employees to benefit from this use case.
- As a point of comparison, the excess accident rate in Construction is 1.8%, suggesting that potentially 18% of construction workers might benefit from Employee Safety Monitoring. Enterprises in these sectors would need only 6 employees to benefit from this use case, although this sector is not included in this analysis.

Basic employee safety monitoring can be implemented as an employee location tracking system, applied to a static "map" of dangerous areas across a facility, and providing alerts to employees entering dangerous areas. This system can also detect motionless tracking devices which might indicate an incapacitated worker.

9 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Self-reported_accidents_at_work_-_key_statistics#Most_affected_sectors_of_activity_and_occupations

Applying the incidence rates above to each sector, the following populations of enterprises and at-risk employees are calculated:

- Using the Farm Structure statistics, the primary and secondary adopting populations of agricultural facilities are determined to be 7,420 and 1,320, respectively. The corresponding numbers of workers at risk, working at facilities (farm holdings) with more than 20 workers, are 9,080 and 1,320, respectively.
- Table 3 and Table 4 can be consulted to establish the adopting populations and numbers of affected employees for manufacturing, energy and transportation.
  - Manufacturing: the 33 employee cutoff falls in the middle of the 20-49 employee size range, so all enterprises and employees from the primary population are included (79,086 and 20,979,003, respectively) as well as roughly half of the enterprises and employees from the secondary population (50,000 and 1,500,000).
  - Energy and other utilities: as with manufacturing, the cutoff falls in the middle of the 20-49 employee size range, so almost all enterprises and employees from the primary population are included (7,126 and 2,142,131) as well as roughly half of the enterprises and employees from the secondary population for the other utility sector (2,500 and 76,000).
  - Transportation: the 33 employee cutoff falls in the middle of the 20-49 employee size range, so all enterprises and employees from the primary population are included (19,799 and 6,340,163) as well as roughly half of the enterprises and employees from the secondary population (18,500 and 550,000).

More advanced employee safety monitoring enhances the employee-based component to gather essential measurements that might indicate employee distress (heart rate, skin or air temperature, breathing rate, etc.). Dangerous areas can also be identified dynamically based on condition monitoring devices in potentially dangerous areas, measuring temperature, the presence of certain gases or smoke, etc.

Deliverable D1.2 identifies Employee Safety Monitoring as an important use case in the Agriculture, Energy, Manufacturing and Transportation sectors. This use case is modelled as three separate use cases in each sector:

- Employee Location Tracking
- Employee Health Monitoring
- Monitoring of Hazardous Conditions.

Employee Location Tracking is quantified using the figures by sector presented above. Enhanced employee safety monitoring is assumed to be potentially adopted at 10% of the facilities adopting basic employee safety monitoring, with 10% of employees provided with more capable monitoring devices, and one or more potentially hazardous locations per facility fitted with condition sensors. It is assumed that 3 such devices would be installed by each facility in the primary adopting population, with only 1 such device installed for facilities in the secondary population.

The assumptions above are summarised in Table 5, below.

This table (and those in the sections that follow) includes the following columns:

- **Use Case Code**: A letter (A, E, H, M, T, denoting the five sectors under consideration), followed by a 2-digit number reflecting the list of use cases presented by WP1 in D1.2 (see Table 1), possibly followed by a 1 digit fraction to distinguish "sub-use cases" created to more fully model the economics of that use case.
- **Short Title**: Brief description of the use case
- **Qty 1º Ents. (A)**: Number of enterprises in the primary adopting population. This and the next value are detailed in section 3 above.
- **Qty 2º Ents. (B)**: Number of enterprises in the secondary adopting population

- **Facilities per 1º Ent. (C)**: Assumed number of facilities per enterprise in the primary adopting population
- **Facilities per 2º Ent. (D)**: Assumed number of facilities per enterprise in the secondary adopting population
- **Cost per Gateway (€):** Estimated capital cost of gateway required for this use case. (Technology Implementation Model and Architectural Patterns for CEI Use Cases[10])
- **Target Type and Estimation Methodology**: Description of the target population of objects to be measured in each use case, along with the method of estimating the number of targets for a given use case.
- **Targets in all 1º Facilities (E=AxC or calculated otherwise)**: Total targets in the primary adopting population
- **Targets in all 2º Facilities (F=BxD or calculated otherwise)**: Total targets in the secondary adopting population
- **Devices per 1º target (G)**: Assumed number of devices per target in the primary adopting population
- **Devices per 2º target (H)**: Assumed number of devices per target in the secondary adopting population
- **Qty 1º IoT Devices involved (I=ExG)**: Calculated total number of devices in the primary adopting population
- **Qty 2º IoT Devices involved (J=FxH)**: Calculated total number of devices in the secondary adopting population
- **Cost per Device (€):** Estimated capital cost of each device required for this use case. (Technology Implementation Model and Architectural Patterns for CEI Use Cases)
- **Average Adoption Rate**: Percent of estimated total market expected to implement this use case each year. (Source: D1.2)
- **Annual Market Gateways (€M)**: Annual market opportunity for the use case for gateways, millions of Euros
- **Annual Market Devices (€M)**: Annual market opportunity for the use case for IoT devices, millions of Euros
- **Annual Market Total (€M)**: Annual market opportunity for the use case for gateways plus IoT devices, millions of Euro

10 https://zenodo.org/records/12544163

Table 5: Quantities and Market Opportunities for Employee Safety Monitoring Use Cases

Use Case Code	Short title	Qty 1° Ents. (A)	Qty 2° Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Cost per gate-way (€)	Target Type - assumptions	Targets in all 1° Facilities (E=AxC or calculated otherwise)	Targets in all 2° Facilities (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per Device (€)	Avg. adop-tion rate	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
A01.1	Employee safety monitoring (A01.1): €0.2 million, Track Employees in Hazardous Environment	7,420	1,320	1	1	900	Employees at risk (see discussion above)	9,080	1,320	1	1	9,080	1,320	185	2.4%	0.2	0.0	0.2
A01.2	Employee safety monitoring (A01.2): €0.1 million, Monitor Employee "Vitals" in Hazardous Environments	742	132	1	1	2,050	Employees at high risk (see discussion above)	908	132	1	1	908	132	295	2.4%	0.0	0.0	0.1
A01.3	Employee safety monitoring (A01.3): €0 million, Monitor Conditions at Known Hazardous Locations	742	132	1	1	850	Risky locations in a facility (see discussion above)	742	132	3	1	2,226	132	270	2.4%	0.0	0.0	0.0
E01.1	Employee safety monitoring (E01.1): €1 million, Track Employees in Hazardous Environment	7,126	2,500	3	1	1,200	Employees at risk (total employees X 3% at risk)	2,142,131	76,000	3%	3%	64,264	2,280	200	1.9%	0.5	0.3	0.8
E01.2	Employee safety monitoring (E01.2): €0.2 million, Monitor Employee "Vitals" in Hazardous Environments	713	250	3	1	2,400	Employees at high risk (total employees X 0.3% at high risk)	2,142,131	76,000	0.3%	0.3%	6,426	228	315	1.9%	0.1	0.0	0.2
E01.3	Employee safety monitoring (E01.3): €0.1 million, Monitor Conditions at Known Hazardous Locations	713	250	3	1	1,150	Dangerous locations (4000 substations+2000 other utility locations. Split 75%/25% between primary & secondary populations) (see section 3.3 below for source of substation quantities)	4,500	1,500	1	1	4,500	1,500	290	1.9%	0.1	0.0	0.1
M02.1	Employee safety monitoring (M02.1): €18 million, Track Employees in Hazardous Environment	79,086	50,000	3	1	1,200	Employees at risk (total employees X 3% at risk)	20,979,003	1,500,000	3%	3%	629,370	45,000	200	3.1%	10.5	4.4	14.9
M02.2	Employee safety monitoring (M02.2): €3 million, Monitor Employee "Vitals" in Hazardous Environments	7,909	5,000	3	1	2,400	Employees at high risk (total employees X 0.3% at risk)	20,979,003	1,500,000	0.3%	0.3%	62,937	4,500	315	3.1%	2.1	0.7	2.8
M02.3	Employee safety monitoring (M02.3): €2 million, Monitor Conditions at Known Hazardous Locations	7,909	5,000	3	1	1,150	Facilities X number of hazardous locations per facility	23,726	5,000	3	1	71,177	5,000	290	3.1%	1.0	0.7	1.7
T01.1	Employee safety monitoring (T01.1): €3 million, Track Employees in Hazardous Environment	19,799	18,500	3	1	1,200	Employees at risk (total employees X 3% at risk)	6,340,163	550,000	3%	3%	190,205	16,500	200	2.1%	1.9	0.9	2.8

Use Case Code	Short title	Qty 1° Ents. (A)	Qty 2° Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Cost per gate-way (€)	Target Type - assumptions	Targets in all 1° Facilities (E=AxC or calculated otherwise)	Targets in all 2° Facilities (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per Device (€)	Avg. adop-tion rate	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
T01.2	Employee safety monitoring (T01.2): €0.4 million, Monitor Employee "Vitals" in Hazardous Environments	1,980	1,850	3	1	2,400	Employees at high risk (total employees X 0.3% at high risk)	6,340,163	550,000	0.3%	0.3%	19,020	1,650	315	2.1%	0.4	0.1	0.5
T01.3	Employee safety monitoring (T01.3): €0.3 million, Monitor Conditions at Known Hazardous Locations	1,980	1,850	3	1	1,150	Facilities X number of hazardous locations per facility	5,940	1,850	3	1	17,819	1,850	290	2.1%	0.2	0.1	0.3

3.2 Other Use Cases in Agriculture

Most of the Considered Use Cases (aside from employee safety monitoring discussed above) are quantified based on the number of agricultural facilities determined in section 2.2 above, namely 48,730 primary facilities and 84,500 secondary facilities. The number of target objects for each use case is calculated assuming a fixed number of the relevant asset for each primary and each secondary facility, which are presented in Table 6 below.

For livestock monitoring (use cases A09 and A10), section 2.2.1 presents data from the Farm Structure Statistics ([5]) quantifying the number of cattle at primary and secondary livestock facilities, as well as the number of such facilities.

For video security and surveillance (A04) and agricultural field monitoring (A06), the aggregate size (in hectares) of the primary and secondary agricultural facilities is derived from the Farm Structure Statistics ([5]) and used as a proxy for the number of surveillance or monitoring devices required. The data are presented in Table 6.

Table 6: Quantities and Market Opportunities for Agriculture Use Cases

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
A01.1	Employee safety monitoring (A01.1): €0.2 million, Track Employees in Hazardous Environment	7,420	1,320	1	1	2.4%	900	Employees at risk (see discussion above)	9,080	1,320	1	1	9,080	1,320	185	0.2	0.0	0.2
A01.2	Employee safety monitoring (A01.2): €0.1 million, Monitor Employee "Vitals" in Hazardous Environments	742	132	1	1	2.4%	2,050	Employees at high risk (see discussion above)	908	132	1	1	908	132	295	0.0	0.0	0.1
A01.3	Employee safety monitoring (A01.3): €0 million, Monitor Conditions at Known Hazardous Locations	742	132	1	1	2.4%	850	Risky locations in a facility (see discussion above)	742	132	3	1	2,226	132	270	0.0	0.0	0.0
A02.1	Asset condition monitoring (A02.1): €3 million, Monitor Condition of Key Fixed Equipment	48,730	84,600	1	1	2.1%	1,050	Facilities X key fixed assets per facility	48,730	84,600	3	2	146,190	169,200	25	2.9	0.2	3.1
A02.2	Asset monitoring & maint. (A02.2): €4 million, Predictive Maintenance for Key Fixed Equipment	48,730	84,600	1	1	2.1%	1,500	Facilities	48,730	84,600			0	0	25	4.2	0.0	4.2
A02.3	Asset condition monitoring (A02.3): €5 million, Monitor Condition of Key Mobile Equipment (e.g. tractors, trucks, harvesters)	48,730	84,600	1	1	2.1%	1,550	Facilities X Key Mobile Equipment (e.g. tractors, trucks, harvesters) per facility	48,730	84,600	7	3	341,110	253,800	25	4.3	0.4	4.7

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
A02.4	Asset monitoring & maint. (A02.4): €6 million, Predictive Maintenance for Key Mobile Equipment (e.g. tractors, harvesters)	48,730	84,600	1	1	2.1%	2,000	Facilities	48,730	84,600			0	0	25	5.6	0.0	5.6
A03	Visual inspection - quality/ integrity (A03): €94 million, Inspect agricultural products (e.g. at harvesters, grading stations) for quality control	48,730	84,600	1	1	2.9%	22,050	Facilities X Inspection Stations (e.g. at harvesters, grading stations) per facility	48,730	84,600	2	1	97,460	84,600	1,440	85.7	8.6	94.3
A04	Video security & surv. (A04): €29 million, Visual monitoring of fields and buildings	48,730	84,600	1	1	3.0%	1,700	Facility size (hectares) as proxy for fields/ buildings (Farm Structure Statistics)	1,216,690	444,390	1	1	1,216,690	444,390	355	6.7	22.1	28.8
A05	Asset command & control (A05): €21 million, Command & Control of Key Assets (e.g. processing machines)	48,730	84,600	1	1	3.3%	4,200	Facilities X Controllable Assets (e.g. processing machines) per facility	48,730	84,600	2	1	97,460	84,600	355	18.3	2.4	20.7
A06	Agriculture Field Monitoring (A06): €6 million, Monitor Condition of Farm Fields, Paddocks and Pasture areas	48,730	84,600	1	1	3.2%	1,050	Facility size (hectares) (Farm Structure Statistics)	1,216,690	444,390	1	1	1,216,690	444,390	25	4.5	1.7	6.2
A07	Asset location tracking (A07): €7 million, Track and Optimise Key Mobile Assets (e.g. tractors, harvesters)	48,730	84,600	1	1	2.9%	1,050	Facilities X Key Mobile Equipment (e.g. tractors, trucks, harvesters) per facility	48,730	84,600	7	3	341,110	253,800	135	4.0	2.6	6.7
A08	Process automation & optimization (A08): €20 million, Manage & Optimise precision agriculture systems	48,730	84,600	1	1	3.5%	3,750	Facilities X Additional devices per facility to enable full control	48,730	84,600	2	1	97,460	84,600	440	17.3	3.1	20.4
A09	Livestock monitoring (A09): €1 million, Collect Livestock health Data from "wearable" devices	3,220	5,670	1	1	4.8%	1,350	Total Livestock (head of cattle) X percentage equipped with monitors (see section 2.2.1)	1,447,430	772,620	10%	5%	144,743	38,631	25	0.6	0.3	0.9
A10	Agriculture Animal Tagging (A10): €4 million, Track Livestock locations from "wearable" devices	3,220	5,670	1	1	4.7%	2,550	Total Livestock (head of cattle, 100% with location tracking) (see section 2.2.1)	1,447,430	772,620	100%	100%	1,447,430	772,620	25	1.1	3.2	4.3
A11	auton. vehicles (A11): €570 million, Enhancing and optimising the production	48,730	84,600	1	1	6.9%	53,550	Facilities X autonomous movable assets (e.g. tractors, harvesters, etc.) per facility	48,730	84,600	2	1	97,460	84,600	5,535	489.2	77.6	566.9
A12	Smart building (A12): €12 million, Smart Building Management	48,730	84,600	1	1	5.8%	600	Facilities X buildings equipped with building control systems	48,730	84,600	5	2	243,650	169,200	270	4.7	7.6	12.2

3.3 Other Use Cases in Energy & Utilities

Many of the Considered Use Cases (E02, E04, E09, E12, E13, E15, E16) are quantified based on the number of energy & utility facilities determined in section 2.1 above, namely 7,928 primary facilities and 6,937 secondary facilities. The number of target objects for each use case is calculated assuming a fixed number of the relevant asset for each primary and each secondary facility, which are presented in Table 7 below.

Several other Considered Use Cases (E03, E07.1, E07.2, E08, E10, E16) are quantified based on the number of "distributed" energy & utility facilities, such as electrical substations and gas compressor stations for electrical and gas utilities respectively. This analysis assumes 20,000 electrical substations[11] plus 2,000 gas compressor stations (for a total of 22,000 distributed facilities), divided 75%/25% between primary and secondary adopting populations. In addition, this analysis assumes an average of 20 key assets at each electrical substation, and 5 key assets at each gas compressor station, yielding a total "distributed asset" population of 307,500 primary and 102,500 secondary assets. Different assumptions about the number of IoT devices per asset are made, depending on the use case.

For Smart Meters (E05) and regulatory compliance reporting (E06), estimates are based on 131 million electric utility customers[12], divided 75%/25% between primary and secondary adopting populations. An average number of IoT devices per customer is assumed in E05 (5 for primary population, 2 for secondary population).

For Smart Grid (E11), the estimate is based on 5% of 119 million smart grid devices[13], divided 75%/25% between primary and secondary adopting populations. An average number of IoT devices per smart meter devices is then assumed (10 for primary population, 5 for secondary population).

For connected drilling (E14), the number of oil & gas primary production enterprises is estimated at 500 in the primary population and 200 in the secondary population. Facilities per enterprise are assumed to be 3 for primary population and 1 for secondary population (the same as most other estimates), and a total of 1,000 IoT devices are assumed to be required in each facility.

All these data are presented in Table 7.

11 https://publications.jrc.ec.europa.eu/repository/handle/JRC132379; total high/medium voltage substations estimated from Figure 13

12 https://avaenergy.org/news/home-of-the-future-climate-friendly-electrified-and-closer-than-ever/

13 https://www.eia.gov/tools/faqs/faq.php?id=108&t=1

Table 7: Quantities and Market Opportunities for Energy & Utilities Use Cases

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1º Ent. (C)	Facili-ties per 2º Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1º Facili- ties (E=AxC or calculated otherwise)	Targets in all 2º Facili- ties (F=BxD or calculated otherwise)	Devices per 1º target (G)	Devices per 2º target (H)	Qty 1º IoT Devices involved (I=ExG)	Qty 2º IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
E01.1	Employee safety monitoring (E01.1): €1 million, Track Employees in Hazardous Environment	7,126	2,500	3	1	1.9%	1,200	Employees at risk (total employees X 3% at risk)	2,142,131	76,000	3%	3%	64,264	2,280	200	0.5	0.3	0.8
E01.2	Employee safety monitoring (E01.2): €0.2 million, Monitor Employee "Vitals" in Hazardous Environments	713	250	3	1	1.9%	2,400	Employees at high risk (total employees X 0.3% at high risk)	2,142,131	76,000	0.30%	0.30%	6,426	228	315	0.1	0.0	0.2
E01.3	Employee safety monitoring (E01.3): €0.1 million, Monitor Conditions at Known Hazardous Locations	713	250	3	1	1.9%	1,150	Dangerous locations (4000 substations + 2000 other utility locations. Split 75%/25% between primary & secondary populations) (see section 3.3 for source of substation quantities)	4,500	1,500	1	1	4,500	1,500	290	0.1	0.0	0.1
E02	Asset location tracking (E02): €130 million, Track Location of Key Movable (portable) Assets (e.g. high value test equipment and tools	7,928	6,937	3	1	2.9%	3,100	Facilities X High value portable assets (e.g. not trucks, but high value test test equipment) per facility	23,784	6,937	1,000	1,000	23,784,000	6,937,000	150	2.7	132.0	134.7
E03	Asset monitoring & maint. (E03): €11 million, Monitor Condition of Key Fixed Equipment	7,928	6,937	3	1	2.5%	5,900	Distributed Assets X IoT Devices per Asset	307,500	102,500	5	2	1,537,500	205,000	150	4.5	6.8	11.3
E04	Fleet tracking (E04): €14 million, Track and Optimise Key Mobile Assets (e.g. repair trucks)	7,928	6,937	3	1	2.9%	1,400	Facilities X key mobile assets per facility	7,928	6,937	300	100	2,378,400	693,700	150	1.2	13.2	14.4
E05	Smart meters (E05): €4.2 billion, Smart Meters: Load Management, Theft Prevention	7,928	6,937	3	1	3.5%	31,600	Residential, Commercial, Industrial Meters	98,250,000	32,750,000	5	2	491,250,000	65,500,000	200	34.4	4,187.2	4,221.7
E06	Regulatory compliance (E06): €0.6 million, Operational Reporting for Regulatory Compliance	7,928	6,937	3	1	3.3%	550	Residential, Commercial, Industrial Meters	98,250,000	32,750,000			0	0	270	0.6	0.0	0.6
E07.1	Remote network mgmt (e.g. fault detection) (E07.1): €120 million, Enhanced Grid Monitoring	7,928	6,937	3	1	4.2%	55,800	Distributed Assets X IoT Devices per Asset	307,500	102,500	5	2	1,537,500	205,000	600	72.0	46.6	118.5

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
E07.2	Remote network mgmt (e.g. fault detection) (E07.2): €190 million, Diagnostics, Incident detection from Enhanced Grid Monitoring	7,928	6,937	3	1	4.2%	109,800	Distributed Assets X IoT Devices per Asset	307,500	102,500	5	2	1,537,500	205,000	600	141.6	46.6	188.2
E08	Sensor-based diagnostics & maint. (E08): €7 million, Predictive Maintenance for Key Fixed Equipment (e.g. transformers, circuit breakers)	7,928	6,937	3	1	4.0%	6,000	Distributed Assets X IoT Devices per Asset	307,500	102,500			0	0	25	7.5	0.0	7.5
E09	Video security & surv. (E09): €150 million, Intrusion Detection & Access Control	7,928	6,937	3	1	4.8%	12,800	Facilities X Surveillance positions per facility	23,784	6,937	200	100	4,756,800	693,700	455	19.0	126.4	145.4
E10	Asset command & control (E10): €13 million, Asset Dispatch of Generation Assets, Command & Control of Key Assets	7,928	6,937	3	1	4.3%	4,850	Distributed Assets X IoT Devices per Asset	307,500	102,500	1	1	307,500	102,500	410	6.4	7.1	13.4
E11	Process automation & optimization (E11): €1.3 billion, Smart Grid: Real-Time Analytics and Dynamic Grid Optimisation	7,928	6,937	3	1	5.0%	26,500	Energy grid/ infrastructure operations	4,462,500	1,487,500	10	5	44,625,000	7,437,500	480	40.7	1,306.6	1,347.3
E12	Drone-based observation (E12): €31 million, Drone-based Inspection (e.g. remote generation, transmission assets)	7,928	6,937	3	1	5.8%	12,500	Facilities X drone inspection systems per facility	23,784	6,937	10	5	237,840	34,685	520	22.4	8.7	31.1
E13	Field service technician monitoring (E13): €26 million, Technician Performance and Work Order Optimisation	7,928	6,937	3	1	6.8%	1,400	Facilities X technicians equipped with monitors per facility	7,928	6,937	225	75	1,783,800	520,275	150	2.9	23.4	26.4
E14	Connected drilling & extraction (E14): €71 million, Optimised Gas & Petroleum Exploration and Production	500	200	3	1	6.5%	107,500	Full oil exploration & production value chain	1,500	200	1,000	1,000	1,500,000	200,000	535	11.9	59.3	71.2
E15	Smart building (E15): €49 million, Smart Building Management	7,928	6,937	3	1	9.0%	4,400	Facilities X building control systems per facility	23,784	6,937	50	20	1,189,200	138,740	290	12.2	37.1	49.2
E16	Automated guided vehicles (AGVs) (E16): €390 million, Automated Guided Vehicles in Special Environments (switchyards, substations)	7,928	6,937	3	1	11.4%	54,550	Total mobile assets (e.g. bucket trucks, repair trucks, see E04) X % with AGV capabilities	2,378,400	693,700	10%	10%	237,840	69,370	5,585	190.3	194.9	385.2

3.4 Other Use Cases in Healthcare

Many of the Considered Use Cases (H02.3, H03, H04, H06, H07, H08, H09) are quantified based on the number of healthcare facilities determined in section 2.3 above, namely 6,376 primary facilities and 6,376 secondary facilities. The number of target objects for each use case is calculated assuming a fixed number of the relevant asset for each primary and each secondary facility, which are presented in Table 8 below.

Several other Considered Use Cases (H02.1, H02.2, H05) are quantified based on the number of hospital patients in the European Union (3,916,734[14]) divided 75%/25% between primary and secondary adopting populations. All these patients are assumed to have 1 hospital bed, matched 10:1 by wheelchairs, 80% with patient monitors.

Finally remote health monitoring (H01) is estimated based on:

- EU population of 449.2 million[15].
- 36.1% with chronic disease[16]
- Of which 5% are assumed to need remote health monitoring.

The resulting population of patients to be monitored remotely are divided 75%/25% between primary and secondary categories.

All these data are presented in Table 8.

Table 8: Quantities and Market Opportunities for Healthcare Use Cases

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili- ties per 1º Ent. (C)	Facili- ties per 2º Ent. (D)	Avg. adop- tion rate	Cost per gate- way (€)	Target Type -- estimation assumptions	Targets in all 1º Facili- ties (E=AxC or calculated otherwise)	Targets in all 2º Facili- ties (F=BxD or calculated otherwise)	Devices per 1º target (G)	Devices per 2º target (H)	Qty 1º IoT Devices involved (I=ExG)	Qty 2º IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate- ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
H01	Remote Health Monitoring (H01): €68 million, Collect Patent Health Data from remote devices (e.g. in patients' homes)	6,376	6,376	1	1	1.1%	6,300	Ill people @home, people with chronic disease @home, emergency response	6,081,045	2,027,015	2	2	12,162,090	4,054,030	290	0.9	60.9	61.8
H02.1	Hospital Asset Tracking - dumb assets (H02.1): €4 million, Track Location of portable Assets (e.g. wheelchairs, hospital beds)	6,376	6,376	1	1	2.2%	2,600	Dumb Assets (beds, wheelchairs)	3,231,306	1,077,102	1	1	3,231,306	1,077,102	30	0.7	3.2	4.0

14 Based on number of beds in hospitals. https://ec.europa.eu/eurostat/databrowser/view/tps00046/default/table?lang=en

15 https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240711-1

16 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Self-perceived_health_statistics&oldid=509628

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili- ties per 1º Ent. (C)	Facili- ties per 2º Ent. (D)	Avg. adop- tion rate	Cost per gate- way (€)	Target Type -- estimation assumptions	Targets in all 1º Facili- ties (E=AxC or calculated otherwise)	Targets in all 2º Facili- ties (F=BxD or calculated otherwise)	Devices per 1º target (G)	Devices per 2º target (H)	Qty 1º IoT Devices involved (I=ExG)	Qty 2º IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate- ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
H02.2	Hospital Asset Tracking - patient monitors (H02.2): €3 million, Track Location of smart Assets (e.g. bedside monitors)	6,376	6,376	1	1	2.2%	2,600	Patients in hospital X % with tracked monitors	2,937,551	979,184	80%	80%	2,350,040	783,347	30	0.7	2.4	3.1
H02.3	Hospital Asset Tracking - other high value assets (H02.3): €0.8 million, Track Location of other high value portable Assets (e.g. dialysis machines, imaging machines)	6,376	6,376	1	1	2.2%	1,400	Facilities X Smart assets (larger mobile assets) per facility	6,376	6,376	50	50	318,800	318,800	30	0.4	0.4	0.8
H03	Video security & surv. (H03): €12 million, Intrusion Detection & Access Control	6,376	6,376	1	1	2.1%	12,800	Facilities X surveillance positions per facility	6,376	6,376	100	20	637,600	127,520	455	3.4	8.9	12.4
H04	Regulatory compliance (H04): €0.2 million, Operational Reporting for Regulatory Compliance	6,376	6,376	1	1	3.0%	550	Facilities	6,376	6,376			0	0	270	0.2	0.0	0.2
H05	Bedside Telemetry (H05): €23 million, Collect Patent Health Data from distributed devices in the hospital	6,376	6,376	1	1	2.2%	4,300	Patients in hospital X % with telemetry-equipped monitors	2,937,551	979,184	80%	80%	2,350,040	783,347	265	1.2	21.8	23.0
H06	AI-enabled Diagnosis & Treatment (H06): €0.4 million, Collect data about pathologies and symptoms to analyse and leverage cures.	6,376	6,376	1	1	3.3%	1,050	Facilities	6,376	6,376	0	0	0	0	270	0.4	0.0	0.4
H07	Robots or augmented-reality- assisted surgery (H07): €19 million, Routine surgical procedures are assisted by robots and/or AR tools for surgeons	6,376	6,376	1	1	2.2%	54,600	Facilities X robotic surgery suites per facility	6,376	6,376	3	1	19,128	6,376	5,610	15.1	3.6	18.7
H08	Smart building (H08): €29 million, Smart Building Management	6,376	6,376	1	1	7.9%	4,400	Facilities X building controls per facility	6,376	6,376	100	50	637,600	318,800	290	4.4	24.2	28.6
H09	Automated guided vehicles (AGVs) (H09): €200 million, Automated Guided Vehicles (medical supplies, specimens) in hospitals	6,376	6,376	1	1	10.7%	54,550	Facilities X AGV units (supply carts, dialysis units) per facility	6,376	6,376	20	10	127,520	63,760	5,585	74.2	126.7	200.9

3.5 Other Use Cases in Manufacturing

All the Considered Use Cases in manufacturing (aside from employee safety monitoring discussed above) are quantified based on the number of manufacturing facilities determined in section 2.1 above, namely 79,086 primary facilities and 102,508 secondary facilities. The number of target objects for each use case is calculated assuming a fixed number of the relevant assets for each primary and each secondary facility, which are presented in Table 9 below.

Table 9: Quantities and Market Opportunities for Manufacturing Use Cases

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1º Ent. (C)	Facili-ties per 2º Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1º Facili- ties (E=AxC or calculated otherwise)	Targets in all 2º Facili- ties (F=BxD or calculated otherwise)	Devices per 1º target (G)	Devices per 2º target (H)	Qty 1º IoT Devices involved (I=ExG)	Qty 2º IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
M01.1	Asset monitoring & maint. (M01.1): €160 million, Monitor Condition of Key Fixed Equipment	79,086	102,508	3	1	2.5%	5,900	Facilities X key fixed equipment per facility	237,258	102,508	100	30	23,725,800	3,075,240	150	49.4	110.0	159.4
M01.2	Asset monitoring & maint. (M01.2): €50 million, Predictive Maintenance for Key Fixed Equipment	79,086	102,508	3	1	2.5%	6,000	Facilities	237,258	102,508			0	0	25	50.2	0.0	50.2
M02.1	Employee safety monitoring (M02.1): €18 million, Track Employees in Hazardous Environment	79,086	50,000	3	1	3.1%	1,200	Employees at risk (total employees X 3% at risk)	20,979,003	1,500,000	3%	3%	629,370	45,000	200	10.5	4.4	14.9
M02.2	Employee safety monitoring (M02.2): €3 million, Monitor Employee "Vitals" in Hazardous Environments	7,909	5,000	3	1	3.1%	2,400	Employees at high risk (total employees X 0.3% at risk)	20,979,003	1,500,000	0.30%	0.30%	62,937	4,500	315	2.1	0.7	2.8
M02.3	Employee safety monitoring (M02.3): €2 million, Monitor Conditions at Known Hazardous Locations	7,909	5,000	3	1	3.1%	1,150	Facilities X number of hazardous locations per facility	23,726	5,000	3	1	71,177	5,000	290	1.0	0.7	1.7
M03	Visual inspection - quality/ integrity (M03): €600 million, Inspect manufactured products at various stages of production for quality control	79,086	102,508	3	1	3.6%	22,550	Facilities X inspection stations per facility	237,258	102,508	20	10	4,745,160	1,025,080	1,480	273.4	326.9	600.3
M04	Manufacturing operations/ automation (M04): €360 million, Manage & Optimise Smart manufacturing at a single facility	79,086	102,508	3	1	3.9%	22,550	Facilities X production control systems per facility	237,258	102,508	10	3	2,372,580	307,524	545	299.8	63.5	363.3
M05	Video security & surv. (M05): €580 million, Intrusion Detection & Access Control	79,086	102,508	3	1	4.2%	2,100	Facilities X surveillance positions per facility	237,258	102,508	100	100	23,725,800	10,250,800	385	29.9	548.8	578.8

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
M06	Food traceability (M06): €1 million, Track flow of food products through the agricultural food chain	300	400	3	1	3.6%	2,600	Facilities X location tracking, surveillance and condition monitoring per facility	900	400	1,000	500	900,000	200,000	30	0.1	1.3	1.4
M07	Asset command & control (M07): €180 million, Command & Control of Key Assets (e.g. conveyor belts)	79,086	102,508	3	1	4.7%	4,800	Facilities X command & control systems per facility	237,258	102,508	20	3.0	4,745,160	307,524	385	77.3	105.3	182.7
M08	Fleet tracking (M08): €54 million, Track and Optimise Key Mobile Assets (e.g. forklifts)	79,086	102,508	3	1	4.5%	1,050	Facilities X key mobile assets per facility	237,258	102,508	20	10	4,745,160	1,025,080	135	16.0	37.5	53.6
M09	Regulatory compliance (M09): €9 million, Operational Reporting for Regulatory Compliance	79,086	102,508	3	1	5.0%	500	Facilities	237,258	102,508			0	0	245	8.6	0.0	8.6
M10	Process automation & optimization (M10): €550 million, Manage & Optimise Smart manufacturing across the enterprise	79,086	102,508	3	1	6.1%	22,550	Facilities X extra enterprise control systems per facility	237,258	102,508	10	3	2,372,580	307,524	480	467.4	87.1	554.5
M11	Smart building (M11): €790 million, Smart Building Management	79,086	102,508	3	1	7.6%	4,400	Facilities X building control systems per facility	237,258	102,508	100	50	23,725,800	5,125,400	290	113.2	679.6	792.7
M12	Asset location tracking (M12): €630 million, Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)	79,086	102,508	3	1	6.2%	2,600	Facilities X key portable assets per facility	237,258	102,508	1,000	500	237,258,000	51,254,000	30	54.9	577.0	631.9
M13	Automated guided vehicles (AGVs) (M13): €2.4 billion, Automated Guided Vehicles in Factories, Warehouses	79,086	102,508	3	1	10.9%	54,550	Facilities X AGV assets per facility	237,258	102,508	2	0.5	474,516	51,254	5,585	2,012.1	357.1	2,369.2

3.6 Other Use Cases in Transportation

Almost all of the Considered Use Cases in transportation (aside from employee safety monitoring discussed above) are quantified based on the number of transportation facilities determined in section 2.1 above, namely 19,799 primary facilities and 68,012 secondary facilities. The number of target objects for each use case is calculated assuming a fixed number of the relevant assets for each primary and each secondary facility, which are presented in Table 10 below.

For use case T03, "Passenger Traffic Flow", it is assumed that 25% of transport facilities could potentially implement this Use Case in the foreseeable future, and in each facility, it is assumed that 3,000 IoT devices would be required by each facility in the primary population, and 600 in each facility in the secondary population. Specific implementation details are uncertain, ranging from video surveillance and image analysis to estimate passenger counts, to RFID readers scanning RFID equipped transit cards held by passengers.

All these data are presented in Table 10.

Table 10: Quantities and Market Opportunities for Transportation Use Cases

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
T01.1	Employee safety monitoring (T01.1): €3 million, Track Employees in Hazardous Environment	19,799	18,500	3	1	2.1%	1,200	Employees at risk (total employees X 3% at risk)	6,340,163	550,000	3%	3%	190,205	16,500	200	1.9	0.9	2.8
T01.2	Employee safety monitoring (T01.2): €0.4 million, Monitor Employee "Vitals" in Hazardous Environments	1,980	1,850	3	1	2.1%	2,400	Employees at high risk (total employees X 0.3% at risk)	6,340,163	550,000	0.30%	0.30%	19,020	1,650	315	0.4	0.1	0.5
T01.3	Employee safety monitoring (T01.3): €0.3 million, Monitor Conditions at Known Hazardous Locations	1,980	1,850	3	1	2.1%	1,150	Facilities X number of hazardous locations per facility	5,940	1,850	3	1	17,819	1,850	290	0.2	0.1	0.3
T02	Fleet tracking (T02): €390 million, Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)	19,799	68,012	3	1	2.8%	3,100	Facilities X movable assets per facility	59,397	68,012	1,000	200	59,397,000	13,602,400	150	11.0	376.7	387.7
T03	Passenger traffic flow (T03): €1.1 billion, Track passenger flow across the transport network to manage capacity and congestion	19,799	68,012	3	1	3.1%	24,500	Various passenger tracking options	14,849	17,003	3,000	600	44,547,750	10,201,800	455	97.9	966.2	1,064.1

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili- ties per 1° Ent. (C)	Facili- ties per 2° Ent. (D)	Avg. adop- tion rate	Cost per gate- way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate- ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
T04	Video security & surv. (T04): €420 million, Intrusion Detection & Access Control	19,799	68,012	3	1	3.8%	12,800	Facilities X surveillance positions per facility	59,397	68,012	200	100	11,879,400	6,801,200	455	61.2	355.7	416.9
T05	Vehicle & infrastructure inspection (T05): €270 million, Drone-based Inspection (e.g. railroad rights of way, switchyards)	19,799	68,012	3	1	3.7%	12,500	Facilities X drone inspection systems per facility	59,397	68,012	10	5	593,970	340,060	5,520	58.7	212.1	270.8
T06	Regulatory compliance (T06): €3 million, Operational Reporting for Regulatory Compliance	19,799	68,012	3	1	4.2%	550	Facilities	59,397	68,012	0	0	0	0	270	2.9	0.0	2.9
T07	Freight monitoring (T07): €3.5 billion, Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)	19,799	68,012	3	1	4.6%	14,300	Facilities X monitored freight assets per facility	59,397	68,012	5,000	2,000	296,985,000	136,024,000	150	83.7	3,432.2	3,515.9
T08.1	Asset monitoring & maint. (T08.1): €160 million, Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	19,799	68,012	3	1	5.1%	3,600	Facilities X key mobile assets per facility	59,397	68,012	1,000	200	59,397,000	13,602,400	30	23.3	137.5	160.7
T08.2	Asset monitoring & maint. (T08.2): €26 million, Predictive Maintenance for Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	19,799	68,012	3	1	5.1%	4,000	Facilities	59,397	68,012	0	0	0	0	25	25.9	0.0	25.9
T09	auton. vehicles (T09): €2.7 billion, Autonomous vehicles leveraging security in a controlled system	19,799	68,012	3	1	4.8%	55,400	Facilities X autonomous mobile assets per facility	59,397	68,012	100	10	5,939,700	680,120	5,610	342.1	2,328.9	2,670.9
T10	Quality of shipment conditions (T10): €610 million, Inspect shipping units (containers, pallets, crates, boxes) to detect damage and insure proper routing	19,799	68,012	3	1	5.9%	23,100	Facilities X quality inspection positions per facility	59,397	68,012	50	20	2,969,850	1,360,240	1,480	174.1	436.0	610.1
T11	Asset command & control (T11): €130 million, Command & Control of Key Assets (e.g. close/open doors to warehouses for truck access)	19,799	68,012	3	1	5.6%	4,850	Facilities X assets with command and control capabilities per facility	59,397	68,012	50	4	2,969,850	272,048	410	34.4	96.7	131.2

Use Case Code	Short title	Qty 1' Ents. (A)	Qty 2' Ents. (B)	Facili-ties per 1° Ent. (C)	Facili-ties per 2° Ent. (D)	Avg. adop-tion rate	Cost per gate-way (€)	Target Type -- estimation assumptions	Targets in all 1° Facili- ties (E=AxC or calculated otherwise)	Targets in all 2° Facili- ties (F=BxD or calculated otherwise)	Devices per 1° target (G)	Devices per 2° target (H)	Qty 1° IoT Devices involved (I=ExG)	Qty 2° IoT Devices involved (J=FxH)	Cost per device (€)	Annual Market Gate-ways (€M)	Annual Market Devices (€M)	Annual Market Total (€M)
T12	Automated guided vehicles (AGVs) (T12): €2.2 billion, Automated Guided Vehicles in railyards, ports, warehouses	19,799	68,012	3	1	7.2%	54,550	Facilities X AGV assets per facility	59,397	68,012	50	4	2,969,850	272,048	5,585	503.5	1,714.0	2,217.5
T13	Smart building (T13): €340 million, Smart Building Management	19,799	68,012	3	1	9.4%	4,400	Facilities X building control systems per facility	59,397	68,012	100	50	5,939,700	3,400,600	290	52.9	285.3	338.2

4. Market Opportunities

This section summarizes the analysis detailed above and compares it with other projections.

4.1 Overview of Opportunities

The estimated market opportunities total over €26 billion per year. Of the five sectors examined by the UNLOCK-CEI project, the Transportation sector represents the largest total market opportunity, estimated at almost €12 billion per year (45% of the total). Energy/Utilities and Manufacturing are each estimated at roughly 25% of the total, with €6.8 and €6.4 billion per year respectively. Agriculture and Healthcare make up the balance, with €0.8 and €0.4 billion per year respectively (3% and 1% of the total, respectively). Figure 4 compares the total annual market opportunity by sector.

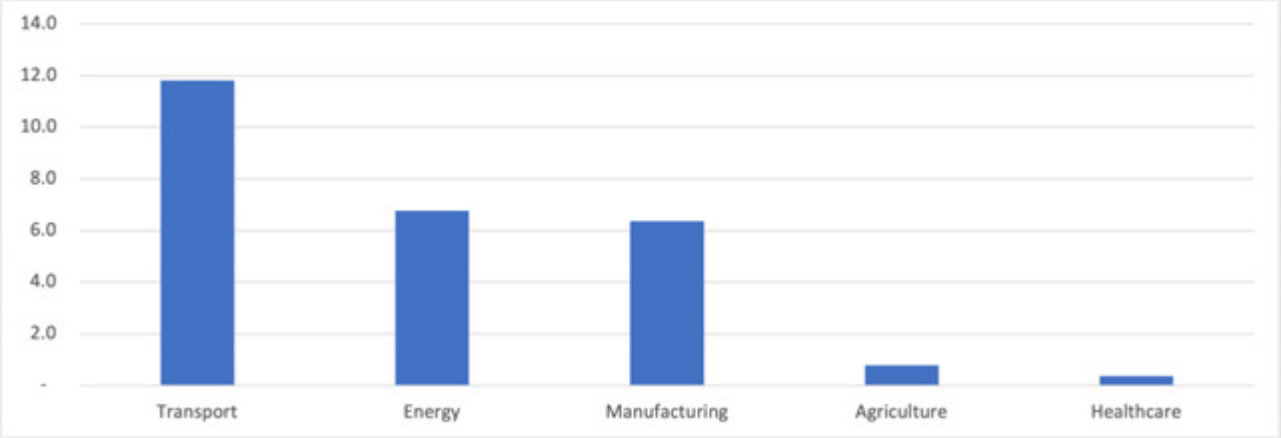

Figure 4: Total Annual Market Estimates for 5 sectors of interest (€ billions)

These market opportunities are very concentrated. The largest 24% of the 79 use cases (19 use cases) account for over 90% of the total annual market estimate. The largest 16.5% of the 79 use cases (13 use cases) account for over 80% of the total annual market. Addressing these top applications represents the most attractive way for suppliers to enter the European CEI market. The top 19 use cases are highlighted in light green in Table 11. Note that 18 of the 19 highest value use cases appear in the Energy/Utilities, Manufacturing and Transportation sectors, with only one appearing in the Agriculture sector, and none in Healthcare.

Table 11: Annual Market Estimates for 79 Considered Use Cases (€ millions: high-value use cases highlighted in green)

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
Agriculture			
A01.1	Employee safety monitoring	Track Employees in Hazardous Environments	0.2
A01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments	0.1
A01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.03

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
A02.1	Asset condition monitoring	Monitor the Condition of Key Fixed Equipment	3.1
A02.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment	4.2
A02.3	Asset condition monitoring	Monitor the Condition of Key Mobile Equipment (e.g. tractors, trucks, harvesters)	4.7
A02.4	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. tractors, harvesters)	5.6
A03	Visual inspection - quality/integrity	Inspect agricultural products (e.g. at harvesters, and grading stations) for quality control	94.3
A04	Video security & surveillance	Visual monitoring of fields and buildings	28.8
A05	Asset command & control	Command & Control of Key Assets (e.g. processing machines)	20.7
A06	Agriculture Field Monitoring	Monitor the Condition of Farm Fields, Paddocks and Pasture areas	6.2
A07	Asset location tracking	Track and Optimize Key Mobile Assets (e.g. tractors, harvesters)	6.7
A08	Process automation & optimization	Manage & Optimize precision agriculture systems	20.4
A09	Livestock monitoring	Collect Livestock health Data from “wearable” devices	0.9
A10	Agriculture Animal Tagging	Track Livestock locations from “wearable” devices	4.3
A11	Process automation & optimization	Enhancing and optimizing the production	566.9
A12	Smart building	Smart Building Management	12.2
Energy			
E01.1	Employee safety monitoring	Track Employees in Hazardous Environments	0.8
E01.2	Employee safety monitoring	Monitor Employee “Vitals” in Hazardous Environments	0.2
E01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.1
E02	Asset location tracking	Track the Location of Key Movable (portable) Assets (e.g. high-value test equipment and tools	134.7
E03	Asset monitoring & maintenance	Monitor the Condition of Key Fixed Equipment	11.3
E04	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. repair trucks)	14.4
E05	Smart meters	Smart Meters: Load Management, Theft Prevention	4,221.7
E06	Regulatory compliance	Operational Reporting for Regulatory Compliance	0.6
E07.1	Remote network mgmt (e.g. fault detection)	Enhanced Grid Monitoring	118.5

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
E07.2	Remote network mgmt (e.g. fault detection)	Diagnostics, Incident detection from Enhanced Grid Monitoring	188.2
E08	Sensor-based diagnostics & maintenance	Predictive Maintenance for Key Fixed Equipment (e.g. transformers, circuit breakers)	7.5
E09	Video security & surveillance	Intrusion Detection & Access Control	145.4
E10	Asset command & control	Asset Dispatch of Generation Assets, Command & Control of Key Assets	13.4
E11	Process automation & optimization	Smart Grid: Real-Time Analytics and Dynamic Grids Optimisation	1,347.3
E12	Drone-based observation	Drone-based Inspection (e.g. remote generation, transmission assets)	31.1
E13	Field service technician monitoring	Technician Performance and Work Order Optimisation	26.4
E14	Connected drilling & extraction	Optimised Gas & Petroleum Exploration and Production	71.2
E15	Smart building	Smart Building Management	49.2
E16	Automated guided vehicles (AGVs)	Automated Guided Vehicles in Special Environments (switchyards, substations)	385.2
Healthcare			
H01	Remote Health Monitoring	Collect Patent Health Data from remote devices (e.g. in patients' homes)	68.2
H02.1	Hospital Asset Tracking - dumb assets	Track Location of portable Assets (e.g. wheelchairs, hospital beds)	4.0
H02.2	Hospital Asset Tracking - patient monitors	Track Location of smart Assets (e.g. bedside monitors)	3.1
H02.3	Hospital Asset Tracking - other high-value assets	Track Location of other high-value portable Assets (e.g. dialysis machines, imaging machines)	0.8
H03	Video security & surveillance	Intrusion Detection & Access Control	12.4
H04	Regulatory compliance	Operational Reporting for Regulatory Compliance	0.2
H05	Bedside Telemetry	Collect Patent Health Data from distributed devices in the hospital	23.0
H06	AI-enabled Diagnosis & Treatment	Collect data about pathologies and symptoms to analyse and leverage cures.	0.4
H07	Robots or augmented-reality-assisted surgery	Routine surgical procedures are assisted by robots and/or AR tools for surgeons	18.7
H08	Smart building	Smart Building Management	28.6
H09	Automated guided vehicles (AGVs)	Automated Guided Vehicles (medical supplies, specimens) in hospitals	200.9
Manufacturing			
M01.1	Asset monitoring & maintenance	Monitor Condition of Key Fixed Equipment	159.4

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
M01.2	Asset monitoring & maintenance	Predictive Maintenance for Key Fixed Equipment	50.2
M02.1	Employee safety monitoring	Track Employees in Hazardous Environment	17.8
M02.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments	3.2
M02.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	1.7
M03	Visual inspection - quality/ integrity	Inspect manufactured products at various stages of production for quality control	600.3
M04	Manufacturing operations/ automation	Manage & Optimize Smart manufacturing at a single facility	363.3
M05	Video security & surveillance	Intrusion Detection & Access Control	578.8
M06	Food traceability	Track flow of food products through the agricultural food chain	1.4
M07	Asset command & control	Command & Control of Key Assets (e.g. conveyor belts)	182.7
M08	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. forklifts)	53.6
M09	Regulatory compliance	Operational Reporting for Regulatory Compliance	8.6
M10	Process automation & optimization	Manage & Optimise Smart manufacturing across the enterprise	554.5
M11	Smart building	Smart Building Management	792.7
M12	Asset location tracking	Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment)	631.9
M13	Automated guided vehicles (AGVs)	Automated Guided Vehicle10s in Factories, Warehouses	2,369.2
Transportation			
T01.1	Employee safety monitoring	Track Employees in Hazardous Environment	2.8
T01.2	Employee safety monitoring	Monitor Employee "Vitals" in Hazardous Environments	0.5
T01.3	Employee safety monitoring	Monitor Conditions at Known Hazardous Locations	0.3
T02	Fleet tracking	Track and Optimise Key Mobile Assets (e.g. trucks, containers, ships, railroad cars)	387.7
T03	Passenger traffic flow	Track passenger flow across the transport network to manage capacity and congestion	1,064.1
T04	Video security & surveillance	Intrusion Detection & Access Control	416.9
T05	Vehicle & infrastructure inspection	Drone-based Inspection (e.g. railroad rights of way, switchyards)	270.8
T06	Regulatory compliance	Operational Reporting for Regulatory Compliance	2.9

Use Case Code	Use Case (from [D1.2] Section 4)	Explanatory title	Annual Market (€)
T07	Freight monitoring	Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes)	3,515.9
T08.1	Asset monitoring & maintenance	Monitor Condition of Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	160.7
T08.2	Asset monitoring & maintenance	Predictive Maintenance for Key Mobile Equipment (e.g. trucks, containers, ships, railroad cars)	25.9
T09	Autonomous Vehicles	Autonomous vehicles leveraging security in a controlled system	2,670.9
T10	Quality of shipment conditions	Inspect shipping units (containers, pallets, crates, boxes) to detect damage and ensure proper routing	610.1
T11	Asset command & control	Command & Control of Key Assets (e.g. close/ open doors to warehouses for truck access)	131.2
T12	Automated guided vehicles (AGVs)	Automated Guided Vehicles in railyards, ports, warehouses	2,217.5
T13	Smart building	Smart Building Management	338.2

The information in Table 11 is presented graphically in Figure 5, where the size of each rectangle is proportional to the estimated annual market opportunity. This reflects the relative importance of the Transport, Energy and Manufacturing sectors, as well as the concentration of opportunity in just a few Use Cases in each sector.

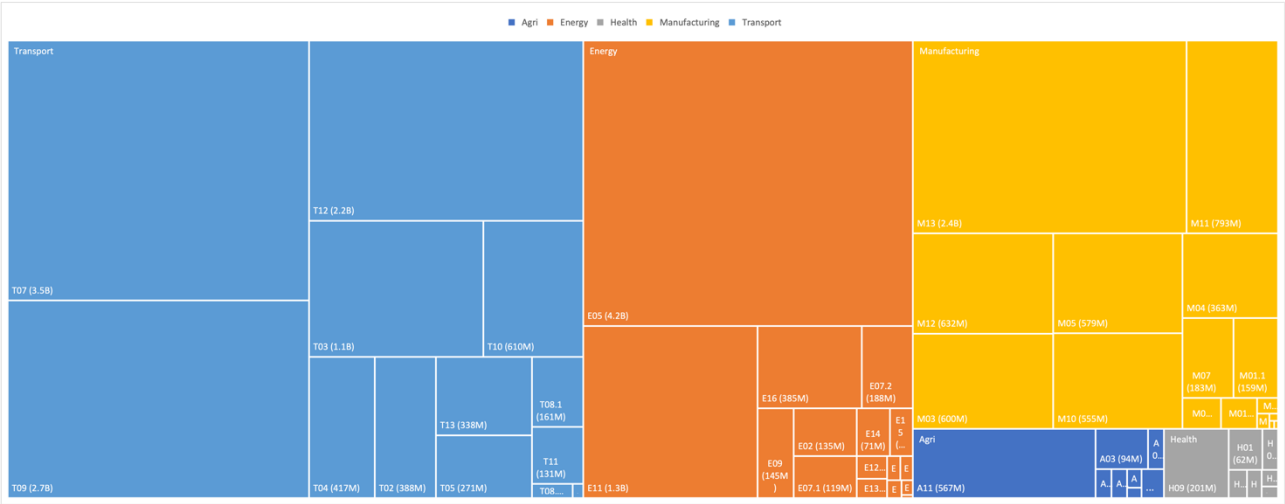

Figure 5: Annual Market Estimates for 79 Considered Use Cases (€ millions) ("treemap" format)

Figure 6 presents the same information as a bar chart sorted in reverse order of market size, highlighting again how market opportunities are concentrated in a relatively small number of Use Cases.

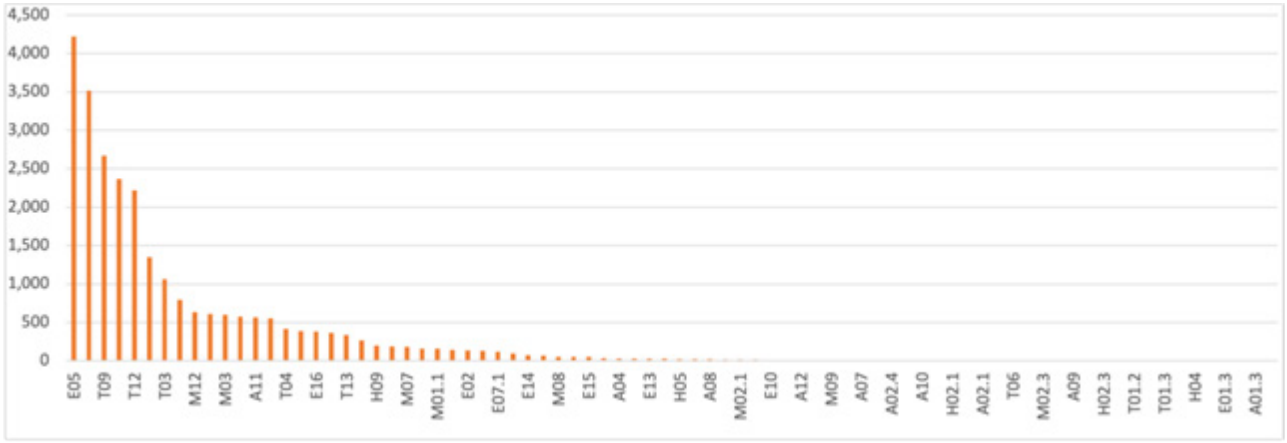

Figure 6: Annual Market Estimates for 79 Considered Use Cases (€ millions) (bar chart)

Table 12 shows how 18 significant market opportunities (in terms of potential annual market size) fall in the Transportation (8 opportunities), Manufacturing (7) and Energy & Utilities (3) sectors, plus one opportunity in Agriculture. These high-value opportunities are summarized here:

Table 12: Market opportunities by sector

Agriculture: A single €560 million opportunity (A11) for autonomous vehicles supporting farming, such as autonomous tractors operating on fields.
Energy & Utilities: Three opportunities totalling almost €6 billion: - Smart meters (E05): €4.2 billion - Smart Grid (E11): €1.3 billion - Automated guided vehicles (E16): €390 million, autonomous vehicles supporting utility operations, such as transmission line repair trucks operating along utility rights of way, or repair vehicles in substations or power generation facilities.
Manufacturing: Seven opportunities totalling almost €6 billion: - Automated guided vehicles (M13): €2.4 billion, vehicles in Factories, Warehouses - Smart building (M11): €800 million, Smart Building Management - Asset location tracking (M12): €630 million, Track Location of Key Movable (portable) Assets (e.g. Pallets, Crates, Boxes, high value test or calibration equipment) - Visual inspection - quality/ integrity (M03): €600 million, Inspect manufactured products at various stages of production for quality control - Video security & surveillance (M05): €580 million, Intrusion Detection & Access Control - Process automation & optimization (M10): €550 million, Manage & Optimize Smart manufacturing across the enterprise - Manufacturing operations/ automation (M04): €360 million, Manage & Optimize Smart manufacturing at a single facility.
Transportation: Eight opportunities totalling €11.2 billion: - Freight monitoring (T07): €3.5 billion, Track Location of Key Movable (portable) Assets (e.g. Containers, Pallets, Crates, Boxes) - Autonomous Vehicles (T09): €2.7 billion, Autonomous vehicles leveraging security in a controlled system - Automated guided vehicles (T12): €2.2 billion, Vehicles in railyards, ports, warehouses - Passenger traffic flow (T03): €1.1 billion, Track passenger flow across the transport network to manage capacity and congestion - Quality of shipment conditions (T10): €610 million, Inspect shipping units (containers, pallets, crates, boxes) to detect damage and insure proper routing - Video security & surveillance (T04): €420 million, Intrusion Detection & Access Control - Fleet tracking (T02): €390 million, Track and Optimize Key Mobile Assets (e.g. trucks, containers, ships, railroad cars) - Smart building (T13): €340 million, Smart Building Management.

4.1.1 Aspects of market estimates that could influence market segmentation and market pathways

Further analysis reveals several factors that could influence how this market might be segmented and the pathways that might be followed as each market develops over time.

4.1.1.1 Balance of spending between IoT devices and CEI gateways

Figure 7 below repeats the bar chart format of Figure 6, breaking down each Use Case opportunity between IoT device spending (grey) and edge gateway spending (orange).

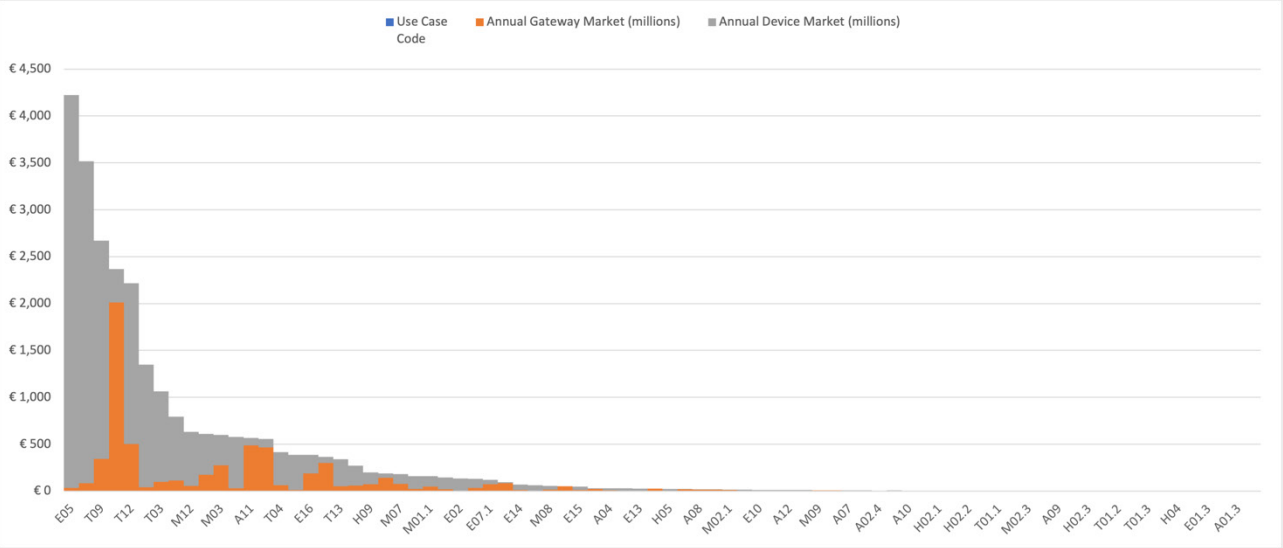

Figure 7: Annual Market Estimates for 79 Considered Use Cases (€ millions) (Gateway vs. Device estimates)

This highlights how the IoT device market is expected to be much larger than the edge gateway market. Across the set of Considered Use Cases, the opportunity for IoT devices is estimated at close to €20 billion per year, compared to just over €6 billion/year for edge gateways (76% and 24%, respectively, of the total €26 billion CEI market estimate).

For twenty-four (24) Use Cases (out of 79), the IoT device portion of each Use Case market estimate represents over 75% of total opportunity estimated for the Use Case. These Use Cases total €15.5 billion in market opportunity, of which over 90% (€14 billion) is estimated for IoT devices alone.

By contrast, for twenty-seven (27) Use Cases, the IoT device portion of each Use Case market estimate represents less than 25% of total opportunity estimated for the Use Case. These Use Cases total €4.3 billion in market opportunity, of which only 15% (€650 million) is projected for IoT devices. One Use Case (M13, automated guided vehicles in manufacturing) represents over half of this total.

4.1.1.2 Quantity and Per-unit Prices of IoT Devices and Edge Gateways

Market estimates are the product of expected quantities and per-unit prices for any given item. Projected market estimates for IoT devices are much larger than for edge gateways, overall and for the most economically significant Use Cases, while per-unit prices for IoT devices are expected to be much less than the corresponding gateway investment in each implementation. Both the quantity of devices required in each Use Case, and the complexity of the gateway needed to communicate with each of these devices, are therefore important for understanding how each Use Case will be implemented. This in turn will play a role in the clustering of individual Use Cases into market segments.

Figure 8 shows the range of IoT device costs across the range of Use Cases (vertical axis, log

scale), the number of these devices installed each year for each Use Case (horizontal axis, log scale), and the projected market for these devices for each Use Case (represented by the area of each circle).

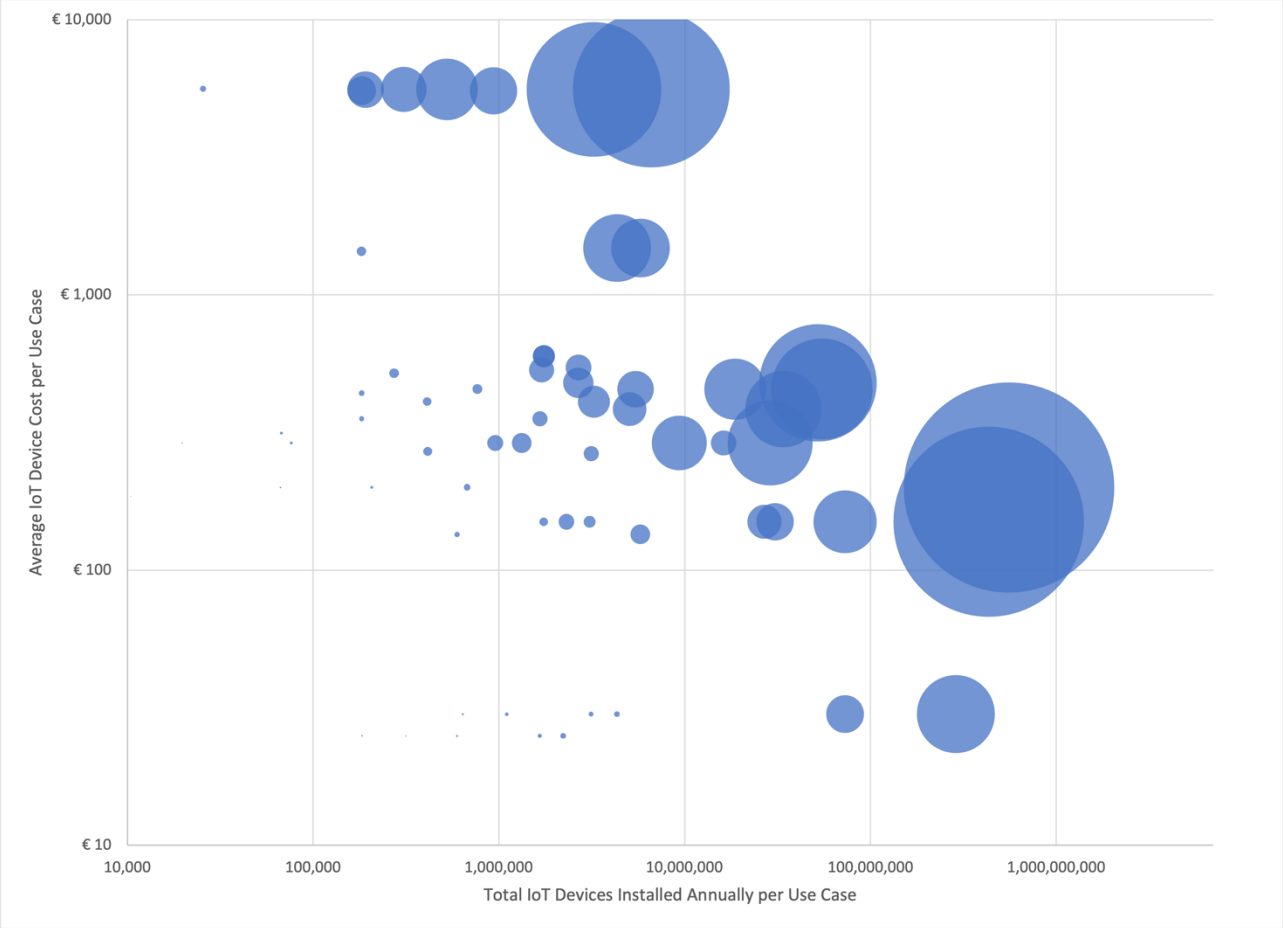

Figure 8: Annual IoT Device Market Estimates for 79 Considered Use Cases, plotted against average IoT device cost (vertical axis) and total IoT devices installed annually (horizontal axis)

The Use Cases with the highest projected IoT Device cost (approximately €5,500 per device), appearing at the top of Figure 8, represent autonomous vehicles and automated guided vehicles, as well as drone inspection devices, where the higher cost reflects the instrumentation needed to implement these complex use cases. Just below these high device cost Use Cases are slightly lower cost devices (€1,500 per device), used in fixed product inspection applications.

Three Use cases are projected to have the highest installed quantities per year:

- E05: energy smart meters, €200 per device, over 500 million devices per year.
- T07: freight monitoring, €150 per device, almost 500 million devices per year.
- M12: manufacturing asset (product) tracking, €30 per device, just under 300 million devices per year.

Between these two extremes, many Use Cases are projected to have per-unit device costs ranging between €100 and €1,000 and installed volumes between 1 and 100 million per year.

CEI suppliers can be expected to respond to this range of implementation characteristics by differentiating their go-to-market plans, targeting Use Cases and markets with specific levels of IoT device complexity and installed device volumes.

Looking at comparable projections for edge gateway systems, Figure 9shows the range of edge gateway system costs across the range of Use Cases (vertical axis, log scale), the number of

these systems installed each year for each Use Case (horizontal axis, log scale), and the projected market for these systems for each Use Case (represented by the area of each circle).

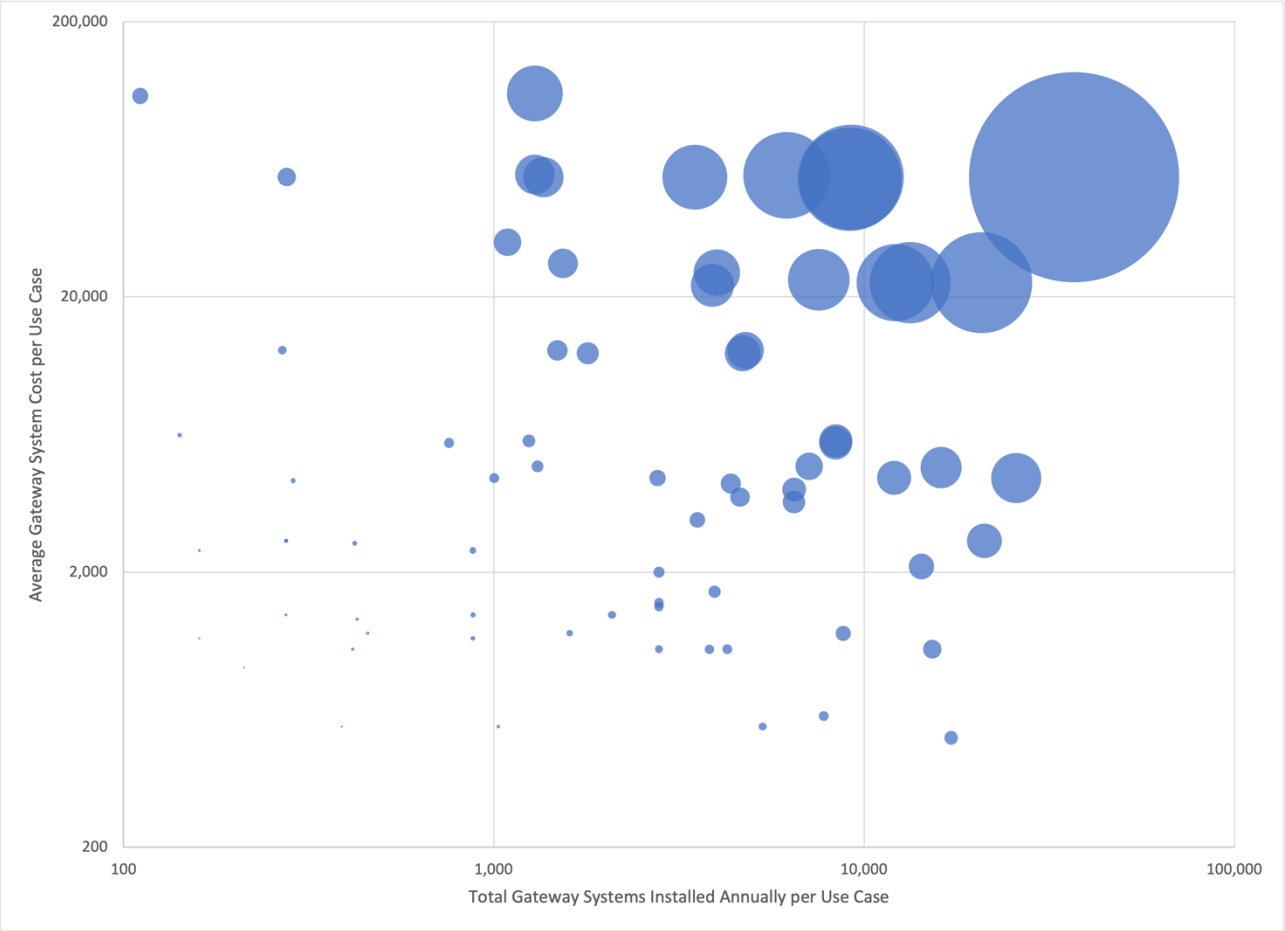

Figure 9: Annual Edge Gateway Market Estimates for 79 Considered Use Cases, plotted against average gateway system cost (vertical axis) and total gateway systems installed annually (horizontal axis)

The Use Cases with the highest projected Gateway System costs (around €50,000 per system), appearing at the top of Figure 9, have a wide range of volumes – from a few hundred to about 30,000 per year – with corresponding market opportunities (increasing in proportion to volume).

- The largest Use Case, in terms of both volume and market for gateway systems is M13, for automated guided vehicles (AGVs) in manufacturing.
- Many of the other large Use Cases, with both high system costs and volumes, relate to AGV or product inspection Use Cases.
- One Use Case, with one of the highest projected Gateway System costs, is E07.2, remote management of energy networks (commonly referred to as "smart grid"), with an average system cost of roughly €100,000, but fewer installations per year (just over 1,000) since this is a more concentrated market.

In parallel with the discussion of IoT device characteristics, CEI suppliers are expected to differentiate their go-to-market plans in response to this range of gateway system characteristics, targeting markets and Use Cases with specific levels of gateway system complexity and installed system volumes.

Figure 10 illustrates how Use Cases can be differentiated by these two perspectives – IoT device volumes and gateway system volumes.

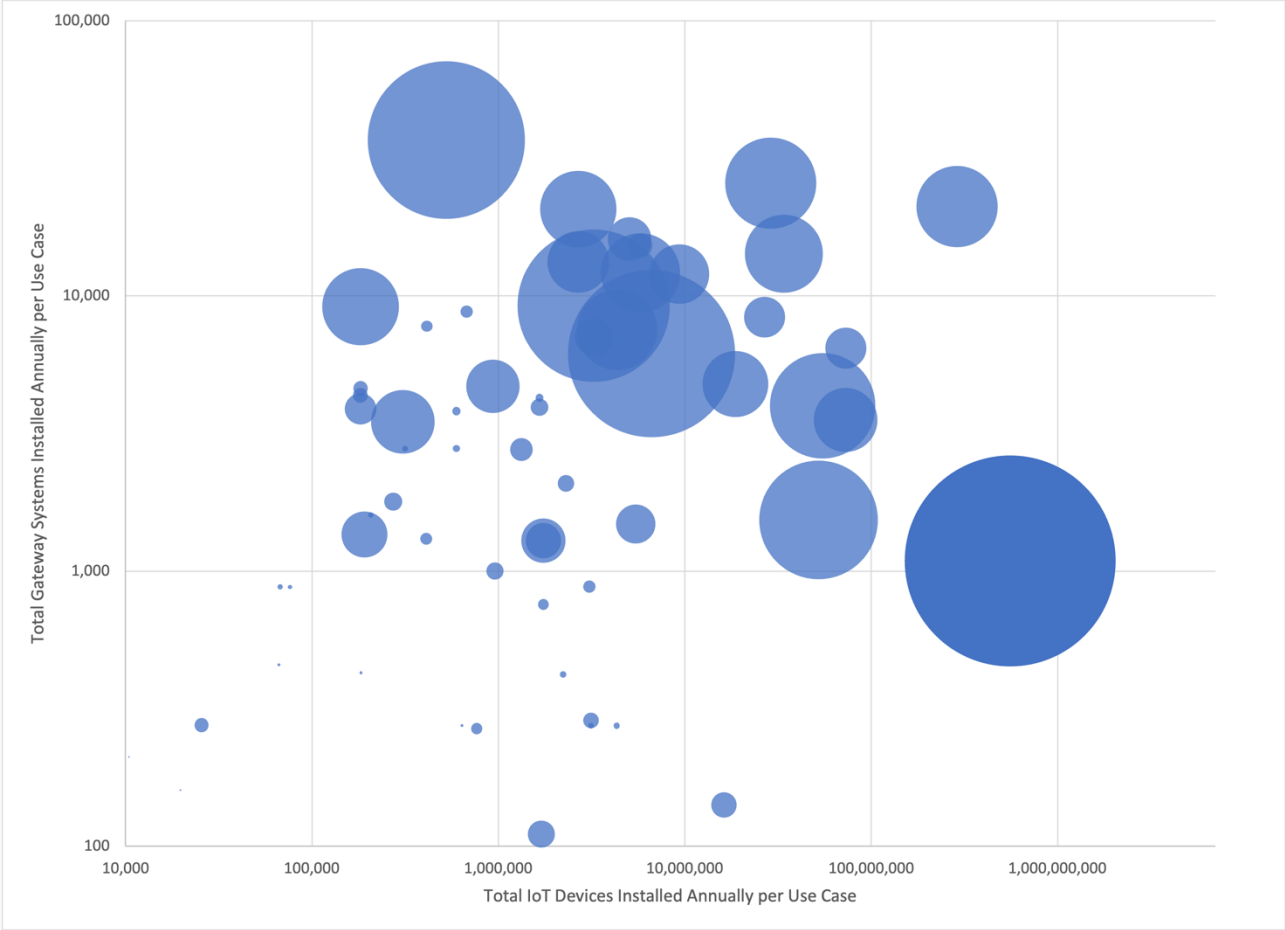

Figure 10: Annual Market Estimates for 79 Considered Use Cases, plotted against total gateway systems installed annually (horizontal axis and total gateway systems installed annually (vertical axis).

Preliminary clustering of Use Cases into Market Segments is presented in D3.3 "Business and Service Requirements, Preferred Market Structures and Pathways for the CEI Ecosystem" and updated in D2.3 "Final Position Paper on the Future Open European CEI Ecosystem". The figure above will be used in D2.3 to illustrate segmentation, as well as the market pathways that can be expected to develop.

4.2 Comparison with other market projections

IDC's "Cloud-Edge-IoT Demand Landscape" [2] estimates Europe's total markets for cloud, edge, and IoT as follows.

Market	2022 (€B)	CAGR to 2026	2026 (€B)
Cloud	109.6	20.8%	233.4
Edge	33.5	14.1%	56.8
IoT	172.3	10.8%	259.7

Recognising that the market opportunities estimated in this report represent only a portion of the total market, forecasts of €6 billion per year for edge gateways system and €20 billion per year for IoT devices are consistent with these projections. This also suggests that the 79 Use Cases examined in this analysis might represent only 10% of the total EU CEI market.

The "Study on the Economic Potential of Far Edge Computing in the Future Smart Internet of Things"[17] from Decision Etudes & Conseil, offers global projections for the CEI market from 2021 to 2027. Taking figures for 2027, the global market is €1.2 trillion per year, of which the EU27 is estimated to represent 25%, or €308 billion. This total is divided into the following segments (presented in Table 13Table 13: Spending categories for Cloud, Edge, and IoT solutions), which are assigned here to each of the "cloud", "edge" and "IoT" categories for comparison:

Table 13: Spending categories for Cloud, Edge, and IoT solutions

Spending Category:		**Total**	**Cloud**	**Edge**	**IoT**
Cloud platforms	3%	9	9		
Far edge platforms	7%	22		22	
Network	3%	9		9	
Installation & Maintenance	10%	31		15	15
Embedded Software	36%	111		55	55
IoT Hardware	39%	120			120
Semiconductors for computing functions (micro-edge)	6%	18			18
Total		**308**	**9**	**102**	**210**

Here again, recognising that the market opportunities estimated in this report represent only a portion of the total market, the forecasts developed here are consistent with the analysis in [17].

17 https://digital-strategy.ec.europa.eu/en/library/europes-potential-edge-computing-supporting-industrial-innovation-through-large-scale-pilots

5. Conclusions

A detailed market analysis methodology is presented for the cloud-edge-IoT (CEI) market in Europe, building in turn on a common technical model for implementation and preliminary estimates of equipment costs. This methodology is applied to 79 Considered Use Cases identified in the UNLOCK-CEI project as significant and important, falling in five sectors: agriculture, energy, healthcare, manufacturing and transport.

The aggregate CEI market opportunity is projected at €26 billion per year. Across the five sectors examined in this project, estimated market opportunities vary widely, based on the structure of those sectors in the EU and the likely technology implementation approach for possible Use Cases.

The Transportation sector represents the largest total market opportunity, estimated at almost €12 billion per year (45% of the total). Energy/Utilities and Manufacturing are each estimated at roughly 25% of the total, with €6.8 and €6.4 billion per year respectively. Agriculture and Healthcare make up the balance, with €0.8 and €0.4 billion per year respectively (3% and 1% of the total, respectively).

These market opportunities are very concentrated. The largest 24% of the 79 use cases (19 use cases) account for over 90% of the total annual market estimate. The largest 16.5% of the 79 use cases (13 use cases) account for over 80% of the total annual market. Addressing these top applications represents the most attractive way for suppliers to enter the European CEI market. Note that 18 of the 19 highest value use cases appear in the Energy/Utilities, Manufacturing and Transportation sectors, with only one appearing in the Agriculture sector.

Based on the common technology implementation model developed for this project, the market estimates for individual Use Cases can be divided between IoT device spending and edge gateway spending. Overall, the IoT device market is expected to be much larger than the edge gateway market. Across the entire set of Considered Use Cases, the opportunity for IoT devices is estimated at close to €20 billion per year, compared to just over €6 billion/year for edge gateways (76% and 24%, respectively, of the aggregate €26 billion CEI market estimate).

Recognizing that the market opportunities estimated in this report represent only a portion of the total market, forecasts of €6 billion per year for edge gateways system and €20 billion per year for IoT devices are consistent with market projections provided by both IDC and Decision Etudes & Conseil.

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