Electric flight in the Kingdom of the Netherlands

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Contents

Authors: Christine Driessen and Marlies Hak

Reviewed by: Marilina Mauri, Kris Pauwels

Approved by: Martin Nagelsmit and Kris Pauwels

Setting the scene

Background

- In 2020, the Netherlands has set ambitions for sustainable aviation, as part of the Luchtvaartnota[1]. The ambition is to reduce CO_2 emissions by amongst others, have zero-emission ground operations and electric taxiing introduced by 2030. By 2050, all short-distance commercial flights departing from the Netherlands should be full-electric.
- Within the Kingdom of the Netherlands, the infrastructure is further developed in the Netherlands than on the Caribbean islands. Therefore, the implementation of electric flight is likely to be easier in the Netherlands than on the islands.
- The feasible range and passenger numbers by 2030 create opportunities for regional mobility services with 9- and 19-seaters. These electric aircraft will be very suitable for the inter-island flights at the ABC islands.
- Learning and innovating is essential for the implementation of electric flight.
- Moreover, reliable and affordable air connectivity is vital to the local communities of the islands. The ABC use case is a great opportunity to start implementing electric flight.
- To get more insight into the steps that need to be taken, the Ministry of Infrastructure and Water appointed NACO and NLR to prepare a roadmap, focusing on the implementation of electric flight in the Kingdom of the Netherlands.

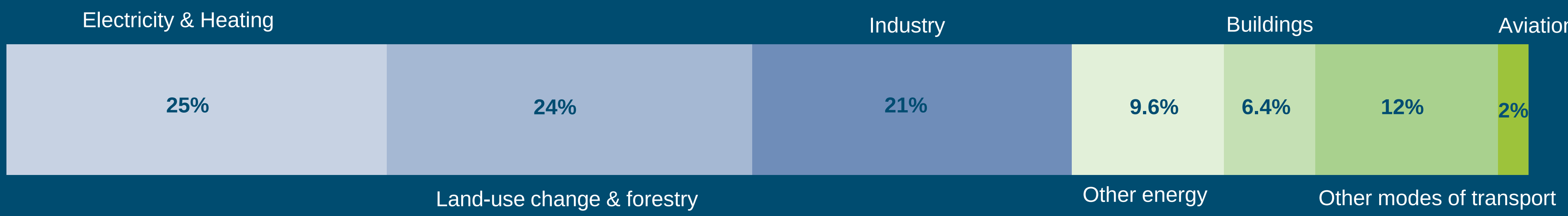
Scope

- This study focuses on the implementation of electric flight in general, for the whole Kingdom of the Netherlands.
- It then zooms in on the use case of the ABC islands to provide a quantification of the impact of the implementation in terms of (new) infrastructure, energy demand and costs.
- The study concludes with a concise roadmap towards 2035.

Introduction

Why are we doing this?

CO_2 emissions of the aviation sector



Today, aviation is responsible for at least

2%[2]

of the carbon emissions

By 2050

aviation emissions are expected to increase to

>20%

if nothing is done by aviation while other industries do.[3]

Therefore, action is needed to make aviation more sustainable.

What are the Dutch sustainable aviation ambitions?

Ambitions set by the government on Luchtvaartnota[1] and in Actieprogramma Hybride Elektrisch Vliegen (AHEV)[4]

2030

- Zero-emission ground operations
- Normative electric taxiing
- Living Lab for innovations in aviation
- 15% emission reduction for domestic flight with respect to 1990
- Start operating hybrid-electric aircraft up to 50 pax
- Reduce CO_2 emissions of international aviation activities to the 2005 level

2050

- Zero-emission domestic flight
- Meet ICAO goals of 50% CO_2-reduction with respect to 2005
- All flights up to 500 km departing from the Netherlands to be fully electric

2070

- Emission-free aviation in 2070

Sustainable aviation initiatives in the Kingdom

Non-exhaustive list of on-going initiatives

In the shared learning environment '**Power Up**', the aim is to gain knowledge of the feasibility and handling of electric flights. Eindhoven Airport, Rotterdam The Hague Airport, Groningen Airport Eelde and Maastricht Aachen Airport are working together. Power Up aims to have the first commercial electric flight in the Netherlands by 2026[5].

Dutch Electric Aviation Centre (DEAC) is a centre which investigates how general aviation can fly more sustainably in the future. Its goal is to make aviation cleaner, quieter and more affordable. To make electric aviation more accessible they conduct research and experiments with aircraft, infrastructure and regulations that can support its implementation[6].

In 2018, "**Stichting Duurzaam Vliegen**" was established as a representative party for General Aviation. Their ambition is to reduce greenhouse gas emissions by 15% by 2030 compared to 1990 and to be able to fly emission-free by 2050. [7]

Bonaire Air Ambulance are responsible for care on the islands. For optimal use, certain care is only available on one of the islands which makes reliable transport between them crucial.[8] To become independent from airlines, Air Ambulance would like to acquire their own fleet and they are investigating the feasibility of having electric or hybrid electric aircraft. There ambition can be a catalyst for new techniques to create a new eco-system.

Dutch Caribbean Cooperation of Airports (DCCA) is an initiative of airports, established in 2021. Their objective is to improve the individual airports on several key elements, such as sustainability. One of their efforts is focused on improving connectivity between islands, aiming for a sustainable (electric), reliable and affordable public transport-like air connection[9].

Stakeholders

Collaboration is key

Who can make the implementation possible?

Overview of stakeholders that play an important role

Manufacturers
E-aircraft
Batteries
Chargers

Authorities & Associations
ICAO
EASA, CAA
IATA, ACI, CANSO

Air Navigation Service Providers
LVNL
Dutch Caribbean – ANSP
ANS Aruba

Airlines
Aircraft
Staff

Airports
Infrastructure
Operations
Maintenance Repair & Overhaul

Energy provider
Local supplier
Airport handler

Educational institutes
Universities
Staff training institutes

Government

What role do these stakeholders have?

Collaboration between the stakeholders is key for a successful transition

Manufacturers

- Besides designing and building aircraft, it is important to exchange experiences with the certification authority: as electric aircraft are evolving, the authorities can learn from the experience of electric flight and adapt their regulations.
- Another role for manufacturers is to take part in standardization groups, for instance for charging infrastructure to enhance the implementation of electric flight.

Authorities

- As aviation regulations are based on conventional aircraft with engines powered by fossil-fuel, the new technology will affect these regulation and changes will have to be made to ensure safety. A close collaboration with the manufacturers will help improving the certification process.
- In addition, changes may have to be made to regulations and standards regarding maintenance systems and pilot training.
- EASA offers under special conditions the possibility to certify aircraft with an electric power system with CS23. This certification process is applicable for commuter aircraft having up to 19 passenger seats. The authorities have not yet published conditions for CS25 used for large airplanes [11].
- Furthermore, a new power system and new infrastructure on the airport will require an update on the safety regulations and standards at the airport.

ANSPs

- The ANSP will have to make sure that the electric aircraft are guided safely through the air space. It is likely that with the introduction of (smaller) electric aircraft or even UAM more movements simultaneously occur. Therefore, the ANSP should together work with the government on solutions for the airspace challenges. This is currently brought under for example SESAR.

What role do these stakeholders have?

Collaboration between the stakeholders is key for a successful transition

Airlines

- The airline will want to investigate the revenue potential the new e-aircraft could have if operating existing or new routes before acquiring them.
- If electric aircraft is adopted in the fleet, the staff will have to be trained, from pilots to maintenance personnel.
- Finally, the airline will have to integrate the electric aircraft into the existing flight network and adjust it if necessary to meet new flight range, flight time and turnaround times.
- In the early ramp-up years, airlines could be stimulated to invest in electric aircraft by attractive landing fees or other risk mitigation measures.

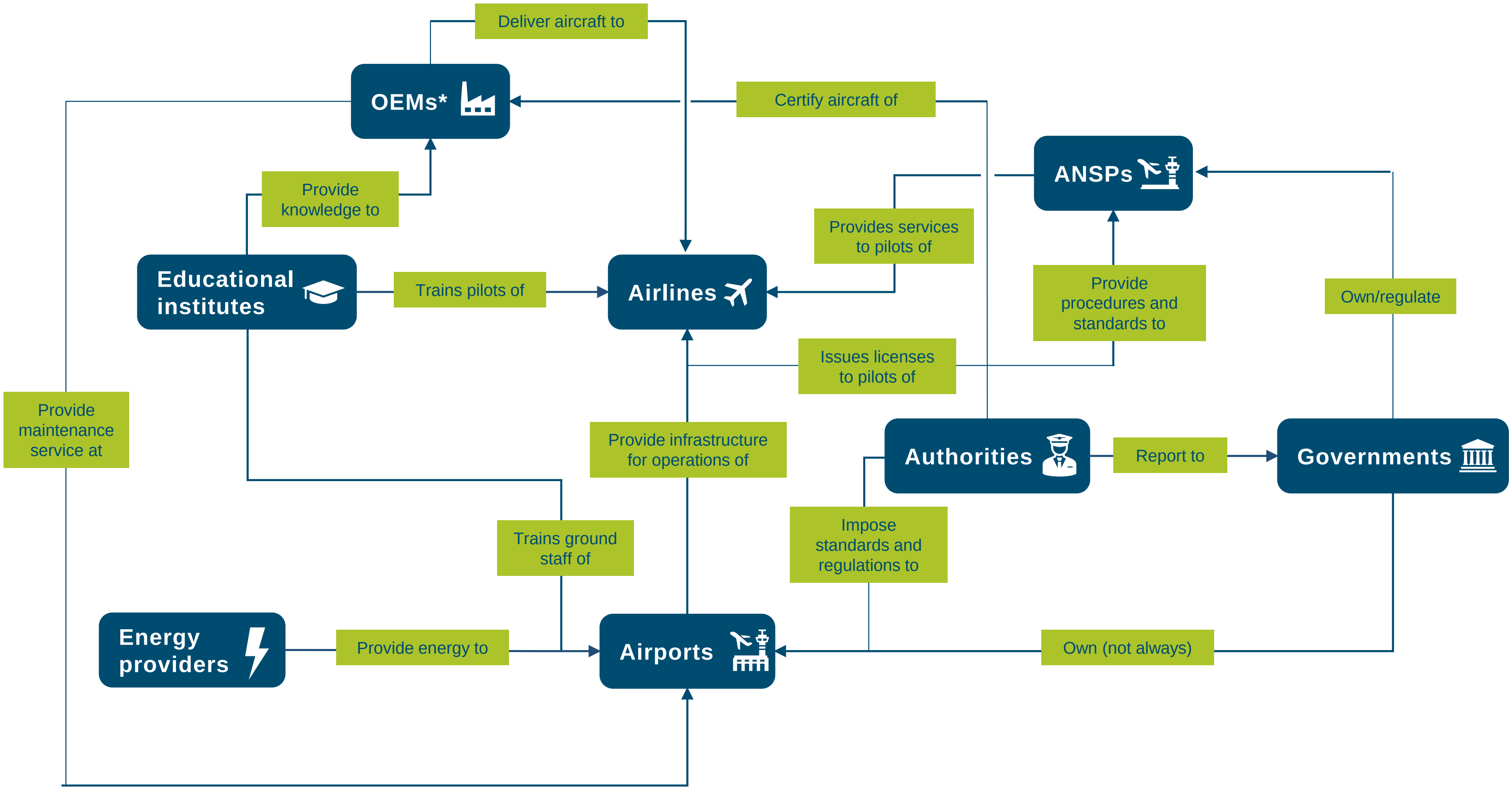
Airports

- For airports to accommodate electric aircraft, suitable energy provision will have to be available. The capacity of the power at the airport might have to be scaled up to cater for simultaneous charging of multiple aircrafts.
- Ground personnel and firefighting will need to be trained for electric aircraft handling.
- Finally, the necessary infrastructure such as cables, energy storage and charging station must be installed.

Government

- The ramp-up years might not be economically attractive for airlines or other aviation businesses to implement new aircraft technologies. The risk could result in long waiting time before ordering.
- Therefore, governments could incentivise the acquisition and operation of electric aircraft and required/associated infrastructure by offering supporting schemes or grants for airlines and airports.
- Taxation of aviation fuel or exemption of taxes can be used to either create a level playing field or stimulate the business case for electric aviation.

What is the relation between these players?



*OEM: Original Equipment Manufacturers

Collaboration is key

- Collaboration of the stakeholders is very important as the implementation of electric aircraft involves a system change in which everyone needs to act.
- Therefore, it is suggested to create a platform where stakeholders meet and exchange information, needs and ideas.
- The existing initiatives in the Netherlands such as AHEV and Power Up are good examples of collaboration between airports, educational institutes, businesses and government.
- In these working groups, the challenges that electric flight is still facing should be addressed, to enhance the implementation of electric flight.
- Currently, main challenges are timely certification, R&D funding, (green) energy supply and profitable business case in the early years.
- Stakeholders should come together on a regular basis to discuss status, challenges faced and next steps.
- It is crucial to have all parties involved working closely together in order to make progress and meet the ambition of ultimately achieving emission-free aviation by 2070.

Technology outlook

Still facing challenges

The rich palette of electric aircraft projects

Currently, over a hundred electric aircraft projects have started. However, due to the current technological limits, range and passenger capacity are still relatively low. As a result, the focus of the projects are mainly on urban air mobility.

- The introduction of fully electric 9-seaters and 19-seaters is planned before 2030.
- Besides, Vertical Take-Off and Landing aircraft (VTOLs) are expected in this time range, offering local air transportation services between cities or rural areas.
- These Urban Air Mobility (UAM) and regional mobility services with 9- and 19-seaters are very interesting opportunities for the Dutch regional airports.
- However, the penetration rate of electric aircraft in the current fleet also depends on the airport infrastructure and energy provision: proper charging facilities, including safe and efficient operations must be in place.
- In the longer term, towards 2050, larger electric aircraft with increased battery capacity are expected to enter into service. Depending on the further evolution of the aviation system in the Netherlands but also in Europe and globally, this may impact the current way of flying and the characteristics of the airports.

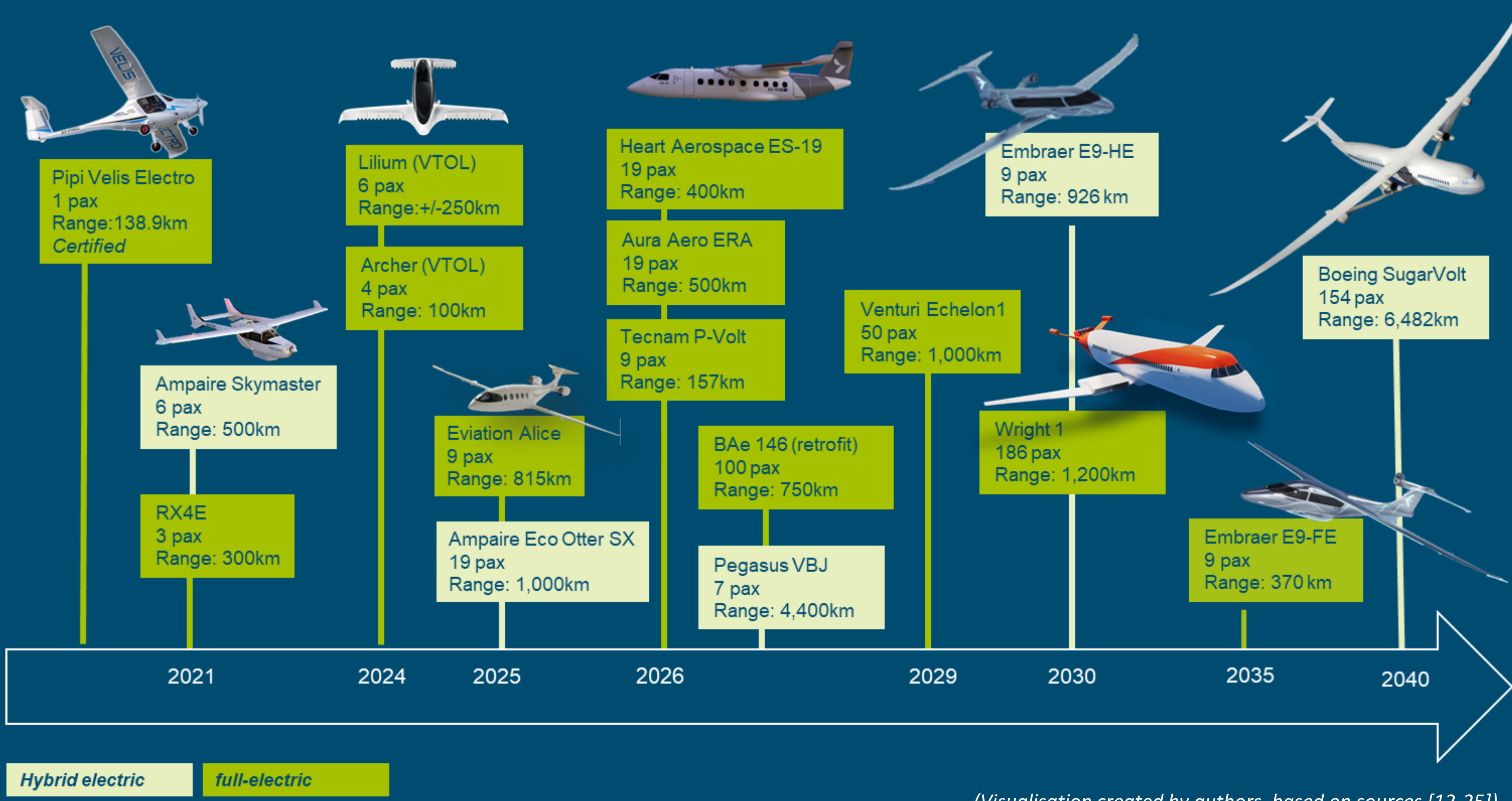
Electric aircraft development started to pick up pace after the introduction of several small electric aircraft like the Pipistrel Alpha Electro between 2010 and 2020.

In general, the following types of aircraft are being developed:

1. General aviation and recreational aircraft
2. Urban Air Taxis
3. Regional and business aircraft
4. Large commercial aircraft

A non-exhaustive list of current relevant projects can be found on the next page. Each party communicates entry into service (EIS) years. It must be noted that in practice these set dates can and often will shift to later dates. Certification and funding are the main delaying factors for this.

The rich palette of electric aircraft projects



(Visualisation created by authors, based on sources [12-25])

Technological challenges of electric flight

- Electric aircraft make use of multiple technologies that are already on the market, for example in the automotive industry: batteries, (fast) chargers, electric motors, battery management systems, etc.
- However, many of these technologies are not fully tailored yet and need more advancement to create an aircraft with sufficient range and passenger capacity.
- Barriers in the development are the very stringent safety and airworthiness requirements in the certification process; although there is good reason to have them, it can prolong the development path by years.
- Moreover, flying electrically requires high-energy density batteries.
- At the same time, to maintain a healthy business case, aircraft need to be in the air as much as possible, demanding short turnaround times and thus quick recharging of batteries.
- Therefore, manufacturers of aircraft, chargers and especially batteries are challenged to increase the capabilities of the components.

This poses the question: where are we today and what needs to be achieved to bridge the gap?

Batteries

- Currently, lithium-ion (li-ion) batteries are most found in electric aircraft. They have one of the best energy-to-weight ratios. Furthermore, the batteries are featured by a low self-discharging rate and a high open circuit voltage[26].
- Although the specific energy density of li-ion is relatively high compared to other chemistries, it is still not sufficient for larger electric aircraft. Li-ion batteries offer as much as 250Wh/kg, which is 50 times lower than kerosene[27].
- This means that today's best performing batteries would have to be levelled up to at least partially meet the performance of kerosene.

Example:

- Bauhaus Luftfahrt developed a concept aircraft “Ce-liner” for 189 pax, range 1,667 km. Powered by two electric fan engines, this aircraft would need 2000 Wh/kg battery packages(!) [28].
- This is out of reach for li-ion. Other battery solutions are needed, such as lithium-sulfur batteries or lithium-air/oxygen. The latter may achieve an energy density of 750 Wh/kg within 15 years, up to 1400 Wh/kg within 30 years[27].

Charging technology and energy supply

Charging technology

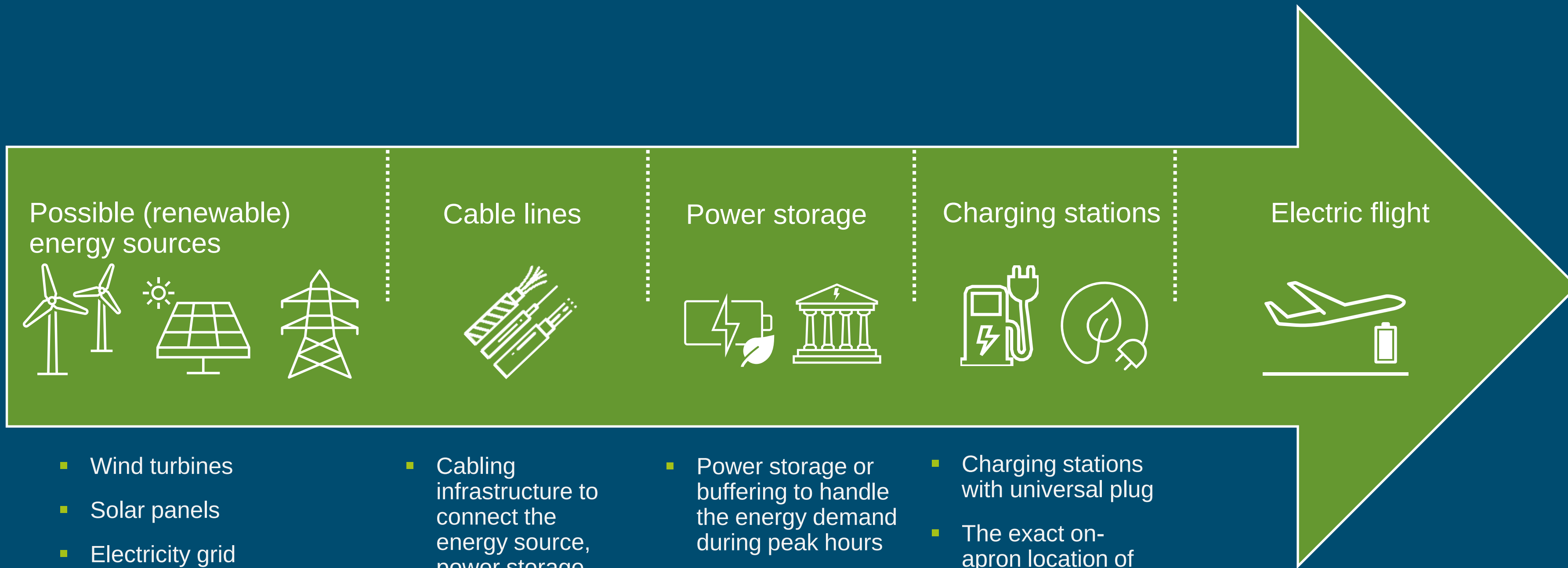
- Charging an aircraft needs to be done swiftly in order to be competitive with regular turnaround times. Therefore, fast chargers are essential for electric aviation.
- Charging technology is under continuous development in the automotive industry and other sectors such as shipping and trucks. Currently, for automotive applications ABB has developed a 350kW fast charger[29]. For heavy duty vehicles experiments have been carried out with Megawatt Charging Systems (MCS) up to 3.75 MW (at 3000 A/1250V)[30]. This might be very interesting for aviation, although it requires very robust energy infrastructure and batteries.
- The alternative for charging would be a battery swap system (BSS) that exchanges the depleted battery for a freshly recharged one. However, based on interviews with manufacturers, due to certification requirements and safety procedures this is not the preferred technology.
- Another step in implementing electric aviation is standardization of charging technology and protocols. In the automotive industry charging is standardized. The standardization is currently being developed under EUROCAE, SAE and ASTM working groups.
- Therefore, for a scaled-up implementation of electric aviation, automation of charging processes and implementation of new safety measures will prove vital.

Energy supply

- The energy supply for the charging stations should be sufficient and robust. For the larger fast chargers high-voltage power supply is necessary. Special cabling needs to be in place and needs to be cooled.
- During peak hours, enough power should be available to be able to charge multiple aircraft at the same time. An energy buffer system would therefore be indispensable.
- Moreover, electric flight can only be zero-emission if the energy is sustainable too. If solar panels or wind energy are used, the peaks of the energy harvest need to be stored.
- The whole airport energy system including energy sourcing will need revision.

From wind and solar to electric flight

To have zero-emission flight, the whole chain should be green.



- Wind turbines
- Solar panels
- Electricity grid

- Cabling infrastructure to connect the energy source, power storage station, and charging stations

- Power storage or buffering to handle the energy demand during peak hours

- Charging stations with universal plug
- The exact on-apron location of the charging stations depends on where the plug is on the electric aircraft

Outlook of electric flight in the Kingdom

Opportunities by 2030:

- A large deal of the commercial air movements in the Netherlands is based on the hub function of Amsterdam Airport Schiphol. The introduction of electric flight would therefore not have a significant impact for the long-haul flights.
- The introduction of fully and hybrid electric 9-seaters and 19-seaters is foreseen before 2030.
- Besides, VTOLs are also expected in this time range, offering local air transportation services between cities or rural areas.
- These Urban Air Mobility (UAM) and regional mobility services with 9- and 19-seaters are very interesting (business) opportunities for the Dutch regional airports and the Caribbean islands.
- Short-haul flights up to 750 km could be partly replaced by (hybrid) electric flights.

Challenges:

- A timely certification is still a challenge for manufacturers.
- Scalability and production/delivery might also become a challenge for manufacturers.
- Funding for manufacturers and R&D: to speed up development in aircraft development getting enough funding is still a challenge
- For airlines, it may be not profitable yet to fly electric aircraft in the early years. Taking this first step of investing in electric aircraft might be a challenge, resulting in a delay of the whole transition.
- The energy supply infrastructure to the airports and at the airports itself need to be robust for high power demand, which will be challenging.
- Electric flight is only zero-emission if powered by renewable energy sources. In the early years converting fully to renewable energy for the amount that is needed is challenging.

In the longer term:

- Towards 2050, larger electric aircraft with improved ranges might be feasible once the battery capacity is increased. Depending on the further evolution of the aviation system in the Netherlands but also in Europe and globally, this may impact the current way of flying and the characteristics of the current airports.

Use case

Electric flight between the ABC islands

Connections between the ABC islands are a perfect use case for electric flight

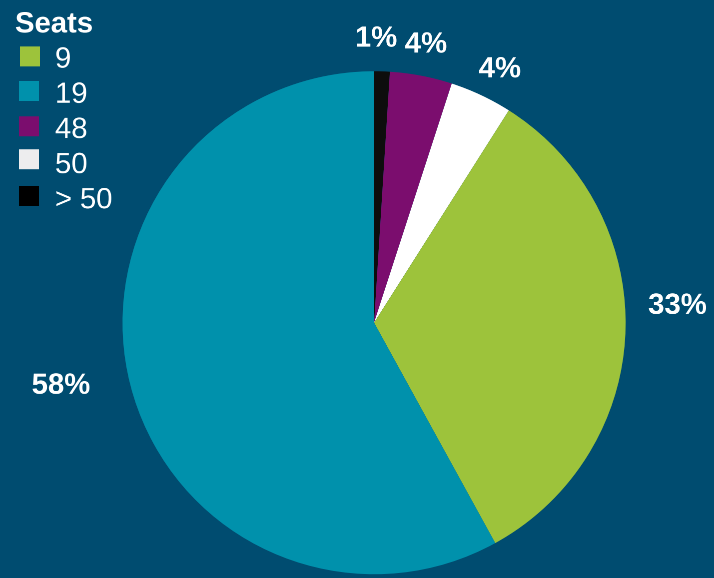
- In 2019, roughly **150,000 passengers** travelled by air between the islands and mostly between the airports of Curaçao and Aruba and Curaçao and Bonaire[31].
- A constant and reliable demand for travel is observed between the islands, both for business and private purposes. For many inhabitants, air transport is not only an important means of transportation, but it is often the only means available.
- Most aircraft movements are carried out by 9- and 19-seat aircraft with Divi Divi Air [32] and EZ Air[33].
- The point-to-point character of the connectivity and at the same time the short distances make it very suitable for the introduction of electric aircraft.
- The inter-island connections have great potential to be replaced by electric 9- and 19-seaters once the necessary infrastructure is there.
- Such a transition does not happen overnight. To get an understanding of what is needed, three phases are defined for which the impact on airport infrastructure and energy supply is derived.

In numbers: domestic inter-island traffic from Bonaire

In 2019, more than 78,000 passengers travelled from Bonaire to Aruba or Curaçao[36].

91%

of the total commercial traffic at Bonaire is done by 9- and 19-seaters, carrying almost 80% of all passengers[36].



Electric flight potential

Potentially, 91% of the traffic could be replaced by electric 9- and 19-seaters[36].

ABC inter-island electric flight - Phasing

A three-phase implementation of electric flight between the ABC islands is outlined below. The transition takes off in 2026 and runs up to 2035. For each phase the required infrastructure, energy and costs are calculated.

Phase 1 – Start of electric flight

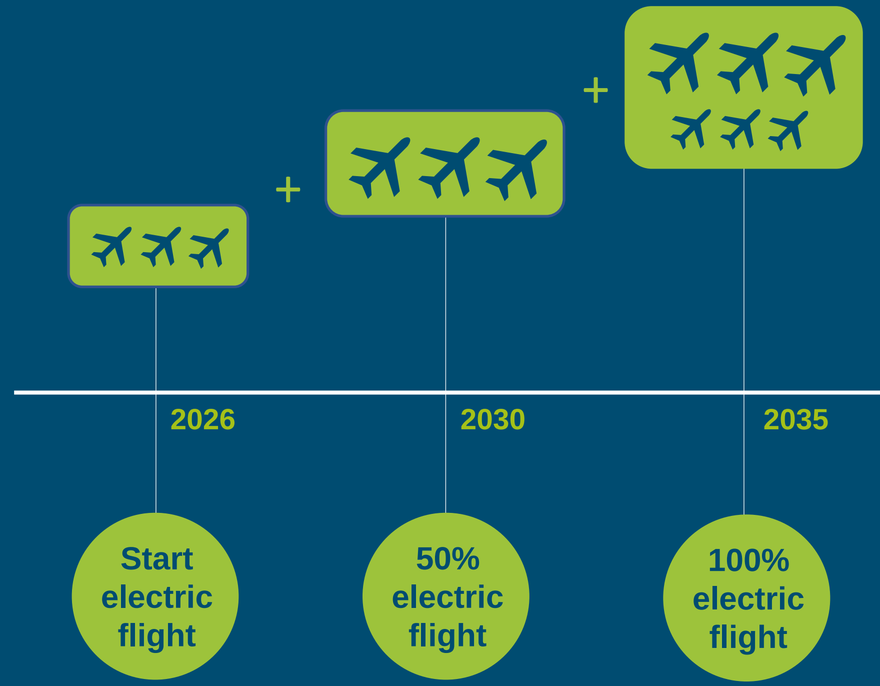
- In 2026, it is expected that the first commercial electric aircraft will have its commercial entry into service.
- Therefore, 2026 is chosen as a starting year. Three 9-seat electric aircraft will be flying the ABC routes.

Phase 2 – 50% electric flight

- The ambition is that 50% of the flights will be carried out by electric aircraft in 2030 as compared to 2019 traffic.
- Therefore, three 19-seaters will be added. The pool of electric aircraft will be of three 9-seaters and three 19-seaters in phase 2.

Phase 3 – 100% electric flight

- Ultimately, in 2035, all air movements between the islands as per 2019 will be electric.
- Another three 9-seaters and three 19-seaters will be incorporated. The total pool of electric aircraft will be of six 9-seaters and six 19-seaters in phase 3.



NB: The scenarios defined for each phase are more ambitious than the ones set in the Luchtvaartnota and AHEV. The proposed phasing should be seen as optimistic scenarios, which are based on technological advancements and achievable if all defined steps are carried out smoothly.


Source: [17]

Eviation Alice | 9 seats | 820 kWh battery | 815 km range [17]

Source: [18]

Heart Aerospace | 19 seats | 900 kWh battery | 400 km range[18]

Use case assumptions

The following operational assumptions were made for the quantification of the use case:

- Two electric aircraft types are used: a 9-seater and a 19-seater (depicted on the left, including specs)
- Each aircraft has a reserve of at least 30% State of Charge (SoC) at the end of its flight. This assumption is based on interviews with manufacturers.
- The time for the turnaround of an aircraft has been set to a maximum of 30 minutes. This assumption is based on interviews with airlines.
- The aircraft should be able to charge after each flight. Therefore, equal energy requirements apply for each island.
- The energy provision at the airport should be high enough to charge the aircraft after 200 km flight within 30 minutes turnaround time. The 200 km distance is more than the distance between the islands but was taken as the maximum flight distance flown before charging to take into account weather variables.

What is the energy requirement and how does it translate into green energy sources?

2026 – per airport

200 km flown

30 min charge

Aircraft stand 1

400kW

Total power required during peak is 400 kW for one station

3MW [37]

3,000 m² [1] **OR** **1x**

Total energy source required

2030 – per airport

200 km flown

30 min charge

Aircraft stand 1

400kW

Aircraft stand 2

900kW

Total power required during peak is 1.3 MW for two stations

3MW [37]

9,000 m² [1] **OR** **1x**

Cumulative total energy source required

2035 – per airport

200 km flown

30 min charge

Aircraft stand 1

400kW

Aircraft stand 2

900kW

Aircraft stand 3

400kW

Aircraft stand 4

900kW

Total power required during peak is 2.6 MW for four stations

3MW [37]

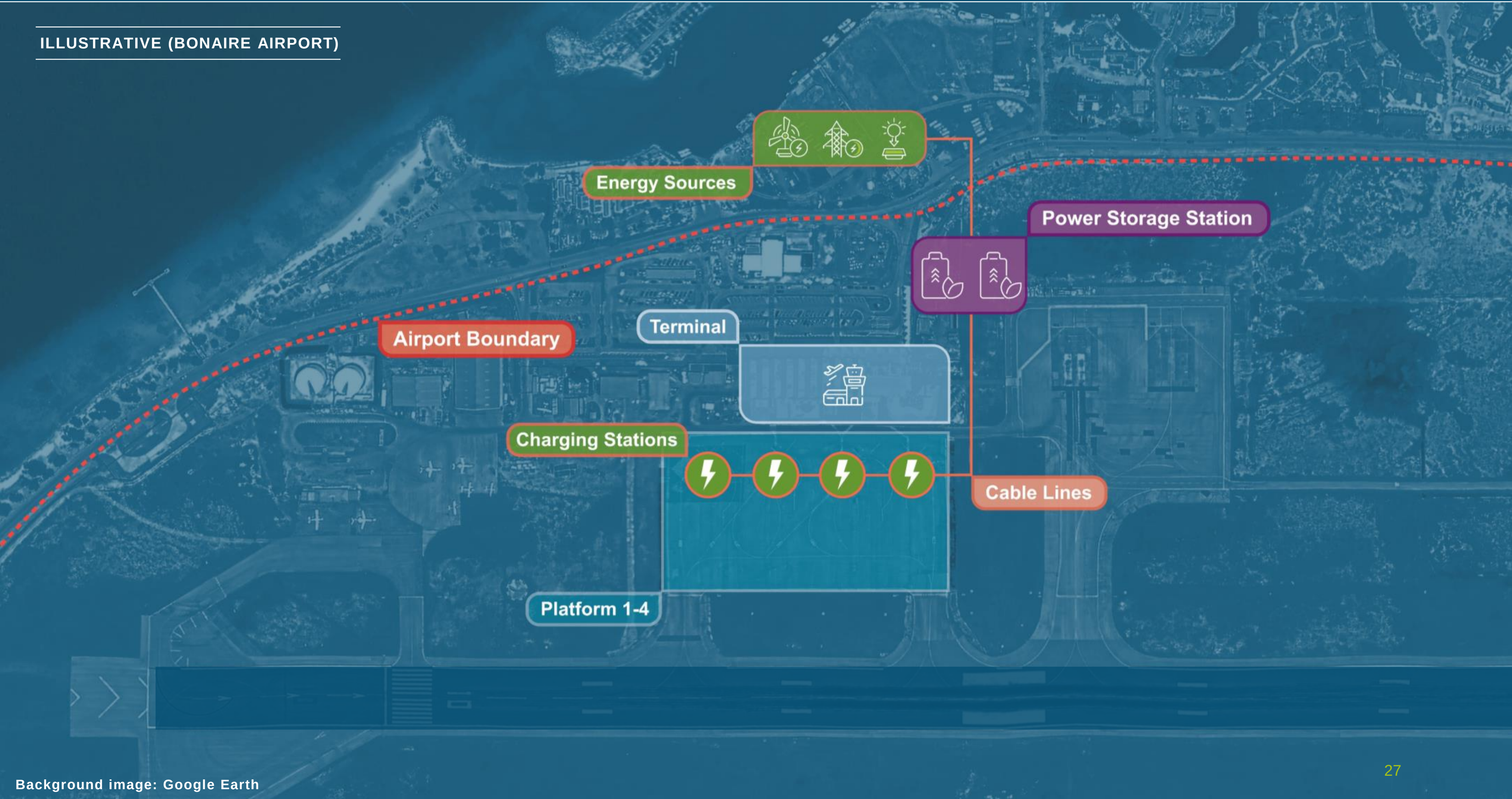
18,000 m² [1] **OR** **2x**

Cumulative total energy source required

[1] It is assumed that one square metre of solar panel installation can generate 200 W peak power

What is the implication of electric flight on the airport infrastructure?

ILLUSTRATIVE (BONAIRE AIRPORT)



Background image: Google Earth

What will the implementation of electric flight cost an airport?

EXAMPLE OF BONAIRE[1]

Infrastructure requirements per phase		Phase 1: 2026	Phase 2: 2030	Phase 3: 2035
	# of additional aircraft simultaneously parked at the airport	1x (9x)	1x (19x)	1x (9x) 1x (19x)
	# of additional charging station(s) required at the airport	1x	1x	2x
	Additional power required during peak periods	1x 400kW	1x 900kW	1x 400kW 1x 900kW

Related cost overview per phase (prices in €)	2026	2030	2035
Connection and installation with energy provider incl. cables and earth works[38] [39]	100,000	50,000	50,000
Stands refurbishment[39]	100,000	100,000	200,000
Charging station incl. installation[38]	350,000	800,000	1,150,000
Power storage station[38]	50,000	100,000	150,000
Risk factor 30%[2]	200,000	350,000	500,000
Total (rounded up)	**1,000,000**	**1,500,000**	**2,200,000**

[1] *Costs are in order of range +/- 50% and approximately the same for all 3 islands. They were estimated for Bonaire Airport as an example*
[2] *Risk factor of 30% is taken from the total costs to reflect on the risk and complexity related to construction on the islands*

What are the costs for an airline?

Electric aircraft are designed to have lower operational and maintenance cost. Manufacturers expect electric motors to reduce maintenance costs by 90% compared to turboprops and fuel costs by 50-75%[10].

The costs of implementation for an airline are split up in investment cost and operating cost. Only the costs which are expected to deviate from conventional aircraft are considered and listed below.

Note that not all costs are available yet, or some are given as estimates.

Costs Deviations

Investment costs

Cost of acquisition of an electric aircraft

Operating costs

Cost of energy carrier [per pax*km]
Based on current kWh price at Caribbean for electric aircraft
Based on gallon price of fuel for conventional aircraft

Costs of maintenance [per year]

Costs per hour

9-seaters

	Eviation Alice	vs.	BN2A-Islander
Acquisition	€ 3,500,000[40]		€ 2,500,000[41]
Energy carrier	€ 0.026[42]		€ 0.028[43,44]
Maintenance	*Not available*		*Not available*
Per hour	*€ 175[53]*		*€ 500**

19-seaters

	Heart Aero. ES-19	vs.	DHC-6 Twin Otter
Acquisition	€ 7,000,000[44]		€ 6,200,000[45]
Energy carrier	€ 0.027[46]		€ 0.033[47]
Maintenance	€ 130,000**[48]		€ 260,000[49]
Per hour	*50-70% lower[18]*		€ 1,160[54]

19-seaters

	Heart Aero. ES-19	vs.	Beech1900D
Acquisition	€ 7,000,000		€ 3,500,000[50]
Energy carrier	€ 0.027		€ 0.042[51]
Maintenance	€ 130,000		*Not available*
Per hour	*50-70% lower[18]*		*€ 1000[52]*

* Based on secondhand acquisition costs of 150k€
**Based on statement maintenance is 50% of equal size fuel plane at [48]

Roadmap

How to get to the first electric flight by 2026?

A roadmap to electric flight

The transition to electric flight calls for a joint effort by multiple stakeholders. This roadmap identifies specific actions for each stakeholder within a concrete timeline. See Roadmap on the next page.

Due to the interdependencies of the stakeholders, their parallel and sequential actions and the suggested timeline to entirely achieve electric flight by 2035, close cooperation among all the parties involved remains essential.

To that end, a collaboration platform is recommended as it will facilitate strategic alignment among the stakeholders to devise a detailed course of action and lead to the development and implementation of technology and the regulatory framework.

Particularly in the light of the ever-evolving technological developments, it is strongly advised to adopt a lean approach to electric flight implementation. This entails periodically revisiting and reviewing e-flight resources, assets, processes and operations to identify and act upon optimization areas during and after implementation.

The roadmap

Actions	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Inform aviation stakeholders on electrification developments	Government	Government	Government	Government	Government	Government									
Stimulate fast certification and standardisation	Government	Government	Government												
Certification process adaptation for electric aircraft and airport infrastructure	Authorities	Authorities	Authorities	Authorities											
Inform on electric aircraft capabilities, requirements and cost	Airline	Airline	Airline	Airline											
Prepare transition plan to increase sustainable power capabilities	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers										
Work on range and capacity increase of electric aircraft	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs	OEMs
Facilitate development of sustainable power generation		Government	Government	Government	Government	Government	Government	Government	Government	Government	Government	Government	Government	Government	Government
Prepare business case for green energy as resource for electric aircraft		Energy Providers	Energy Providers	Energy Providers											
Support standardisation of charging stations and power plugs		OEMs	OEMs												
Define universal standards for charging stations and procedures		Authorities	Authorities	Authorities											
Define guidelines for fire department at the airport		Authorities	Authorities	Authorities											
Share aircraft specifics and requirements with other stakeholders		OEMs	OEMs												
Work with the government on strategy plan for renewable energy sources		Energy Providers	Energy Providers												
Investigate replacement potential of eletric aircraft within company		Airline	Airline	Airline											
Set up pilot training		Eductional Institutes	Eductional Institutes												
Set up research programs			Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes
Upscale energy requirements to allow for higher demand			Airport	Airport											
Investigate revenue potential of electric flying			Airline	Airline											
Train pilots, ground staff and handlers				Airline / Airport	Airline / Airport	Airline / Airport									
MRO adaptation for electric aircraft and training of staff				OEMs / Airport	OEMs / Airport	OEMs / Airport									
Design ATM procedures and routing for electric aircraft				Purple	Purple	Purple									
Start transition to 100% green power sources				Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers	Energy Providers
Introduce electric motors in propulsion curriculums				Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes	Eductional Institutes
Purchase infrastructure (charging stations, energy storage etc.)				Airport	Airport										
Update/optimise flight schedule and network for eletric flights					Airline	Airline									
Integrate electric aircraft into fleet and operations					Airline	Airline	First Electric Flight → continuous improvement and upscaling	→	→	→	→	→	→	→	→
Install infrastructure					Airport	Airport									

Authorities · ANSP's · Energy Providers · Eductional Institutes · OEMs · Airline · Airport · Government · First Electric Flight

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