Notification of a Proposal to issue a Certification Memorandum

Acceptable approaches for the certification of Electric/Hybrid Propulsion Systems

EASA CM No.: CM–21.A-004 Issue 01 issued 30 July 2024

Regulatory requirement(s): Part 21, 21.A.21(a)

EASA Certification Memoranda clarify the European Union Aviation Safety Agency's general position on specific initial airworthiness, validation, continuing airworthiness or organisational items. They are intended to provide guidance on a particular subject and may provide complementary information for compliance demonstration, similar to AMC/GM even if not formally adopted through an ED Decision. Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements.

Log of issues

Issue	Issue date	Change description
01	30.07.2024	First issue.

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1. Identification of Issue

1.1. Purpose and scope

Electric/Hybrid Propulsion Systems (EHPS) are considered as means to reduce direct aircraft gaseous emissions and to contribute to a cleaner aviation system. Such systems use novel electrical propulsion technologies that are combined with traditional thermal propulsion engines in various ways. For several years, design organisations started to develop different concepts and architectures of aircraft and engines based on full electric or hybrid propulsion systems. The degree of hybridisation highly depends on the intended use of the aircraft, the selected fuel/power supply, suitable energy storage solutions and the required safety objectives.

An EHPS may include, but is not limited to, electrical engines, turbine engines, piston engines, generators, electrical power generation, distribution, wirings, propulsion batteries, integrated fans, cooling systems, controllers and power management systems. (Ref: SC E-19 EHPS Issue 01).

Note: An EHPS is energy source and power source agnostic except when the electrical power source is included in the type certificate (TC) definition. While a propulsion battery may be included within the engine TC boundary, other electrical power sources are so far excluded. Interaction with hydrogen technology is not addressed in this Certification Memorandum (CM) at this stage.

The novel boundaries between aircraft, engine and propeller and the high level of integration in the aircraft presented by EHPS, challenge and complexify the typical methods used for the certification of more conventional products.

The purpose of this CM is to provide guidance to applicants on type certification approaches for an EHPS.

2. Applicability

This CM is applicable to any EHPS used to provide or produce lift/thrust/power for flight in a manned or unmanned aircraft, during both normal and emergency operations on all aircraft applications.

3. EASA Certification Policy

3.1. Background

EASA received applications to certify, or to provide advice[1] on the certification of, propulsion systems that range from single electric engines to complete Electric/Hybrid Propulsion Systems (EHPS) with or without energy storage system.
According to Regulation (EU) 2018/1139 Article 11, products shall be issued with a type certificate. The same regulation specifies in Article 3 that a product is ‘an aircraft, an engine or a propeller’.
CS-Definitions Amendment 2 further specifies that an engine ‘means an engine used or intended to be used for aircraft propulsion’, and that ‘it consists of at least those components and equipment necessary for the functioning and control but excludes the propeller’. This definition is similar to the ‘engine’ definition provided by ICAO Annex 8.

[1] E.g., via Technical Advice Contract, Innovation Partnership Contract

The different requests received by EASA challenge the boundaries of the above '*engine*' definition, hence opening the question of what components can be included in a single engine type certificate as part of such product.

Regulation (EU) 2018/1139 Article 11 states the following: 'No separate type certificate shall be required for the design of engines and propellers that have been certified as part of the design of an aircraft […]'. This provision is implemented in Regulation (EU) No 748/2012 point 21.A.21 and provides the possibility to certify the propulsion system as part of the aircraft.

3.2. Acceptable approaches for the certification of EHPS

According to the existing regulatory framework, at least two possible approaches to certify an EHPS have been identified:

1. **Aircraft approach**: the EHPS is certified as part of an aircraft.
2. **Engine approach**: the EHPS is certified as an engine product -by determining ***those components and equipment*** (*of the EHPS*) ***necessary for the functioning and control*** in line with the 'engine' definition of CS-Definitions Amendment 2. A propeller may receive its own type certificate.

The above-mentioned "engine approach" provides the flexibility to include in the scope of an engine TC some/all parts of the EHPS, except the propeller.

Although flexibility on the certification approach is available to applicants, at the time of application/pre-application, EASA may advise on what it considers to be the most appropriate approach, depending on the complexity of interfaces between products and their elements, and also based on the level of systems integrations, to mitigate the risk of dispute between the different design organisations regarding their respective responsibilities.

No matter which approach is used, the applicable requirements will remain consistent between the Aircraft approach and the engine approach.

Reminder: As required by Part 21, the scope of work of the applicant design organization shall be consistent with the selected approach used for type certification.

In addition, the following should be taken into consideration:

- The scope and interfaces of the EHPS should be accurately identified (including maximum boundaries, refer to guidance in paragraph 3.3).
- The final integration needs to be demonstrated at aircraft TC level (including installation instructions addressing potentially complex interfaces)

The below example illustrates the flexibility that could be offered to an applicant willing to certify an EHPS.

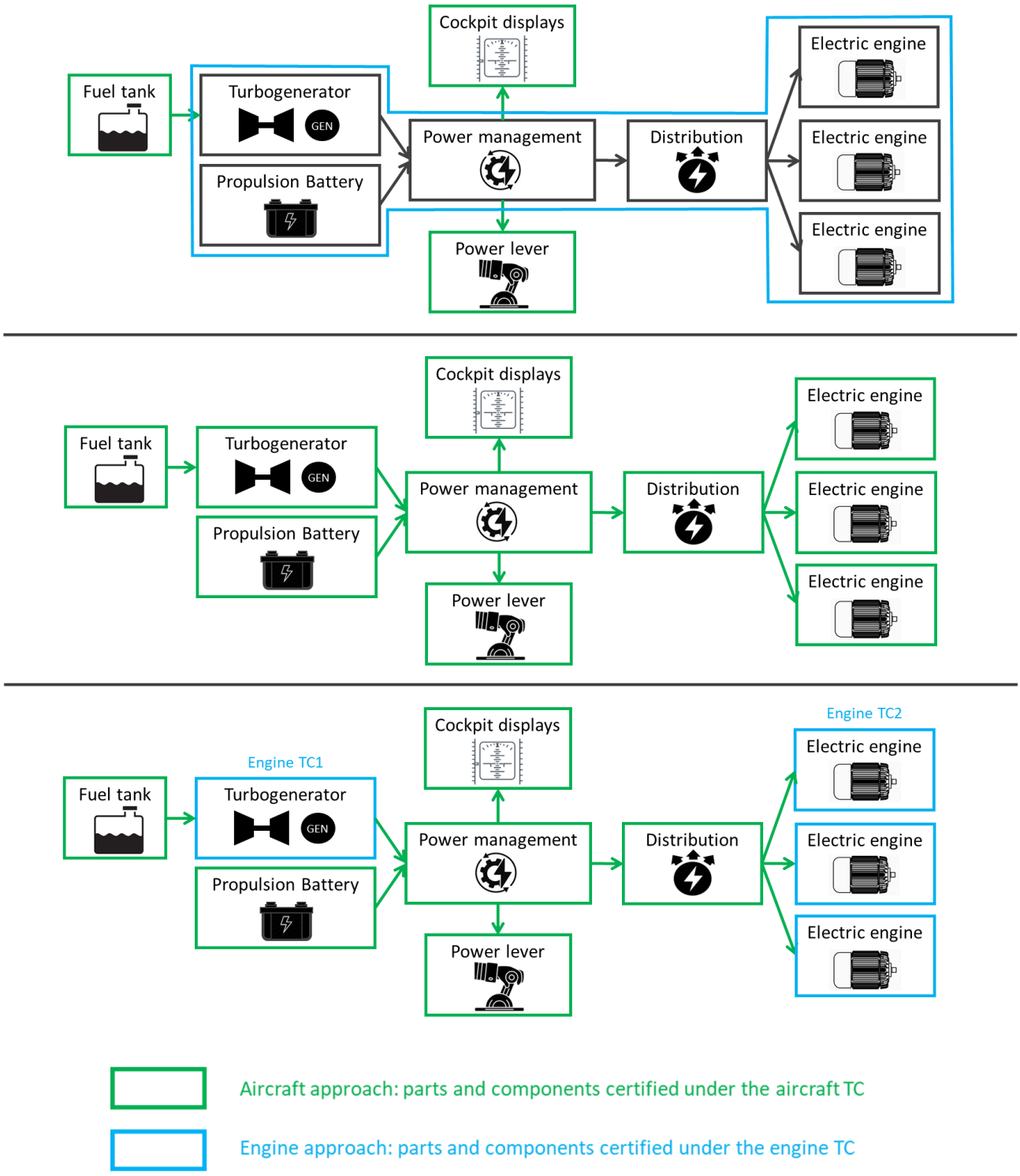

Figure 1-Illustration of certification approaches (example of a distributed Electric propulsion)

Whatever certification approach is chosen by an applicant, it is essential to maintain the same level of safety of the end-product. **This means that the EHPS certification requirements will be the same, independently from the selected certification approach, which is the prerequisite for offering the requested flexibility**. From an EASA perspective, compliance demonstration should not be duplicated. In the case of a separate extended engine TC, the aircraft type certification will rely on the EHPS TC while ensuring a safe installation on the aircraft (equivalent to a traditional engine installation).

In the example shown at the bottom of the picture above, the potential exists for a multiplication of certificates (TCs). It is therefore crucial that responsibilities for continued airworthiness of the EHPS are not diluted. In this regard point 21.A.3A contains continuing airworthiness responsibilities for each of the design approval holders and covers the interfaces amongst them. AMC 20-8 contains additional guidance regarding coordination.

3.3. Elements that may be certified within an engine Type Certificate

A typical EHPS aircraft installation is described in the here figure 2.

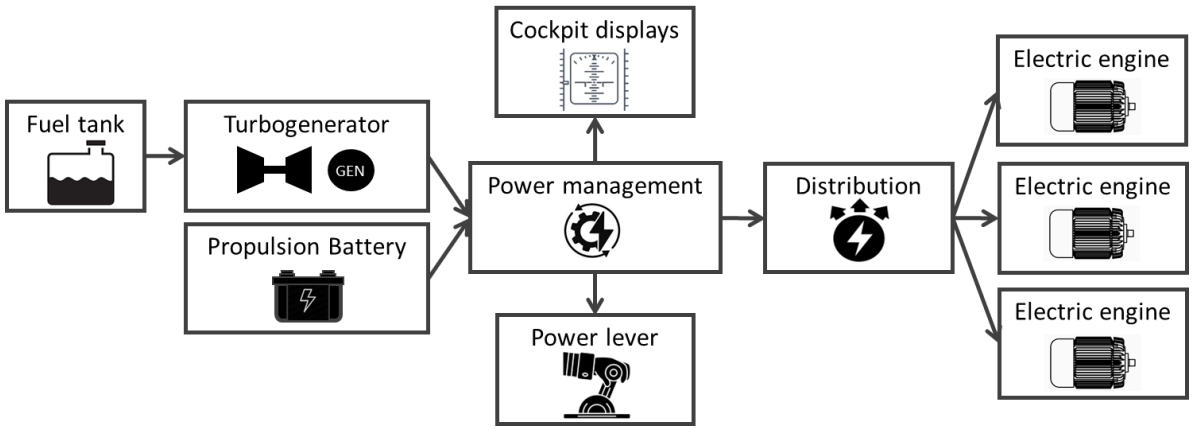

Figure 2-Schematic view of EHPS installation and interaction

The 'engine approach', which would allow to certify a complete EHPS under one engine TC, requires to reconsider the scope of the 'engine TC' as it is known today, in the form of an extended engine TC including additional components such as generators, power management, power distribution and propulsion batteries. All these components, despite being part of the system and physically installed at different locations, should be shown to be "*components and equipment necessary for the functioning and control of the engine"* thus fulfilling the applicable 'engine' definition of CS-Definition Amendment 2.

When looking at the schematic above, one could state that the elements providing the power or the thrust for the aircraft propulsion, are only the electric engines.
However, turbogenerators (possibly reciprocating engine-generators) also fall under the 'engine' definition when used for aircraft propulsion. They are often derivatives of type certified engines according to CS-E (CS-APU may be used under conditions to be agreed with EASA). Therefore, it makes sense to integrate the turbogenerator in the extended engine definition for EHPS. Following this reasoning, as the power management and the distribution make the link between the electric engines and the turbogenerator, they are necessary for the functioning and control and therefore belong to the extended engine definition.

Fuel tank and propulsion battery:
The fuel tank and the propulsion battery are not considered equivalent in view of an 'extended engine TC', although both systems influence the center of gravity and surrounding systems of the aircraft and shall be compliant with crashworthiness requirements defined at aircraft level.
They differ as regards two aspects:

- From a functional point of view, the propulsion battery is equivalent to the combination of fuel tank and turbogenerator(s) as they both provide electrical power.
- From an integration point of view, the fuel tank is a 'passive' element in the EHPS (it provides fuel flow to combustion engines) whereas the propulsion battery is an 'active' element in the EHPS:

- The electric engine efficiency is dependent on the voltage level of the propulsion battery (related to the energy quantity), whereas a turbine efficiency is not dependent on the fuel flow or fuel quantity.
- When the propulsion battery discharges, the voltage level decreases accordingly. This may force the engine designer to change the engine control laws (field weakening function) to reach the higher declared speeds. This has implications as regards the engine control system software development and the certification tests performed during the electric engine certification process.
- The engine controller also has an influence on the energy drawn from the propulsion battery.

This 'active' relation between the propulsion battery and electric engines demonstrate that the propulsion battery could be considered as part of the *components and equipment necessary for the functioning and control of the engine* as stated in the 'engine' definition of the CS-Definitions.

The various components of an EHPS that may be included under the engine TC are illustrated by the below schematic:

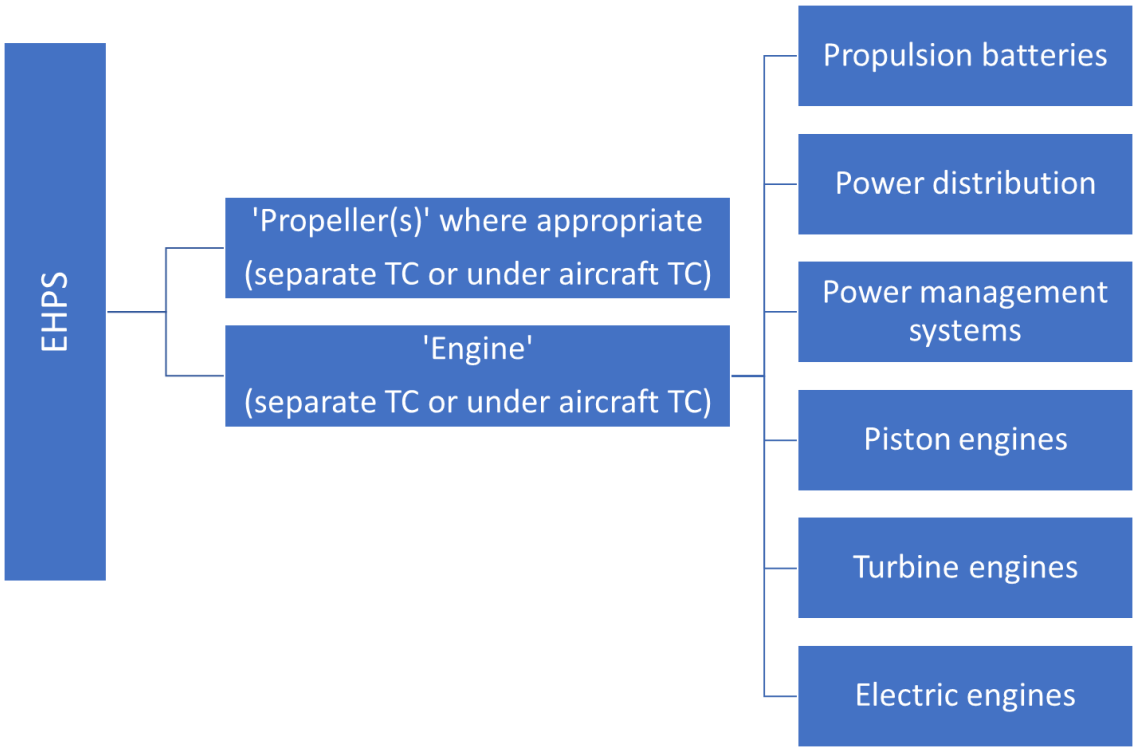

Figure 3-Components of an EHPS that can be included under Engine TC

This extended engine definition should however exclude aircraft cockpit displays, power levers, fuel tanks and their fuel distribution systems usually certified within the aircraft TC.

When electric engines are designed with fans, the associated fans are certified as part of the engine definition, similarly to turbine engines.

The engine TC must always include the engine(s) used or intended to be used for aircraft propulsion. For example, an engine TC can not be granted for a propulsion battery only.

3.4. Certification basis for the EHPS

This chapter proposes a set of guidance to support applications for the certification of EHPS powered by propulsion batteries and / or fuel.

When defining the certification basis, EASA uses a performance-based approach considering a level of proportionality that depends on the intended aircraft application, ranging from powered sailplanes up to CS-25 large aeroplanes. The below figure list the available guidance and their applicability:

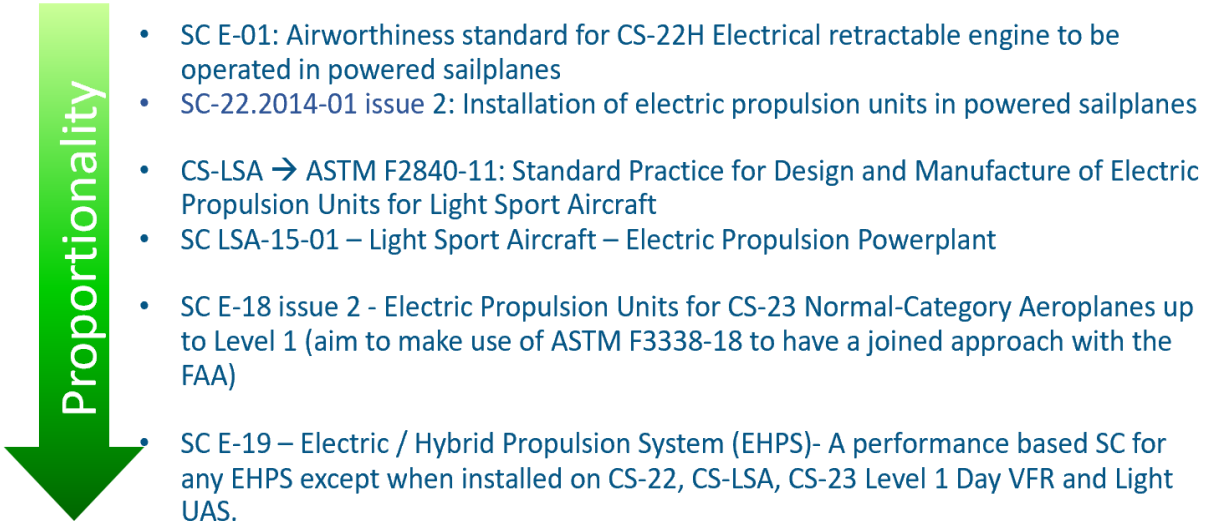

Figure 4- Performance-based guidance for EHPS certification, including proportionality linked to Aircraft Application

An applicant intending to provide the same EHPS for installation on different aircraft applications should consider taking into account, at an early stage of the design, the most demanding certification specifications, and corresponding Special Conditions (SC). For example, one company that develops a propulsion system for a CS-LSA aeroplane as first application may consider the requirements contained in SC E-19 if they intend to propose the same propulsion system for a CS-23 level 2 aeroplane.

Dedicated SCs complement SC E-18 and SC E-19 on the integration tailored to the aircraft application and with appropriate emissions requirements that are yet to be defined for EHPS.
Certification of an EHPS to be installed on a light unmanned aircraft (UA) is addressed directly in the SC-Light UAS Subpart E- lift/thrust/power system installation.

EASA is currently working on developing means of compliances (MoC) to the above performance based SCs to support applicants' demonstration of compliance. The (MoC) development will strongly rely on Industry standards and close coordination with Industry, harmonisation with EASA bilateral partners will be ensured to the maximum extent.

4. Supporting Data

4.1. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
Regulation (EU) 2018/1139 of the European Parliament and of the Council	Regulation on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency (the 'Basic Regulation')	Art. 3 Art.11		4.07.2018
Commission Regulation (EU) No 748/2012	Implementing rules for the airworthiness and environmental certification of aircraft and related products, parts, and appliances, as well as for the certification of design and production organisations	Art.2 21.A.21(a) 21.A.3A		3.08.2012
SC E-01	Airworthiness standard for CS-22H Electrical retractable engine to be operated in powered sailplanes.	-		15.04.2006
SC-22.2014-01	Installation of electric propulsion units in powered sailplanes	-	02	14.11.2014
CS-LSA - ASTM F2840-11	Standard Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft	-		
SC LSA-15-01	Light Sport Aircraft – Electric Propulsion Powerplant	-	01	13.02.2019
SC E-18	Electric Propulsion Units for CS-23 Normal-Category Aeroplanes up to Level 1 (aim to make use of ASTM F3338-18 to have a joined approach with the FAA)	-	02	22.10.2020
SC E-19	Final Special Condition SC E-19 – Electric/Hybrid Propulsion System	-	01	13.04.2021
CS-Definitions	Definitions and abbreviations used in Certification Specifications for products, parts, and appliances	-	Amdt 2	23.12.2010

4.2. Abbreviations

AMC	Acceptable Means of Compliance
APU	Auxiliary Power Unit
CS	Certification specification
EHPS	Electric/Hybrid Propulsion System
ETSO	European Technical Standard Order
ETSOA	European Technical Standard Order Authorisation
FAA	Federal Aviation Administration
ICA0	International Civil Aviation Organization
LSA	Light Sport Aircraft
MoC	Means of Compliance
SC	Special Condition
TC	Type Certificate
UAS	Unmanned Aircraft System

4.3. Definitions

EHPS	Electric/Hybrid Propulsion System (EHPS) may include, but is not limited to, electric engines, turbine engines, piston engines, generators, electrical power generation, distribution, wirings, propulsion batteries, integrated fans, cooling systems, controllers and power management systems. (Ref: SC E-19 EHPS Issue 01).
Electrical power generation	Process of converting different forms of energy into electrical energy.
Energy source	Term that refers to any substance or phenomenon that can produce useful energy
Battery system or ESS (Energy storage system):	Top-level configuration for installations that include multiple battery packs or a dedicated battery charger.
Power source	Device or machine that supplies electric power to a system.
Propulsion battery	Propulsion Battery (System) - Means a battery or battery system used primarily for electric and hybrid propulsion applications. The battery system may supply power to other systems as well. (Note: definition agreed with the FAA)

5. Remarks

1. This EASA Proposed Certification Memorandum will be closed for public consultation on the **[06th of Sept 2024]**. Comments received after the indicated closing date for consultation might not be taken into account.
2. Official comments to the proposed CM are to be filed through the EASA Comment Response Tool.
3. For any question concerning the technical content of this EASA Certification Memorandum, please contact: [*include the contact details of the author*]
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