



CAAM
Canadian Advanced Air Mobility Consortium

Pathway to Zero Emission Aviation by 2040 in British Columbia

An Executive Brief | August 2020



*Designed and adapted in collaboration with El Fly Norway. Credit to [Avinor](#)
& [Luftfartstilsynet](#)*

Background

The Provincial Government has outlined the Zero-Emissions Vehicles (ZEV) Standard in the CleanBC Plan released in December 2018. The legally binding ZEV Standard outlines that all new light-duty cars and trucks sold in British Columbia will run on clean electricity from batteries or hydrogen fuel cells by 2040. Specifically, by 2020, the Provincial Government of British Columbia activated the ZEV Standard to make sure British Columbians have access to the numbers and types of zero-emission vehicles they want. The standard will require automakers to meet an escalating annual percentage of new light-duty ZEV sales, reaching:

- 10% in 2025
- 30% in 2030 and
- 100% by 2040.

The Canadian Advanced Air Mobility Consortium proposes a programme for the introduction of Zero-Emission Aviation in British Columbia building on the established and legal policy platform of the ZEV Standard. The programme is to be formulated in accordance with the 25+ organizations of the Canadian Advanced Air Mobility Consortium, the National Regulators of Transport Canada & NAV Canada, the varying Ministries of the Province of British Columbia and close collaboration with the Nordic Electric Aviation Group (Figure 1.0). This program 'Pathway to Zero-Emission Aviation by 2040 in British Columbia', in practice means that recommendations will be expressed as goals, measures and instruments for the introduction and safe operation of Zero-Emission Aircraft (ZEA) for all domestic commercial aviation flights in British Columbia.

The CleanBC framework has established goals that by 2030, fossil fuel use for transportation has dropped by 20%. The Canadian Advanced Air Mobility Consortium proposes to be the

provincial leader in driving the aviation industry to represent our commitment in achieving these goals.

NORDIC NETWORK FOR ELECTRICAL AVIATION



*Figure 1.0 Collaboration with the Nordic Network
for Electrical Aviation*

Problem Identification

Greenhouse gas emissions from many sources, including air travel, must be reduced significantly over the coming decades. To achieve the targets set out in the Paris Agreement, we

must cut our greenhouse gas emissions from fossil fuel sources to almost zero between 2050 and 2100, depending on the magnitude of possible emission reductions in the short term.

In British Columbia, we depend on aviation and we must search for fossil fuel-free alternatives.

The aircraft currently in use on the short-haul network needs to be replaced within the next 10–20 years. Some operators of the short-haul network, specifically Helijet International & Harbour Air, are clearly stating that the next generation of aircraft should be zero- or low-emission solutions and have taken public actions towards that vision.

If it proves impossible to identify aircraft types or technologies capable of operating on the short-haul network, the consequence will be either a reduction in the quality of the service and/or a greater divide in the equity and accessibility for all residents, Urban, Rural and Remote Indigenous Communities.

What do we want to achieve?

To ensure high-quality transport services continue to be offered in British Columbia, it is in British Columbia's own interest – from the perspective of both the environment and climate and transport policy – that zero- and low-emission aircraft are developed which are capable of operating on the unique British Columbia domestic short-haul network under the prevailing meteorological conditions in the province.

In the long term, it is anticipated that ZEA will have lower operating and investment costs than fuel-based aircraft. This is an important premise for the further comparable fossil development of ZEA and helps to explain the level of interest amongst many stakeholders. Electrification and hydrogen fuel cells should also result in more energy-efficient motors, and as a consequence, a reduction in overall energy consumption, in addition to simpler maintenance and greater

flexibility in terms of design. In the long term this can enable completely new types of aircraft requiring reduced runway lengths or vertical takeoff and landing capacity.

An initiative to move to Zero-Emission Aviation can also generate new jobs in British Columbia. No aircraft for use in passenger service are currently being manufactured in British Columbia, however it is possible to envision a market in which specialized British Columbia companies operating as subcontractors could produce components and parts for ZEA given the advancements in 3D printing and rapid prototyping within the provincial tech sector. Boeing Canada, which has set up a digital operation in Richmond, is a good example for a company to expand upon manufacturing opportunities. Furthermore, it is possible to imagine industrial development in the aviation ecosystem, e.g. within charging and hydrogen production.

The phasing-in of ZEA can help to ensure the fulfilment of national and international climate commitments. As in the photovoltaic cell industry, the automotive industry and eventually also in ferry traffic, advances made in British Columbia, i.e. using British Columbia as a development arena and test market, could have impacts in terms of emission reductions beyond the emission reductions that are actually achieved in British Columbia.

Why British Columbia?

British Columbia's dependence on aviation, abundant access to renewable electricity, unique short-haul network, active and interested stakeholders and political will to decarbonize the transportation sector, make British Columbia both well-suited and recognised as a very interesting test area and the first market for Zero-Emission Aviation operations. If British Columbia does not take the lead, there is also a risk that the zero- and low-emission aircraft developed will be unsuitable for British Columbia winter conditions and runway lengths on the short-haul network. The United Nations International Civil Aviation Authority (ICAO) is also indicating that Zero-Emission Aviation is presenting an excellent opportunity to show that

aviation is actively taking steps to reduce greenhouse gas emissions and that the initiative and level of interest in British Columbia is of high value from a global perspective.

Technological Status

By 'Zero-Emission Aircraft (ZEA)', we are referring to aircraft which are fitted with one or more electric motors for propulsion by battery or hydrogen fuel cell.

The pace of development of ZEA has accelerated over the past four to five years. According to consultancy firm Roland Berger, as of January 2020, there are over 200 initiatives of varying maturity working to develop and realize electric, hydrogen fuel cell and/or hybrid-electric aircraft for passenger transport use. Many of these are fixed-wing aircraft or vertical takeoff and landing aircraft, which in the short term, we consider to be of greatest relevance for British Columbia conditions in relation to both range and capacity (number of passengers).

Many small companies and start-up businesses are positioning themselves in the up to 19 seats segment (certified aircraft in accordance with Transport Canada regulations), but some of the larger players also have development projects under way in this segment. As regards larger aircraft, it is the major players, most notably Airbus, Safran and Rolls-Royce, which have a clearly stated strategic position that decarbonization is part of the future, but Boeing, Embraer and all the major engine manufacturers also have ongoing ZEA projects.

Airlines are also expressing interest, and many airlines in the USA and Northern Europe (Widerøe, Logan Air, SAS, EasyJet, etc.) have been clear as regards their wishes and expectations, and also have collaborative projects with aircraft and aircraft engine manufacturers.

It seems clear that there are no insurmountable technological obstacles to developing ZEA. Based on our existing technological know-how and the expected pace of development, it should



be technically possible to develop, certify and introduce aircraft carrying up to 19 passengers on regular civil scheduled flights from 2025–2030, and larger aircraft after that.

Battery technology is one of the biggest technological obstacles to the rapid development of battery electric aircraft. Current dominant battery technology (Lithium-ion) offers an energy density of about 250 Wh per kg battery. This figure is expected to increase by 50–75% to 400–450 Wh/kg. Developments are taking place rapidly in this field, and batteries have also become significantly more affordable over the past decade. The next generation of batteries is expected to be 'solid state' batteries, which at present appear to have a potential maximum energy density of just over 650 Wh/kg. This will have a major impact on the range of electric aircraft.

Based on current battery technology and certification standards, up to 19 seats and about 350–400 km of effective range (>500 km of actual range due to energy reserve) appear to be of greatest relevance for first-generation battery electric aircraft. However, this is sufficient for many domestic flights in British Columbia, including the vast majority of routes on the British Columbia short-haul network.

For longer range, given current known battery technology, it will be necessary to rely on series hybrid solutions, where the aircraft is equipped with a battery and a "range extender", such as a generator powered by jet biofuel, which can charge the batteries as and when necessary, or hybrid solutions that have both electric and conventional jet engines. A third possibility is to use fuel cells. There are players in all these segments.

It is important to stress that the development of ZEA is still in its infancy, so it is not possible at the present time to make accurate predictions as regards timespans or costs. To date, the only certified aircraft with electric propulsion are motorized gliders, however a number of projects are in the process of being certified. As of 2020, many manufacturers are currently testing ZEA around the world, but only Pipistrel is actually delivering electric aircraft to customers (the two-seater Alpha Electro with a range of about 130 km + reserve). However, "all" aircraft and aircraft

engine manufacturers are actively working on ZEA. This is an important difference from the automotive industry, where it could be argued that the dominant car makers initially "obstructed" the electrification of road traffic but have since fully embraced the idea.

Challenges which must be overcome

On the technology side, the biggest challenge is to develop appropriate total solutions for new aircraft. Electric motors, generators, power distribution systems, energy storage (batteries/hydrogen/other) and airframes must be developed which are adapted to new technologies. Thermal control, high-voltage, electromagnetic radiation, energy density, weight reduction and safety requirements are some of the challenges highlighted by aircraft and engine manufacturers. Manufacturers do not see these challenges as insurmountable but overcoming them will require new and effective forms of collaboration and facilitation.

We believe it will be technically possible to develop aircraft that can operate on the short-haul network in British Columbia (with up to 19 seats and capable of withstanding British Columbia winter conditions) and put them into service between 2025 and 2030. However, there is a risk that aircraft manufacturers will not find the segment sufficiently interesting (especially 800 meter runways) to invest in it.

Aviation regulations have mainly been written for fossil-fuel based engine systems and aircraft. The development of new technology, aircraft and operating concepts will affect the entire aviation system. It may lead to changes in safety regulations and requirements regarding the certification of parts (propulsion systems) and aircraft, airports including all ground-based infrastructure, pilot training and certification, air operations regulations and maintenance systems. If the development of the framework does not form an integral part of technology development, it could delay the processes involved.

Even if effective regulation is facilitated, it will take both time and resources to develop and certify an electrified aircraft. Most companies that are developing smaller aircraft (up to 19 seats) have limited funding available to them, and there is a risk that companies will be unable to secure financing in order to complete the development process and actually launch an aircraft on the market. The larger aircraft manufacturers - which have access to more funding - have so far shown relatively modest interest in developing smaller aircraft for short runways.

For the airlines, there is always some risk associated with being the first to buy a newly developed aircraft, and it can be assumed that this risk will be even greater when brand new propulsion technology is introduced. Risk mitigation for airlines looking to invest ZEA would seem to be crucial.

Summary of Recommendations

Based on the mapping and assessment of technology, challenges, and opportunities, we have developed a set of recommended goals and associated measures and instruments to achieve the goals. The sum of the recommendations is the Canadian Advanced Air Mobility Consortium and aligned with CleanBC's ZEV Standard for the 'Pathway to Zero-Emissions Aviation by 2040 in British Columbia' in Commercial Air Transport.

British Columbia depends on aviation, and aviation must be considered to be part of the public transport network across much of the province. The Canadian Advanced Air Mobility Consortium therefore believes that it will be vital for British Columbia to have concrete and timed goals concerning implementation and emissions reductions, as well as a goal of being a driving force and an arena for the development and implementation of new technology which will lead to significantly lower emissions and help us meet our climate obligations. In the long term, greener aviation is also expected to become significantly more affordable both for air passengers and for the province compared with fossil fuel-based solutions.

British Columbia already has something of a position as a driving force and is promoting the ZEA, and by setting clear and ambitious provincial goals through the ZEV standard, it will be possible to further develop this position. By taking a leading role, we can facilitate the international cooperation that will be necessary and at the same time increase the likelihood of new technological solutions being able to cope with British Columbia climatic and topographic conditions, short runways and the needs of passengers and the market. Aviation will be able to draw on British Columbia's experiences of decarbonization within the maritime and private car sectors, and British Columbia and the Cascadia Region of Washington State and Oregon State may be an important first market for regional aircraft with zero or low emissions.

It is vital that goals, initiatives and instruments are seen as an entirety. We recommend that the Provincial Government establishes clear goals which are formulated in such a way that they appear effective and concrete – and that they set out a clear direction. This will be especially important for the market players involved. However, the goals will only have the desired effect if they are followed up with binding and predictable incentives which are effective in all phases until ZEA are in regular scheduled traffic in British Columbia. We particularly wish to emphasise the importance of measures that will make the early adoption of new and climate-friendly technology both profitable and attractive to passengers, operators and other stakeholders alike.

We have chosen to divide the development process from today through to the established commercial operation of zero-emission passenger aircraft into three phases. Each of these phases has its own special characteristics and we have assessed initiatives and instruments linked to each of them. The recommended goals are long-term in nature and extend across all phases (Figure 2.0).





Figure 2.0: Phases in the development and phasing of Zero Emissions Aircraft

Goals

- British Columbia will be a driving force and arena for the development, testing and early implementation of ZEA.
- By 2030, the first ordinary domestic scheduled flights will be operated with ZEA.

- By 2040, all civil domestic aviation in British Columbia will be operated with ZEA, reducing greenhouse gas emissions by at least 80% compared with 2020.

Technological Development

- To ensure a systematic and holistic approach to technological and conceptual development for regional ZEA, the joint multiannual international zero-emissions programme developed by the Norwegian and European civil aviation authorities (through CAA Norway and EASA) will be key partners in helping transfer learnings, insights and policies to the Provincial Government of British Columbia. The programme will include goals, measures, instruments, and organisation – and have provincial, national and international elements. It will build on the information presented in this executive brief and the bilateral innovation agreement between the Canadian Advanced Air Mobility Consortium and the Nordic Electric Aviation Group (*pending*).
- A working group (the High Level Task Force for Zero-Emission Aviation) with key local and international players (airlines, aircraft manufacturers, aircraft engine manufacturers, airports and public authorities), facilitated by the Canadian Advanced Air Mobility Consortium, will develop a roadmap for innovation relating to zero-/low-emission regional aircraft for presentation to the Ministry of Transport and Infrastructure in summer 2021. It is recommended that the roadmap and associated recommendations form the basis for further measures and that relevant aspects be incorporated into the work relating to the CleanBC Plan.
- To address and further develop the zero-emissions programme, an international arena/centre is established in British Columbia for the development, testing and

implementation of zero- and low-emission aviation technology. This will be organised either virtually or physically and will act as an arena for cooperation between players in different fields (aircraft, engines, batteries, airlines, airports, government authorities, research communities, etc.) and other stakeholder groups. Clear criteria for participation and a funding model for the centre must be established, where users, suppliers, the public support system and public authorities contribute. Clear evaluation criteria should also be developed for the selection of measures which will be eligible for support. The centre will contribute to effective and efficient innovation and be organised with provision for both Canadian and international involvement and support.

- Suitable airspace should be established, including approach and departure zones, which are intended for testing purposes and meet the necessary safety requirements. This is intended to be completed in conjunction with NAV Canada's Vancouver Airspace Modernization Project currently underway.
- Government ministries and agencies, provincially funded companies and the public support system must work together more closely and in a more coordinated manner regarding aviation and climate. The clear delegation of responsibility and appropriate processes for ongoing coordination and prioritisation are essential to facilitate effective and targeted innovation. It is recommended that the Ministry of Transport and Infrastructure establishes clear guidelines for further work.
- Design an administrative and economic scheme which supports the establishment and operation of facilities and organisation linked to test activities in British Columbia. It should be possible to partially fund such a scheme through one or more of the existing national instrument schemes. The scheme must also be based on clear evaluation criteria for the selection of measures which will receive support.
- A targeted dialogue with the public support system should be established in order to

assess whether any of the current schemes can be utilised, or whether new schemes should be established to support measures relating to aviation and climate.

- British Columbia is taking on a clear role in influencing the United Nations International Civil Aviation Organization (ICAO) research programme for a comprehensive initiative relating to ZEA.
- Develop and implement a communication strategy with messages relating to the initiatives and measures that are being launched. Players must be encouraged to contribute articles, lectures and meetings in important arenas in order to promote the work linked to aviation and climate in general – and the development of low- and zero-emission technology in particular. The communication strategy shall include the need for communication in international arenas.

Risk Mitigation

- Establish a grant scheme to develop charging infrastructure at British Columbia airports similar to the BC Air Services Fund run by the Ministry of Transportation and Infrastructure.
- Establish support schemes for the procurement of ZEA. This may be already of relevance in local operators capital planning phases, so a close dialogue with relevant ministries and utility companies (BC Hydro & Fortis) concerning how such a scheme could be designed will be important. Alternatively, government loans and guarantees may be an appropriate instrument.
- Consider appropriate new elements in future tender contracts (routes covered by a public

service obligation – PSO), such as investment support, residual value guarantees and longer contracts. The purpose of the incentives is to ensure that future contracts are formulated so that the level of risk is reduced to acceptable levels if zero- or low-emission aircraft are introduced on routes covered by a PSO.

- Exemption from PST for ZEA used in voluntary activities (e.g. run by flying clubs), flying in flying clubs and private flying. Such an exemption – as applies in the case of road traffic – could have a major impact on general aviation in British Columbia, while the loss in revenue for British Columbia will be modest. As it is precisely in the general aviation and flying school segment that electrified aircraft can first be put into operation and tested, the impact will be significant.

Operations

- The Province of British Columbia should require regions and municipalities to include emission-based evaluation criteria in future invitations to tender for routes covered by a PSO. Alternatively, explicit zero-emission requirements or defined maximum emissions may be imposed. A grant scheme should be established for regions and municipalities to cover the added costs that such a requirement can be expected to entail during a transitional phase. In addition, a bonus scheme may be established which will have a positive outcome for suppliers if they phase in zero-/low-emission technology during the contract period. Due to experiences gained during the introduction of electric ferries and vehicles, consideration should be given to whether the Provincial Government can support the regions and municipalities in the formulation of these requirements.
- The Provincial Government should give out a clear signal that the tax system will be

aligned so that travel by ZEA will become more affordable in relative terms. For example, tickets for flights operated by electrified aircraft could be exempted from fiscal taxes for a transitional period. Such a tax policy would accelerate the development, production, and procurement of zero- and low-emission technology.

- Exemption from or reductions in PST on tickets for air travel by ZEA through to 2040 (possibly with re-evaluation in 2035).
- Exemption from or reductions in air passenger duty for ZEA through to 2040 (possibly with re-evaluation in 2035).
- Reduced aviation charges (Airport Authorities, NAV Canada) (evaluated in accordance with federal regulations)
- Reduction in electricity or hydrogen fuel rate for aircraft used in commercial operations in accordance with a model taken from the shipping sector
- The Province's travel agreements require business travel to be made in the manner that is fastest and most affordable way for the Government. In future travel agreements, climate considerations should be afforded weight and form part of the evaluation basis when procurement agreements are established, and employees choose their mode of travel. The aim is to provide clear signals from the public administration in British Columbia about the importance of more climate-friendly aviation and offer both manufacturers and operators an incentive.
- British Columbia supports the development of an eco-labelling system in aviation, regardless of whether this is a provincial, national or a global scheme. To promote new technology, the system must be scalable, so ZEA are accorded considerably better eco-labelling than existing traditional solutions. The aim is to help climate labelling become a clear and predictable incentive for manufacturers and operators of zero- and low-

emission technology.

Goals

Technological Development

- International innovation cooperation**
- National coordination**
- Innovation arena/centre in British Columbia**
- Collective expertise**
- Access to infrastructure and airspace**
- Financial support for testing and development**

Risk Mitigation

- Grants for charging infrastructure**
- Support scheme for purchase of aircraft**
- Possible Provincial guarantee concerning residual value**
- PST exemption for light aircraft**

Operation

- Requirements for routes covered by a public service obligation (with grant scheme)**
- Exemption from air passenger duty**
- Exemption from PST on tickets for air travel**
- Reduced electricity or hydrogen fuel rate for charging of aircraft**
- Reduced aviation charges (evaluated in accordance with Transport Canada regulations)**

Designed and Written in Vancouver, British Columbia, Canada

Canadian Advanced Air Mobility acknowledges this work was completed on the unceded and traditional ancestral territories of the Coast Salish Peoples of the Skwxwú7mesh (Squamish), xʷəəθkwəəy̓əəm (Musqueam), kwikwəəχ'əəm (Kikwetlem), qícəəy̓ (Katzie), Kwantlen and Semyome (Semiahmoo) Nations.