



FIRST EDITION

IAF ARES

Automotive Resource and Efficiency Standard

Requirements for measured resource performance
across vehicles and the automotive value chain

DRAFT FOR TECHNICAL REVIEW

Working Draft 0.1 | 13 September 2026

Technical validation and formal adoption are required before conformity mark issue.
Release conditions are set out in Annex J.

International Automotive Federation

English master text

iaf.com

Document control and reader guide

IAF ARES defines how automotive organizations can demonstrate that vehicles, products and services use resources efficiently while preserving their required function. It connects energy, material and water accounts to useful output, representative operating conditions and independently reviewable evidence.

The proposed framework covers the complete value chain through a mandatory core and eleven application modules. It separates measured performance from verified improvement and from any future benchmark classification. The central requirement is a defensible resource outcome within a stated safety, quality and service envelope.

Document name IAF ARES Automotive Resource and Efficiency Standard

Edition and version Proposed First Edition | Working Draft 0.1

Document date 13 September 2026

Intended audience IAF technical reviewers, manufacturers, suppliers, operators, infrastructure providers, laboratories and assessors

Review purpose Validate scope, technical rules, numerical pilot criteria, reproducibility and scheme operation before adoption

How to use this working draft

Begin with Clauses 1 to 12, complete the applicability register in Annex A, then apply the relevant operational clauses. Clauses 24 to 30 govern value, improvement, assessment, decisions and communication. Annexes A to G are normative within the proposed draft. Annexes H to J are informative.

The draft includes its own proposed measurement and decision rules. Numerical pilot criteria require validation and may change before adoption. No universal energy class thresholds are asserted. Annex J records the work still needed for an approved First Edition.

All standard text is written as an original IAF proposal. No external organization, standard or programme is cited as a normative reference in this document.

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1 Purpose and scope

1.1 This document specifies requirements for planning, measuring, evaluating and improving resource efficiency across the automotive value chain. It addresses the useful outcomes delivered by vehicles, components, manufacturing operations, infrastructure, fleets and service networks in relation to the energy, materials, water, time and assets they consume.

1.2 It applies to organizations of any size and to combustion, hybrid, battery electric, fuel cell and other propulsion architectures. Passenger cars, two and three wheelers, commercial vehicles, buses, trailers, special purpose road vehicles and their supporting services are within scope. Off road equipment may use an expressly defined application profile; an assessment shall not imply road vehicle comparability.

1.3 An assessment shall identify its object as a product, component, site, operational service, fleet, infrastructure installation or defined portfolio. Product development, sourcing, conversion, distribution, use, maintenance, repair, reuse, remanufacturing and recovery shall be considered when their resource effects are material to the claim.

1.4 The intended outcomes are reliable resource accounts, representative performance indicators, protected service quality, defensible comparisons and verified improvement. Financial savings, lower emissions, higher utilization and technical innovation may support these outcomes, but shall not substitute for evidence of physical resource performance.

1.5 This document complements environmental and energy programmes through outcome measurement. Conformity does not by itself establish complete environmental sustainability, product safety approval, vehicle market authorization or compliance with every applicable legal requirement. An organization shall maintain those obligations separately and apply the safeguards in Clause 11.

1.6 The mandatory core consists of Clauses 1 to 12 and 24 to 30. Operational modules in Clauses 13 to 23 shall apply where the assessed object performs, controls or materially depends on the corresponding activity. Annex A governs selection. Selecting one module does not entitle an organization to claim that its entire business conforms.

2 Document status and application rules

2.1 IAF ARES means Automotive Resource and Efficiency Standard. This text is a proposed First Edition, Working Draft 0.1, prepared for technical review and pilot application. It has not been presented as an adopted or internationally recognized standard. Publication as an approved edition requires the decisions and validation described in Annex J.

2.2 Within this draft, “shall” indicates a proposed requirement, “should” a recommendation, “may” a permission and “can” a possibility. Clauses and annexes marked normative form the proposed conformity criteria. Informative annexes explain implementation and do not create additional conformity requirements.

2.3 This document contains no external normative references. Its requirements are stated within the document. Applicable legislation shall be identified in the organization's own obligations register without being reproduced as an external reference in this standard.

2.4 Numerical limits in this working draft are proposed IAF procedural rules for pilot evaluation unless expressly identified as a mathematical identity or an illustrative example. They are not established world

averages, statutory limits or claims of proven universal technical feasibility. Annex J records the required validation of these choices.

2.5 The draft supports scoped pilot assessment and preparation of evidence. An official conformity mark, public comparative class or claim of IAF approval shall not be issued from this working draft. Numerical performance results may be communicated as pilot results when their scope, status and limitations are visible.

2.6 Following adoption, each assessment shall use an identified edition, module set and approved application profile. Where a needed comparative profile is absent, measured results and specifically verified improvements may be reported; a universal ranking or equivalence to another product class shall not be inferred.

3 Terms and measurement language

The terms below apply throughout the document. Each organization shall add application specific terms to its measurement plan where necessary without changing these meanings.

Term	Meaning
Resource efficiency	Relationship between useful, conforming output and the resources required to deliver it within a stated boundary.
Resource intensity	Resource input divided by a defined functional output. A lower value is favourable only when output quality and boundaries remain comparable.
Functional unit	Quantified service against which resource use is assessed, such as one passenger kilometre or one accepted component of a defined specification.
Useful output	Delivered output meeting predeclared acceptance and service requirements. Scrap, failed deliveries and unrequested empty travel are not useful output.
Assessed object	Identified product, installation, organization, activity or service to which evidence and conclusions apply.
Reference period	Historical or experimental period used to establish a baseline, with its operating conditions and data limits.
Adjusted baseline	Estimated resource use that the reference system would have required under the reporting period conditions.
Normalization	Adjustment for relevant variables to support a valid comparison, using a documented model or matched conditions.
Routine adjustment	Adjustment for recurring variables such as output mix, weather, distance or payload within the validated model domain.
Structural change	Change in equipment, boundaries, specification or service that requires a separately documented nonroutine adjustment or a new baseline.
Material resource flow	A flow whose size, uncertainty, criticality or effect could change the conclusion or a user's decision.

Term	Meaning
Delivered energy	Energy entering a specified assessed boundary, measured by carrier before conversion inside that boundary.
Primary energy	Energy associated with upstream extraction or generation before conversion and delivery, calculated using declared factors and scenarios.
Service envelope	Required safety, quality, capacity, comfort, accessibility, timeliness and durability conditions for the claimed output.
Rebound effect	Increase in activity or other resource use associated with an efficiency intervention that offsets part or all of its potential saving.
Leakage	Resource demand displaced outside the stated operational boundary by a change, including outsourced work or additional user activity.
Expanded uncertainty	Interval half width derived from combined uncertainty and a stated coverage factor or another justified coverage method.
Evidence coverage	Share of the relevant resource or output total supported by a specified quality of measurement or validated calculation.
Performance passport	Versioned record of scope, methods, measured indicators, uncertainty, limitations and the assessment decision.
Comparative cohort	Predefined population of sufficiently similar objects assessed with compatible boundaries, service requirements and methods.

3.1 Energy quantities shall be reported in kWh or MJ, with the identity $1 \text{ kWh} = 3.6 \text{ MJ}$ applied exactly. Electricity, liquid fuels, gaseous fuels and heat shall also retain their carrier specific quantities where useful. Fuel energy conversions shall state the heating value basis, composition, density and reference conditions used.

3.2 Symbols and abbreviations shall be defined at first use in an assessment report. State of charge is abbreviated SoC; state of health is SoH; alternating current and direct current are AC and DC. A displayed SoC percentage shall not be treated as a calibrated measurement of stored energy.

4 Assessment boundaries and functional output

4.1 Before data collection, the organization shall approve a boundary description identifying physical interfaces, sites, outsourced processes, assets, data systems, geographic coverage, time period and the claim to be supported. The description shall distinguish controlled operations, purchased services, upstream inputs and downstream consequences.

4.2 Each claim shall use a functional unit and service envelope suited to the decision. At minimum, report vehicle energy per distance, passenger transport energy per passenger distance, freight energy per freight mass distance, and manufacturing energy per accepted product specification where those activities apply. Installed capacity and nominal seats shall not replace actual output.

4.3 Product comparisons shall disclose capacity, vehicle class, payload, mass, aerodynamics, intended use, climate, operational speed and relevant configuration. A per tonne vehicle mass indicator may be diagnostic

but shall not be the sole consumer efficiency indicator because increasing vehicle mass can improve that ratio without reducing consumption.

4.4 Shared activities shall first be subdivided using physical measurements. Where subdivision is impracticable, allocation shall follow a justified causal driver such as machine hours, processed mass, thermal demand or occupied space. Revenue allocation is permitted only as a separately disclosed fallback, with sensitivity analysis and no unsupported physical efficiency inference.

4.5 Individually excluded noncritical flows shall each be less than 1% of the relevant resource total, and all such exclusions together shall be no more than 5%. These draft cutoffs apply separately to energy, material mass and water. Safety critical, hazardous, scarce resource and conclusion changing flows shall not be excluded regardless of size.

4.6 An excluded flow shall still have a conservative estimate, rationale, owner and sensitivity check. Outsourcing, replacing suppliers or transferring a process shall not create a saving by removing its consumption from the account. Original and revised boundaries shall be reconciled.

4.7 Resource flows at different lifecycle stages shall be reported separately before aggregation. Product and site accounts may share the same underlying data but shall identify the overlap; their totals shall not be added as though they were independent consumption.

5 Governance and responsibility

5.1 Top management shall approve the assessed scope, resource efficiency policy, decision rights, targets and required resources. It shall assign an accountable efficiency owner with authority to obtain data and to challenge claims unsupported by evidence.

5.2 Responsibilities shall cover resource accounting, metrology, production or operational control, product engineering, procurement, information security, environmental safeguards, financial analysis and claims approval. A smaller organization may combine roles, but the final assessment review shall be independent of the work being judged.

5.3 Incentives shall not reward lower recorded consumption through unreported shutdowns, deficient product quality, unsafe workloads, data suppression or reduced service. Staff shall be able to report suspected manipulation or unintended effects through a protected review process.

5.4 The organization shall maintain a risk and opportunity register covering supply scarcity, grid constraints, extreme weather, product changes, data failure, technology obsolescence and resource dependency. Actions shall be prioritized using expected physical benefit, feasibility, uncertainty, service consequences and whole life effects.

5.5 Personnel performing tests, calculations and reviews shall demonstrate competence through relevant training, supervised work, practical evaluation or documented experience. Authorization shall identify the methods and equipment for which each person is competent.

5.6 Management shall review the programme at least annually and after a material change or serious integrity event. The review shall address absolute consumption, normalized performance, target progress, adverse effects, corrective actions, data quality and continuing validity of public statements.

6 Resource mapping and opportunity planning

6.1 A resource inventory shall identify electricity, fuels, process heat, water, virgin and recovered materials, consumables, critical components, waste streams and externally provided digital services. Quantities, measurement points, estimates, data owners and relevant output drivers shall be recorded.

6.2 Resource balances shall cover normal production or service, startup, shutdown, idle periods, failed operations, test activities, maintenance and recovery. An energy flow shall be counted once at the declared boundary; internal conversion shall not create a second input.

6.3 Significant uses shall be identified by quantity, improvement potential, variability, supply risk and effect on claims. The organization shall examine losses attributable to friction, thermal rejection, leakage, standby, rework, low loading, empty movement, degradation, incompatible interfaces and unnecessary computation where relevant.

6.4 An opportunity register shall state the current condition, proposed change, affected resource, expected outcome, implementation cost, accountable owner, interaction risks, measurement method and review date. Expected savings shall be distinguished from measured savings.

6.5 Targets shall include at least one physical outcome for every selected operational module and all material resource categories within it. Targets shall have a defined baseline, functional output, service safeguards, time period and measurement uncertainty. A universal annual reduction percentage is not imposed by this draft.

6.6 A resource reduction target shall be accompanied by an absolute consumption budget or explanation of demand growth. Where lower intensity coincides with higher total use, both outcomes shall be disclosed. Efficiency projects shall not be described as absolute resource reduction projects unless the totals support that description.

7 Data architecture and measurement quality

7.1 The measurement plan shall identify each quantity, unit, boundary point, instrument, sampling interval, calibration basis, uncertainty, time reference, retention period and responsible person. It shall describe how raw records become reported indicators, including every conversion and allocation.

7.2 For a verified quantitative claim, at least 95% of its relevant resource total shall be supported by direct measurement or validated calculations using measured inputs. Material output denominators shall be independently reconciled. Proxy estimates shall be identified, conservatively bounded and included in the remaining share; exclusion limits in Clause 4 apply independently.

7.3 Instruments shall be suitable for their operating range, environment, waveform or fluid properties and direction of flow. Calibration and intermediate checks shall establish traceability through documented measurement comparisons. A supplier specification alone shall not establish the uncertainty of an installed measurement system.

7.4 As pilot targets, integrated test energy shall have expanded uncertainty no greater than 2% and distance, payload or accepted production output no greater than 1%. A larger uncertainty shall be declared and assessed under Clause 10; it shall not be concealed by reporting additional decimal places.

7.5 Dynamic vehicle measurements shall normally record energy related signals at least once per second, with faster acquisition where required to capture switching, transient charging or regeneration. The plan shall

justify sample rates, anti aliasing, integration and clock alignment. An interval counter may replace high rate logging where its integrated accuracy is demonstrated.

7.6 Facilities shall retain resource totals at least daily for significant uses where technically feasible. Billing records may support reconciliation but shall not by themselves establish process attribution. Charging and digital services shall record transaction or task level totals with sufficient detail to separate active, waiting and failed states.

7.7 Missing, duplicated, out of range and substituted records shall be flagged. Imputation shall follow a predeclared method; the fraction and effect of imputed data shall be reported. Unexplained gaps affecting critical events or a conclusion shall require additional evidence or an inconclusive decision.

7.8 Raw data, calculations, software versions, approvals and evidence supporting a public claim shall be retained for the life of that claim and at least five years after its last use, subject to longer applicable obligations. Identifiable personal data shall be minimized and retained only for a justified lawful purpose; aggregation shall preserve auditability without unnecessary tracking.

8 Baselines and normalization

8.1 A baseline shall be established before evaluating a claimed intervention. It shall represent the actual reference system and relevant seasonal and operational variation. Selecting only unusually inefficient reference days or unusually favourable reporting days is prohibited.

8.2 An annual organization or service claim shall normally use twelve consecutive months for both reference and reporting periods. A shorter pilot shall cover at least ninety consecutive days and be labelled with that period; annual extrapolation shall remain a modelled estimate until seasonality and operating conditions have been validated.

8.3 Product and component tests shall instead use the controlled repeated procedures in Annex D. A new product without historical data may report a measured baseline or a comparison with a valid reference product, but shall not claim historical improvement from an invented previous condition.

8.4 Relevant variables shall include output volume and mix, payload, distance, climate, operating time, congestion, equipment condition and service specification as applicable. Adjustments shall be based on physical reasoning or a validated statistical relationship. Variables changed by the efficiency intervention itself shall not be adjusted away as if they were unrelated causes.

8.5 Model selection, parameters, exclusions and validation data shall be recorded. Performance shall be checked on data not used to fit the model where sample size permits; residuals, systematic bias, autocorrelation and extrapolation shall be evaluated. A high goodness of fit alone is insufficient evidence of causal savings.

8.6 A structural change shall trigger a documented decision to retain the baseline with a nonroutine adjustment or establish a new one. Both versions, the reason and the effect shall be preserved. A new baseline shall not erase prior underperformance or remove a disclosed obligation.

8.7 Reports shall show unadjusted totals, functional output, raw intensity, adjusted baseline, reporting period use and the adjustment contribution. Normalized values from incompatible models shall not be placed in one ranking without a validated harmonization method.

9 Indicators and performance reporting

9.1 The organization shall maintain an indicator register using Annex B. Each indicator shall identify its purpose, numerator, denominator, unit, boundary, reporting frequency, method version, direction of improvement, data coverage and uncertainty. Indicators shall be linked to accountable decisions.

9.2 The core dashboard shall show absolute energy by carrier, normalized energy intensity, relevant material and water use, useful output, quality or service performance, availability, and all material adverse effects. A nonapplicable resource shall be justified; an unmeasured resource shall be marked “not measured”, not zero.

9.3 Aggregate intensity shall be calculated from summed inputs divided by summed compatible outputs. Averaging individual intensity ratios without appropriate output weighting is prohibited. Where functional units differ, separate results shall be retained or combined only through a predeclared equivalent output method.

9.4 Energy efficiency, energy cost, grid peak reduction and emission intensity shall remain separate indicators. Procuring a lower emission energy source or shifting charging time may change emissions or cost without lowering physical energy use. Those changes shall not automatically be recorded as energy efficiency improvement.

9.5 Resource categories shall not be added in incompatible units. A dashboard may present energy, water, materials, time and cost together, but a single composite value requires an approved weighting method, transparent tradeoffs and sensitivity analysis. This draft does not authorize a universal composite score.

9.6 Achieved results shall be shown against targets with explanations of variance. Negative results and regression in material indicators shall receive the same visibility as gains. A claim shall use sensible precision and disclose the applicable period and sample population.

10 Verification of improvement and uncertainty

10.1 The verification plan shall be approved before implementation or comparative testing. It shall define the hypothesis, counterfactual, boundaries, service equivalence, measurement design, sampling, uncertainty calculation, decision rule and treatment of interactions.

10.2 Savings shall equal the adjusted baseline resource requirement minus measured reporting period use, subject to separately stated corrections for leakage, overlap and material rebound outside that measured boundary. Changes already included in reporting period use shall not be subtracted a second time.

10.3 A positive verified saving shall be declared only when the lower bound of the approximately 95% coverage interval for that saving is greater than zero and all relevant safeguards pass. If the interval includes zero, the conclusion shall be “improvement not demonstrated at the stated confidence”, even where the point estimate is favourable.

10.4 A claim of “at least x% improvement” shall use the lower supported percentage bound rather than the point estimate. A measured point estimate may be reported with its interval and explicitly identified as such. Uncertainty in the adjusted baseline denominator and correlation with savings shall be included.

10.5 Uncertainty shall include metering, sample variability, output measurement, imputation, allocation, model fit, nonroutine adjustments and conversion factors where relevant. Correlations shall be evaluated rather than assuming every input is independent. Approximate normal coverage with factor 2 is permitted only when justified; small samples require an appropriate distribution or resampling method.

10.6 The primary comparison shall be specified before results are examined. Multiple tests, optional stopping, selective subgroup reporting and repeated model tuning shall be controlled so that favourable chance findings are not presented as confirmed improvement.

10.7 Savings from interacting projects shall be assessed together or assigned with a documented order and interaction adjustment. Project totals shall be reconciled to the larger resource account. The same physical saving shall not be sold or reported repeatedly as an additive benefit by multiple parties.

10.8 Persistence shall be checked over the claim period. Early test results shall not be extrapolated to vehicle life, an entire production year or an entire fleet without supporting durability, representativeness and uncertainty evidence.

11 Safety quality and service safeguards

11.1 Efficiency actions shall preserve applicable safety functions, roadworthiness, braking, visibility, protective equipment, emissions control, cybersecurity, privacy and occupational health. No resource benefit shall compensate for an unresolved critical failure in these areas.

11.2 Before assessment, the organization shall define measurable service acceptance limits for capacity, product tolerances, defect rates, comfort, noise where relevant, delivery completion, accessibility, response time and operating availability. Limits shall reflect the promised service and applicable obligations; they shall not be weakened after results are known.

11.3 Vehicle tests shall preserve specified tyre condition and pressure, payload security, battery protection, driver assistance and thermal protection. Disabling a function solely to obtain a favourable test result shall invalidate the representative claim unless the disabled configuration is the actual declared product and remains lawful and safe.

11.4 Manufacturing improvements shall be checked for defects, rework, premature failure, hazardous exposure and ergonomic overload. Faster cycle time or lower staffing shall not by itself establish resource efficiency where quality or safe work conditions deteriorate.

11.5 Service optimization shall consider people with reduced mobility, essential rural access, emergency operations and required waiting times. Eliminating an essential low utilization service may be a policy or service change, but shall not be represented as like for like efficiency improvement.

11.6 Durability and maintenance requirements shall remain explicit. Where a change reduces current energy use while increasing replacement frequency, scarce material consumption or repair difficulty, the tradeoff shall be quantified and the claim qualified.

11.7 A critical safeguard breach shall immediately stop the affected claim and trigger containment, investigation and independent review. An average score, cost benefit calculation or favourable result in another module shall not override this gate.

12 Product and process design

12.1 Design requirements shall establish functional output, expected duty, service life, resource budgets, repair strategy and foreseeable degradation. Alternatives shall be compared at equivalent service and under realistic use assumptions, including regional conditions.

12.2 The design review shall examine mass, aerodynamics, rolling and mechanical losses, conversion efficiency, thermal management, component sizing, standby demand, packaging, modularity, manufacturing yield and software demand where relevant. Adoption of a named technology shall not be treated as proof of efficiency.

12.3 Resource budgets shall be allocated to subsystems and reconciled with measured system performance. Interactions shall be assessed, including lightweight materials requiring greater production energy, fast charging requiring additional cooling, or software improvements increasing computational demand.

12.4 Design validation shall include representative operation, extreme but intended conditions, degraded components and user misuse that can reasonably affect resource use. Simulation may support design, but final public physical performance claims shall include measured validation within the claimed domain.

12.5 Product variants shall be grouped only where efficiency relevant differences are bounded. The selection shall include an adverse configuration where it could change the claim. Changes in tyres, wheels, mass, battery, inverter, software, body or thermal system shall trigger review of family coverage.

12.6 End of support, parts availability, diagnostics and repair access shall be considered as resource efficiency factors. A short support life or an avoidable whole assembly replacement shall be recorded when it changes expected lifetime resource demand.

13 Vehicle energy performance

13.1 This module applies to complete vehicles and propulsion systems. Tests shall identify vehicle configuration, accumulated distance, maintenance condition, software, tyres, accessories, payload, fuels, electrical states, ambient conditions and operating mode.

13.2 Delivered energy shall include the energy needed to restore the vehicle to an equivalent initial energy state. For electric vehicles, charging losses and conditioning energy shall be included in the declared supply boundary metric. Battery terminal discharge shall also be reported where measured, with its narrower boundary clearly labelled.

13.3 Combustion and gaseous fuel systems shall measure consumed quantity and fuel properties. Hybrid tests shall achieve comparable initial and final stored energy or use a validated correction. Plug in hybrid results shall report fuel and grid electricity separately for charge depleting and charge sustaining operation; any combined usage weighting shall be explicit and supported by actual use or a declared scenario.

13.4 Assessments shall include urban, interurban and higher speed operation appropriate to the intended class, together with relevant load and climate cases. A single favourable journey shall not represent year round performance. The baseline test sequence and repeatability rules are given in Annex D.

13.5 Auxiliary energy shall include cabin conditioning, battery heating and cooling, pumps, lighting, powered work equipment, trailer loads and electronics as applicable. Cabin comfort and task output shall be recorded so lower auxiliary energy cannot conceal a degraded service.

13.6 Regenerative energy is an internal recovery flow and shall not be added to useful transport output or subtracted twice from supply energy. The assessment shall distinguish gross discharge, recovered energy and net battery energy when these are presented.

13.7 Range claims shall distinguish directly measured range from range estimated using usable battery energy and measured consumption. Estimated range shall state climate, loading, speed, SoH and auxiliary assumptions. Refuelling time, charging time and energy intensity shall remain separate results.

13.8 Vehicle improvement claims shall cover sensitivity to ageing, tyre wear, alignment, temperature and software changes. The absence of long term evidence shall be disclosed instead of assuming that initial performance persists unchanged.

14 Components materials and subsystems

14.1 This module applies to components whose operation or production affects vehicle or industrial resource use. The component specification shall define required output, allowable losses, operating map, life, interfaces and the system boundary for any claimed benefit.

14.2 Motors, transmissions, inverters, pumps, compressors and thermal devices shall be evaluated over a representative distribution of operating points, including partial load and transients. Peak efficiency at one point shall not serve as a duty cycle efficiency claim.

14.3 Tyres, wheels, bearings, lubricants, seals and aerodynamic devices shall be assessed with relevant speed, load, temperature and ageing conditions. Any change in grip, braking, wear, noise or service life shall be included in the safeguard review.

14.4 A component loss reduction shall not automatically be expressed as an equal whole vehicle saving. Integration effects, control behaviour, additional mass, cooling demand and usage shall be measured or modelled and validated at system level.

14.5 Battery and storage assessments shall distinguish usable energy capacity, round trip efficiency, power capability, ageing and resource composition. Capacity retention shall not be used as a synonym for energy efficiency retention. Results shall identify charge and discharge windows, temperature and rate.

14.6 Material substitution shall quantify accepted product yield, process scrap, input mass, service life and recovery options. A reduction in purchased mass caused by thinner parts or lower specification shall qualify as efficiency improvement only if the required performance and life are preserved.

15 Manufacturing and assembly operations

15.1 This module covers forming, casting, machining, moulding, joining, coating, heat treatment, cell and battery production, electronics manufacture and final assembly as applicable. The site shall map resource use to accepted product families and supporting services.

15.2 Resource intensity shall use accepted output of a specified quality and complexity. Scrap, rework loops and process trials shall remain in the numerator. Product mix shall be normalized using validated process drivers; nominal unit counts shall not conceal a shift to easier products.

15.3 The organization shall distinguish productive operation, idle readiness, changeover, startup, shutdown, unplanned stops and maintenance. Significant base load shall be reported independently of production so higher utilization does not conceal unchanged losses.

15.4 Significant equipment shall have operating windows, shutdown rules, inspection and maintenance controls addressing leaks, insulation, fouling, lubrication, alignment, motor loading, cooling and control tuning. Override conditions shall be logged with their reasons.

15.5 Process improvements shall be assessed using first pass yield, total resource use, accepted throughput, scrap, rework, downtime and field quality as relevant. Equipment utilization and cycle time may support diagnosis, but shall not substitute for resource outcomes.

15.6 Heat recovery, process integration, electrification and shared utilities shall identify the resource input displaced, new inputs introduced, thermal quality, seasonal demand and simultaneous operation. Recovered heat shall not be credited where no useful demand is served.

15.7 Battery cell and electronics operations shall address dry rooms, controlled environments, formation, ageing, yield loss, solvent handling, cleaning, compressed gases and supporting computation where material. Energy per accepted storage capacity shall retain cell specification and usable capacity assumptions.

16 Facilities utilities and water

16.1 This module applies to buildings and utility systems supporting the assessed activity. Electricity, combustion fuels, purchased heat or cooling, self generation, compressed air, water treatment and common infrastructure shall be included as relevant.

16.2 Supply and end use meters shall be reconciled. Onsite generation, grid import, export, storage charge and storage discharge shall be separately recorded. Renewable generation shall not be treated as a physical reduction in facility demand merely because grid purchases fall.

16.3 Compressed air, steam, heating, cooling, ventilation and extraction shall have defined service conditions. Efficiency changes shall preserve process pressure, air quality, temperature, humidity, ventilation and worker protection. Unnecessary pressure or conditioning shall be identified without weakening necessary controls.

16.4 Water accounts shall separately record withdrawal by source, consumed water, discharge, internally reused water and losses. Circulated water may be reported as a process flow, but repeated circulation of the same water shall not be counted repeatedly as new withdrawal or as newly created savings.

16.5 Water reduction projects shall assess water quality, treatment energy, chemicals, concentrate disposal and local scarcity. A lower water withdrawal result shall not imply lower consumption or reduced ecosystem impact without the corresponding evidence.

16.6 Peak demand, load flexibility and resilience shall be reported with resource consumption. Shifting load may be beneficial but is not automatically an energy saving. Backup generation tests, outages and recovery shall remain in the account for the stated reporting period.

16.7 Facility boundaries shall identify shared tenants, laboratories, offices, charging depots and contracted utilities. Changes in occupied area or weather shall be normalized only using validated relationships and shall not conceal a change in production responsibility.

17 Supply chain and distribution

17.1 This module covers inbound materials, intersite movements, packaging, storage and product or spare parts distribution. The organization shall identify relevant suppliers, logistics stages, handling processes and outsourced resource consumption.

17.2 Supplier evidence shall state product specification, boundary, period, allocation, primary data share and uncertainty. Data from one site or product shall not be assigned to a different supply without documented representativeness. Unknown upstream values shall be shown as unknown or estimated rather than zero.

17.3 Freight metrics shall include vehicle distance, actual cargo mass, cargo volume where constraining, tonne kilometres, empty distance, failed deliveries, consolidation and damage. The return leg and repositioning shall be included when attributable to the service.

17.4 Packaging changes shall evaluate packaging mass and reuse, product protection, transport loading, cleaning and return logistics. Lower packaging mass is not an improvement if damaged products or additional shipments offset the saving.

17.5 Warehouse performance shall include energy, accepted dispatches, handling activity, storage duration, temperature control and order accuracy. Resource savings from moving stock or outsourced fulfilment shall account for the receiving operation.

17.6 Procurement decisions shall consider measured use phase demand, service life, repairability, maintenance, spare parts and data access. Contractual efficiency guarantees shall state the operational conditions, measurement method and responsibility for deviations.

17.7 Consolidation and route changes shall preserve delivery commitments, hazardous material controls, driver welfare and product integrity. Faster delivery, lower price or higher load factor shall not be represented as lower energy use without quantified evidence.

18 Fleet and mobility services

18.1 This module applies to owned, leased and contracted fleets, public passenger services, freight operations, shared mobility and road based automated services. The assessed fleet shall have an asset list, duty categories, operating territory and defined service requirements.

18.2 Passenger kilometre totals shall use actual passengers and travelled distance. Drivers and crew shall not be counted as passenger service output. Freight tonne kilometres shall use actual carried cargo and distance. Zero payload and empty vehicle travel shall remain in resource totals while contributing no payload output.

18.3 Route planning shall evaluate traffic, terrain, weather, charging access, payload and delivery or passenger commitments. Energy optimization shall not rely on unsafe speed, shortened rest, unapproved loading or avoiding essential services.

18.4 Fleet indicators shall include energy per vehicle kilometre and per useful transport output, utilization, empty travel, idling, availability, punctuality or completed delivery, and maintenance condition. Aggregation shall follow Clause 9 and retain meaningful duty groups.

18.5 Driver guidance shall be based on safe operation and representative evidence. Comparisons between drivers shall account for route, traffic, load and vehicle condition; personal monitoring shall be necessary, proportionate and subject to appropriate access controls.

18.6 Electrification or propulsion replacement shall compare equivalent delivered services. Infrastructure losses, downtime, backup vehicles, charging detours and relevant upstream scenarios shall be disclosed. Local energy reduction shall not be represented as a complete lifecycle result.

18.7 Automated and shared services shall count empty repositioning, remote assistance, cleaning, charging trips, computing and induced activity where attributable. Higher occupancy or smoother driving may improve efficiency, but the total service account shall establish the net result.

18.8 Emergency and special purpose fleets shall use task appropriate functional units such as completed intervention or powered equipment operating hour alongside distance measures. Readiness and response obligations shall remain within the protected service envelope.

19 Charging refuelling and energy storage

19.1 This module applies to charging, refuelling, battery swapping and associated stationary storage. The boundary shall identify supply connection, transformer, conversion equipment, cables, dispensers, cooling, communications, onsite storage and vehicle interface as applicable.

19.2 Charging assessment shall distinguish station conversion efficiency, vehicle charging efficiency and supply to usable discharge efficiency. These quantities use different boundaries and shall not share an unqualified “charging efficiency” label. Each energy measurement point and direction shall be identified.

19.3 Tests shall cover relevant supply configurations, power levels, battery states and temperatures. Active transfer, plugged waiting, disconnected standby, failed starts, cooling after transfer and communication demand shall be recorded separately. Annual energy claims shall include the applicable state durations and utilization assumptions.

19.4 A complete matched boundary charge and discharge round trip shall begin and end at equivalent stored energy and thermal conditions. Grid export shall be reported separately from vehicle propulsion demand. Exported energy shall not make driving energy negative or be deducted from a driving numerator without a defined allocation method.

19.5 Fast charging reports shall state the complete power curve, transferred energy, start and end SoC, temperature, preconditioning energy, elapsed time and interruptions. Peak power alone shall not establish overall charging performance or energy efficiency.

19.6 Wireless and dynamic charging shall include alignment, air gap, speed where relevant, transfer availability, road or station standby and distribution losses. The assessment shall report the validated operating envelope and avoid extrapolating laboratory alignment to all field operation.

19.7 Hydrogen and other pressurized fuel services shall account for compression, cooling, storage losses, dispensing and relevant standby use. Fuel production may be assessed in an upstream scenario, but shall not be omitted from a claim described as covering the complete energy chain.

19.8 Battery swapping shall account for inventory charging, conditioning, handling, station demand, waiting inventory and pack condition. Allocation shall reflect actual delivered usable energy and service, with pack identity and degradation traceable across swaps.

19.9 Station availability and successful transaction rate shall accompany resource metrics. A station that consumes less energy by remaining unavailable shall not receive a service equivalent efficiency improvement claim.

20 Digital systems and artificial intelligence

20.1 This module applies where vehicle electronics, embedded computation, cloud services, artificial intelligence, simulation or digital operations materially affect the assessed resource use. The organization shall map hardware, software versions, operating states, external dependencies and required task performance.

20.2 Energy budgets shall distinguish onboard computing, sensors, communications, storage, data transfer, remote processing and associated cooling. Training and development energy shall be reported separately from inference or operational task energy and allocated transparently when included in lifecycle claims.

20.3 Digital efficiency shall use a useful task denominator with required accuracy, latency, availability and safety performance. Energy per computation, model parameter or transaction shall not imply service efficiency where the task, accuracy or workload has changed.

20.4 Resource optimization shall preserve security monitoring, cryptographic protection, diagnostic capability and safety functions. Reducing sensor coverage, model accuracy or redundancy requires validated service equivalence and the applicable safety review before an efficiency claim is accepted.

20.5 Software releases shall undergo regression testing for energy, standby, thermal demand and task performance. The organization shall identify changes in default settings, background activity, remote polling and update frequency. A material regression shall trigger review of the passport and affected claims.

20.6 Adaptive systems shall log model and policy versions, operational domain and relevant change events. Continuous learning shall have bounded deployment conditions, monitoring, rollback capability and a method to distinguish software drift from changes in workload or hardware condition.

20.7 Digital twins and optimization models shall be validated against independent physical measurements, with errors, extrapolation limits and recalibration triggers disclosed. A simulation shall be labelled as such and shall not be substituted for a measured outcome without explaining the validated linkage.

20.8 Shared computing and communications shall use a documented allocation method. Provider averages may support estimates but shall not be presented as task specific measurements. Claims of computational savings shall include any additional data preparation, transfer, storage or displaced processing that materially affects the result.

21 Maintenance repair and circular service

21.1 This module applies to vehicle servicing, workshops, repair, refurbishment, remanufacturing and recovery operations. The assessment shall define the accepted service result, restored capability, expected remaining life and associated resource inputs.

21.2 Maintenance shall monitor factors that materially affect efficiency, including tyre pressure, alignment, brakes, bearings, lubrication, filters, thermal systems, battery condition and software. Deferred necessary maintenance shall not be used to reduce reported workshop resource use.

21.3 Repair and replacement alternatives shall compare equivalent restored service over a defined remaining life. Inputs shall include parts, diagnostics, transport, cleaning, test energy, repeated repairs and disposal where material. A lower repair cost alone shall not establish lower resource use.

21.4 Remanufacturing shall identify incoming core condition, recovery yield, replacement content, accepted output quality and durability evidence. Resource claims shall include rejected cores and test failures. Avoided new production shall be presented as a separate counterfactual scenario, not automatically subtracted from measured process use.

21.5 Recovery accounts shall distinguish collected material, sorted material, recovered output and material actually accepted for a useful subsequent application. Collection rate and theoretical recyclability shall not be described as realized recovery efficiency.

21.6 Second life storage or components shall have documented condition, usable capacity, safety suitability and expected duty. Allocation between first and subsequent life shall be explicit. The same avoided production benefit shall not be counted in full for every participating product.

21.7 The service provider shall track repeat visits, unresolved faults, service completion, parts wastage, downtime and customer access to necessary information. Digital diagnostics and predictive maintenance shall be evaluated for false alarms, missed faults and unnecessary replacement as well as potential savings.

22 Lifecycle effects and environmental interfaces

22.1 A lifecycle resource assessment shall identify raw material supply, manufacturing, distribution, use, maintenance, replacement and end of life. The assessed life, distance, service output, geography, technology and recovery scenarios shall be stated.

22.2 Upstream energy and material estimates shall distinguish measured data, supplier data, models and default scenarios. Data age, regional relevance and completeness shall be evaluated. Operational delivered energy shall remain visible alongside upstream or lifecycle totals.

22.3 Greenhouse gas results shall use declared emission factors, time periods, geographic assumptions and treatment of energy supply. Physical energy performance shall not be inferred from an emissions result alone. Purchased attributes, offsets and avoided emissions shall remain outside the physical efficiency numerator.

22.4 Resource changes shall be screened for shifts in air pollution, hazardous substances, waste, water scarcity, land effects, noise and critical material demand where relevant. Quantitative claims shall be limited to impacts actually assessed; one favourable indicator shall not imply improvement in every environmental dimension.

22.5 Service life and replacement assumptions shall be tested for sensitivity. A longer claimed life requires evidence from design, durability testing, field data or a defensible model. Future recovery routes shall be distinguished from existing demonstrated routes.

22.6 Cross propulsion or technology comparisons shall disclose differences in delivered energy, upstream conversion, supply mix and service assumptions. A common energy unit permits arithmetic comparison but does not by itself establish equal lifecycle impact.

22.7 Rebound and leakage shall be evaluated at the scale relevant to the claim. An improvement in energy per trip accompanied by more trips shall be reported with total energy. Unknown wider effects shall be described with scenarios rather than invented precise deductions.

23 Resilience and future technologies

23.1 The organization shall maintain a technology and operating context review covering anticipated changes in propulsion, storage, fuels, manufacturing, digital control, mobility service and resource availability. Forecasts shall be presented as scenarios with assumptions, not guaranteed future outcomes.

23.2 Emerging batteries, fuel cells, synthetic fuels and new material systems shall use the same boundary, service and evidence principles as established technologies. No preferred chemistry or energy carrier is prescribed. Novelty alone shall not receive a performance credit.

23.3 Bidirectional energy services, coordinated fleets and flexible manufacturing shall demonstrate their net resource effect after conversion losses, degradation, communication, standby and the preserved primary service are included. Revenue from flexibility shall remain separate from energy savings.

23.4 Additive manufacturing, advanced recycling and autonomous production shall assess accepted yield, feedstock preparation, supporting facilities, post processing, quality assurance and service life. The disappearance of a conventional process step shall not be treated as a saving without accounting for the replacement process.

23.5 Extreme climate and disrupted supply scenarios shall identify minimum service, additional resource needs, backup arrangements and recovery performance. Resource resilience shall be described by measured or modelled capability; an efficiency result in normal conditions shall not imply resilience in all conditions.

23.6 Emerging technology pilot claims shall identify maturity, scale, test conditions, failure modes and the evidence required for scale up. Benefits projected for future hardware or an unavailable supply chain shall be excluded from a present measured performance statement.

23.7 Application profiles shall allow new technologies through documented extension and validation. Extensions shall preserve compatibility of units, boundaries and service requirements, and shall not retrospectively alter published results without a versioned correction.

24 Economic and operational value

24.1 Economic evaluation shall support implementation decisions while retaining physical performance as the basis of efficiency claims. The organization shall state currency, price period, energy tariffs, utilization, asset life, discount assumptions where used and included cost categories.

24.2 Whole life cost shall consider purchase, installation, financing where applicable, resource use, maintenance, downtime, software support, replacement, recovery and residual value. Uncertain costs shall be evaluated with ranges appropriate to the decision.

24.3 Simple payback may be reported as an initial screening measure, but shall not be used as a complete account of lifetime value. Changing tariffs, grants or taxes shall not be described as physical resource savings.

24.4 Cost savings shall distinguish quantities avoided from unit price changes and timing effects. Monetized benefits from several projects shall be reconciled to avoid duplicate resource or downtime credits.

24.5 Output growth, lead time reduction and greater asset availability shall be disclosed as operational results with their own denominators and service limits. Workforce productivity shall not be represented as resource efficiency solely because fewer workers are employed.

24.6 Customer and user consequences shall include access, charging or refuelling time, downtime, necessary subscriptions and maintenance burden where material. A saving transferred to the supplier at the expense of increased user resource demand shall be visible.

25 Improvement control and persistence

25.1 Each selected project shall have an approved change record linking the opportunity, baseline, expected result, service safeguards, verification plan, responsible owner and implementation evidence. The authorization shall precede normal deployment.

25.2 Commissioning shall confirm installation, control settings, instrument function and safe operation. Deviations from the design shall be recorded and the performance expectation updated before comparison.

25.3 Post implementation review shall compare measured results with the expected outcome and examine interactions, rebound, leakage and maintenance needs. Unexpected resource increases shall receive corrective action even where financial performance is favourable.

25.4 Monitoring shall detect significant deterioration relative to the validated operating model. Alert thresholds shall reflect natural variability, measurement uncertainty and the consequence of a false or missed alarm. A universal fixed percentage alarm is not required.

25.5 The organization shall assign actions, deadlines and evidence of effectiveness for deviations. Repeated failures shall trigger review of design assumptions, controls, training and claims. Closing an action by completing paperwork without checking performance is insufficient.

25.6 Portfolio reviews shall retain unsuccessful projects and negative results. Improvement capability may be demonstrated through sound controls, but claims of achieved savings shall require the specific evidence in Clause 10.

26 Assessment process and evidence

26.1 The assessment shall follow scope agreement, readiness review, assessment planning, evidence collection, calculation review, safeguard evaluation, findings resolution, independent decision and issue of a scoped result. Annex F defines the records at each stage.

26.2 The assessor shall examine the complete applicability register and all mandatory core requirements. Evidence shall include interviews, observation, records, source data, independent recalculation and witnessed or repeated measurements appropriate to the claim.

26.3 Sampling shall be risk based and predeclared. Sites, shifts, vehicle variants, climates, service types and adverse conditions likely to change the conclusion shall be represented. Convenience samples shall be labelled and shall not support an unrestricted population claim.

26.4 Every critical safeguard and every material resource flow shall be evaluated. Sampling may reduce repeated checks of homogeneous activities but shall not remove a material activity from the scope. Sample size and selection rationale shall be documented under Annex C.

26.5 The assessor shall record the clause, evidence, affected scope, uncertainty and significance for every finding. Lack of access to essential data shall lead to a limited or inconclusive result rather than a presumption of conformity.

26.6 Remote evidence may supplement onsite work where identity, completeness and integrity are established. Physical observation or testing shall be required when it is necessary to verify the actual boundary, equipment configuration, meter installation or suspected manipulation.

26.7 The assessor shall reproduce at least one end to end calculation for each material indicator family and all headline savings claims. Digital dashboards and screenshots shall not substitute for underlying records.

26.8 An assessment report shall identify which requirements were evaluated, which were not applicable, all unresolved findings, methods, limitations and the proposed conclusion. The independent decision maker shall have enough evidence to challenge that conclusion.

27 Decisions findings and comparative claims

27.1 The decision shall distinguish conformity of the selected controls, verification of measured performance and verification of an improvement claim. Passing the management and measurement requirements shall not automatically prove lower consumption or superior performance.

27.2 A critical finding is an actual serious safeguard breach, intentional material data manipulation or misuse of identity that invalidates trust in the result. A major finding is a missing or ineffective required control, material unaccounted flow, unsupported headline claim or repeated systemic failure. A minor finding is an isolated lapse that does not undermine the result or a safeguard.

27.3 Critical and major findings shall be resolved and their effectiveness verified before a positive conformity decision. Minor findings shall have accepted actions and completion dates; overdue or recurring minor findings shall be escalated. Efficiency values may still be reported as observations where the limitations are explicit and no approval is implied.

27.4 Permitted result descriptions after formal adoption are “scoped conformity assessed”, “measured performance verified” and “improvement verified”, with the exact scope and evidence period. Pilot versions shall use “pilot assessment” and shall not use an official conformity mark.

27.5 A comparative performance class requires a separately approved IAF application profile and benchmark dataset satisfying Annex E. Until those exist, no global grade, star rating, percentile or claim of world leadership is authorized by this draft.

27.6 A benchmark shall not mix products with incompatible service, methods or boundaries. The cohort, date, coverage, weighting and uncertainty shall be public with the comparison. A rank change caused only by a new dataset shall be distinguished from a change in physical performance.

27.7 A critical safeguard failure shall block a positive result regardless of quantitative efficiency. Strong energy performance shall not compensate for missing water, material or digital evidence that is material to the stated scope.

28 Performance passport and public statements

28.1 Each assessed object shall have a versioned performance passport using Annex G. It shall identify the object, owner, assessment basis, module set, application profile, period, functional units, indicators, uncertainty, data quality, findings status and assessment decision.

28.2 A public statement shall be understandable without consulting confidential technical files. It shall display the measured object and scope, the type of result, the reference conditions, relevant limitations, date and a means to access the current passport status.

28.3 Promotional language shall not enlarge the assessed scope. A single efficient component shall not establish conformity of the complete vehicle; one assessed factory shall not establish conformity of every company site. A measured reduction shall not be described as zero impact or unlimited sustainability.

28.4 Quantified improvements shall state whether they are normalized, absolute, modelled or measured and whether they are point estimates or conservative lower bounds. Baseline period and preserved service conditions shall be visible with the claim or one directly accessible explanation.

28.5 Passports shall support human readable and machine readable forms with stable field definitions. Digital signing or equivalent tamper evidence may be used. A digital signature confirms provenance and integrity, not the scientific validity of the underlying result.

28.6 Public data shall be sufficient to assess the claim while confidential manufacturing data and personal information remain protected. The assessor shall retain access to the evidence needed to verify conclusions. Commercial confidentiality shall not justify hiding a material limitation.

28.7 Material hardware, software, duty, boundary or methodological changes shall trigger a passport review. Superseded versions shall remain traceable and their status clear. An obsolete passport shall not continue to appear current.

29 Continuing validity and corrective action

29.1 A measured result is valid for the identified configuration, method, conditions and evidence period. This draft establishes no automatic multiyear product certificate. The continuing validity of a claim shall depend on its scope and the evidence that supports it.

29.2 The organization shall review ongoing operational claims at least annually and after material changes, serious complaints, integrity incidents or persistent deterioration. Product results shall be reviewed on relevant configuration and software changes even when the original test date remains unchanged.

29.3 When evidence becomes unreliable, the affected claim shall be suspended or qualified promptly. The organization shall investigate the cause, identify affected versions and users, correct public information and obtain an independent reassessment where required.

29.4 Corrections shall preserve the original record, reason, date, responsible person and quantitative effect. Data shall not be silently overwritten to maintain a favourable result. Where an incorrect claim has been distributed, the correction shall reach the same audience through appropriate channels.

29.5 Changes in an approved method shall have a defined transition period and comparability assessment. Retesting or recalculation shall be required when the change can alter a decision. Older results shall retain their original methodological identity.

29.6 Withdrawal, reinstatement and closure decisions shall be documented with evidence. Reinstatement shall require verified correction of the causes of suspension, not solely a new application or payment.

30 Impartiality and scheme stewardship

30.1 The assessment provider shall manage financial, organizational and personal conflicts. Personnel shall not make an independent decision on their own design, consultancy or measurement work. Assessment fees shall not depend on achieving a favourable result.

30.2 Reviewers and decision makers shall have competence appropriate to the technical scope. Subcontracted testing and digital analysis shall remain subject to the same evidence, confidentiality and impartiality requirements.

30.3 Complaints and appeals shall have accessible submission, acknowledgement, independent review, documented reasons and communication of outcome. A person whose decision is appealed shall not control the appeal decision. Retaliation against a complainant is prohibited.

30.4 Before scheme launch, IAF shall establish transparent rules for approval of methods, assessor authorization, use of marks, public result status, fees, complaints, appeals and suspension. Drafting this standard does not imply that those operational services already exist.

30.5 Technical stewardship shall include balanced input from manufacturers, suppliers, operators, test specialists, digital developers, resource experts and users. Decisions shall record the evidence considered, unresolved dissent and reasons for numerical criteria.

30.6 Revisions shall consider field evidence, reproducibility, new technology, unintended incentives and accessibility for smaller organizations. Requirements may be proportionate in implementation effort while retaining the same integrity and safeguard expectations for comparable claims.

30.7 Annex J defines the current development work needed for adoption. It shall be maintained as an informative review record until the normative text and operational scheme are approved.

Annex A Applicability and scope register

Normative

A.1 The organization shall complete the following module register before collecting claim evidence. Applicability shall follow actual activities and material dependencies. The register shall identify the selected objects, included clauses, excluded activities, reasons, evidence owner and functional units.

Code	Module and clauses	Application trigger
C	Core 1 to 12 and 24 to 30	Every assessment.
V	Vehicle performance 13	Complete vehicle or propulsion performance claim.
P	Components 14	Component or material performance claim.
M	Manufacturing 15	Production or assembly within the assessed boundary.
U	Facilities and water 16	Material supporting utility or water use.
L	Supply and distribution 17	Sourcing or distribution within the claim.
F	Fleets and services 18	Actual transport or mobility service operation.
H	Energy infrastructure 19	Charging, refuelling, swapping or stationary storage.
D	Digital systems 20	Material onboard or external digital resource demand.
R	Circular service 21	Maintenance, repair, remanufacture or recovery claim.
X	Lifecycle effects 22	Lifecycle claim or material burden shifting assessment.
T	Future technologies 23	Emerging technology or resilience claim.

A.2 Every assessment shall screen all modules. Clauses 22.4 and 22.7 shall apply to the safeguard and burden shifting screen even when a full lifecycle study is outside scope. Clause 23.1 shall apply to the governance risk review; the remaining future technology requirements apply when their triggers are present.

A.3 A manufacturer assessing one assembly plant shall ordinarily select C, M and U, with L, D, R and X where material to the claim. This example does not create an automatic full lifecycle product assessment. A vehicle energy result ordinarily requires C and V, with P, H, D and X to the extent their interfaces form part of the stated measurement and claim.

A.4 A fleet operator shall include outsourced transport, charging or digital activities when their resource effects are material to the service claim, even if the operator does not own the equipment. Supplier evidence may satisfy the interface requirement when its scope and quality are verified.

A.5 The following fields shall be completed for each scope line. They may be maintained in a controlled digital register rather than a paper table.

Field	Required record
Object identity	Product or variant, site, asset group, service and responsible entity.

Field	Required record
Boundary	Input and output interfaces, geography, outsourced stages and period.
Module decision	Applicable, not applicable with reason, or outside the expressly limited claim.
Functional output	Unit, accepted specification, service envelope and output source.
Resource coverage	Material flows, measured share, estimates and exclusions.
Assessment route	Control conformity, measured performance, improvement or approved comparison.
Responsibility	Data owner, technical approver and independent reviewer.

Annex B Indicator dictionary and calculation rules

Normative

B.1 The indicators below define a common reporting vocabulary. Each applicable module shall use its principal resource and useful output indicators and the safeguards necessary to interpret them. Diagnostic indicators are not mandatory when irrelevant, but their omission shall not remove a material resource category.

ID	Indicator and unit	Calculation and boundary
E01	Delivered energy kWh	Sum of energy entering the assessed boundary by carrier; show exports separately.
E02	Vehicle energy kWh per 100 km	Delivered energy divided by actual distance, multiplied by 100.
E03	Passenger intensity Wh per passenger km	Total attributable energy in Wh divided by actual passenger kilometres.
E04	Freight intensity kWh per tonne km	Total attributable energy divided by actual cargo tonne kilometres.
E05	Product energy kWh per accepted unit	Production and allocated support energy divided by accepted specified output.
E06	Baseline ratio dimensionless	Reporting energy divided by adjusted baseline energy at equivalent output.
E07	Verified saving kWh	Adjusted baseline minus reporting use and applicable outside boundary adjustments.
E08	Saving percentage percent	Verified saving divided by adjusted baseline, multiplied by 100.
E09	Idle energy share percent	Energy in defined nonproductive states divided by total boundary energy.
E10	Peak demand kW	Highest demand averaged over the declared interval; report the interval.

ID	Indicator and unit	Calculation and boundary
E11	Recovery flow kWh	Measured internal recovered energy, reported separately from boundary input.
M01	Material intensity kg per accepted unit	Input material mass divided by accepted specified output.
M02	First pass yield percent	Units accepted without rework divided by units entering the defined process.
M03	Material yield percent	Mass incorporated in accepted output divided by material input on a matched basis.
M04	Scrap intensity kg per accepted unit	Process scrap mass divided by accepted output; distinguish reusable and disposed fractions.
M05	Recovered input share percent	Verified recovered input mass divided by total equivalent input mass.
M06	Realized recovery yield percent	Output accepted for defined recovery use divided by corresponding waste input.
M07	Critical material intensity g per service unit	Mass of the named critical material divided by the specified useful output.
W01	Water withdrawal m ³	Water entering from external sources, distinguished by source.
W02	Water consumption m ³	Water not returned to the same relevant water system over the period, with stock changes addressed.
W03	Water intensity litres per accepted unit	Defined withdrawal or consumption divided by output; specify which numerator.
W04	Reuse fraction percent	Reused supply to a defined process divided by its total water supply; do not equate this to withdrawal reduction.
O01	Useful availability percent	Time capable of required service divided by committed service time.
O02	Empty distance share percent	Empty repositioning and attributable empty travel divided by total vehicle distance.
O03	Occupancy passengers per vehicle km	Passenger kilometres divided by vehicle kilometres.
O04	Payload utilization percent	Actual tonne kilometres divided by available payload tonne kilometres for the same movements.
O05	Service completion percent	Accepted completed tasks divided by all committed tasks in the stated period.
O06	Repeat repair share percent	Repeated repairs for the same unresolved issue divided by completed repair cases.
H01	Station conversion percent	Energy at the declared station output divided by station input during the matched transfer.

ID	Indicator and unit	Calculation and boundary
H02	Charge round trip percent	Usable discharged energy divided by supply energy for a matched charge and discharge boundary.
H03	Standby demand W	Average power during the specified nontransfer state and duration.
H04	Transaction success percent	Successful requested transfers divided by all valid transfer attempts; exclusions disclosed.
H05	Refuelling support kWh per kg	Attributable station electricity divided by dispensed fuel mass; identify the fuel.
D01	Digital task energy Wh per accepted task	Onboard and attributable external energy divided by tasks meeting required performance.
D02	Digital operating demand W	Average and peak demand in specified workload and operating states.
D03	Software energy change percent	Change against a matched software reference at equivalent task quality and hardware.
R01	Restored service resource	Energy or material input divided by accepted restored service with its remaining life.
Q01	Data coverage percent	Supported resource quantity divided by estimated complete resource total.
Q02	Output acceptance percent	Accepted output divided by attempted output under the stated acceptance rules.
Q03	Relative expanded uncertainty percent	Expanded uncertainty divided by the absolute reported estimate where meaningful.

B.2 The equations below use compatible units. E is resource energy input; Q is useful output; I is intensity; B is adjusted baseline use; R is reporting period use; L is leakage outside the measured boundary; J is the separately evidenced rebound adjustment outside that boundary; S is net saving; U is expanded uncertainty. L and J shall be zero when not applicable, and shall not duplicate changes already included in R.

$$I = \frac{E}{Q}$$

B.3 A grouped intensity shall use the sum of inputs and sum of compatible outputs. In the following equation, i identifies a comparable record. Where Q is zero, intensity is undefined; input shall remain in the period total and shall not be discarded.

$$I_{\text{group}} = \frac{\sum E_i}{\sum Q_i}$$

B.4 Net savings and the corresponding percentage shall use the same adjusted baseline and boundary. Additional effects that cannot be quantified reliably shall be disclosed and the claim narrowed rather than silently assigned zero.

$$S = B - R - L - J$$

$$S_{\%} = \frac{S}{B} \times 100$$

B.5 The conservative lower bound is the point estimate minus its expanded uncertainty. A positive claim requires the lower bound to be greater than zero. For percentage claims, uncertainty of the ratio shall be calculated; dividing an energy lower bound by an uncertain baseline is not automatically a valid percentage bound.

$$S_{\text{lower}} = S - U$$

B.6 Where independent input quantities support a linear difference, combined standard uncertainty may be calculated by root sum of squares. Where they are correlated, covariance terms with the appropriate signs shall be included. Multiplying by an appropriate coverage factor gives expanded uncertainty; the factor and coverage shall be reported.

$$U = k \times u_c$$

Here u with subscript c is combined standard uncertainty and k is the justified coverage factor. The simplified multiplication does not remove the need to assess nonnormal distributions or correlations.

B.7 Passenger output and freight output shall use distance resolved actual payload records or a validated equivalent method. Occupancy changes during a route shall be represented by route segments; applying maximum occupancy to the entire journey is prohibited.

$$Q_{\text{passenger}} = \sum (n_i \times d_i)$$

In this equation, n_i is the actual number of passengers on segment i and d_i is its distance. The corresponding freight calculation replaces passenger number with actual cargo mass in tonnes.

B.8 For a complete matched energy transfer, efficiency is useful measured output divided by measured input. If the result exceeds 100% for a process where this is physically impossible, check stock changes, boundaries, units, meters and synchronization before publication. Thermal performance coefficients are different quantities and shall not be mislabelled as this conversion efficiency.

$$\eta = \frac{E_{\text{useful out}}}{E_{\text{in}}} \times 100\%$$

B.9 A lifecycle total shall identify the stages added and apply consistent allocation. Recycling or avoided production credits, if reported, shall be separate scenario results. They shall not create a negative measured resource input for the assessed physical operation.

Annex C Evidence coverage and sampling

Normative

C.1 The sampling plan shall identify the target population, primary claim, material strata, selection mechanism, expected variation, required precision and confidence. The sample shall be selected before the headline results are known, with retained records of unsuccessful or invalid observations.

C.2 Product testing shall have at least three valid repetitions for every primary test case. This minimum supports an initial repeatability check and does not establish population representativeness. Additional repetitions shall be collected when variance or uncertainty prevents the intended conclusion.

C.3 A product family claim shall include independent physical units selected by the assessor. Three independent units is the pilot minimum where such units exist; one prototype may support only a result for that prototype. Large family or market claims shall use a statistically justified sample and configuration coverage beyond this minimum.

C.4 Field datasets shall represent seasons, load, geography, duty, age and relevant technology. High frequency records from one vehicle or one day shall not be counted as independent vehicles or independent days. Clustering and autocorrelation shall be addressed in the precision calculation.

C.5 For an initial estimate of an independent sample mean, sample size may be planned using the square of the product of the intended coverage multiplier and coefficient of variation divided by the relative precision target. This approximation shall be refined for small samples, finite populations, clustering, stratification and the actual decision method.

C.6 As an informative calculation within this rule, a coefficient of variation of 20%, a multiplier of 1.96 and a relative precision target of 5% produce an initial estimate of 62 independent observations after rounding upward. This is not a universal sample size requirement and does not replace the validation required by C.5.

C.7 Data shall be classified as directly measured, validated calculation from measured inputs, supplier specific estimate, generic proxy or unavailable. The first two classes count toward the coverage requirement in Clause 7. Their classification shall be supported by method and validation records.

C.8 A measurement point balance shall compare independent supply totals with the sum of allocated uses, stock change and known losses. An unexplained difference greater than the combined uncertainty or 5% of supply, whichever is larger, shall trigger investigation under this pilot rule. A smaller difference shall still be investigated if it can change the claim or conceal a critical flow.

C.9 Outliers shall be investigated using predeclared physical and statistical criteria. Legitimate adverse performance shall not be removed because it lowers the average. Invalid tests may be excluded only with a recorded cause, retained data and the effect of exclusion reported.

C.10 Missing data and excluded flows shall be bounded conservatively. Where a conservative bound changes the decision, the result shall remain inconclusive until adequate evidence is obtained. A favourable point estimate shall not override inadequate coverage.

C.11 Supplier data shall be checked for identity, period, product specification and boundary. A sample of material supplier calculations shall be independently challenged. Repeated unexplained discrepancies shall reduce reliance on that source and may require direct measurement.

C.12 The assessment file shall retain the sampling frame, selected units, replacements, invalid tests, calibration checks, raw data, processing scripts or formulas, uncertainty budget and independent review record.

Annex D Test and evaluation protocols

Normative

D1 Protocol registration

D1.1 Before testing, a protocol record shall freeze the object, variant, objective, boundary, service envelope, measurement points, test sequence, ambient conditions, loading, operating states, repetitions, acceptance limits, uncertainty method and decision rule. Deviations shall be recorded and evaluated before the result is accepted.

D1.2 This annex defines minimum protocol content and baseline pilot cases. It does not claim to provide a universal executable drive cycle for every vehicle class. Comparative class issuance remains blocked until the applicable detailed speed trace, tolerances and weighting are approved under Annex E.

D2 Vehicle pilot sequence

D2.1 Inspect the vehicle, verify the configuration and instrument installation, document maintenance and select representative software settings. Weigh the test vehicle and payload and measure tyre pressures using the specified reference condition. Document battery or fuel state, ambient conditions and auxiliary settings.

D2.2 Use the baseline cases below. The temperatures and payload points are proposed IAF pilot conditions for method development. Add more severe conditions where the product's intended use requires them. Testing shall remain within safe and authorized operating limits.

Case	Pilot condition	Required output
V1	Temperate ambient 23 ± 2 °C	Urban, interurban and higher speed energy results for the intended class.
V2	Cold ambient minus 10 ± 2 °C	Cold start, conditioning energy, cabin service and relevant route results.
V3	Hot ambient 35 ± 2 °C	Cooling energy, cabin service, thermal derating and relevant route results.
V4	Light and representative load	Actual mass, functional output and energy in each selected duty.
V5	High load at $90 \pm 5\%$ of rated payload	Capability, energy and any speed or thermal limitation; never exceed the rated payload.
V6	Default and optional efficient mode	Resource result with service, safety and user setting differences disclosed.
V7	Parked and connected states	Twenty four hour energy including wake events, conditioning and connectivity.

Case	Pilot condition	Required output
V8	Aged or degraded state	Energy intensity and service capability with declared age, condition and remaining usable energy.

D2.3 For thermal cases, condition the vehicle until representative battery or powertrain temperatures are within 2 °C of the target and stable within 1 °C over one hour, unless the method records a justified technology specific criterion. Record soak duration and any supply energy used. Ambient stability alone does not prove internal thermal equilibrium.

D2.4 Keep a fixed cabin setpoint of 22 °C for the baseline occupied vehicle pilot where cabin conditioning is fitted. Record achieved temperatures, humidity, warmup or cooldown time and occupants represented. A setpoint is a command rather than proof of equivalent comfort. Climate dependent service limits shall be fixed in the protocol.

D2.5 The route or laboratory trace shall state speed against time, distance, acceleration demand, stops, elevation, road surface and wind treatment. Route length and repetitions shall make the measurement uncertainty adequate for the claim. Public road tests shall obey traffic rules and shall record interruptions and actual achieved trace.

D2.6 At least three valid runs shall be obtained per primary case. Matched comparisons shall alternate or randomize reference and modified conditions where practicable. The laboratory shall investigate a coefficient of variation above 3% for controlled energy results as a pilot repeatability trigger; it shall not discard legitimate variation to meet that value.

D2.7 Restore energy state after the run and meter replenishment through the declared supply interface. Record battery temperature, rest time and stored energy correction. Small SoC differences may be accepted only when their energy effect is demonstrated to be immaterial within the uncertainty budget; dashboard percentages alone are insufficient.

D2.8 Report each case separately before any weighted result. Weightings shall sum to one and come from the registered application profile or a disclosed usage dataset. A user specific scenario shall not be presented as a universal driving result.

D3 Component operating map

D3.1 Establish the required output map and representative duty distribution. Measure input and useful output at the selected load, speed, voltage, pressure and temperature points, including startup and partial load where material. Record control state and stabilize according to the registered method.

D3.2 Repeat primary points, integrate duty weighted input and output, and report the weighted efficiency together with the map. Do not average efficiencies arithmetically when input weighting is required. Validate the component to system translation before making a vehicle or site saving claim.

D4 Charging and storage protocol

D4.1 Install synchronized meters at the supply and declared output interfaces. Record equipment rating, cable, firmware, supply voltage, active auxiliary systems and thermal conditions. Identify whether the onboard converter is inside or outside the test boundary.

D4.2 For controllable equipment, test approximately 10%, 25%, 50% and 100% of continuous rated output where safe and supported. Unsupported points shall be identified. Vehicle limited output shall be recorded as achieved output rather than assumed station capability.

D4.3 For a charging time comparison, use a declared 10% to 80% SoC window where the vehicle supports it, while also reporting actual transferred energy. This interval is a pilot reporting choice and is not a universal optimum operating window. Report temperature and preconditioning demand.

D4.4 Measure disconnected standby, connected waiting and post transfer cooling for representative periods, including at least one twenty four hour observation where scheduled wake events occur. A short quiet interval shall not represent daily standby demand when events are known to occur later.

D4.5 A round trip test shall return the storage system to an equivalent energy and thermal state. Compare supply input and useful delivered discharge over that complete process, including the declared rest and auxiliary periods. Meter checks shall distinguish actual losses from initial stock depletion.

D5 Facility intervention protocol

D5.1 Map the affected system and its interactions, select a baseline model, meter the resource input and measure the useful production or service. Select isolated system measurement where the effect is too small to distinguish reliably from variability in a whole site account.

D5.2 Record commissioning and begin a reporting period representative of normal operation. Calculate the adjusted baseline using reporting period conditions, quantify uncertainty and reconcile the result with independent supply totals. Report short term results as short term until seasonal performance is established.

D6 Fleet service protocol

D6.1 Select representative assets and duty groups, record actual distance and passenger or payload segments, capture all attributable charging or refuelling, and include empty movement and failed service. Reconcile telematics totals with supply records and asset availability.

D6.2 Compare matched service conditions or use a validated normalization model. Report intensity, absolute energy, service completion and time performance. Route optimization shall include additional user access travel or displaced journeys where material to the claim boundary.

D7 Digital task protocol

D7.1 Freeze hardware, software, workload, network conditions and required task accuracy or completion criteria. Measure active, idle, startup, update and remote processing contributions. Include cooling and communications where they fall within the claimed boundary.

D7.2 Compare versions using the same accepted task set and service limits. Randomize execution order where relevant and control caching and warmup. Report resource use per accepted task, failures, latency distribution, operating demand and uncertainty; synthetic tasks shall be labelled as such.

D8 Repair and remanufacturing protocol

D8.1 Define accepted restored function and expected remaining life. Measure all incoming cores, replacements, energy, cleaning, rejects and test outcomes. Follow a representative sample for return failures or use a justified durability evaluation before extending claims to a long service period.

D8.2 Compare alternatives at equivalent restored output and life. Report measured process inputs separately from modelled avoided production. State the assumptions that determine whether repair, replacement or remanufacturing has the lower total resource demand.

Annex E Application profiles and benchmarks

Normative

E.1 An application profile shall translate the general requirements into reproducible criteria for a defined object and use. A profile shall be approved before it supports public comparative classification. A test record for one project is not automatically an approved profile.

Profile element	Required specification
Eligibility	Vehicle, component, site or service classes; exclusions; family grouping.
Useful output	Functional units and service acceptance limits.
Boundary	Energy interfaces, upstream scope, auxiliaries, stock changes and allocations.
Test method	Executable trace or operating sequence, equipment, tolerances and validation.
Conditions	Climate, load, age, operating states and software configuration.
Sampling	Population, unit selection, repeats, precision and adverse variants.
Weighting	Source of duty weights and handling of missing or unsupported cases.
Decision	Uncertainty method, guard bands, safeguard gates and permitted result language.
Benchmark	Dataset eligibility, representativeness, period, governance and update rules.
Disclosure	Passport fields, public limitations and method version.

E.2 A benchmark dataset shall have verified provenance, compatible methods, defined geographic and temporal coverage, adequate sample size, and protection against duplicate or strategically selected entries. The approval record shall explain why the population is sufficient for the proposed decision.

E.3 Thresholds shall be supported by observed distributions, reproducibility, relevant service requirements and policy intent. Thresholds chosen solely to create attractive marketing categories shall not be approved. Pilot data shall be checked for whether they represent the intended market rather than only volunteering high performers.

E.4 Cohorts shall use meaningful service categories. Separate reports may show cross technology scenarios, but ranking shall not obscure differences in payload, utility, climate or duty. Any normalization model used to merge cohorts shall be independently validated and its uncertainty included.

E.5 A class boundary shall have a documented uncertainty decision rule. A result whose uncertainty straddles that boundary shall receive an explicitly qualified or conservative classification under the approved rule. Point estimates shall not be rounded across a boundary to gain a class.

E.6 No universal class thresholds or class names are set in this working draft. This deliberate hold prevents provisional numerical choices from being mistaken for established global performance levels. Clause 27 permits measured results and specific improvement verification without such classes.

E.7 Benchmark revisions shall record changes in the eligible population, method, values and effect on existing decisions. Historical results shall remain identifiable. New benchmark versions shall not silently overwrite the basis of earlier passports.

Annex F Assessment records and decision gates

Normative

F.1 The following sequence shall be recorded for each assessment. Each gate shall have an owner, date, evidence reference and decision. Evidence may be managed electronically provided the complete sequence remains traceable.

Gate	Required evidence	Decision to proceed
1 Scope	Annex A register and proposed claim	Object and all material interfaces defined.
2 Readiness	Obligations, safeguards, inventory and data plan	No known critical safeguard breach; test access available.
3 Method	Registered protocol, baseline and sampling plan	Method adequate for the stated claim.
4 Evidence	Raw data, calibration, output and coverage	Completeness and quality adequate or limits declared.
5 Calculation	Reproduced indicators and uncertainty	Arithmetic and modelling support the conclusion.
6 Safeguards	Quality, safety, service and burden review	All applicable critical gates pass.
7 Findings	Classified findings and verified actions	No unresolved critical or major finding for positive conformity.
8 Decision	Independent technical decision record	Exact result type and scope authorized.
9 Disclosure	Passport and proposed public wording	Claims match evidence and draft or adopted status.
10 Follow up	Change triggers and monitoring plan	Continuing validity responsibilities assigned.

F.2 For every assessed clause, the file shall record requirement identity, applicability, evidence, observed condition, result, finding if any, responsible reviewer and closure evidence. Acceptable results are met, not met, not applicable with rationale and not determined. “Not determined” shall not be treated as met.

F.3 Headline claims shall have a claim record containing the exact proposed wording, supporting indicator, baseline, interval, service assumptions, module scope, evidence period, reviewer and approved use. Altering the wording to broaden the claim requires renewed review.

F.4 A finding record shall contain the requirement, objective evidence, affected claim or object, classification, immediate containment, cause, correction, prevention, deadline and effectiveness evidence. Closure shall be authorized by a competent person independent of the corrective work where the finding is major or critical.

F.5 The decision record shall distinguish control conformity, measured values, improvement and any approved comparison. It shall identify unresolved uncertainty, limitations and the reasons for a negative or inconclusive result. Commercial considerations shall not change the technical conclusion.

F.6 A sampled object with an adverse configuration shall not be replaced by a favourable object without a documented legitimate reason. If access is withdrawn, the limitation and its effect on the decision shall be recorded.

F.7 Assessment duration shall be sufficient for the object, modules, complexity, sampling and evidence. This draft sets no universal number of audit days. Any reduced effort shall retain complete evaluation of the core, critical safeguards and material claims.

Annex G Performance passport data fields

Normative

G.1 The passport shall contain the fields below in a controlled human readable record and, where used, a structured digital representation. Field names shall remain stable within a schema version. Units shall be explicit and quantities shall not be stored solely in formatted promotional text.

Field group	Mandatory content
Identity	Passport identifier; object identifier; owner; site or model; configuration.
Document basis	IAF ARES edition; draft status where applicable; module codes; profile version.
Scope	Boundary; geography; included and excluded operations; resource categories.
Time	Test dates; reference period; reporting period; issue date; review trigger.
Service	Functional units; required capacity; quality and service limits.
Method	Protocol identifier; measured or modelled status; baseline and allocation methods.
Results	Each indicator identifier; value; unit; period; applicable test case.
Confidence	Expanded uncertainty; coverage method; data coverage; material assumptions.
Comparison	Reference object or baseline; saving point estimate; interval; approved cohort if any.
Safeguards	Gate result; material tradeoffs; unresolved limitations.
Assessment	Provider identity; reviewer; result type; decision date; finding status.
Integrity	Version; creation and change timestamps; provenance; superseded record link.

Field group	Mandatory content
Public status	Pilot, current, under review, suspended, superseded or withdrawn as applicable.

G.2 A digital implementation shall distinguish missing, not applicable and zero values. It shall use explicit time zones and decimal precision. Unique identifiers shall not encode unnecessary personal data. The record shall support export without dependence on a single software provider.

G.3 Access controls shall separate raw evidence, confidential technical records and public results. Changes shall retain the actor, reason and previous value. Validation shall check units, required fields, time order and consistency between module scope and result types.

G.4 Cryptographic or equivalent integrity controls shall protect released records from undetected alteration. The implementation shall support key or credential replacement and recovery without losing historical provenance. The existence of a digital record alone does not constitute an independent assessment.

G.5 A public claim shall link to its specific passport version or a stable identifier that clearly exposes the current status and historical version used. Redirecting a claim to an unrelated favourable result is prohibited.

Annex H Illustrative calculations

Informative

The values in this annex are invented examples for explaining the method. They are not measured IAF results, industry averages or performance thresholds. The calculations use simplified assumptions stated in each example.

H1 Production efficiency with changing output

A plant used 1,200,000 kWh to deliver 10,000 accepted units in the reference period. Its raw intensity was 120 kWh per unit. In the reporting period it delivered 12,000 comparable units using 1,260,000 kWh, giving 105 kWh per unit.

If the validated reference model for this example is directly proportional to output, its adjusted baseline is 1,440,000 kWh. The normalized saving is 180,000 kWh, or 12.5% of the adjusted baseline. Absolute use nevertheless increased by 60,000 kWh, or 5% of the original total. Both statements belong in the report.

Assume the net energy saving has an expanded uncertainty of 40,000 kWh with approximately 95% coverage. The lower energy bound is 140,000 kWh, so a positive energy saving is supported. If the baseline is treated as fixed only for this simplified example, the percentage interval is approximately 9.72% to 15.28%. In a real assessment, baseline uncertainty and covariance must also enter the percentage interval.

The example shall not be used to assume that every manufacturing baseline is proportional to output. Fixed loads, mix, weather and operating schedules often require a different model.

H2 Electric vehicle charging boundary

An electric vehicle travels 100 km. A matched restoration of its energy state draws 18.0 kWh at the stated supply meter. A separate complete matched charge and discharge test returns 16.0 kWh of usable discharge at the battery terminals for the same 18.0 kWh supply input.

The supply boundary driving metric is 18.0 kWh per 100 km. The matched supply to usable discharge efficiency is approximately 88.9%. The 16.0 kWh terminal value describes a narrower boundary; it must not be advertised as the supply energy required for the journey.

This simplified example assumes no export, unchanged stored energy at the end of the complete matched process and all declared auxiliaries included. It does not permit energy efficiency to be calculated from displayed SoC percentages alone.

H3 Correct aggregation for passenger services

Service A consumes 20 kWh while delivering 100 passenger km. Service B consumes 30 kWh while delivering 600 passenger km. Their individual intensities are 200 and 50 Wh per passenger km.

The combined result is 50,000 Wh divided by 700 passenger km, or approximately 71.4 Wh per passenger km. The arithmetic mean of the two intensities, 125 Wh per passenger km, is not the correct combined result because the delivered output differs.

If an additional empty repositioning movement consumes 5 kWh, combined intensity becomes 55,000 divided by 700, or approximately 78.6 Wh per passenger km. Empty movement contributes energy and no passenger output.

H4 An inconclusive improvement

A controlled comparison estimates a 2.0 kWh saving with expanded uncertainty of 3.0 kWh at approximately 95% coverage. The interval extends from minus 1.0 to plus 5.0 kWh.

The correct conclusion is that improvement has not been demonstrated at the stated confidence. The point estimate may be reported with the interval, but it does not support an unqualified verified saving claim. More precise measurement, more independent observations or a better matched design may resolve the uncertainty.

H5 Factory account with onsite generation

A site receives 800 MWh from the grid and 200 MWh from onsite generation during a period with no export or net storage change. Total delivered electricity available to the site is 1,000 MWh under this electrical boundary.

If grid imports fall to 600 MWh while onsite generation rises to 400 MWh and demand remains 1,000 MWh, grid purchases have decreased but electricity demand has not. Cost or emissions may change, but the data alone do not demonstrate improved physical energy efficiency.

H6 Bidirectional storage

A complete matched storage cycle takes 50 kWh from the supply and later returns 42 kWh to the declared output while the storage state is restored to its starting condition. The round trip efficiency is 84%, and the difference is 8 kWh within the stated boundary.

The exported 42 kWh is an energy service output. It is not a negative driving consumption entry. Any benefit from time shifting, grid support or revenue requires its own indicators and assumptions, including degradation and any standby demand excluded from this simplified example.

H7 Resource tradeoff in repair

Option A repairs an assembly using 8 kWh and 0.5 kg of replacement material. Option B replaces it using an attributed 25 kWh and 4 kg of new material. These inputs alone favour repair only if both options deliver the required remaining service.

If the repair lasts one quarter as long, repeated repairs, transport and downtime may change the result. The assessment therefore needs equivalent restored life, failure probability and functional acceptance. A single repair event cannot automatically support a lifetime saving.

Annex I Implementation workbook

Informative

This workbook provides a practical starting sequence. The organization can combine records for a small operation or maintain separate controlled systems for a complex network. Suggested durations are planning examples, not conformity periods or certificate validity rules.

I1 Establish the first assessment

During the initial planning stage, identify the decision the assessment should support: a plant improvement, a vehicle performance statement, a fleet intervention or another defined result. Select the object and modules, appoint an owner and agree the functional output and service envelope.

Create the boundary register, resource map and claims register before choosing targets. Review whether current meters and output records can support the required uncertainty. A narrow claim with complete evidence is preferable to a broad claim containing unknown material flows.

I2 Build the measurement file

For each material resource, record the meter, allocation, output driver, data owner and known gaps. Reconcile a trial period against independent supply and production records. Prioritize additional measurement where uncertainty can change a decision rather than installing sensors without a clear purpose.

For an existing operation, assemble an annual baseline where available. If only a shorter period exists, plan a ninety day or longer pilot and preserve the limitation. For a new product, register controlled tests and state that the result establishes a baseline.

I3 Select and implement an intervention

Choose an opportunity with a clear mechanism and measurable effect. Record the reference condition, expected change, supporting engineering, safeguards, commissioning checks and verification plan. Freeze the primary comparison before implementation.

After commissioning, review resource and service outcomes together. If performance deteriorates, retain the evidence and improve the intervention. Failed trials provide information and should remain in the development record.

I4 Prepare for independent review

Complete a self assessment using Annex F. Provide direct access to raw data, model versions, calibration evidence and the claim wording. Resolve boundary ambiguities and incomplete output records before requesting a positive conclusion.

Prepare a passport showing exactly what was measured, over which period and with what uncertainty. Use pilot status while the draft is under development. An assessor should be able to reproduce the principal result without relying on undocumented verbal explanations.

I5 Working templates

The following prompts may be copied into controlled records. Entries should identify actual evidence rather than simply answering yes or no.

Record	Questions to complete
Scope sheet	What object is assessed? Which activities, period, geography and modules are included? What is explicitly outside the claim?
Service sheet	What output is accepted? Which safety, quality, capacity, comfort and availability limits must remain satisfied?
Resource sheet	What enters and leaves each boundary? Which flows are measured, estimated, excluded or unknown?
Baseline sheet	Which period and conditions represent the reference? What changes need normalization? Is the model validated?
Project sheet	What change is proposed? Why should it reduce input? What new loads or adverse effects can arise?
Evidence sheet	Which raw files, instruments, samples and calculations support each indicator? Who checked them?
Decision sheet	Which gates passed? What findings remain? Is the result measured performance, verified improvement or only a pilot observation?
Claim sheet	What exact words will be public? Are the scope, baseline, uncertainty and limitations visible?

I6 Suggested initial pilot portfolio

A useful development portfolio would include a passenger vehicle, a commercial vehicle, a mixed fleet, an assembly plant, a component manufacturer, a charging installation and a repair or remanufacturing operation. Selection should vary climates, organization size and propulsion technologies.

Each pilot should test whether the proposed rules produce reproducible results and fair incentives. The purpose is to identify weaknesses in the method as well as successful applications. Participation would not itself establish certification or endorsement.

Annex J Technical development and adoption register

Informative

J.1 This annex identifies the work required to turn Working Draft 0.1 into an adopted and operational standard. The tasks below are proposed next steps for IAF; no completed consultation, laboratory validation, scheme approval or public recognition is implied.

Work item	Required development evidence	Proposed release gate
Scope review	Stakeholder review of objects, module dependencies and service units.	Resolve material scope gaps and conflicting interpretations.
Metrology review	Trials of 95% coverage, measurement targets and balance rules.	Confirm achievable uncertainty and resistance to omitted flows.
Baseline review	Pilot normalization across seasonal and changing output conditions.	Confirm defensible comparisons and clear treatment of new operations.
Vehicle profiles	Executable traces, tolerances, weights, climate and loading rules by class.	Independent reproduction before comparative classes.
Charging profiles	Boundary checks across AC, DC, wireless, swap and bidirectional systems.	Demonstrate correct stock accounting and comparable transfer tests.
Industrial profiles	Trials in assembly, components, batteries and diverse production mixes.	Demonstrate accepted output normalization and utility allocation.
Digital methods	Workload definitions, remote allocation and software regression trials.	Preserve task performance while measuring complete material demand.
Circular methods	Repair life, recovered output and allocation trials.	Avoid unsupported avoided production and duplicate benefits.
Reproducibility	Independent laboratories or assessors apply the same registered protocols.	Explain discrepancies and meet profile specific precision criteria.
Benchmarks	Representative data, cohort governance and uncertainty aware thresholds.	Publish no class until population and method are approved.
Scheme governance	Rules for competence, impartiality, marks, complaints and appeals.	Approve operating rules before official assessment services launch.
Editorial review	Requirement consistency, definitions, calculations and claim examples.	Resolve contradictions and approve controlled edition text.

J.2 The numerical pilot rules requiring explicit review include the 1% individual and 5% total flow cutoffs; 95% supported resource coverage; 2% energy and 1% output measurement targets; twelve month annual and ninety day pilot periods; approximately 95% claim confidence; minimum repetitions and independent units; 5% balance trigger; and the proposed climate, loading and repeatability conditions.

J.3 Validation shall investigate whether these rules work for small workshops, low volume manufacturers, high power charging, commercial fleets and emerging technologies. The committee may revise a numerical rule when evidence supports a better choice, documenting its effect on earlier pilot results.

J.4 Draft progression should move from internal technical review to multi context pilots, independent reproducibility exercises, consultation, resolution of comments and formal approval. No calendar deadline is assumed. Each stage should produce reviewable evidence and a record of unresolved issues.

J.5 The completed First Edition should preserve a clear distinction between general measurement requirements and class specific test profiles. Additional profiles can extend coverage over time without presenting unvalidated technologies as already benchmarked.

J.6 Working Draft 0.1 establishes a broad normative architecture, practical indicators, decision gates, protocol content and application records. Its central development question is whether each claim can be reproduced at a defined service level with known uncertainty. Adoption should depend on that evidence rather than the breadth of the document alone.