MACBETH

MACBETH Validation Workshop – 28th January 2026

Stakeholder needs on the exploitation of MCS

Co-funded by
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1.1. Project summary

MACBETH aims to support the deployment and scale-up of Megawatt Charging Systems (MCS) in logistics to electrify long-haul freight, through developing and showcasing multipoint MCS hubs combined with tools facilitating the scale-up. MACBETH intends to address many of the technical, social, and economic challenges of mass deployment of MCS by setting up two demonstration sites, one in Sweden and one in Belgium to address various operational conditions, users' needs, and business cases.

By exploring these diverse environments, the project will generate valuable insights into the practical integration of Megawatt Charging Systems within real-world logistics operations. This approach will not only demonstrate the feasibility of large-scale electrification for long-haul freight but also inform future deployments by identifying best practices and potential obstacles. Ultimately, the knowledge gained from these pilot hubs is expected to lay the groundwork for broader adoption, fostering collaboration among stakeholders and shaping policy recommendations to accelerate the transition towards sustainable freight transport across Europe.

1.2. Objective of this task

This report is part of **Task 2.1 "Identification of stakeholder needs and challenges towards deployment and use of MCS"**, whose aim was to collect insights from a list of targeted stakeholders groups involved, either directly or indirectly, to the truck charging ecosystem. The project aims to identify:

- Current technical, operational, infrastructure, economic, and regulatory challenges in relation to MCS deployment and use;
- Stakeholder-specific needs and expectations for successful MCS adoption;
- Concrete use-cases and deployment scenarios for MCS across different settings.

To delve deeper into the topics introduced and the list of stakeholders involved, it is important to highlight the multi-layered nature of the truck charging ecosystem. Key stakeholder groups, directly or indirectly connected to the truck charging ecosystem, were identified and categorized in detail depending on each group's interests and day-to-day roles. The project engaged a diverse set of actors within the following 21 groups:

- Distribution System Operator (DSO)
- Grid hardware providers
- Energy producers and suppliers
- Charging hardware providers
- Truck OEMs
- CPOs
- Carriers
- Retailers
- Freight forwarders
- Shippers
- Owner of logistics sites
- Safe and Secure Parking owners
- Gas Stations operators
- eMSPs and eRoaming operators
- Complementary charging technology providers
- EU/National Industry Associations
- Road Authorities
- Public bodies/policymakers
- Funding and financial institutions
- Certification and standards advisors

- Consultancies

Of the 117 organizations identified as ideal respondents, 109 contacts were retrieved and reached out to. This resulted in **65 interviewees** who agreed to participate in the MACBETH stakeholder requirement gathering from September to November 2025.

As each stakeholder might belong to more than one group due to their diversified portfolio of services and products, the analysis also considered needs from a “dual role” or a complementary service. For example, an increasing number of OEMs are developing their own EV routing tools and reservation systems, overlapping their services and products with those of eMSPs. The same applies to carriers and logistics companies, which might be the owners of logistics sites like warehouses or distribution centers and install charging stations at their premises. In case these charging facilities are opened to third parties, the LSP can decide to either operate the charging station themselves, becoming a CPO, or partner up with charging point operators to manage them.

As a result, stakeholders such as LSPs, carriers, and logistics site owners often play between user and operator roles, influencing both the demand for and provision of charging infrastructure. After identifying these multifaceted relationships, the team decided to cluster stakeholder groups into 6 categories, as explained below. For each cluster, a unique ID has been assigned; xx refers to the ID number:

i. Demand-side users: URxx
ii. Site hosts & facility operators: LSRxx
iii. Charging point operators: CRxx
iv. Energy and grid actors: ERxx
v. Tech & solution providers: TSRxx
vi. Governance, finance, standards and knowledge: GVRxx

The user requirements consist of requirements for value propositions to be achieved by electric trucks and MCS in long haul operations and criteria or conditions for fulfilling those value propositions. For example, *LSR2 - Operational planning, reliability and service quality.* Value: *charging concepts at logistics facilities must fit real operations.* Then, the requirement for value fulfilment were breakdown into multi-dimension

aspects grouped by a specific topic: …*charging infrastructure must deliver stable, predictable power over planned sessions…"; "…should be aligned with loading/unloading and driving/rest rules…"*.. The stakeholder requirements are summarized below.

Alongside assessing stakeholder needs, the **research identified recurrent challenges, expectations, prospective use cases, and potential deployment pathways for MCS**. These findings were synthesized to establish a comprehensive stakeholder vision that integrates multiple perspectives, which will be presented and discussed on January 28 during the online workshop.

What to expect during the interactive session:

- 4 discussion blocks with **short presentations, live polls, and open discussion**.
- Topics include:

    1. **Where electrification is really happening**
    2. **What blocks scale-up today**
    3. **What makes the business case work**
    4. **The future of truck charging – MCS or CCS?**

2. STAKEHOLDER NEEDS AND REQUIREMENTS

The successful deployment of battery-electric trucks infrastructure hinges on the close collaboration of a wide range of stakeholders, each bringing unique expertise and perspectives to the table. The groups listed above collectively shape the strategic and technical landscape needed to enable the transition to zero-emission freight transport. This chapter provides an overview of the main needs and requirements that must be addressed from each of the stakeholders' perspective to ensure the adoption and long-term viability of battery-electric trucks on longer routes, as well as, of course, the deployment and scale-up of MCS technology. The requirements have been collected through in-depth discussions with representatives from each group. These requirements are not intended to address user or stakeholder needs for demonstrations or pilots involving MCS, but rather to identify what is necessary for MCS and electric trucks to be integrated into actual long-haul operations. It is essential that these requirements inform the design and development of the MACBETH use cases, ensuring that each use case delivers maximum relevance and value to logistics businesses and stakeholders.

The complexity of information collected and the number of engaged organizations required us to first compile a list of preliminary requirements, available in **Error! Reference source not found.** of the final report (which will be published after review by the EC, to be then synthesized into core aggregated requirements below:

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2.1. Demand-side/user aggregated requirements

ID	Aggregated requirement
UR1 – TCO and business case	The total cost of operating battery-electric trucks must be competitive with, or only moderately higher than, diesel, and support schemes should cover both vehicles and private infrastructure (including grid connections and civil works) so that logistics actors can build robust TCO models and justify investment.
UR2 – Cost transparency and modelling tools	Electricity prices, grid fees, taxes and tariff structures should be transparent and predictable over time, and suitable tools should be available to model TCO, asset lifetimes and risk under different charging events and logistics models.
UR3 – Fair and risk-sharing business models	Business models for semi-public and public MCS hubs should share costs and utilisation risks fairly between site owners, carriers and CPOs (depending on the partnership), optimize logistics performance and infrastructure utilization while providing clarity on residual values and contract durations.
UR4 – Service reliability and schedule keeping	Chargers must be reliable enough that planned charging sessions happen as expected, without frequent derating, outages or blocking, so that delivery schedules and service levels can be maintained without excessive buffers or spare capacity.
UR5 – Integration with operations and driving/rest rules	Charging events must be integrated into real operations and current legislation, meaning charging must be compatible with driving and rest-time rules, compatibly with loading/unloading and yard processes, and designed so that drivers can take effective breaks while trucks charge.

ID	Aggregated requirement
UR6 – Predictable charging power and contingency	The power and energy used in planning must reflect the power that the CPO can actually deliver in a given time window, with a committed power or energy “handshake” for booked sessions, and contingency options should be available for failures or delays at planned charging slots.
UR7 – Depot/grid readiness and energy management	Access to sufficient grid capacity at depots and private sites must be timely and affordable, with grid operators providing early, clear information, and depot energy management should coordinate building loads and truck charging, including options for on-site renewables, storage and flexibility services.
UR8 – Depot design, safety and scalability	Depot layouts must support safe and efficient access, protect equipment, comply with safety requirements, and should be designed to scale from overnight charging to higher-power without full redesign.
UR9 – Corridor and public network coverage	A basic network of truck-compatible high-power chargers and future MCS hubs along main freight corridors and at key logistics nodes must be available, with locations and capacities aligned with real freight flows, cross-border routes and typical rest locations.
UR10 – Truck-compatible site geometry and layout	Public charging sites must be designed for long combinations, provide sufficient length, width, height and turning space, and should use layouts (such as drive-through or angled bays) that minimise complex manoeuvres and separate truck flows from cars where needed. MCS hubs must follow standardized layout principles, including adequate bay length/width and drive-through height, safe cable and dispenser positioning relative to standardized inlet locations, the possibility to charge vehicles without decoupling where relevant, and clear circulation patterns and queue management so that MCS operations can be performed safely, quickly and with minimal manual handling and conflict between vehicles.
UR11 – Safety, security and amenities at hubs	Public charging sites must meet high safety and security standards (clear boundaries, lighting, monitoring, controlled access, emergency procedures) and must provide basic amenities such as covered parking, toilets, food and rest facilities with sufficient capacity for trucks.
UR12 – Digital planning and navigation for e-trucks	Transport management and planning tools must support electric trucks natively, estimating energy use with links with both depot and public charging; navigation systems should integrate detailed charging data (availability, realistic power, price and services) in a form usable also by SMEs and owner-drivers.
UR13 – Data, billing and price transparency	Real-time charger status data must be reliable, billing across networks should be consolidated and clear. Pricing (e.g. ad-hoc vs contract-based, energy vs time) should be transparent and distinguishable for planning and comparable.
UR14 – Booking and reservation systems	Booking and reservation systems for HDV charging should be optional but interoperable across networks, allow booking of site or pool rather than single satellites, include a committed power or energy amount, support anonymized data updates from the onboarding systems (e.g. SoC, ETA, O/D data) and booking transfer, and apply fair, standardised rules for no-shows, delays and fees. The system should be open, transparent, and neutrally governed.
UR15 – Semi-public site and access governance	Governance models should enable logistics companies and CPOs to co-develop and operate charging at private sites, allowing site owners to grant access to multiple carriers without becoming full CPOs, and provide fair prioritisation rules at shared sites.

ID	Aggregated requirement
UR16 – Roles, responsibilities and liability	Roles and responsibilities for safety, security, service quality and incident handling at depots and public hubs must be clearly defined, including who is responsible when a planned charging session cannot be delivered and how liability is allocated between actors.
UR17 – Supportive regulatory and incentive framework	The wider framework of incentives, taxation, road tolls, permitting, weight/length rules, rest-time guidance and AFIR implementation must support the economic and operational viability of electric HDVs and MCS-compatible models, with specific attention to smaller carriers.
UR18 – MCS deployment at private depots and logistics sites	The deployment of MCS at private depots and logistics sites must be technically and economically feasible where high-energy turnaround is needed, and should be modular so that a few MCS outlets can be added on top of existing CCS infrastructure, integrated with yard operations, energy management, grid constraints and safety rules, and, where desired, made accessible as semi-public infrastructure for selected external carriers without disrupting core operations.

Table 1: Aggregated user requirements

2.2. Logistics facility operators aggregated requirements

ID	Aggregated requirement
LSR01 - Business case, TCO and investment risk	Logistics site owners must be able to integrate charging and future MCS into a viable business model that does not undermine core terminal or warehouse activities.
LSR02 - Business case, TCO and investment risk	Charging and MCS investments at logistics sites should increase the long-term attractiveness and asset value of the property, rather than create unused or low-value infrastructure.
LSR03 - Business case, TCO and investment risk	Public support schemes and partnership models must share utilisation and technology risk between landlords, CPOs and investors, and should cover both charging infrastructure and required grid upgrades.
LSR04 - Operational planning, reliability and service quality	HDV charging and especially MCS at logistics facilities must fit real operations, aligning with loading and unloading processes, time-slot management and driving/rest rules.
LSR05 - Operational planning, reliability and service quality	High-power charging and MCS at logistics sites must deliver stable, predictable power over planned sessions so that yard schedules and service levels are not disrupted.
LSR06 - Operational planning, reliability and service quality	Charging areas must be integrated so that they do not create congestion, block docks, gates or rail interfaces, or compromise the primary function and safety zones of the site.

ID	Aggregated requirement
LSR07 - Depot and private-site charging	Depots, warehouses and logistics parks must be able to obtain and upgrade grid connections to support an evolving mix of CCS today and MCS tomorrow, with phased development aligned to BE-HDV uptake.
LSR08 - Depot and private-site charging	Greenfield logistics sites should be planned as "MCS-ready", reserving technical space, cable routes and layout options for future high-power equipment without redesigning the entire yard.
LSR09 - Depot and private-site charging	For existing, space-constrained or grid-limited sites, practical upgrade options are needed, including the possibility to relocate part of the charging function to nearby yards with better grid access.
LSR10 - Depot and private-site charging	Grid capacity at multi-tenant logistics parks should be optimised across tenants through fair metering and contractual models that distinguish between tenant-only charging and semi-public access for subcontractors and external carriers.
LSR11 - Public and corridor charging/MCS hubs	Secure truck parks, logistics clusters near motorways and port areas should be recognised as priority candidates for public or semi-public HDV/MCS hubs when sufficient grid capacity and space are available.
LSR12 - Public and corridor charging/MCS hubs	Layouts at such hubs must combine secure parking, high-power CCS and selected MCS bays in a way that serves both local and through traffic, while keeping truck flows clearly separated from car and retail traffic where relevant.
LSR13 - Public and corridor charging/MCS hubs	Operators of logistics-located hubs need clarity on whether chargers are fully public, port-community or semi-public, and on target user groups, so that access rules and prioritisation can be defined upfront.
LSR14 - Public and corridor charging/MCS hubs	MCS and very high-power infrastructure should be targeted to sites and use cases where short dwell times justify megawatt-level investment, while overnight and long-dwell charging at the same sites can rely on lower-power solutions.
LSR15 - Digitalisation, data and booking/ billing systems	Logistics facility operators hosting charging or MCS need digital systems that integrate parking, access control, yard or terminal operations and charging into a single operational view.
LSR16 - Digitalisation, data and booking/ billing systems	Back-end systems at logistics sites should interoperate with CPO platforms and support multiple vehicle types (cars, vans, trucks, future MCS), avoiding lock-in to proprietary or "dumb" charger solutions across a property portfolio.
LSR17 - Digitalisation, data and booking/billing systems	Combined booking of parking and charging at secure sites should be possible, allowing drivers and fleets to reserve both a safe rest slot and an energy slot in an integrated way.

ID	Aggregated requirement
LSR18 - Digitalisation, data and booking/billing systems	Metering, access control and reporting must distinguish tenants' internal use from third-party trucks and support site- and portfolio-level monitoring of CCS vs MCS energy use and associated ESG indicators.
LSR19 - Governance, access models and partnerships	Ports, terminal owners, logistics landlords and secure parking operators must retain control over land use, safety, access rules and strategic energy planning while partnering with professional CPOs and investors for high-power and MCS operations.
LSR20 - Governance, access models and partnerships	Standard contractual or concession models should clearly allocate roles, responsibilities and liabilities between landlords, tenants, CPOs, grid operators and public authorities, including how safe-and-secure parking certification and evolving port energy systems interact with high-power and MCS charging.

Table 2: Aggregated logistics operators requirements

2.3. Charging point operators aggregated requirements

ID	Aggregated requirement
CR1 – Site selection and permitting	HDV charging hubs must be located where there is sufficient existing or potential truck traffic, adequate land for truck-suitable layouts and a realistic path to recovering investments. Permitting, environmental assessment and distance rules should be clear, reasonably harmonised and flexible enough to allow CPOs to choose technically and economically feasible locations, with early clarity on any remediation needs.
CR2 – Grid access, capacity and reinforcement	CPOs must be able to obtain medium-voltage connections sized to current and medium-term demand within reasonable lead times, with transparent processes, contacts, timelines and curtailment conditions. Policy and regulation should explicitly support grid reinforcements and shared-connection solutions (for example cable pooling) at priority HDV locations, recognising that these are prerequisites for large MCS sites.
CR3 – Tariff structures and energy options	Tariff structures for capacity and energy must be compatible with the slow ramp-up of HDV utilisation and should avoid excessive fixed costs for unused capacity that make early hubs uneconomic. CPOs should be able to combine grid power with storage and renewables, and tariff and market design should enable new products (for example flexibility services or differentiated capacity products) that help recover high fixed costs.
CR4 – CCS/MCS standards and technology roadmap	MCS and CCS systems must be based on stable, fully specified and interoperable standards (connector, communication, ISO 15118-20, V2X) and clear OEM commitments, so CPOs can invest without repeated redesigns. CPOs should be able to plan coherent CCS/MCS roadmaps per site, deciding when to deploy hybrid sites, when to upgrade CCS bays and when to move to MCS-only hubs, without being forced into technology choices that do not match existing freight flows.

ID	Aggregated requirement
CR5 – Hardware performance, footprint and cost	High-power CCS and MCS hardware must deliver stable power at high current without frequent derating or restarts and must be compact enough not to erode truck parking capacity. Hardware prices, lifetime and upgrade paths should be predictable and competitive; given that MCS equipment is currently much more expensive than CCS, funding and regulation should avoid locking CPOs into premature high-cost deployments.
CR6 – HDV-oriented site design and geometry	HDV charging sites must follow clear design guidelines that work for long combinations, with sufficient bay length/width, turning radius, drive-through height and one-way circulation to minimise reversing and coupling/decoupling. Where LDVs and HDVs share sites, layouts must prevent conflicts and maintain safe truck circulation; in many contexts, truck-only zones or hubs should be preferred.
CR7 – Security, amenities and driver experience	Public truck charging hubs must provide secure perimeters, controlled access, good lighting, surveillance and clear safety procedures, aligned with expectations for safe and secure parking at night. CPOs or partners should ensure a minimum level of amenities (toilets, showers, food, rest space) sized to expected truck volumes, so that charging time can be aligned with mandatory rest and perceived as valuable by drivers and fleets.
CR8 – Flexible, mixed-use and scalable layouts	Site layouts should allow phased expansion and, where relevant, flexible mixed use, so that a given bay can serve different vehicle types over time and multiple dispensers/satellites per bay can be used to raise utilisation. Designs should support gradual scaling from initial CCS deployments to later MCS additions without requiring full redesign of civil works and traffic flows.
CR9 – Robust backend, CPMS and interoperability	CPOs must operate reliable backend and CPMS systems that manage dynamic load balancing across CCS and MCS, integrate with energy management and storage, and interoperate with multiple eMSPs, routing and planning tools. Protocols and platforms should be harmonised to support roaming, HDV-specific data fields and contract management, so fleets are not forced to adapt to bespoke solutions at each hub.
CR10 – Booking, reservation and access control	Reservation and capacity-booking systems for HDV charging must allow fleets to reserve time, bay type and guaranteed power or energy, and must be tightly integrated with load management so reserved capacity is actually delivered. Effective systems should typically book a site or group of chargers rather than a single plug, link to physical access control (for example licence plate or vehicle ID), handle delays and no-shows with clear rules, and, ideally, be based on open, interoperable standards usable across multiple CPO networks.
CR11 – Data sharing, transparency and pricing	CPMS and data platforms must publish reliable real-time information on station status, bay availability and realistic deliverable power, not just nameplate ratings. CPOs must provide clear, transparent information on energy prices and all additional fees, and should receive better data from fleets (for example SoC, expected energy, ETA, trailer configuration) in standardised and privacy-compliant ways, so that planning, booking and on-site operation can be optimised.
CR12 – Utilisation, business model and ROI	Public HDV and MCS hubs must be able to reach sustainable utilisation within a reasonable timeframe; otherwise early investments remain fragile and discourage further roll-out. Support schemes should cover not only chargers but also grid connections, transformers, civil works, storage, security and amenities, and CPOs should have access to mechanisms such as long-term capacity contracts with fleets to de-risk utilisation and improve ROI.
CR13 – Policy support and tariff innovation	Policy and support frameworks should recognise that HDV electrification will progress at different speeds across regions, allowing more flexible obligations and higher support intensity where fleets and grids are less mature. Tariff and market regulation should allow CPOs to offer pricing models beyond simple per-kWh (for example subscriptions,

ID	Aggregated requirement
	capacity/availability fees), while ensuring that funding rules do not artificially push MCS where robust CCS plus storage would deliver more value.
CR14 – Coherent, non-discriminatory regulatory framework	EU and national regulation must treat different HDV charging actors (independent CPOs, fleet-owned sites, gas-station operators, utilities) in a non-discriminatory way regarding grid access, obligations and support. AFIR implementation schedules and power/spacing requirements should reflect actual grid and permitting realities, and coordination between transport and energy policy must ensure that HDV charging targets are aligned with grid operators planning and investment cycles.
CR15 – Safety, secure parking	Rules on safe and secure truck parking should explicitly address electric HDV charging areas, so CPOs know which security and service levels are expected and can plan CAPEX/OPEX accordingly.
CR14 – MCS governance	Governance around MCS corridors and hubs should provide realistic roadmaps and clear expectations for security, operations and site classification, including where sites act as both charging hubs and safe and secure parking areas.

Table 3: Aggregated charging point operators requirements

2.4. Energy and grid requirements

ID	Aggregated requirement
GR1 – System demand growth and sector coupling	Grid operators must plan for transport electrification together with other fast-growing loads (heating, industry, data centres), using scenario-based planning so capacity is not consistently underbuilt at logistics nodes and corridors.
GR2 – Joint demand forecasting inputs	DSOs/TSOs need early, structured demand inputs from fleets, CPOs and site operators (commissioning dates, duty cycles, simultaneity, seasonal peaks) to size reinforcements correctly and avoid repeated redesign.
GR3 – Capacity visibility for site selection	DSOs/TSOs should provide practical hosting-capacity visibility (maps or equivalent) plus forward-looking outlooks for priority areas, so developers can screen sites and reduce speculative requests.
GR4 – Anticipatory and staged investments	Regulation should enable anticipatory grid investments and staged connection pathways (connect now, upgrade later under a pre-agreed plan) with clear triggers and cost recovery, to match ramp-up realities.
GR5 – Spatial planning and land readiness	Grid and spatial planning must be coordinated so land, servitudes, and corridors for substations and lines are reserved early for multi-megawatt hubs, reducing later permitting risk and delays.
GR6 – Standardised, digital connection processes	Connection processes should be digital by default, standardised in required inputs, milestone-based, and traceable end-to-end, to handle higher volumes and complexity of requests.
GR7 – Early pre-feasibility service	DSOs should offer an early, non-binding pre-feasibility check (capacity, likely reinforcements, indicative costs and timelines) before developers commit major CAPEX and permitting.

ID	Aggregated requirement
GR8 – Complexity-adapted assessment pathways	Connection processes must be adaptable by complexity (fast vs binding, LV vs MV/HV, hub+storage, industrial hybrid), with a coordinated DSO/TSO assessment to avoid duplicate studies and inconsistent assumptions.
GR9 – Clear timeline ownership and external dependencies	DSOs/TSOs should separate what they control (studies, grid works) from external bottlenecks (permits, land rights, supply chain) and state assumptions clearly in offers and schedules.
GR10 – Queue management and regulator-defined prioritisation	Queue rules should be transparent, auditable, and readiness-based, with prioritisation criteria defined by regulators (chronological or public-interest) and applied by DSOs without discretion.
GR11 – Tariffs aligned with utilisation ramp-up	Network tariffs and contracted-power charges must work during low early utilisation (avoid punitive fixed costs), while still preventing capacity hoarding through clear milestone rules.
GR12 – Funding for strategic reinforcements	Dedicated funding should support grid reinforcements and upstream works needed for multi-megawatt charging hubs, especially where these are public-interest corridor assets.
GR13 – Flexible and non-firm connection products	DSOs should offer standard flexible/non-firm connection products with clear curtailment limits, notice times, and compensation principles, so constrained grids can still host early hubs.
GR14 – Interoperable control and curtailment interface	Curtailment and load-management interfaces must be interoperable and cyber-secure (standard protocols, defined telemetry and control signals) to avoid bespoke integrations and operational risk.
GR15 – Two-way operational data exchange	Grid operation increasingly requires two-way data exchange with hubs (day-ahead forecasts, real-time power telemetry) under clear technical requirements and service levels.
GR16 – Data governance and confidentiality	Data sharing must be privacy-compliant and protect commercially sensitive information, with clear rules on access, permitted uses, retention, and security responsibilities.
GR17 – Permitting coordination	Connection delivery should embed early coordination with municipalities and permitting bodies (standard documentation packs, safety concepts) to reduce delays beyond the DSO process itself.
GR18 – Supply chain resilience and standardisation	Grid hardware providers need earlier visibility on reinforcement pipelines and more standardised technical specifications, plus modular options (e.g., transportable substations) to reduce lead times and cost volatility.
GR19 – Grid-code, power quality, and cybersecurity compliance	Technical requirements must be clear for multi-megawatt hubs (grid-code compliance, protection schemes, ramp rates, reactive power, metering) and include cybersecurity expectations aligned with critical infrastructure.

ID	Aggregated requirement
GR20 – Energy supply contracts and carbon accounting	Energy suppliers should provide hub-suitable supply products (long-term indexed or hedged contracts), transparent cost breakdowns (energy vs network vs taxes), and clear GoO and carbon accounting compatible with corporate reporting.

Table 4: Aggregated energy and grid requirements

2.5 Technology and solution providers requirements

ID	Aggregated requirement
TSR01 – MCS standard finalisation and roadmap	The MCS standard must be finalised with a stable roadmap (mechanical, electrical, cooling, safety, communication) so OEMs and suppliers can industrialise products and avoid prolonged pilot-only deployments.
TSR02 – Conformance testing and certification	Harmonised conformance testing and certification must exist for vehicles, chargers and backend interfaces, recognised across markets, to prevent country-by-country implementation differences and delayed approvals.
TSR03 – End-to-end interoperability assurance	Interoperability must be validated end-to-end (vehicle ↔ charger ↔ backend ↔ roaming) through regular multi-OEM test events and shared defect learnings, because “standard-compliant” does not guarantee field compatibility.
TSR04 – CCS to MCS coexistence strategy	The transition must support CCS and MCS coexistence with clear rules (hybrid sites, dual inlets, retrofit strategies, timelines), so early infrastructure and vehicle choices do not become stranded.
TSR05 – Vehicle charging acceptance transparency	OEMs must provide reliable, usable charging acceptance information (power curve vs SoC/temperature, voltage windows, limits) and manage software changes transparently, so infrastructure sizing and performance guarantees match real vehicle behaviour.
TSR06 – High-power reliability and sustained performance	MCS charging must deliver stable high power with minimal derating, restarts and cooling-related failures under real duty cycles, since downtime and unstable performance destroy trust and utilisation.
TSR07 – Power sharing and “committed power” behaviour	Multi-outlet power allocation must be predictable and contractible, including a “committed power or energy” concept per time window where reservations exist, so planning and SLAs remain valid when other vehicles plug in.
TSR08 – Footprint efficiency and modular scalability	Hardware must improve power-to-footprint and support modular scaling (more connectors per cabinet, phased upgrades), because space constraints and utilisation ramp-up make one-shot overbuilding uneconomic.
TSR09 – Robust HDV-grade design and maintainability	Chargers, connectors, cables and cabinets must be designed for HDV environments (high connect cycles, impacts, weather), with remote diagnostics and maintainability that sustain high uptime without permanent on-site staff.
TSR10 – Ergonomics and cable management	Connector handling and cable management must be driver-feasible and intuitive, with clear inlet positioning assumptions and reach envelopes, to prevent usability failures and mis-parking at both depot and public sites.

ID	Aggregated requirement
TSR11 – Automation readiness	Automated plug-in (robotics) must be supported via standardised mechanical/communication interfaces and defined integration envelopes, reducing bespoke engineering per vehicle, charger and site.
TSR12 – Hybrid hub energy architecture integration	Solutions must support hybrid hub architectures (CCS + MCS + destination charging) and integrate cleanly with site energy management and BESS control, enabling peak shaving and grid-constrained operation.
TSR13 – Grid constraint and curtailment compatibility	Charging systems must handle grid constraints (curtailment, non-firm limits) with defined behaviour and signalling to vehicles and planning tools, so charging outcomes remain predictable.
TSR14 – Standardised operational data set	A common HDV charging data model must be standardised (real deliverable power, connector/bay constraints, availability, reliability indicators), enabling consistent routing, booking and operational integration.
TSR15 – API interoperability and role clarity	Digital integration must rely on standard APIs and clear role boundaries (OEM tools, eMSPs, CPO platforms, third parties) to reduce fragmentation and repeated bespoke integration work for fleets.
TSR16 – Data quality and governance	Data quality must be measurable (definitions, update rates, accuracy) and governed (privacy, consent, commercial sensitivity) so optimisation and automation can be trusted at scale.
TSR17 – Booking, roaming and commercial interoperability	Booking and roaming must work across networks and tools (OEM and third-party), support pool-based assignment on arrival, and expose operational constraints (e.g., trailer-on compatibility), avoiding lock-in to proprietary ecosystems.
TSR18 – Commissioning and validation toolchain	Commissioning and validation processes must test real performance before go-live (interoperability, power sharing, cooling limits, telemetry correctness), reducing field failures and expensive troubleshooting.
TSR19 – Cybersecurity and safety-by-design	Cybersecurity and functional safety requirements must be built into charging, automation and data interfaces (authentication, encryption, incident handling), aligned with critical infrastructure expectations.
TSR20 – Industrialisation, cost-down and lifecycle support	Market scale-up requires credible demand signals, cost-down through industrialisation, clear upgrade paths, and strong after-sales support (spares, remote service, maintenance processes) to keep lifetime TCO acceptable.

Table 5: Aggregated technology and solution providers requirements

2.6 Governance, finance and standards

ID	Aggregated requirement
GFS1 – Policy stability and long-term signals	CO_2 pricing, tolls, taxes, exemptions and subsidy rules must be predictable over multiple years, with transition periods, so investors can commit to high-CAPEX HDV charging and grid works without policy-driven stranded assets.

ID	Aggregated requirement
GFS2 – Policy alignment with deployment reality	Vehicle uptake policy, AFIR implementation, grid reinforcement timelines, and corridor delivery plans must be aligned, with sequencing that avoids building assets far ahead of demand without compensating mechanisms.
GFS3 – Avoiding unintended fossil advantages	National measures that shift TCO should avoid creating unintended cost advantages for fossil solutions that slow ZE truck uptake and reduce utilisation of early charging infrastructure.
GFS4 – Cross-border regulatory consistency	Cross-border framework conditions (including weight/dimension allowances for battery trucks and corridor rules) should be consistent along key freight corridors to enable international operations and bankable networks.
GFS5 – Funding eligibility	Funding schemes must cover the full cost stack (chargers, civil works, grid connection and substations, safety and security, digital systems), not only dispenser hardware.
GFS6 – De-risking low utilisation phase	Early-stage financial instruments are needed to manage low utilisation risk (for example minimum-revenue or availability-type support), so projects can be financed before volumes ramp up.
GFS7 – Strategic location steering	Public support and tenders should steer build-out toward strategic locations and sufficient capacity (power and number of points), not only lowest-cost projects, to meet corridor needs and reduce underperforming sites.
GFS8 – Corridor governance and multi-actor coordination	Corridor planning must coordinate road authorities, regulators, DSOs/TSOs, municipalities and market actors, with clear roles, timelines, and escalation paths for delivery blockers.
GFS9 – Land access and concession bankability	Public land and service-area concessions must be structured for bankability (clear access rights, responsibilities, payback-compatible durations, and clauses that allow adding HDV charging without contractual conflicts).
GFS10 – Faster, predictable permitting	Permitting for hubs, substations and storage must be time-bound and predictable, supported by one-stop coordination for complex sites and early screening for showstoppers.
GFS11 – Clear safety rules and liability	Safety rules (including co-location and fire safety) must be clear and risk-based, and legal frameworks must clearly allocate liability and incident responsibilities across landlord, concessionaire and operator.
GFS12 – Stable standards roadmap for MCS and related systems	Standards and guidance for MCS and supporting systems must follow a stable roadmap, reducing ambiguity and enabling investment and industrialisation across the value chain.
GFS13 – Conformance testing and certification regime	Harmonised, independent conformance testing and certification should cover vehicle–charger interoperability and regression testing after updates, with recognition across countries.
GFS14 – Metering and billing compliance clarity	Clear metering accuracy and compliance requirements are needed for high-power and MCS so billing is auditable, trusted and enforceable across markets.
GFS15 – Transparent performance and data definitions	Common definitions are needed for key performance terms (online, available, reduced power, deliverable vs peak power) and for what data must be published in machine-readable form.

ID	Aggregated requirement
GFS16 – Booking, roaming and access governance	Interoperable rules should govern booking, penalties, no-shows and “committed power or energy”, plus roaming, authentication and dispute handling, to avoid fragmentation into proprietary ecosystems.
GFS17 – Public monitoring and KPI enforcement	Authorities should define a shared KPI set and monitoring method for corridor readiness and service quality (uptime, delivered power, waiting time), and link it to enforcement or contractual remedies.
GFS18 – Cybersecurity and physical security baselines	Minimum cybersecurity and physical security requirements should be defined for charging infrastructure and backends, including incident response and measures against theft and vandalism.
GFS19 – Practical guidance, templates and standard clauses	Advisory bodies should publish practical toolkits (design guidance, permitting documentation packs, standard concession and contract clauses) to reduce transaction costs and accelerate replication.
GFS20 – Knowledge transfer and capability building	Structured knowledge-sharing, training and neutral decision-support tools should help municipalities, inspectors and corridor actors apply consistent methods and learn from early deployments (including failures).

Table 6: Aggregated governance, finance and standards requirements