O-CEI

TECHNICAL GUIDELINE

O-CEI

1st Open Call for Upscale projects

Submission of applications starts on the 1st of September 2025, at 13:00 Brussels Time

Submission deadline: 3rd of November, 2025, at 17:00 Brussels Time

Co-funded by the European Union

Document overview and basic information

The **Technical Guideline Document** has been prepared by the **O-CEI Consortium Partners** to provide clear, comprehensive, and authoritative guidance to all participants in the **1st Open Call**. This document serves as a critical reference to ensure that applicants' proposed solutions are fully aligned with the overarching objectives, scope, and technical framework of the **O-CEI project**.

All applicants are **required** to carefully review and adhere to the specific **technical requirements** associated with each challenge outlined in this document. These requirements have been designed to ensure technical coherence and innovation within the project's ecosystem. Each challenge presents unique specifications, constraints, and expectations that must be addressed by the applicants in their proposals.

Applicants are **strongly encouraged** to thoroughly familiarise themselves with all technical guidelines relevant to their chosen challenge before preparing and submitting their application. Compliance with these requirements is a **mandatory condition** for eligibility and will be a key criterion during the evaluation process.

By following this document, applicants will be better equipped to develop high-quality, impactful proposals that contribute meaningfully to the O-CEI project's mission and goals.

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Domain: Electricity and Heat Pumps

1. PILOT 1: Energy Grid Performance Optimization upon RES Integration

The pilot consists of three locations:

- Limerick (IE), serving electricity and heating to three neighborhoods with a mix of residential and commercial buildings;
- Krk island (CR), facing significant fluctuations in connected users; and
- the "Concept Grid" demonstrator by EDF in the Isle of France, Paris

The overarching motivation of P1 three components is to transition towards a greener, more efficient, and resilient energy system. Ireland is the least efficient country in EU in heat energy decarbonisation, urging a paradigm shift in energy consumption. In Krk, achieving energy self-sufficiency apart from the mainland connection is crucial, aiming to incorporate a sustainable blend of renewable energy sources. Meanwhile, in France, electrification of residential areas, and the increasing availability of coexistent decentralized energy sources calls for flexibility fostered by Smart IoT platforms interoperability and IoT devices as NILM (Non-Intrusive Load Monitoring). In Limerick, the infrastructure includes various heating sources like natural gas and electricity, with sensors monitoring temperature, humidity, CO2, lux, flow and energy usage. O-CEI will leverage information from bills and prices to be integrated through CitiXchange. Limerick will also integrate a Combined Heat and Power (CHP) unit into one of the communities to further ensure flexibility of heat and electricity in the PED. Krk Island is enhancing its extensive array of renewable energy installations to achieve energy independence and climate neutrality. However, ensuring efficient energy flexibility amidst diverse complex systems interoperability like transport, storage, and distribution poses a significant challenge. Localised real-time processing, centralised simulations and short-and-long term planning is required. EDF's "Concept Grid" replicates a residential area with primary sub-stations, medium- and low-voltage networks. It incorporates distributed energy resources, various load types and an EV charging station. Equipped with a robust CEI infrastructure connected to Linky smart meters via Zigbee-compatible Local Radio Transmitter, int enables real-time, fine-grained measurement of electrical power loads. The infrastructure serves to validate innovative techniques that are later directly fed into EDF network.

1.1. CHALLENGE P1C1

ALF: Adjusted Load Forecaster

Description	Key Requirements	
The ALF model uses Non-Intrusive Load Monitoring (NILM) data to accurately forecast short-term building energy consumption (0–2 hours). It aggregates and disaggregates 15-minute data and applies a hybrid stack of ARIMA, machine learning, and deep learning models (e.g., CNNs, SVMs, Random Forests) to account for variables like occupancy, weather, special events, and DER generation. The ALF model supports real-time adjustments and operates in a federated, privacy-preserving architecture with Edge AI at the building level. This UCC Challenge requires a hardware	*Novel CEI utilities*	Use of federated learning, edge AI processing, TinyML, semantic energy models, multi-model fusion (forecast + classification).
	Added value	Enables precise load forecasting critical for demand response, peer-to-peer trading, and smart energy management.
	Energy-related asset	Smart meters, NILM devices, heat pumps, DERs (e.g., PV, battery), occupancy sensors.
	Edge solutions	Edge IoT and AI deployed locally for real-time NILM disaggregation and fast local

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manufacturer with expertise in data gathering and edge AI to carry out TinyML or alternative analysis at building level with inputs/outputs from/to the FLEXUS Platform.		predictions; synced with central platform.

1.2. CHALLENGE P1C2: FlexSurveyEU: Mapping Flex Potential Across Cultures

Description	*Key Requirements*	
A European-wide, multilingual survey initiative designed to capture the diverse cultural, social, and behavioural perspectives on electricity and heat flexibility. The survey investigates awareness of energy systems, flexibility willingness, thermal comfort norms, tariff preferences, trust in automation, and DER engagement, tailored to local customs and climate contexts. Results will guide national and regional strategies, ensuring flexibility mechanisms are socially acceptable, inclusive, and effective across varying cultural settings	*Novel CEI utilities*	Semantic tagging of responses with SHIFT Ontology; NLP pipelines for multilingual interpretation; dynamic dashboards for cross-cultural analytics and persona generation.
	Added value	Uncovers regional patterns in flexibility perception and willingness, supporting culturally sensitive DR design, equitable energy policy, and inclusive CEI deployment strategies.
	Energy-related asset	PV systems, battery storage, heating systems, EVs, inverters, heat pumps, thermal storage, hot water tanks, programmable appliances.
	Edge solutions	Informs building-specific DR thresholds, comfort windows, and flexibility participation scores; edge agents use personas to adapt automation behaviour.

1.3. CHALLENGE P1C3 GenFlex: Synthetic Energy Data Engine

Description	*Key Requirements*	
Training ML models is challenging due to the shortage or access to real datasets—primarily caused by GDPR restrictions. GenFlex is a synthetic data generation framework that produces large volumes of high-fidelity, realistic training data across key domains, including: building electrical and thermal load profiles, PV generation, battery charge/discharge cycles, occupant thermal comfort preferences and heating usage, and flexibility service response behaviours. GenFlex uses physics-informed simulation engines, generative AI (e.g., GANs), and multi-agent occupant behaviour models to replicate realistic, temporally consistent	*Novel CEI utilities*	Use of GANs and VAEs for sequence-level generation; integration of EnergyPlus, CityLearn, and agent-based comfort/emotion modelling; semantic structure via SHIFT Ontology.
	Added value	Unlocks access to large, privacy-compliant training corpora for NILM, load forecasting, anomaly detection, DR optimization, and occupant-behaviour-aware control; reduces overfitting and increases generalisability of ML pipelines.
	Energy-related asset	PV panels, battery systems, electric heaters, thermostats, sensors (temperature, CO2, Relative Humidity, lux etc.) smart appliances,

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scenarios. The synthetic data accounts for local context, ensuring alignment with real solar irradiation, real weather conditions, building types, occupancy profiles, and technology deployment. It can simulate thousands of diverse, interlinked datasets for ML pretraining, benchmarking, or digital twin use.		BAC systems, HEMS, smart meters.
	Edge solutions	Edge agents can be pretrained on GenFlex data and fine-tuned on local data; synthetic edge datasets enable real-world benchmarking, robustness testing, and fault injection scenarios.

1.4. CHALLENGE P1C4
Virtualized voltage control for smart grids

Description	*Key Requirements*	
Transform existing smart grid applications for voltage control at the secondary substation level (MV/LV) to a fully virtualised and distributed environment	*Novel CEI utilities*	Gateway hardware for handling protocol conversion in real time (interfacing with "Linky" smart meter + IEC 61850 client/servers and IEC 60870-5-104 Remote Terminal Units Real-time application server Real-time OS and hypervisor
	Added value	Overcome legacy hardware restrictions Improve RES integration while ensuring grid stability Vendor independent solution Compliance with smart grid standards (e.g. IEC 61850)
	Energy-related asset	MV/LV transformer, on-load tap changer, circuit breakers, MV/LV measuring equipment Voltage control system Linky smart meter
	Edge solutions	Decentralized measurement, computation and control in real-time at the secondary substation level Voltage control algorithms ported to a virtualized environment

1.5. CHALLENGE P1C5
Node – Level Scada

Description	*Key Requirements*

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	Novel CEI utilities	
	Added value	
	Energy-related asset	
	Edge solutions	

1.6. CHALLENGE P1C6
AI for Energy Management and Decision Making

Description	*Key Requirements*	
Provide novel energy management services and systems for end consumers (energy cost control, appliance control, flexibility in a context of increasing RES) based on edge AI data analysis of electricity load curves.	*Novel CEI utilities*	Advanced AI-based load curve analysis (NILM, Load- Forecasting) at the Edge
	Added value	Real-time energy services as opposed to “day-after” legacy systems. Improved cybersecurity and privacy thanks to local data processing.
	Energy-related asset	“Linky” smart meter Home appliances (all types)
	Edge solutions	Ecosystem of load curve acquisition devices (e.g., Local Radio Transmitter plugged into the smart meter, or smart plugs for home appliances. Gateway object for local data storage and processing.

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Domain: SDV and VaS

2. PILOT 2: Software Defined Vehicle for VaS in Urban Areas

P2 proposes four SDV scenarios, all orbiting around VaS for impacting one area of urban mobility (each).

P2-SC1: VaS for vehicle safety: Continuous monitoring of numerous embedded systems within the car (e.g., engine management, braking, steering, infotainment) will be dynamically exposable and interfaceable in a distributed fashion thanks to O-CEI data management block. Software controlling them may run in diverse elements (edge), which lifecycle (including OTA updates) will be orchestrated thanks to P2 blueprint.

P2-SC2: VaS for sustainability: The scenario will explore, utilise and publish AI utilities from/to the O-CEI marketplace to minimize environmental impact of the car in various ways. Central storage for training will be coupled with AI inference at the edge for making powertrain operation more efficient based on the battery level of the EV and the proximity to charging stations (modifying acceleration, braking and idling curves).

P2-SC3: VaS for fleet V2G integration: EVs provided by CONTI equip storage units that, if decided by the AI algorithms, will be able to revert energy back into the network. Battery Management System of the car will be managed by containerized software of O-CEI that will run on the far edge (EV), with potential cloud counterpart for global fleet and grid data comprehension.

P2-SC4: VaaS for grid optimization: Fourth scenario complements the two previous, allowing the circulating car to interact with exposed data of energy grid across the city to optimize electricity mix integration. FENIX2.0 and CONTI will leverage Catena-X and O-CEI semantic data catalogue in the marketplace to communicate with smart grid infrastructure to schedule charging during off-peak hours, take advantage of dynamic electricity pricing, and support grid balancing initiatives, contributing to overall energy optimization and grid stability

2.1. CHALLENGE P2C1

Vehicle as Software (VaS) for Vehicle Safety

Description	*Key Requirements*	
One of the biggest challenges in this paradigm shift is ensuring vehicle safety while leveraging software-intensive systems. The traditional vehicle safety mechanisms (e.g., mechanical systems, passive and active safety devices) are now being augmented or even replaced by software-based features. While these innovations offer enhanced functionalities, they introduce new risks that must be managed to ensure vehicles remain safe, secure, and reliable.	*Novel CEI utilities*	Edge Computing capabilities for real-time decision-making in vehicle safety systems, ensuring that critical safety data (e.g., collision avoidance, driver assistance) is processed locally on the vehicle rather than relying solely on the cloud. This is essential for minimizing latency and enabling the vehicle to react in milliseconds to critical situations (e.g., automatic emergency braking or lane-keeping assistance).
	Added value	Reduced dependency on the cloud, ensuring immediate response time for safety-critical actions. Ensures the vehicle's autonomy in making immediate decisions even in the event of cloud disconnection or communication

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		delays.
	Energy-related asset	Integration of energy management systems with safety systems to ensure that the vehicle's power supply is always optimized for critical functions, including safety features (e.g., airbags, sensors, braking systems).
	Edge solutions	IoT integration across all vehicle components, from sensors to cameras to cloud-based platforms that allow for continuous monitoring, real-time alerts, and remote diagnostics of safety features. Cloud-based updates to continuously enhance vehicle safety systems, improve algorithms, and update the vehicle's software to reflect the latest safety protocols, driving standards, and regulatory requirements.

2.2. CHALLENGE P2C2
Vehicle as Software (VaS) for Sustainability

Description	*Key Requirements*	
Challenges in achieving the sustainability goals set by various governments, organizations, and industries. While VaS can contribute to reducing a vehicle's carbon footprint, emissions, and resource consumption, it also introduces complexities related to software optimization, data management, and lifecycle impacts that need to be carefully addressed	*Novel CEI utilities*	Edge computing for real-time monitoring and optimization of energy consumption in vehicles, ensuring efficient use of battery power and supporting the energy transition to renewables. Edge computing and cloud-based analytics must work together to optimize the energy consumption of vehicles in real time, based on driving conditions, energy availability, and energy efficiency goals. This integration enables vehicles to make intelligent decisions on energy use based on external and internal data streams. Real-time emissions monitoring via IoT sensors integrated into the vehicle ensures that emissions, including tailpipe emissions for internal combustion engines (ICE) and electric consumption data for EVs, are accurately tracked and optimized to reduce carbon footprints.
	Added value	Improves vehicle energy efficiency, reducing CO2 emissions. Helps the vehicle operator optimize their driving to minimize energy consumption. Reduces reliance on grid power during peak hours by managing battery charging and

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		discharging based on demand and supply dynamics. Optimizes energy consumption in real time, ensuring vehicles are energy-efficient under varying driving conditions. Reduces emissions by minimizing unnecessary energy usage, particularly during driving and charging. Enhances vehicle sustainability by considering energy availability from renewable sources in route planning.
	Energy-related asset	Contributes to grid stability, reducing peak demand and facilitating sustainable energy transitions. Monetizes energy storage by providing vehicle owners with financial incentives for participating in V2G services.
	Edge solutions	Contributes to grid stability, reducing peak demand and facilitating sustainable energy transitions. Monetizes energy storage by providing vehicle owners with financial incentives for participating in V2G services.

2.3. CHALLENGE P2C3 Vehicle as Software (VaS) for Fleet V2G Integration

Description	*Key Requirements*	
Vehicle-to-grid (V2G) integration with fleet management systems presents several technical, regulatory, and operational challenges that need to be addressed. Leveraging VaS to ensure seamless communication, control, and energy exchange between the fleet and the grid is a complex process that requires innovations in software architecture, data management, and energy optimization algorithms.	*Novel CEI utilities*	Seamless real-time monitoring and control of energy flow between fleet vehicles and the grid using cloud-edge IoT utilities. This includes the ability to charge vehicles during low-demand periods and discharging them to the grid when demand peaks. Analytics and insights for understanding and optimizing the energy flow between fleet vehicles, the charging infrastructure, and the grid. These insights help maximize the operational benefits of the fleet while ensuring that energy interactions remain efficient and sustainable.
	Added value	Optimizes grid stability by facilitating demand response and balancing the grid during peak periods. Minimizes energy costs by scheduling vehicle charging when energy prices are low (e.g., during off-peak hours or when renewable energy is abundant). Increases energy flexibility by enabling fleet

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		vehicles to act as mobile storage units, providing grid support through V2G integration. Reduces energy waste and ensures that the fleet uses optimal energy sources, reducing costs and environmental impact.
	Energy-related asset	Edge computing enables real-time energy optimization for each vehicle in the fleet, based on vehicle status, grid demand, and environmental conditions, to maximize the overall value proposition of the fleet's energy-related assets. Enable fleet vehicles to participate in energy markets through smart contracts, providing a secure and transparent mechanism for buying and selling energy credits or providing grid services (like frequency regulation or peak load management).
	Edge solutions	Edge devices integrated into the vehicles enable local energy decision-making, such as when to charge, discharge, or defer charging based on factors like battery health, state of charge, and expected driving patterns. Edge systems adjust charging and discharging behavior based on grid load, local energy prices, and renewable energy availability, ensuring that fleet vehicles provide maximum value without negatively impacting their performance or lifespan.

2.4. CHALLENGE P2C4

Vehicle as Software (VaS) for Grid Optimization

Description	*Key Requirements*	
Through technologies like Vehicle-to-Grid (V2G), EVs can act as mobile energy storage units, allowing the grid to draw power during peak demand or store excess energy during off-peak times, providing a smart, dynamic energy management solution. However, while the integration of EVs into grid optimization presents a wealth of opportunities for enhancing grid flexibility and supporting the transition to renewable energy sources, it also raises a number of technical, operational, and regulatory challenges. From managing charging and discharging cycles to ensuring data interoperability, to maintaining grid stability during high energy flows, the role of VaS in grid optimization requires innovative solutions in energy management, software development,	*Novel CEI utilities*	Real-time monitoring and dynamic control of energy flows between vehicles, charging stations, and the grid to maintain grid stability and optimize energy distribution. Dynamic charging schedules and demand response systems that adjust vehicle charging times based on grid demand, energy prices, and renewable energy availability.
	Added value	Grid stability is enhanced by continuously balancing supply and demand, preventing blackouts and ensuring the efficient use of energy resources. Provides the flexibility needed for grid operators to dynamically respond to fluctuating demand or renewable energy variability, particularly in grids with high

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and real-time communication between vehicles and grid systems.		renewable penetration (solar, wind, etc.). Reduces grid congestion by automatically redirecting power flows based on real-time energy availability and grid conditions.
	Energy-related asset	Integration of EVs as energy storage assets that can participate in Vehicle-to-Grid (V2G) interactions. This allows vehicles to provide stored energy back to the grid, acting as distributed energy resources (DERs) for peak load management and grid stabilization. Integration of fleet vehicles with Distributed Energy Resources (DERs) like solar panels, wind turbines, and local energy storage systems, to optimize grid interaction and reduce reliance on centralized energy production.
	Edge solutions	Edge computing within the vehicles monitors battery health, state of charge, and grid demand. Based on this information, the vehicles decide when to charge (during off-peak hours) and when to discharge (during peak demand) to the grid. Cloud platforms manage V2G interactions, optimizing fleet charging and discharging schedules, ensuring that vehicles provide grid services like frequency regulation and demand response without compromising vehicle readiness.

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Domain: Electric vehicle fleet management and EV charging

3. PILOT 3: Energy Consumption and Emission Reductions in Postal Service Fleet Operation via Intelligent BEV Charging Strategies

Pilot 3 presents two scenarios, aimed at optimizing energy consumption and reducing emissions:

P3-SC1: Optimizing storage battery systems: Distributed processing at the edge (brought by the selected O-CEI blueprint) will assess the energy consumption patterns, grid dynamics and renewable energy potential of the pilot elements (charging stations, fleet operations). AI utilities from the marketplace will identify optimization opportunities, which will drive strategies for battery storage systems to minimize peak demands and enhance grid stability. Predictive modelling techniques at the edge (shared learning among fleet and stations) will anticipate trends and allow actuation in real time over the storage systems.

P3-SC2: V2G-Vehicle as mobile energy storage unit: Building upon P3-SC1, this scenario will engage the battery storage (and surplus provision) from trucks. Vehicle operations will be virtualized (modelled, quantified, predictable) so that EV could harness their own storage units in the most efficient way, relaxing the need of bidirectional charging infrastructure.

P3-SC3: Smart and innovative energy management systems including energy market and decentralized renewables: Based on scenarios 1 and 2,O-CEI will allow to understand to which extent mobile storage systems can be used to support the power grid trucks as storage systems could support the grid on peak shavings and reactive power management.

3.1. CHALLENGE P3C1

Services to ease the data sharing process

Description	*Key Requirements*	
• Dataspace connector as a Service (DSC) • DLT implementations of dataspace • Competing concepts regarding data sharing: instead of bringing the data to the code (“data spaces”) one can bring the relevant code to the data (“distributed ledger”)	*Novel CEI utilities*	End user friendly tools for data curation & sharing.
	Added value	Othe hurdles in task sharing automotive supply chain energy supply chain.
	Energy-related asset	Curation of measurable data as an economic asset.
	Edge solutions	Curation of sensitive data at the edge DSC at the edge.

3.2. CHALLENGE P3C2

Performing ML training process at the edge

Description	*Key Requirements*	
Containerized workloads for ML to be executed across the computing continuum (particularly in at the fog- and edge nodes).	*Novel CEI utilities*	Privacy-enhanced learning that allows agent training without sharing the data; instead share the trained model, and make sure that the model cannot be re-engineered
	Added value	Incorporate data that cannot be shared with

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		third party
	Energy-related asset	Solar panel Vehicle
	Edge solutions	Vehicle + edge

3.3. CHALLENGE P3C3
Dealing with legacy assets (IT, energy)

Description	*Key Requirements*	
How to retrieve data from legacy assets (e.g., no protocols are available). Smart electronic device that sits on legacy asset and "injects" a communication protocol; sensor data could then be retrieved from the legacy asset.	*Novel CEI utilities*	Device for IoT that listens to legacy assets and enables them via an IP-like protocol.
	Added value	Integrate legacy assets into the IoT world.
	Energy-related asset	Old inverters Old charing stations Old smart meters
	Edge solutions	Heterogeneous landscape of such older(legacy) edge devices.

3.4. CHALLENGE P3C4
Synthetic data generation

Description	*Key Requirements*	
How to retrieve data from legacy assets (e.g., no protocols are available) Smart electronic device that sits on legacy asset and "injects" a communication protocol; sensor data could then be retrieved from the legacy asset.	*Novel CEI utilities*	Synthetically generate time series data (e.g., using LLMs & GenAI.
	Added value	Domain specific generation of data, focus on time-series data generation.
	Energy-related asset	Increase continuity and consistency of data sets.
	Edge solutions	• PV panels • Vehicle sensors • Grid-related data • Market prices

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Domain: Logistic hub value chain efficiency via energy flexibility

4. PILOT 4: Variable Demand in Challenging Maritime Terminal Landscape

Three scenarios aiming at monitoring, prioritization, and AI-based prediction are foreseen in the pilot. For the latter, different regression and classification algorithms will be cooperatively developed (i.e., FL), engaging decentralized nodes (e.g., CHEs) to train, and infer privacy preserving models, that might be published in O-CEI marketplace for cross-domain pilot involvement.

P4-SC1: Vessel energy management: The holistic monitoring platform (O-CEI visualization and decentralised storage utilities) will integrate all energy related flows coming from the Off-Power Supply plugs connected to berthed vessels. Here, the historical and real-time dashboard will be fed by the decentralized monitoring of O-CEIleveraging the metering, sensors and other IoT elements.

P4-SC2: Terminal energy management: The historical and currently energy consumed data from previous scenario will be accompanied in this scenario with the energy data consumed by the different assets from the terminal side (e.g., CHE data, lighting, buildings, cooling reefers and vessel charging).

P4-SC3: Home consumers: In this third scenario, the energy capacity adjustment of the island with the vessel and terminal operations will be addressed by replacing the normal electricity meter at homes, by the optimized O-CEI orchestrated control system, able to control the relay protections, providing a basic but O-CEI secure priority connection list of home devices (from critical services, light, water heater, up to home appliances) thanks to the O-CEI data governance schemas, and the pub/sub models of the project.

4.1. CHALLENGE P4C1: RTGs energy acquisition

Description	*Key Requirements*	
a) Data acquisition module that gathers energy data from PLCs of RTG cranes. b) AI-based predictions of energy consumption of Malta Freeport Terminal RTGs	*Novel CEI utilities*	No-code tools for time-series data in real time (up to 100 Hz sampling frequency) Lightweight regression (and possibly frugal) AI/ML assets
	Added value	Structure of PLC data bases is not straightforward to understand. A no-code tool can help on the acquisition and collection processes.
	Energy-related asset	Cranes of the port
	Edge solutions	Yes, definitely needed, as IoT gateways will be the equipment connected to the PLCs.

4.2. CHALLENGE P4C2: Smart energy circuit breakers for homes

Description	*Key Requirements*	
Novel and open-source smart circuit breakers that are able to analyse trends of energy consumption and performs, according to pre-configured rules, disconnection of the energy flow (some commercial examples are AirZone Aidoo, Schneider Smartlink, or Tigo TS4).	*Novel CEI utilities*	Hardware devices that are supported by most of the open-source software communities of home/industrial energy platforms
	Added value	Most of the current devices in the market are still very manufacturer dependant, without the possibility of customising their associated services.
	Energy-related asset	AC, home appliances, lighting
	Edge solutions	Yes, although connection with a common cloud platform can also be accepted.

4.3. CHALLENGE P4C3: Large-scale energy emulator

Description	*Key Requirements*	
a) Large-Scale simulator based on the energy data gathered from the office scenario b) Opensource software that can predict AI-based the energy consumption in 2035 in the island of Malta	*Novel CEI utilities*	Energy-based software simulator that help to predict in advance potential energy deployments and prioritization rules.
	Added value	In the Port scenario, it is extremely relevant to carry out previous testing and simulation campaigns in order not to affect to such critical infrastructure.
	Energy-related asset	n/a
	Edge solutions	No. The envisioned simulations are needed for understanding the complete energy ecosystem of the pilot, so it should not be assumed that this challenge is edge-based.

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Domain: Farm to fork dairy energy tracking

5. PILOT 5: Energetically and Environmentally Sustainable Halloumi Cheese Production

Four scenarios will holistically tackle energy efficiency and animal welfare in Cyprus halloumi production.

P5-SC1: IoT assisted livestock management based on edge intelligence and automations: It will optimize energy use consumed in stables but on the same time addressing the needs for reduced animal's heat stress. Cameras will be installed that, combined with available IoT sensors will allow decentralized intelligence (classification) and modelling of animal behaviour (thus, stress) monitoring.

P5-SC2: Controlled sharing of data from various stables to the dairy production factory: Selected datasets from stables having a trusted relation with the production factory will be collected and dynamically shared thanks to O-CEI mechanisms and marketplace. O-CEI semantic stack will integrate and expose datasets about milk quantity, quality, properties, feed mix or energy footprint along the supply chain.

P5-SC3: Intelligent selection of energy mix for dairy production. Cheese production in factory involves several processes that may have varying energy needs depending on aspects such as milk quantity or cheese type. This scenario is oriented to optimise the energy source selection (local grid network, own solar panels, biodiesel engines) according to such needs. It will leverage models from other pilots (e.g., P2, P3, P6).

P5-SC4: Calculation of energy footprint of dairy (halloumi) products. This scenario will obtain an aggregated energy footprint metric escorting each produced unit that will encapsulate the energy consumption (and the selected mix) across the chain. This will include an optimal selection of the IoT-edge-cloud elements (O-CEI orchestration engine) for computing an energy consumption algorithm.

5.1. CHALLENGE P5C1: Dairy product Traceability System based on Distributed Ledger Technologies

Description	*Key Requirements*	
A DLT based system for enhancing dairy-cheese traceability across the supply chain — from farm to fork. The objective is to ensure transparency, authenticity, and food safety throughout the cheese production and distribution process using a tamper-proof, decentralized ledger. It will be important to provide mechanisms for data capture and storage at each stage with a focus on Energy Consumption:	*Novel CEI utilities*	Use CEI utilities to facilitate automation in data collection from relevant sources including IoT sensors (monitoring temperature, location tracker, energy monitoring) and inference of higher level information (e.g. temperature is within acceptable thresholds, travelled distance for transportation is optimal, calculate energy consumption and store footprint within the DLT.)
	Added value	Increase food production transparency

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Farm: Milk origin, animal health, feed records, total consumed energy Transport: Distance travelled, Transferred Quantity, Transportation means, Conditions during transport (temperature), Consumed energy/fuel. Processing: Pasteurization, additives, aging conditions, total consumed energy Packaging: Batch info, expiry dates, transport conditions The DLT should support the specification, implementation and compliance checks in an automated way through the use of smart contracts of relevant with the dairy industry requirements. For example, ensure food safety and energy sustainability with regards to transportation conditions.		considering energy optimisation parameters.
	Energy-related asset	Close to real time assessment of energy footprint. Avoid retrospective data collection and assessment.
	Edge solutions	Using smart contracts for assessing energy footprint and evaluation of conditions can potentially include complicated calculations that can't be realised in small mobile devices. Hence, miniPCs other computing devices deployed at the edge/fog layer need to be employed.

5.2. CHALLENGE P5C2

Description	*Key Requirements*	
D	*Novel CEI utilities*	D
	Added value	D
	Energy-related asset	D
	Edge solutions	D

5.3. CHALLENGE P5C3

Description	*Key Requirements*	
D	*Novel CEI utilities*	D
	Added value	D
	Energy-related asset	D
	Edge solutions	D

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Domain: Sustainable yield and harvesting

6. PILOT 6: Smart Re-Charging and Efficiency of Robot Tractors in Large Fruit Production Fields

Pilot 6 proposes three scenarios which tackle energy efficiency of agricultural operation of tractors.

P6-SC1: Real-time energy consumption aid for agricultural decisions: O-CEI platform will timely provide the farmer (Single SignOn) with suggestions of agricultural decisions to optimize the energy value and efficiency of all their assets (battery recharging, operations, charging stations).

P6-SC2: Remote route optimization and task planning of robot tractors: AI-block of O-CEI will complement the blueprint of P3 to perform optimization algorithms (to be shared via marketplace) over agricultural tasks in kiwi plantations. The proper moment, quantity and location for executing mowing, fertilization, pruning, agrochemical application, and harvest will be explainably and frugally obtained via SotA models to ensure efficient and timely operation.

P6-SC3: Autonomous tractor re-charging strategy: P3 tractors' batteries can recharge either from fixed stations scattered across the fields or via own-equipped solar panels. The goal is let the tractor itself or the farmer manage the tractor's battery charging efficiently. First, analytics at the edge will exploit real-time data, historical usage patterns, and seasonal energy demands (predicted by AI-inference at the edge extracted from the marketplace).

6.1. CHALLENGE P6C1: Use of interchangeable batteries for energy storage from PV surplus energy production

Description	*Key Requirements*	
Develop a system of interchangeable batteries that could be worth for both purposes: apart from providing energy to the tractor, to be used in any other energy need from the farm site	*Novel CEI utilities*	Orchestration tools for charging and discharging management
	Added value	Flexibility to run multiple farm devices under different situations. Reduce energy waste Increase autonomy
	Energy-related asset	Batteries PV panels & supporting HW
	Edge solutions	Zetrack app

6.2. CHALLENGE P6C2: Enhance PV to AV for extreme solar conditions during specific periods

Description	*Key Requirements*	
Taking into account climate change is lately affecting negatively to the crops in high heat and insolation events. Agro-Solar panels could be used for the extraction of energy and for the prevention of heat events	*Novel CEI utilities*	Weather prediction tools / models (maybe using AI driven tools
	Added value	Dual functionality (crop protection + energy production)
	Energy-related asset	PV panels with adjustable tilt

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		Solar radiation sensors
	Edge solutions	Edge control units to adjust automatically the panels

6.3. CHALLENGE P6C3: Develop and implement a tool for spring pruning

Description	*Key Requirements*	
For the cleaning of the sprouts and limiting of excess growth, a tool that cuts and cleans would be valuable	*Novel CEI utilities*	Unlikely because is mainly a HW development. In any case an orchestration tool that accounts for the energy consumption in real time
	Added value	Reduces manual labour, hence cost. More uniform pruning. The bigger the field, the higher the value.
	Energy-related asset	Electric powered pruning tool attached to the tractor. Energy supply comes from main batteries.
	Edge solutions	Edge-based vision system for precision. Included in Zetrack app.

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Domain: Energy flexibility involving 5G telco operators

7. Trustworthy and Secure EV Charging upon Reliable 5G Networks

Pilot 7 proposes two scenarios that complement each other in the context of 5G-driven EV charging.

P7-SC1: Edge optimization of power flow to EV needs: AC and DC chargers are available in the load areas, that can act as bidirectional elements from EVs (V2G). This scenario shifts the current paradigm and will allow every charger included in the 5G network to be "intelligent" and to compute their power setpoints together with information obtained from vehicles.

P7-SC2: Increasing trustworthiness and security in EV charging data exchange: O-CEI blueprint will include security utilities such as vulnerabilities detection and continuous monitoring and response to cope with mentioned cyberprotection challenges. Other enablers coming from O-CEI marketplace (and other pilots) will also be deployed. The scenario will integrate to a full data driven workflow that will keep lineage and sovereignty of data coming from metering sensors, EV position and battery needs, etc. Auditing and reputation of the information used to balance the energy mix (from the previous scenario) will be used, as well as trustworthiness score of computing elements used in each case.

7.1. CHALLENGE P7C1: RES emulator

Description	*Key Requirements*	
Reference forecasting (data about power availability) based on real data from different res (e.g. wind power)	*Novel CEI utilities*	Real-time RES generation emulator for closed-loop control.
	Added value	Improved demand-response coordination and grid balancing.
	Energy-related asset	PV solar, wind emulator integrated into the charging station.
	Edge solutions	Edge forecasting models for RES input prediction.

7.2. CHALLENGE P7C2: Increasing battery lifecycle

Description	*Key Requirements*	
Second life battery lifecycle (SOH, best min - max scope etc) under B2G, B2H, B2B solicitation. Analysis and cross technology assessment.	*Novel CEI utilities*	Edge-based SOH estimation and predictive maintenance
	Added value	Prolonged asset usability, circularity, and cost-efficiency
	Energy-related asset	Second-life EV batteries, BESS in charging infrastructure
	Edge solutions	Edge analytics for SOH, lifecycle prediction

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7.3. CHALLENGE P7C3: External penetration testing of Pilot 7 infrastructure

Description	*Key Requirements*	
Comprehensive penetration testing to evaluate vulnerabilities across the full stack of Pilot 7 infrastructure (including IoT, edge computing nodes, EV chargers, V2G interfaces, communication and cloud services).	*Novel CEI utilities*	Security auditing of CEI infrastructure components
	Added value	Strengthened cyber posture of smart charging and grid balancing systems
	Energy-related asset	EV smart chargers, V2G interfaces, gateways, RES integration modules
	Edge solutions	Edge security, threat modeling at the edge

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Domain: Smart Energy City

8. PILOT 8: Heightened Social Engagement and Acceptability of Energy Flexibility in Urban Areas

The three locations will propose one scenario each, oriented to develop new SES over an improved solution.

P8-SC1: Democratization of energy demand forecasting for e-vehicle charging SES: Residential buildings are surrounded by local grid and specific charging stations options for charging e-vehicles (EV). This scenario is designed for (i) end-customer (EV owners) to derive insights from energy grid and for (ii) independent software vendors to develop SES that will suggest such customers how to better employ grid resources for optimized (complete) charging of their vehicles.

P8-SC2: Advanced graph data processing and LLM for energy prediction: O-CEI Data Fabric will be employed as an information graph containing energy data and results from previous scenario, together with chatbot inputs from users in different buildings. A combination of interdisciplinary technologies (encapsulated as O-CEI utilities) will orbit around LLM models, edge computing (in the edge locations of buildings) and serverless functions.

P8-SC3: Self-adaptive energy and computation continuum in distributed tourism area: In and around the valley of Val D'Anniviers, edge equipment (e.g., sensors, actuators, energy meters and computing elements) will leverage the O-CEI orchestration engine, monitoring and cybersecurity to enhance the previously existing CEI solution.

8.1. CHALLENGE P8C1: Social Smart Meter

Description	*Key Requirements*	
A smart meter enriched with behavioural insights can guide prosumers in adopting sustainable habits and making informed energy choices.	*Novel CEI utilities*	Strategic decision Open EMS
	Added value	Empowers citizens to actively participate in energy transition through informed choice
	Energy-related asset	Smart meter with embedded behavioural analytics module
	Edge solutions	Edge device processes energy and behavioural data locally to deliver real-time, personalised recommendations

8.2. CHALLENGE P8C2: Extend to other utilities

Description	*Key Requirements*	
The AI techniques and flexibility services that will be developed in pilot 8 can be adapted to other forms of energy consumption/production as well as other	*Novel CEI utilities*	Adaptation of EMS tools for integrated control across electricity, heating, water, and gas.
	Added value	Supports long-term engagement and

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utilities such as heating, water management, etc.		unified control across electricity, heating, water, and gas systems.
	Energy-related asset	Modular edge platform with support for additional sensors and contextual data for multi-utility monitoring.
	Edge solutions	Scalable edge processing extended to support additional utilities and contextual data.

8.3. CHALLENGE P8C3: Gamification for individual and group engagement

Description	*Key Requirements*	
Energy-efficient behaviour is promoted through gamified interactions and friendly competition among individuals or groups.	*Novel CEI utilities*	Gamification layer integrated into EMS with individual and group challenges
	Added value	Sustained motivation and behavioral change through social engagement and peer benchmarking
	Energy-related asset	Smart meters, interactive user interfaces, and engagement modules for feedback and challenges.
	Edge solutions	Edge device processes real-time usage data to enable gamified feedback and social comparisons

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