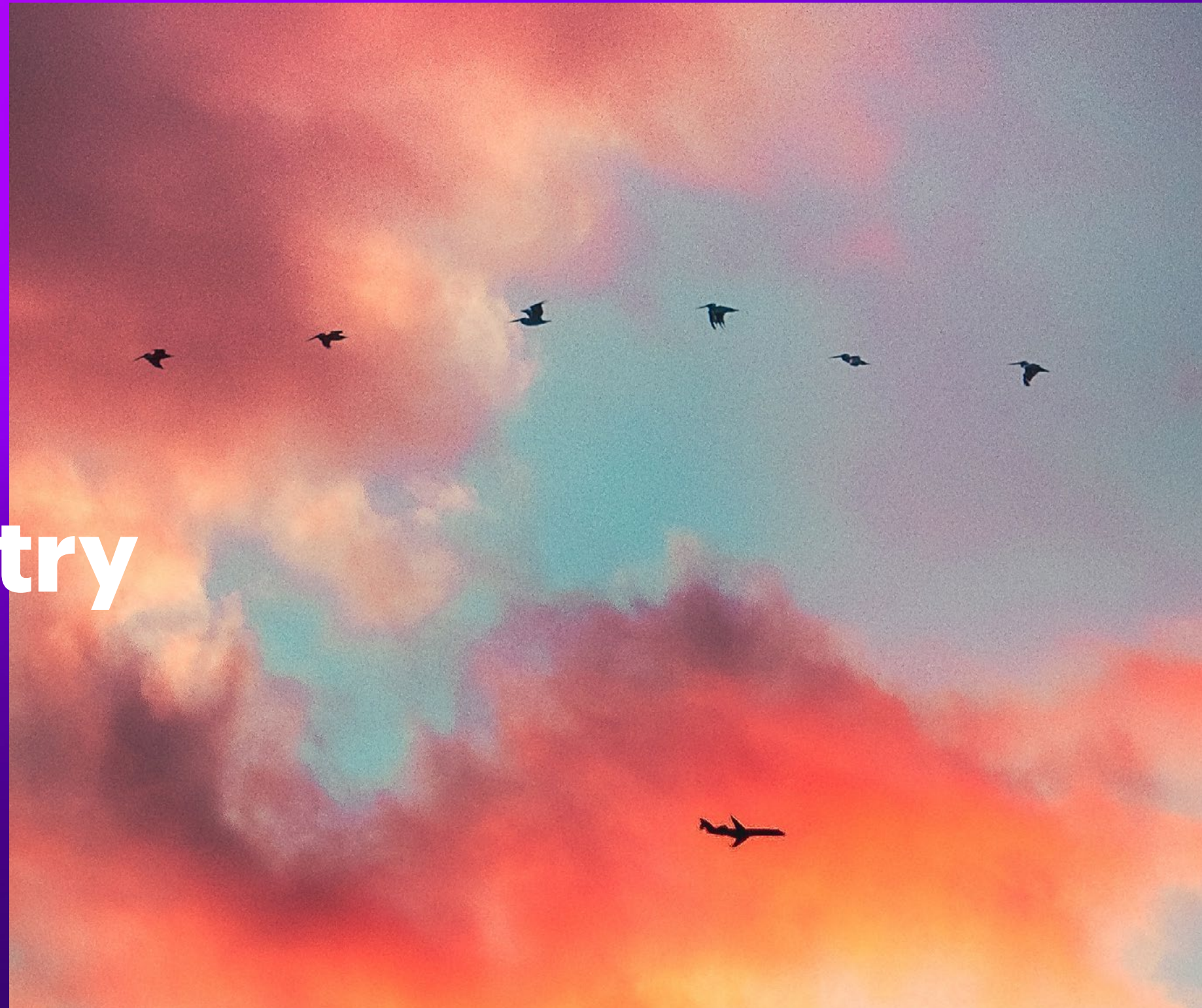


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Sustainability takes off in aviation industry

A blueprint for a shorter
runway to net-zero emissions



The aviation industry has been home to great innovation since its inception in 1903, when the Wright brothers became “first in flight.” Today, that innovative lens has a new focus: **creating a more sustainable sector.**

The number of global air passengers is projected to nearly double over the next 20 years.¹ This growth will drive higher fuel consumption, which is expected to climb to 1.4 billion liters (370 million gallons) of jet fuel per day.² More fuel consumption means more carbon emissions, and without action, aviation-related emissions are likely to increase 40% by 2040.³

Indeed, it won't be long before the sector sees emissions on a new scale. While the aviation industry carbon emissions are about 2% of the current annual global carbon budget, experts forecast aviation to consume between 12-27% of the remaining carbon budget through 2050 to limit global temperature rise below 1.5C above pre-industrial levels.⁴

Understanding the stakes, the aviation industry has committed to reaching net-zero emissions by 2050. However, no single strategy can deliver on this promise. It will require a combination of industry and government initiatives and ecosystem plays to simultaneously decarbonize the energy supply and deploy new technologies needed to fully realize the benefits of carbon reduction.

Decarbonizing the energy supply may take the form of sustainable aviation fuel (SAF), hydrogen or electric infrastructure. Prioritizing and mobilizing new onboard aircraft technologies into the airline fleets is equally complicated. We have identified 11 priority technologies in the areas of new energy pathways, engine technology, airframe configurations, structures and onboard systems that have the greatest potential for successful mobilization in the 2030-2050 timeframe.

Government and industry need to be aligned in terms of planning, funding, standards and safety, however, for these technologies to succeed. It will take time, but with the proper flight path, the aviation industry may land on its emissions reduction objectives.

Net Zero 2050: A daunting challenge

The aviation industry has been committed to creating more sustainable operations for some time now. Modern aircraft produce 50% less CO₂ than the same flights in 1990.⁵ Each new generation of aircraft has typically improved fuel efficiency by 15% to 25% on a per-passenger-kilometer basis. Still, much work remains to be done.

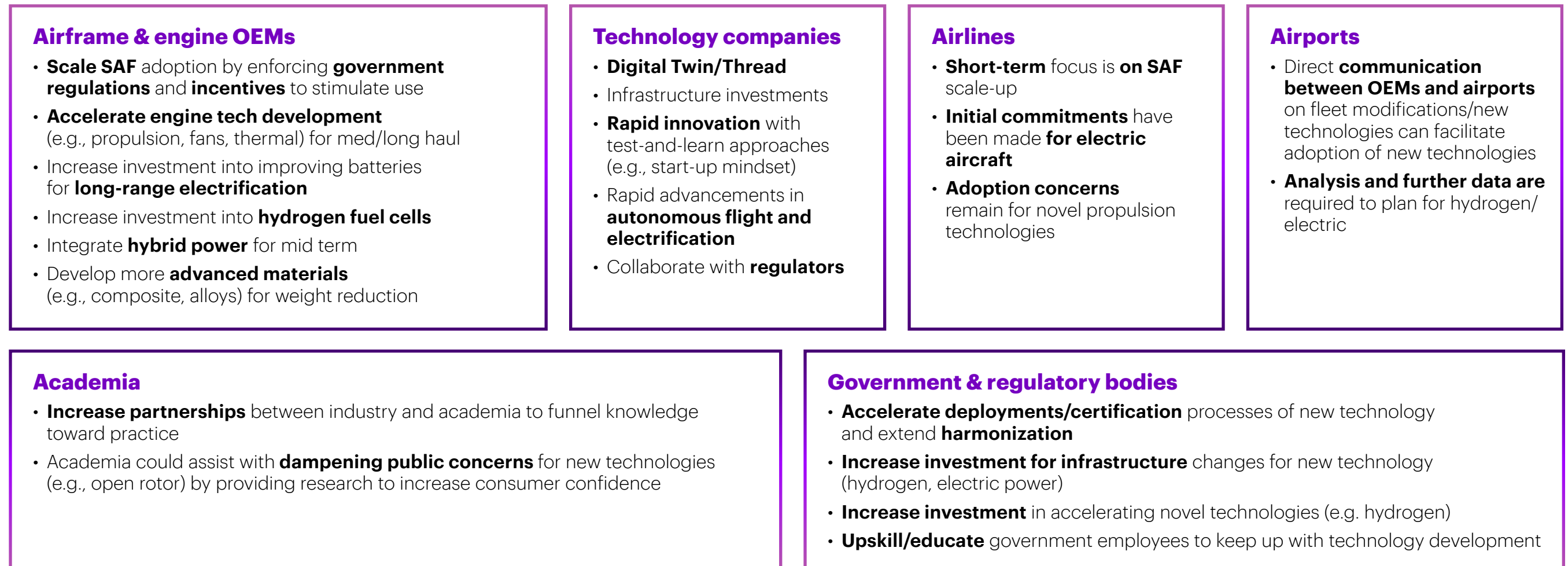
In aerospace, many onboard aircraft technologies have the potential to reduce carbon emissions. Our methodology (Figure 1) accounts for key aspects: specific improvements attributable to each technology, which market segments the technology will be mobilized in, and fleet size/flight operation characteristics for different aircraft market segments.

Figure 1—Aircraft technology decarbonization selection methodology



This methodology drew heavily from research and literature review. Accenture’s researchers also relied on a series of executive interviews with industry stakeholders—including aircraft OEMs, tier-one suppliers, airlines, airports, government agencies and academia. The interviews explored a wide range of topics, from technology to solution time horizons to partnership opportunities. The result was the several common themes across the stakeholder segments coming to light, as depicted in Figure 2.

Figure 2—Common themes and insights from stakeholder executive interviews



Timing is everything: No quick fix

Reaching net-zero carbon emissions by 2050 will require the industry to deploy new onboard aircraft technologies. The mobilization of these technologies will need to take place over a long time frame, though. Myriad technology candidates were identified from the initial list of 35 technology candidates (Figure 3) which emerged from the ATAG Waypoint 2050 report, stakeholder interviews and industry research. This initial long list covers a broad range of engine, new energy pathways, aircraft structures and systems.

For each of the initial technology candidates, we assessed decarbonization potential, technical readiness and market segment applicability. Today, technologies like composite structures and flight deck optimization software are already on their way to being adopted at scale. However, many of the technologies identified will need broader support in the form of investments and prioritizations both in the mid-term and long-term horizons. Here's how they break down in terms of time frames:

- **Today-2030:** Near-term, market-ready technologies
- **2030-2040:** Mid-term technologies, typically in planning stages
- **2040 and beyond:** Promising longer-term technologies, mostly in research and development

Figure 3—Technology and solution candidates

Identified technologies

- Bladeless propulsion (UAM)
- Advanced composites
- Morphing wing
- Double bubble fuselage
- Electric/advanced auxiliary power units (APUS)
- Canard box wing transonic truss-braced wing (ttbw)
- Blended-wing body (BWB)
- Open rotor
- Active load alleviation
- Riblets
- Flightpulse
- Electric vertical takeoff and landing (EVTOL)
- Advanced turbomachinery
- Autonomous flight
- Civil supersonic jet engine
- Plasma combustion
- All-electric propulsion
- Advanced fly-by-wire system
- Laminar flow control technology (natural and hybrid)
- Digital thread
- Structural health monitoring
- EV charging
- Folding wing tip
- Adaptive trailing edges
- Direct air carbon capture
- Aircraft surface treatment technologies (LEAF)
- High-pressure ratio core engines
- Geared turbofan engines
- Hybrid-electric propulsion
- Wingtip devices
- Fuel cells for onboard power
- Electric taxiing
- Hydrogen propulsion

By defining specific time frames and the technologies that are not near-term and market-ready, we developed a focused list of 11 technologies (Figure 4) that could be mobilized in the mid-term and long-term horizons.

Figure 4—Focused list of 11 technologies

Grouping	Technology	Description
New energy pathways	All-electric propulsion	Engine technology that utilizes electric motors to drive conventional propellers or a set of small fans; power is stored in batteries.
	Hydrogen propulsion	Hybrid-electric, motor-driven propulsion powered via fuel cells or hydrogen combustion through modified gas turbine engines; liquid hydrogen is used as fuel for combustion with oxygen.
	Hybrid-electric propulsion	Propulsion system that utilizes a battery-powered motor and a conventional gas turbine engine. This is categorized as being both an engine technology and new energy pathway since it will need to utilize batteries in conjunction with jet fuel.
Engine technology	Open rotor	Engine technology that uses an unducted fan or propfan that increases engine bypass ratios and fuel efficiency.
	Geared turbofan	Engine technology that utilizes a gearbox between the fan and the compressor; each rotates at the most efficient speed, improving the propulsive efficiency of the engine.
	High-pressure ratio core engines	Engine technology with an enhanced efficiency compressor that operates at a higher pressure, reducing engine weight and improving thermal efficiency, which delivers more power and increases fuel efficiency.
Airframe configurations	Blended-wing body	Aerodynamic technology for a fixed-wing aircraft without clear differentiation between wings and fuselage; airfoil-shaped bodies and high-lift wings significantly improve lift-to-weight drag ratio.
	Transonic truss-braced wing	Aerodynamic technology that utilizes a structural wing support to allow for larger wing spans without increases in structural weight; increasing the span reduces drag and the higher wing position can enable larger engines, like open rotors.
Structures	Laminar flow control technology	Aerodynamic technology that maintains the airflow over the aircraft surface and nacelles turbulence-free; this can be achieved through shaping of the aircraft surface (natural) or boundary layer suction (hybrid). This assessment looks at the combinatory effects of both hybrid and natural.
	Advanced composites	New class of materials that decrease aircraft weight and provide improved environmental performance for aircraft; the raw materials for advanced composites can be derived from natural renewable resources.
Systems	Fuel cells for onboard power	Power generation technology that utilizes fuel cells instead of engine-driven generators; this creates more-efficient onboard electrical power generation.

Direct public funding, public-private partnerships and industry incentives will be instrumental in advancing the industry on its journey toward net-zero emissions by 2050.

2030-2040: Promise, but mostly on smaller aircraft

Technologies in this mid-term time horizon emphasize applications on regional and narrow-body aircraft.

In the near future, the industry anticipates several innovative advancements. These range from increased electrification to new aerodynamics such as transonic truss-braced wings to advanced composites—and those are just the beginning. We also expect laminar flow control technologies to be available for regional and narrow-body aircraft. Figure 5 summarizes the focus technologies, their benefits and the most likely applicability in this time frame.

The average maximum addressable emission-reduction potential for technologies in their respective market segments ranges from 1% to 20%.

Technologies like geared turbofan engines, laminar flow, high-pressure ratio core engines and advanced composites are deemed the most feasible in the mid-term time frame due to higher maturity and certification status. Hybrid-electric was observed to be less feasible due to its technical complexity and advancements required for high-energy-density batteries.

Figure 5—2030-2040 time horizon technology focus list

Technology	Average maximum addressable emission reduction (%CO ₂ emission reduction)	2030-2040		
		Wide-body	Narrow-body	Regional
Geared turbofan engines	20%	●		
High-pressure ratio core engines	7%		●	●
Open rotor	20%	●	●	●
Laminar flow control	5%		●	●
Advanced composites	2%	●	●	●
Hybrid-electric propulsion	1%			●
Transonic truss-braced wing	5%		●	●

Note: Maximum Addressable Emission Reduction is calculated as the percent reduction that could be achieved when the specific technology is mobilized in the applicable market segments.

2040 and beyond: Broader applicability, early stage development

Looking to 2040 and beyond, we expect to see more novel solutions enter the market. Technologies such as hydrogen propulsion, all-electric propulsion and revolutionary fuselage designs will have a massive impact on reducing emissions. Other technologies—like transonic truss-braced wing and fuel cells for onboard power—are also expected to help innovate the industry.

Figure 6 summarizes the focus technologies, their benefits, and the most likely applicability in this time frame.

The average maximum addressable emission-reduction potential for the technologies in their respective market segments ranges from 1% to 46%.

Technologies like transonic truss-braced wing and fuel cells for onboard power have the greatest feasibility in this longer-term horizon. Hydrogen propulsion has the lowest feasibility due to the technical complexity and infrastructure requirements to enable it.

Figure 6—2040 and beyond time horizon technology focus list

Technology	Average maximum addressable emission reduction (%CO ₂ emission reduction)	2040 and beyond		
		Wide-body	Narrow-body	Regional
Hydrogen propulsion	46%		●	●
All-electric propulsion	1%			●
Transonic truss-braced wing	5%	●		
Blended-wing body fuselage	9%	●		
Fuel cell for onboard power	2%		●	●

Note: Maximum Addressable Emission Reduction is calculated as the percent reduction that could be achieved when the specific technology is mobilized in the applicable aircraft segments.

Technologies in this segment show significant potential to reduce emissions. However, due to their longer deployment runway, it will be difficult for aircraft programs to incorporate and field them sooner. Companies should highly consider accelerating their development given the large emissions impact that these longer-term technologies promise. Since wide-body aircraft drive 45% of aircraft emissions, scaling these technologies further could significantly decrease overall aircraft emissions, but in a post-2050 time frame.



Mobilization: It's an ecosystem play

The potential for new, exciting technologies in the mid-term and longer term is massive. With the appropriate level of support from industry and governments, they could be brought to market in the anticipated time horizons and provide a promising emission impact reduction by 2050.

The public and private sector need to work hand in hand for these technologies to succeed. Both can play a crucial role in advancing them by doing three things:

1. Creating a cohesive, multiyear strategic plan tied to reliable funding.
2. Working with international organizations to shape industry standards.
3. Ensuring that new technologies can be incorporated as quickly as possible while maintaining safety as the top priority.

Implementing these strategies to reduce carbon emissions won't happen overnight. Fortunately, by prioritizing the right technologies at the right time, the aviation industry can shorten its runway to becoming net-zero.

To learn more about our methodology, download the [full report](#).

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