ITALY’S ACTION PLAN

ON CO_2 EMISSIONS REDUCTION

2018 edition

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Cover: photoshop based on a real picture of Castelluccio di Norcia, Umbria - Italy

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1. INTRODUCTION

Italy has been a member of ICAO since its foundation in 1944 and has always been represented in the Part 1 of the Council due to its longstanding engagement in the International Civil Aviation Regulatory body, its important industrial aeronautical achievements, its strong contribution to the development of safe and sustainable Air Transport.
Italy has also participated to the CAEP - Committee for Aviation Environmental Protection, consulting Committee of the ICAO Council - since its constitution in 1983. Today, Italy has its experts inside the CAEP groups and task forces. In particular, they have recently contributed to the most challenging CAEP technical analyses such as the Standards on CO_2 and CORSIA. Actually, they are engaged in the amendments of Annex 16 as regards Aircraft Noise certification plus the Standards on Emissions (CO_2 and Particulate matters) and on the recently issued CORSIA scheme.
Italy is also a member of the European Union and of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States[1] of any European organisation dealing with civil aviation. It is currently composed of 44 Member States, and was created in 1955.
ECAC States share the view that environmental concerns represent a potential constraint on the future development of the international aviation sector. Together they fully support ICAO's on-going efforts to address the full range of these concerns, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.
Italy, like all of ECAC's forty-four States, is fully committed to and involved in the fight against climate change, and works towards a resource-efficient, competitive and sustainable multimodal transport system.
Italy has its experts in ECAC environmental Groups (EAEG - European Aviation Environmental Group and the ENVFORUM) whose activities deal with the environmental objectives foreseen by ICAO CAEP groups and TFs and is in charge of framing the European environmental strategy, taking the appropriate actions, following the provisions outlined by the European legislation and policy.
In this light, Italy recognises the value of each State preparing and submitting to ICAO an updated State action plan for emissions reductions, as an important step towards the achievement of the global collective goals agreed since the 38th Session of the ICAO Assembly in 2013.
In that context, it is the intention that all ECAC States submit to ICAO an Action plan. This is the action plan of Italy.
Italy shares the view of all ECAC States that a comprehensive approach

[1] Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, Ukraine, and the United Kingdom

to reducing aviation emissions is necessary, and that this should include:

i. emission reductions at source, including European support to CAEP work,

ii. research and development on emission reductions technologies, including public-private partnerships,

iii. the development and deployment of low-carbon and sustainable alternative aviation fuels, including research and operational initiatives undertaken jointly with stakeholders,

iv. the improvement and optimisation of Air Traffic Management and infrastructure use within Europe, in particular through the Single European Sky ATM Research (SESAR), and also beyond European borders, through the Atlantic Initiative for the Reduction of Emissions (AIRE) in cooperation with the US FAA, and

v. Market-Based Measures, which allow the sector to continue to grow in a sustainable and efficient manner, recognizing that the measures at (i) to (iv) above cannot, even in aggregate, deliver in time the emissions reductions necessary to meet the global goals. This growth becomes possible through the purchase of carbon units that foster emission reductions in other sectors of the economy, where abatement costs are lower than within the aviation sector.

In Europe, many of the actions which are undertaken within the framework of this comprehensive approach are in practice taken collectively, throughout Europe, most of them led by the European Union. They are reported in Section 3 of this Action Plan, where the involvement of Italy is described, as well as that of other stakeholders.
In Italy a number of actions are undertaken at the national level, including those by stakeholders, in addition to the regional ones. These national actions are reported in Section 4 of this Plan.

In relation to European actions, it is important to note that:

i. The extent of participation will vary from one State to another, reflecting the priorities and circumstances of each State (economic situation, size of its aviation market, historical and institutional context, such as EU/ non EU). The ECAC States are thus involved to different degrees and on different timelines in the delivery of these common actions. When an additional State joins a collective action, including at a later stage, this broadens the effect of the measure, thus increasing the European contribution to meeting the global goals.

ii. Nonetheless, acting together, the ECAC States have undertaken to reduce the region's emissions through a comprehensive approach which uses each of the pillars of that approach. Some of the component measures, although implemented by some, but not all of ECAC's 44 States, nonetheless yield emission reduction benefits across the whole of the region (for example research, ETS).

This National Action Plan was finalized in August 2018.
The section 4.2. related to "National actions for sustainable development of Air Transport" may be subject to further update after that date.

2. CURRENT STATE OF AVIATION IN ITALY

ENAC - the Italian Civil Aviation Authority - was established on 25th July 1997 by the Legislative Decree no. 250/97 as the National Authority.
By the wording of its official Mission, ENAC is committed to regulate, control and oversee the field of civil aviation, by promoting the development of the civil aviation sector, in an environmentally friendly framework.
ENAC is engaged in dealing with the diverse regulatory aspects of air transport system and performs monitoring functions related to the enforcement of the adopted provisions, regulating administrative and economical issues. ENAC is also entrusted to provide traffic rights or related authorizations to Air Transport Services according to bilateral or multilateral agreements in force.
Its core business is doubtless represented by safety and security control.
According to its institutional mandate, ENAC performs, in addition to the issues referred to above:

- preliminary inquiries leading to the entrustment to joint-stock companies of concessions for the total management of airports;
- oversight on free access to the market of handling services in national airports;
- regulating procedures of airport services;
- examination and assessment of land use projects and intervention programmes, as well as investments and airport development;
- evaluation of the conditions for warranting the application of State funded fares on certain city pairs;
- certification of personnel operating in the aeronautical/air navigation field;
- enforcement of recommendations issued by the National Flight Safety Agency.

ENAC HQs are in Rome and Representative Offices are located in the major Italian airports.
ENAC is strongly engaged at national and international level in pushing forward decision making processes for an environmental and territory protection policy. This is carried out with a holistic approach and through attentive assessments aiming at limiting the environment impact on airport areas and reducing aircraft noise and emissions pollution.

2.1 Airlines

At date of Feb 1, 2018, 57 Italian Air Operators had a valid Air Operator Certificate, issued by ENAC, in accordance with Regulation (EU) 965/2012. Among others, the following commercial airlines have an Italian AOC for airplanes with more than 19 seats capacity:

- Air Dolomiti S.p.A.
- Air Italy S.p.A.
- Alitalia Società Aerea Italiana S.p.A.
- Alitalia CityLiner S.p.A.
- Blue Panorama Airlines S.p.A.
- Meridiana S.p.A. (now Air Italy)
- Mistral Air S.r.l
- Neos S.p.A.

Main airlines operating in Italy in 2017

According to EU Regulations, any operator from any EU/EFTA Member State has full right to operate domestic and intra EU/EFTA flights, regardless of the country that issued the AOC. Italy is fully integrated in the European Aviation Market.
Extra-European air transport is regulated by bilateral agreements, both traditional (Italy/Third Countries) and European ones, on the basis of the EU External Aviation Policy. Some of them allow the open-skies template and provide for an exchange of fifth freedom traffic rights.
That said, the traffic share of the major airlines operating in Italy, sorted by the total number of passengers transported in 2017, is displayed in the chart below:

	Domestic and International Traffic		
	Airline	Nationality	N. Passengers
1	Ryanair	Ireland	36.272.693
2	Alitalia	Italy	21.765.476
3	Easyjet	Great Britain	16.526.021
4	Vueling Airlines	Spain	5.873.506
5	Deutsche Lufthansa	Germany	4.529.777
6	Wizz Air	Hungary	4.307.344
7	British Airways	Great Britain	3.391.785
8	Air France	France	2.784.450
9	Meridiana (now Air Italy)	Italy	2.474.714
10	Volotea	Spain	2.295.845
11	Emirates	UAE	1.936.043
12	Klm	Netherlands	1.917.342
13	Blue Air	Romania	1.786.026
14	Turkish Airlines	Turkey	1.552.095
15	Eurowings	Germany	1.532.528
16	Blue Panorama	Italy	1.443.652
17	Air Berlin	Germany	1.353.084
18	Iberia	Spain	1.333.050
19	Neos	Italy	1.163.808
20	Swiss	Switzerland	1.079.460

Table 1.1.A: Airlines sorted by the total number of passengers transported in 2017. This includes both domestic and international flights. The source is Enac publication "Dati di Traffico", Edition 2018; data source comes from the airport managing company.

	International Traffic Only		
	Airline	Nationality	N. Passengers
1	Ryanair	Ireland	25.168.097
2	Easyjet	Great Britain	13.697.732
3	Alitalia	Italy	9.614.368
4	Vueling Airlines	Spain	5.285.602
5	Deutsche Lufthansa Ag	Germany	4.529.474
6	Wizz Air	Hungary	4.307.344
7	British Airways	Great Britain	3.391.785
8	Air France	France	2.784.450
9	Emirates	UAE	1.936.043
10	Klm	Netherlands	1.917.251
11	Turkish Airlines Inc.	Turkey	1.552.095
12	Eurowings Ag	Germany	1.532.528
13	Air Berlin Gmbh	Germany	1.353.084
14	Iberia	Spain	1.333.050
15	Blue Panorama Airlines	Italy	1.198.774
16	Meridiana (now Air Italy)	Italy	1.128.973
17	Neos	Italy	1.095.064
18	Swiss Air International	Switzerland	1.079.460
19	Aeroflot	Russia	1.068.834
20	Blue Air	Romania	1.050.147

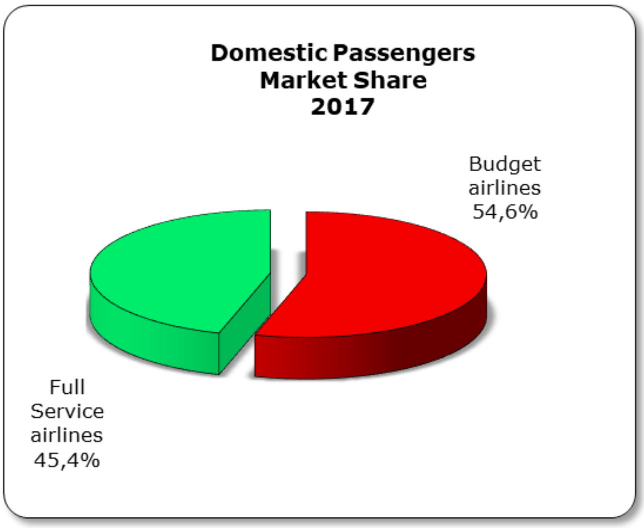
Table 1.1.B: Airlines sorted by number of international passengers transported in 2017

	Domestic Traffic Only		
	Airline	Nationality	N. Passengers
1	Alitalia	Italy	12.151.108
2	Ryanair	Ireland	11.104.596
3	Easyjet - Easyjet Switzerland	Great Britain	2.828.289
4	Volotea	Spain	1.617.120
5	Meridiana (now Air Italy)	Italy	1.345.741
6	Blue Air	Romania	735.879
7	Vueling Airlines	Spain	587.904
8	Blue Panorama Airlines	Italy	244.878
9	Mistral Air	Italy	185.072
10	Neos	Italy	68.744

Table 1.1.C: Airlines sorted by number of Domestic passengers transported in 2017

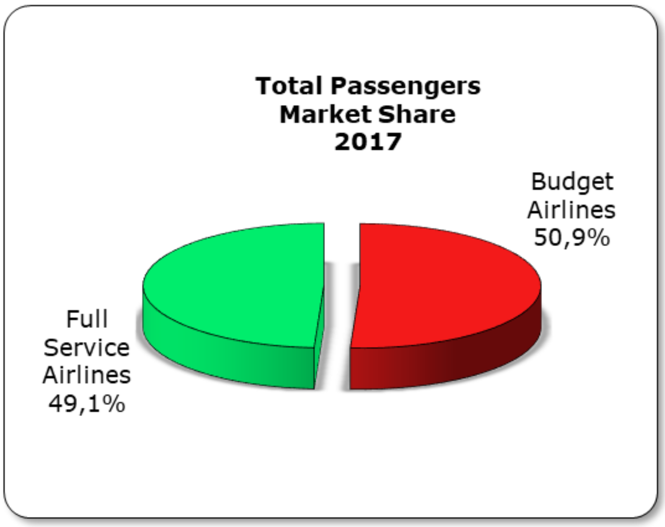
Market Share

The Italian market of civil aviation has been evolving year by year, as it goes all over the world.
The number of budget airlines operating in Italy has increased, and many of them have now some aircraft permanently based in Italy.
Budget airlines continued to gain market share in 2017 vs. traditional airlines.
The domestic traffic is shifting to a more price sensitive market, and consequently budget airlines transported more than 50% of passengers, as shown in the next chart:



On the contrary, considering the international traffic, full service airlines transported more than 50% of passengers, as shown in the next chart:

Globally, considering both domestic and international passengers, the market share of the budget airlines is slightly above 50%, as shown in the next chart:

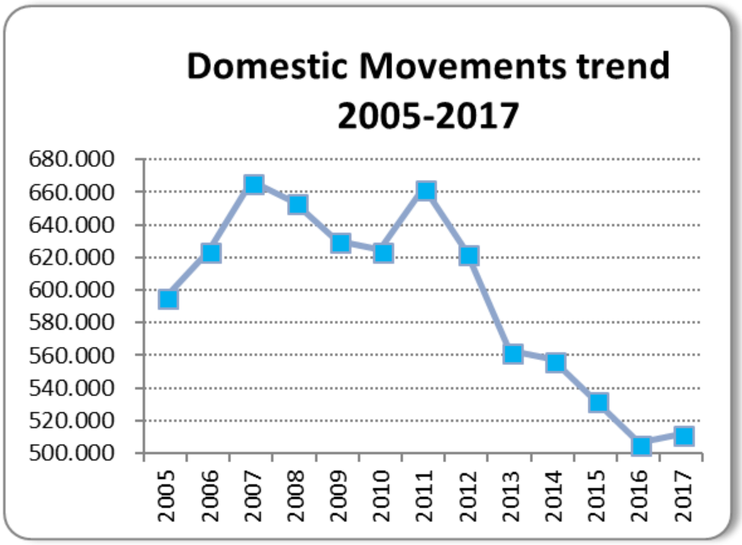


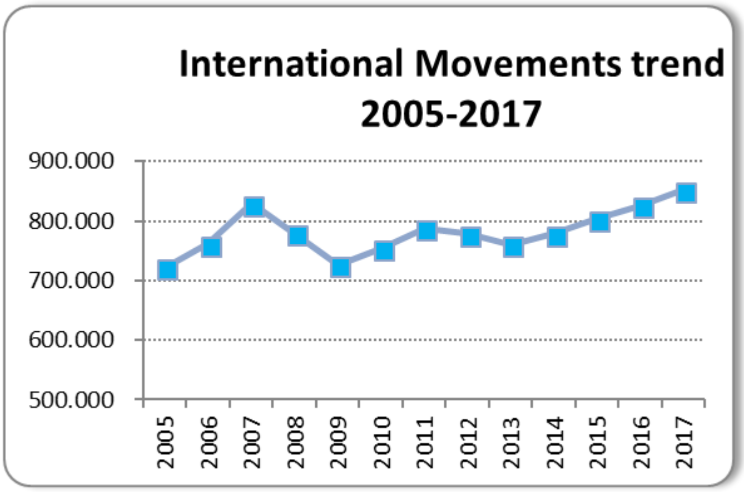
Commercial air carriers - traffic

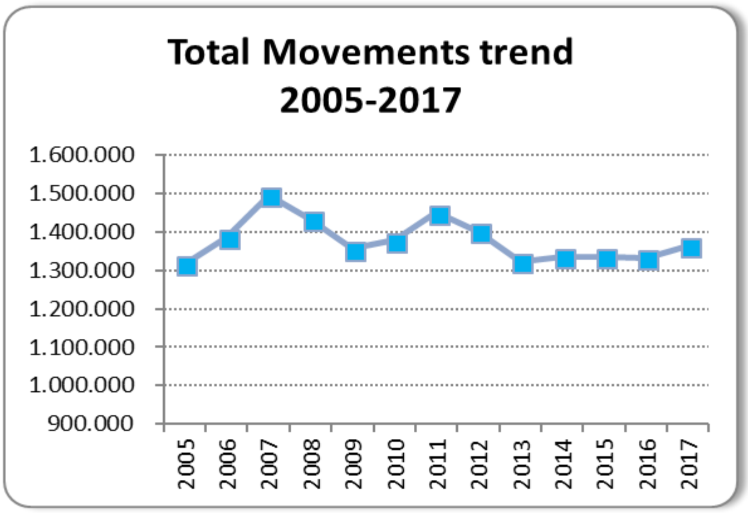
Considering the number of movements of commercial aircraft, 2017 was characterized by a growth of both domestic and international traffic, as showed in the charts below.
After almost a decade of shrinking numbers in the domestic market, in 2017 Italy registered a slight increase of 1.2% for domestic flights compared to the previous year. In the same year, the number of international movements increased by 3.2%.
In 2017, the number of international movements is at its all time maximum of the decade. For domestic movements, there is no long period clear trend.
A comparison between the global numbers of 2017 and those of 2015 shows a clear contraction of the domestic movements, compensated by an increase of international ones.

AIRCRAFT MOVEMENTS (2005-2017)

YEAR	DOMESTIC	Δ%	INTERNATIONAL	Δ%	TOTAL COMMERCIAL	Δ%
2005	595.925	-1,1	721.965	5,9	1.317.890	2,6
2006	624.321	4,8	761.902	5,5	1.386.223	5,2
2007	666.608	6,8	829.257	8,8	1.495.865	7,9
2008	654.006	-1,9	779.777	-6,0	1.433.783	-4,5
2009	630.404	-3,6	726.204	-6,9	1.356.608	-5,4
2010	624.737	-0,9	754.148	3,8	1.378.885	1,6
2011	662.807	6,1	787.535	4,4	1.450.342	5,2
2012	622.979	-6,1	778.684	-1,1	1.401.663	-3,4
2013	562.799	-9,7	759.954	-2,4	1.322.753	-5,6
2014	557.381	-1,0	778.303	2,4	1.335.684	1,0
2015	532.694	-4,4	803.916	3,3	1.336.610	0,1
2016	506.307	-5,0	826.081	2,8	1.332.388	-0,3
2017	512.250	1,2	852.314	3,2	1.364.564	2,4


Domestic Movements trend
2005-2017
680.000
660.000
640.000
620.000
600.000
580.000
560.000
540.000
520.000
500.000
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

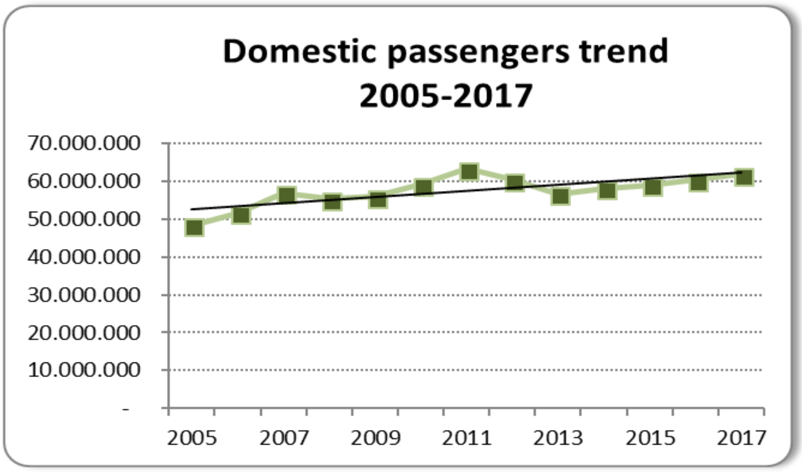

International Movements trend
2005-2017
900.000
800.000
700.000
600.000
500.000
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


Total Movements trend
2005-2017
1.600.000
1.500.000
1.400.000
1.300.000
1.200.000
1.100.000
1.000.000
900.000
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

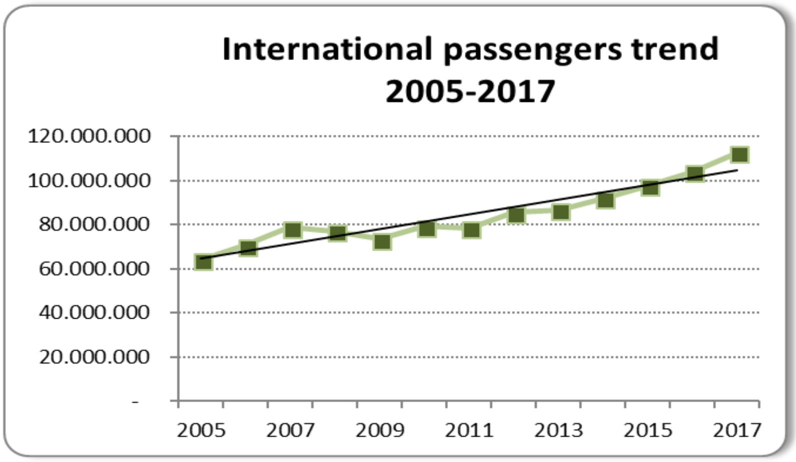
As far as the total traffic of passengers in 2017 registered in Italy was 174,6 millions, of which 112,6 millions international, with origin/destination airports located outside Italy, representing the 64% of the total number. The table below shows a total passenger traffic growth of +6.2% compared to 2016, with +8.3% related to international traffic. On the 12 year long period the total increase was +55% (2017 vs 2005), of which more than 50% refers to international traffic. Since 2014 we have observed a positive growth of both domestic and international passengers.

PASSENGERS (2005-2017)

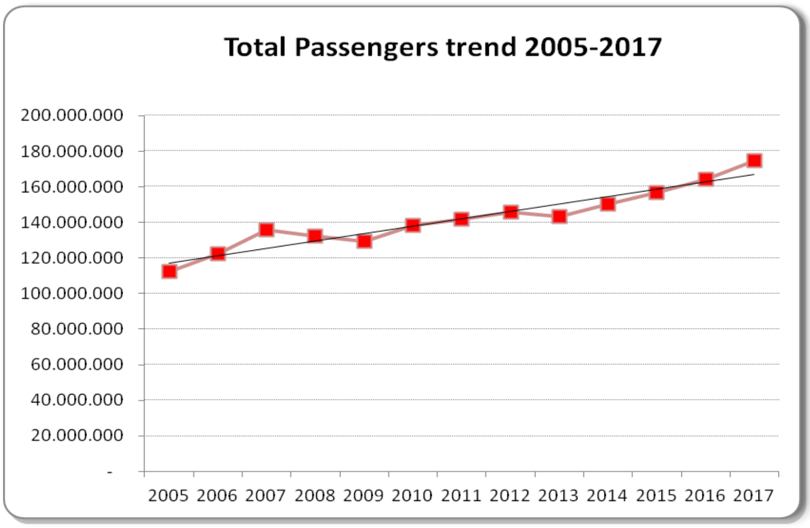
YEAR	DOMESTIC	Δ%	INTERNATIONAL	Δ%	TOTAL COMMERCIAL	Δ%
2005	48.440.901	-0,4	64.095.668	10,6	112.536.569	5,5
2006	51.741.346	6,8	70.657.262	10,2	122.398.608	8,8
2007	56.961.572	10,1	78.847.623	11,6	135.809.195	11,0
2008	55.347.732	-2,8	77.089.380	-2,2	132.437.112	-2,5
2009	55.940.298	1,1	73.501.762	-4,7	129.442.060	-2,3
2010	59.228.056	5,9	79.297.183	7,9	138.525.239	7,0
2011	63.365.984	7,0	78.627.665	-0,8	141.993.649	2,5
2012	60.377.775	-4,7	85.623.008	8,9	146.000.783	2,8
2013	56.704.847	-6,1	86.805.487	1,4	143.510.334	-1,7
2014	58.205.235	2,6	92.037.907	6,0	150.243.142	4,7
2015	59.094.395	1,5	97.870.858	6,3	156.965.253	4,5
2016	60.323.096	2,1	104.045.013	6,3	164.368.109	4,7
2017	61.941.472	2,7	112.686.769	8,3	174.628.241	6,2



Domestic passengers trend 2005-2017
70.000.000
60.000.000
50.000.000
40.000.000
30.000.000
20.000.000
10.000.000
-
2005
2007
2009
2011
2013
2015
2017



International passengers trend 2005-2017
120.000.000
100.000.000
80.000.000
60.000.000
40.000.000
20.000.000
-
2005
2007
2009
2011
2013
2015
2017

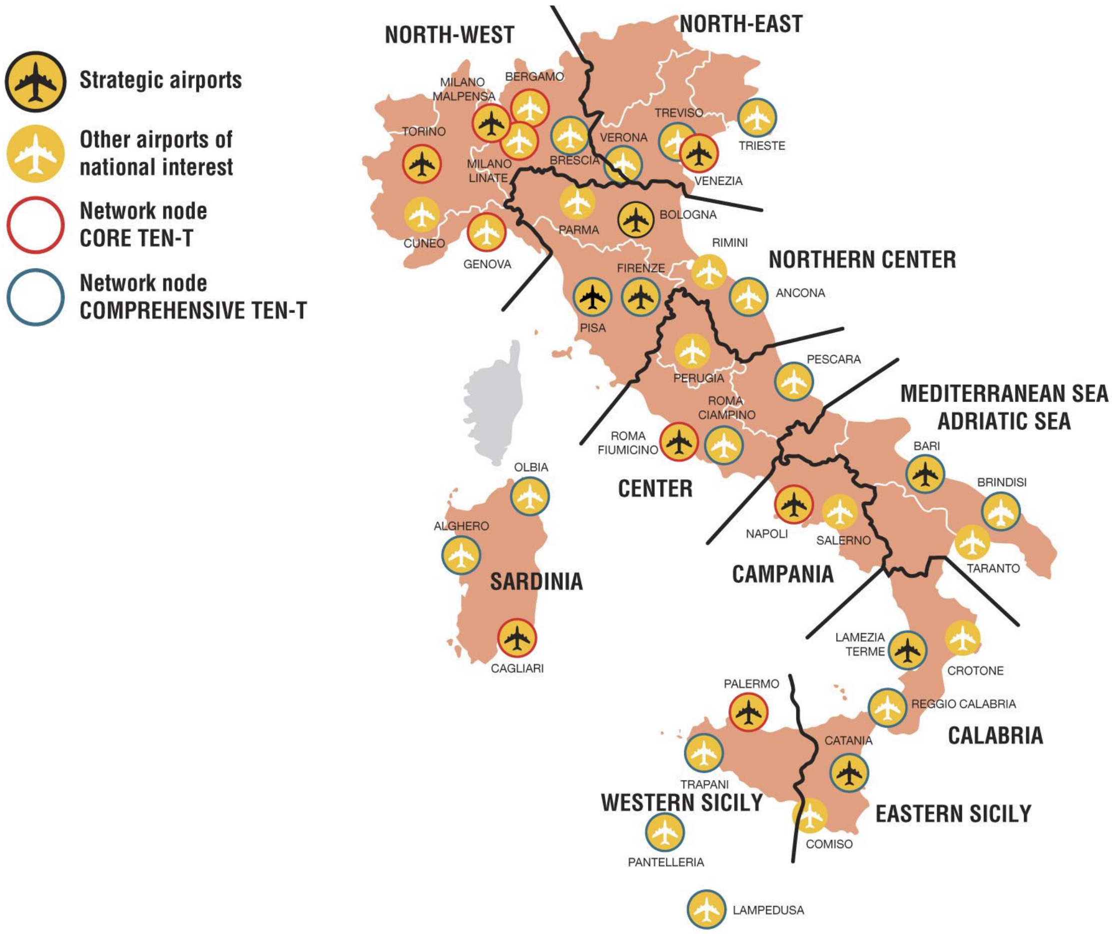


Total Passengers trend 2005-2017
200.000.000
180.000.000
160.000.000
140.000.000
120.000.000
100.000.000
80.000.000
60.000.000
40.000.000
20.000.000
-
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

2.2 Airports

Civil airports open to commercial traffic are distributed all over the Italian territory, as illustrated in the map below:

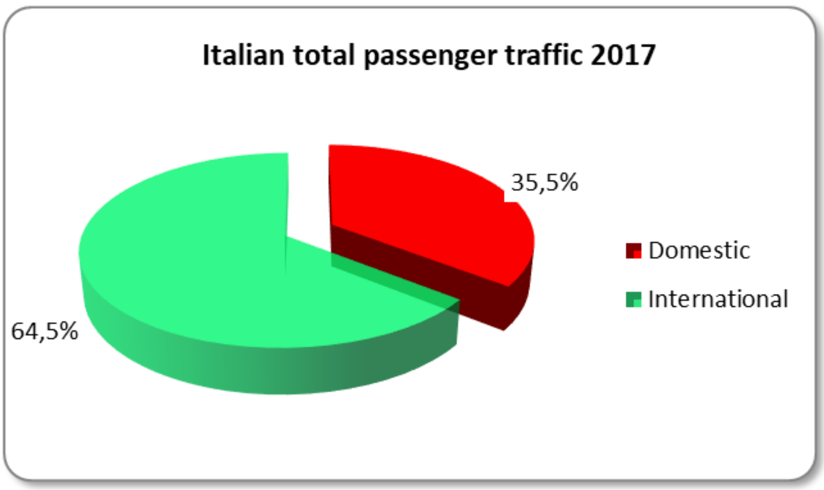
Map of Italian airports open to commercial traffic



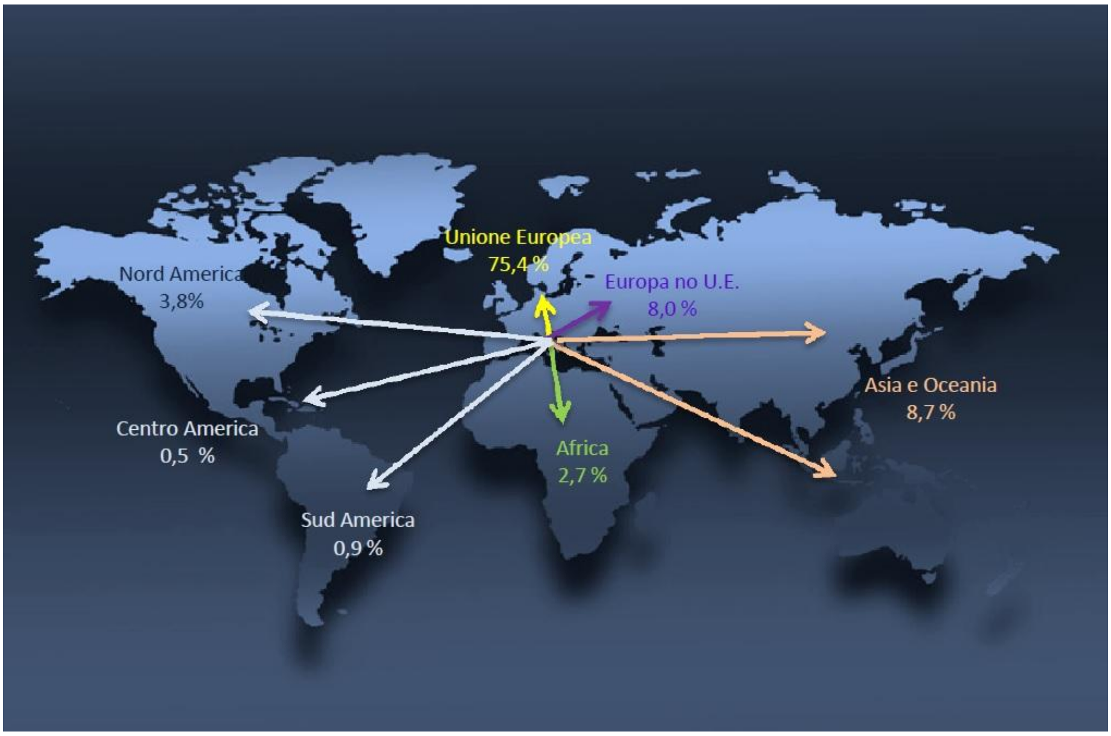
The major Italian airport for passenger traffic is Roma Fiumicino, whose traffic volume was higher than 40 million passengers in 2017. Italian airport that registered in 2017 more than 1 million passengers are listed in the table below:

	Airport	N. Passeggers	Δ %	% of total	Share (%)	
					Domestic	International
1	ROMA FIUMICINO	40.841.141	*-1,8*	*23,4*	*28,1*	*71,9*
2	MILANO MALPENSA	22.037.241	*14,1*	*12,6*	*14,4*	*85,6*
3	BERGAMO	12.230.942	*10,6*	*7,0*	*26,5*	*73,5*
4	VENEZIA	10.282.611	*7,7*	*5,9*	*13,1*	*86,9*
5	MILANO LINATE	9.503.065	*-1,4*	*5,4*	*51,9*	*48,1*
6	CATANIA	9.027.604	*15,3*	*5,2*	*67,9*	*32,1*
7	NAPOLI	8.552.223	*26,6*	*4,9*	*34,8*	*65,2*
8	BOLOGNA	8.181.654	*6,8*	*4,7*	*23,7*	*76,3*
9	ROMA CIAMPINO	5.855.450	*9,1*	*3,4*	*3,7*	*96,3*
10	PALERMO	5.753.046	*8,3*	*3,3*	*76,5*	*23,5*
11	PISA	5.222.427	*4,9*	*3,0*	*27,4*	*72,6*
12	BARI	4.669.277	*8,4*	*2,7*	*60,7*	*39,3*
13	TORINO	4.165.930	*5,8*	*2,4*	*51,0*	*49,0*
14	CAGLIARI	4.149.585	*11,8*	*2,4*	*78,7*	*21,3*
15	VERONA	3.046.269	*10,8*	*1,7*	*33,2*	*66,8*
16	TREVISO	2.982.741	*14,5*	*1,7*	*32,0*	*68,0*
17	OLBIA	2.785.263	*10,6*	*1,6*	*51,7*	*48,3*
18	FIRENZE	2.646.050	*5,7*	*1,5*	*14,5*	*85,5*
19	LAMEZIA TERME	2.539.233	*1,0*	*1,5*	*76,0*	*24,0*
20	BRINDISI	2.314.619	*-0,2*	*1,3*	*78,0*	*22,0*
21	ALGHERO	1.318.210	*-1,8*	*0,8*	*75,4*	*24,6*
22	TRAPANI	1.291.186	*-13,4*	*0,7*	*71,5*	*28,5*
23	GENOVA	1.241.502	*-1,6*	*0,7*	*57,5*	*42,5*

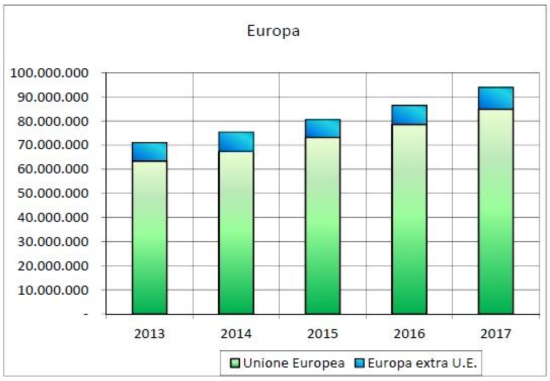
In 2017, the Italian international traffic share reached more than 64% of the total traffic and registered an additional increase vs. the domestic share, if compared to the previous years.

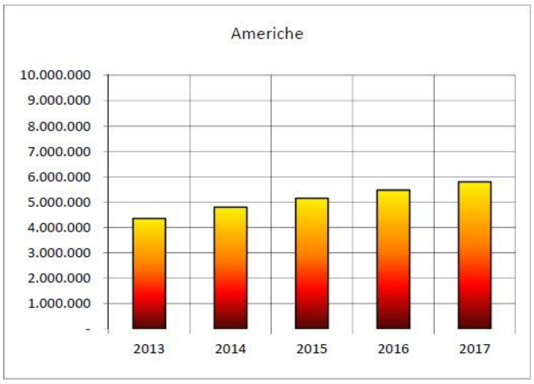


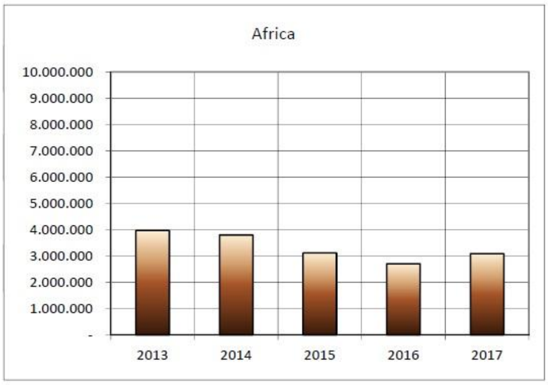
Details on the share of the international passenger traffic by continent are shown in the charts below. EU traffic represents the largest percentage of international traffic with more than 75%. Asia-Oceania and Europe Extra-EU cover around 8%-9% each.

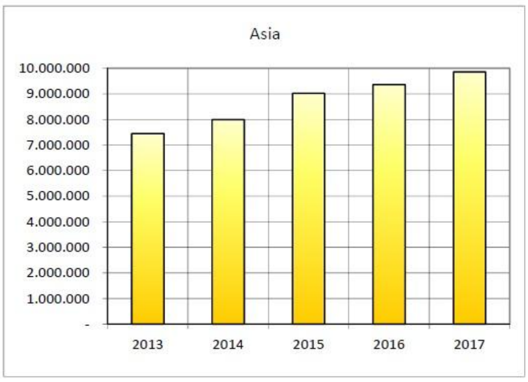


The traffic trend from/to Europe, Americas and Asia 2013-2017 is continuously increasing, whereas from/to Africa is slightly recovering, after a decrease in 2015-2016.

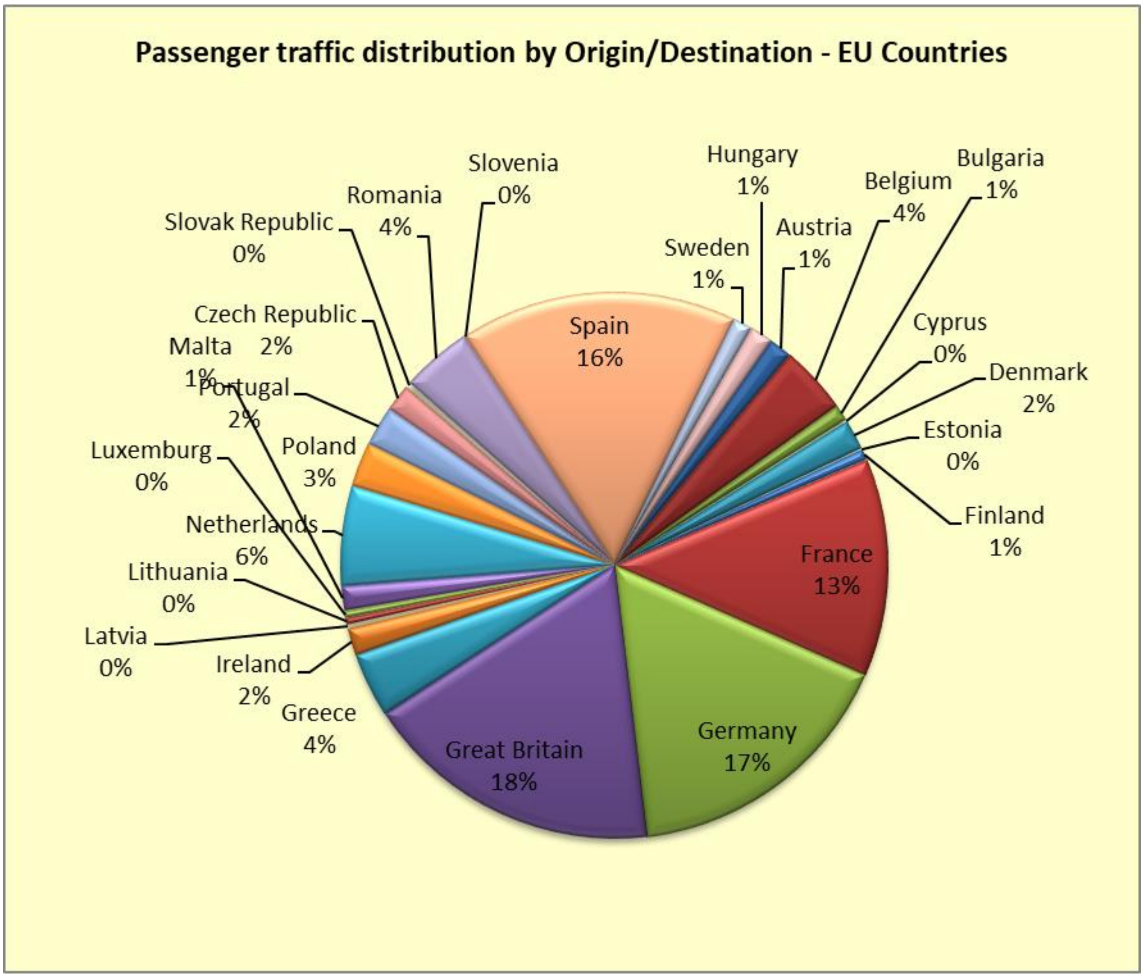








As for the traffic from/to EU States, the most is operated from/to UK, Germany, Spain and France.



Note: all the charts are based on non-stop flights operating from/to Italy

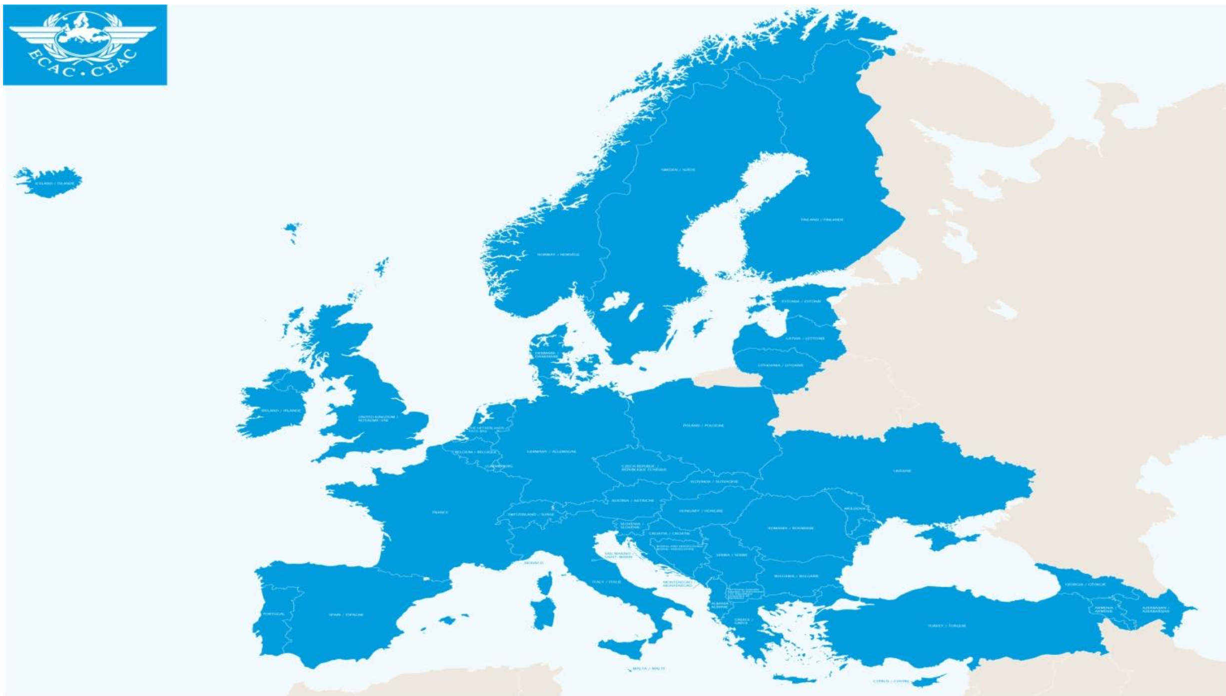
2.2.1 Italy's current airport capacity

The main Italian airports are coordinated.
A coordinated airport is an airport where an air carrier, or any other aircraft operator, needs a slot, in order to land or take off, with the exemption of State flights, emergency landings and humanitarian flights.
The slot is assigned by the Coordinator, according to the capacity of that specific airport.
The airport capacity is the expression, in operational terms, of the whole capacity available for slot allocation at an airport during each coordination period, reflecting all technical, operational and environmental factors that affect the performance of the airport infrastructure and its different sub-systems.
The scheme below (data from Assoclearance website) shows the coordination parameters (capacity availability) of the main Italian airports for the Summer Season 2018:

Summer 2018	Runway capacity		Air Terminal Capacity					
			International		Domestic + Schengen		International + Domestic	
Airport	Movements per hour	Number of stands	Arriving pax/h	Departing pax/h	Arriving pax ph	Departing pax/h	Arriving pax/h	Departing pax pax/h
Bergamo	26	37	1600	1800	2800	3300	2800	3300
Bologna[1]	24	31	1000	1000	2000	2000	3000	3000
Cagliari	12/16	23/25	1200	600	1850	1200	3050	1800
Catania	20	25	600	400	1400	1600	2000	2000
Firenze	15	14/16	760	350			2000	1400
Genova	25	20	1250	700	1250	700		
Lamezia Terme	20	19	350	350	600	800		
Lampedusa	4	3					250	250
Milano Linate	18	39					4400	3800[5]
Milano Malpensa	70	132					13800[6]	7700[6]
Napoli	30	25/26	2150		2600		4500	4750
Olbia	14	27	270	270	600	1200		
Palermo	21	25/33	450	400	1450	1050	2000	1950
Pantelleria	4	4					350	350
Pisa[1]	10/14[3]	17	3450[9]		550[8]		4000	4300
Rimini	7	8	860	1000	730	500		
Roma Ciampino	10/12[2]	12/17					1400	1400
Roma Fiumicino[7]	90	117/125	4800	6000	9500	9000		
Torino	27	/[4]					2500	2500
Treviso	8	7/9	350	350			700	700
Venezia	32	45	1800	1630		2780	4400	
Verona	14	20/24	720	720	1500	1600	1500	1600

Note 1 - Scheduled Facilitated Airports
Note 2 - Limitation due to noise impact analysis in progress by ENAC (max 100 movements per day)
Note 3 - on different hours
Note 4 - Aircraft stands of Turin airports are foreseen into four flexible area, arranged for a maximum capacity of 6 wide bodies plus 19 narrow bodies
Note 5 - With maximum 600 extra - Schengen.
Note 6 - Total of terminal 1 and terminal 2 capacities
Note 7 - Runway movement restriction
Note 8 - Domestic only
Note 9 - International + Schengen

3. EUROPEAN STATES' ACTION PLANS ECAC/EU common section



3.0 Executive summary

The European Section of this action plan, which is common to all European State action plans, presents a summary of the actions taken collectively in the 44 States of the European Civil Aviation Conference (ECAC) to reduce CO_2 emissions from the aviation system against a background of increased travel and transport.
For over a century, Europe has led the development of new technology, monitoring its impacts and developing new innovations to better meet societies developing needs and concerns. From the dawn of aviation, governments and industry across the region have invested heavily to understand and mitigate the environmental impacts of aviation, initially focussing on noise, then adding air quality and more recently the emissions affecting the global climate and CO_2 from fuel burn in particular. This is all taking place in a sector ever striving to improve safety and security whilst also reducing operating costs and improving fuel efficiency.
Some of these mitigating actions have domestic beginnings that stretch to international aviation whilst others are part of centralised cross-cutting funding such as through the EU Research Framework programmes. The aviation sector has also benefited from large bespoke programmes such as the EU's Single European Sky ATM Research Initiative (SESAR). This has a vision stretching to 2050, which may turn utopian dreams of flight with seamless end-to-end co-ordination, optimised for efficiency, with minimal environmental impacts and complete safety into reality.
The European common section also includes new innovations being tried and tested in a range of demonstration trials to reduce fuel burn and CO_2 emissions at different stages of different flights, airports or routes. These might not be contributing to measured benefits in day-to-day operations yet, but Europe can anticipate a stream of future implementation actions and additional CO_2 savings.

Aircraft related technology

European members have worked together to best support progress in the ICAO Committee on Aviation Environmental Protection (CAEP). This contribution of resources, analytical capability and leadership has undoubtedly facilitated leaps in global certification standards that has helped drive the markets demand for technology improvements. Developing what became the 2016 ICAO CO_2 standards for newly built aircraft relied on contributions from many across the ECAC States. Airlines now have confidence that fuel efficient aircraft are future proof which may even have generated orders for manufacturers and demonstrates a virtuous circle that efficiency sells. Solutions and technology improvements have already started to go into service and are helping to support demand for ever more ambitious research.
Environmental improvements across the ECAC States is knowledge lead and at the forefront of this is the Clean Sky EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough "clean technologies". This activity recognises and exploits the interaction between environmental, social and competitiveness aspects with sustainable economic growth. Funding and its motivation is critical to research and the public private partnership model of the EU Framework Programmes underpins much that will contribute to this and future CO_2 action plans across the ECAC region. Evaluations of the work so far under the JTI alone estimate aircraft CO_2 reductions of 32% which, aggregated over the future life of those products, amount to 6bn tonnes of CO_2.
The main efforts under Clean Sky 2 include demonstrating technologies: for both large and regional passenger aircraft, improved performance and versatility of new rotorcraft concepts, innovative airframe structures and materials, radical engine architectures, systems and controls and consideration of how we manage

aircraft at the end of their useful life. This represents a rich stream of ideas and concepts that, with continued support, will mature and contribute to achieving the goals on limiting global climate change.

Alternative fuels

ECAC States are embracing the introduction of sustainable alternative aviation fuels but recognise the many challenges between the current situation and their widespread availability or use. It has been proven fit for purpose and the distribution system has demonstrated its capacity to handle sustainable alternative fuels. Recent actions have focussed on preparing the legal base for recognising a minimum reduction in greenhouse gas emissions and market share targets for such fuels in the transport sector. The greatest challenge to overcome is economic scalability of the production of sustainable fuel and the future actions of the ECAC states are preparing the building blocks towards that goal. The European Commission has proposed specific measures and sub-quotas to promote innovation and the deployment of more advanced sustainable fuels as well as additional incentives to use such fuels in aviation. Public private partnership in the European Advanced Biofuels Flight-path is also continuing to bring down the commercial barriers. In that framework, Europe is progressing towards a 2 million tonne goal for the consumption of sustainably produced paraffinic biofuels by 2020. Europe has progressed from demonstration flights to sustainable biofuel being made available through the hydrant fuelling infrastructure, but recognises that continued action will be required to enable a more large-scale introduction.

Improved Air Traffic Management

The European Union’s Single European Sky (SES) policy aims to transform Air Traffic Management in Europe, tripling capacity, halving ATM costs with 10 times the safety and 10% less environmental impact. Progress is well underway on the road map to achieve these ambitious goals through commitment and investment in the research and technology. Validated ATM solutions alone are capable of 21% more airspace capacity, 14% more airport capacity, a 40% reduction in accident risk, 2.8% less greenhouse emissions and a 6% reduction in flight cost. Steps 2 and 3 of the overall SES plan for the future will deploy ‘Trajectory-based Operation’ and ‘Performance-based Operations’ respectively. Much of the research to develop these solutions is underway and published results of the many earlier demonstration actions confirm the challenge but give us confidence that the goals will be achieved in the ECAC region with widespread potential to be replicated in other regions.

Economic/Market Based Measures (MBMs)

ECAC members have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The 31 EEA states in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap and trade approach to limit CO_2 emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO_2 emissions.

ECAC States, through the Bratislava declaration, have expressed their intention to voluntarily participate in CORSIA from its pilot phase and encourage other States to do likewise and join CORSIA. Subject to preserving the environmental integrity and effectiveness it is expected that the EU ETS legislation will be adapted to implement the CORSIA. A future world with a globally implemented CORSIA aimed at carbon neutral growth of international aviation would significantly reduce emissions.

ECAC Scenarios for Traffic and CO_2 Emissions

Aviation traffic continues to grow, develop and diversify in many ways across the ECAC states. Whilst the focus of available data relates to passenger traffic, similar issues and comparable outcomes might be anticipated for cargo traffic both as belly hold freight or in dedicated freighters. Analysis by EUROCONTROL and EASA has identified the most likely scenario of influences on future traffic and modelled these assumptions out to future years. On the basis of this traffic forecast, fuel consumption and CO_2 emissions of aviation have been estimated for both a theoretical baseline scenario (without any mitigation action) and a scenario with implemented mitigation measures that are presented in this action plan. Results are visualised in the below figure.

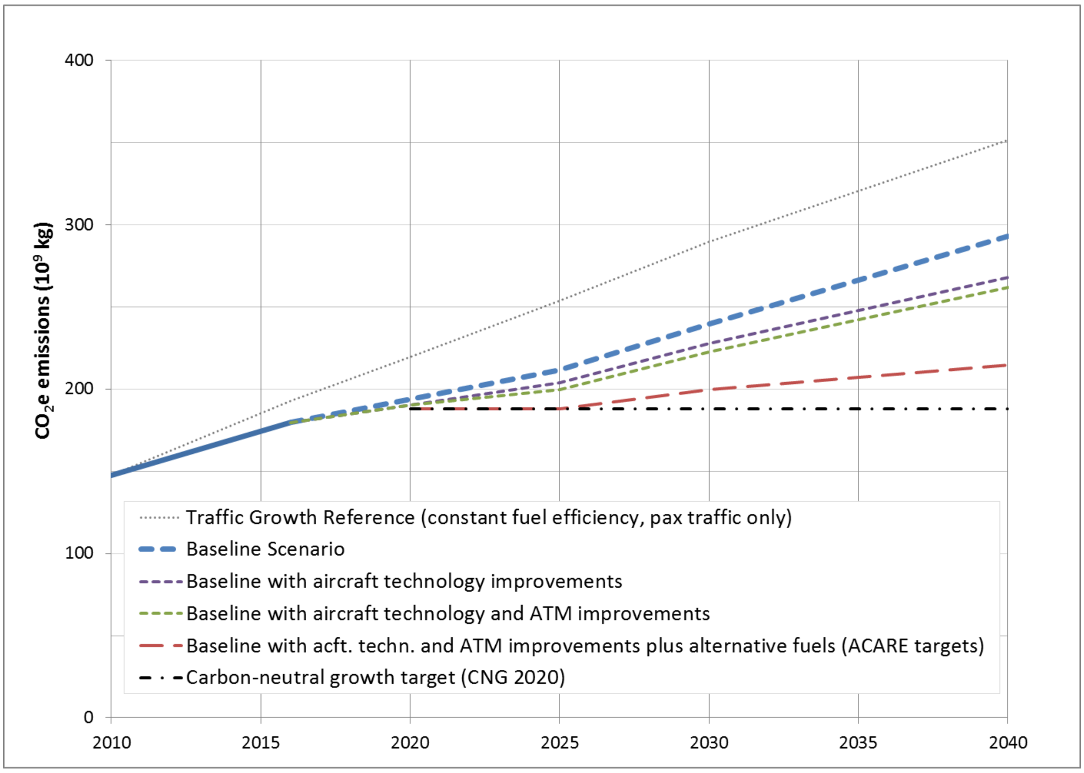


Figure 1 Equivalent CO_2 emissions forecast for the baseline and implemented measures scenarios

Under the baseline assumptions of traffic growth and fleet rollover with 2010 technology, CO_2 emissions would almost double for flights departing ECAC airports. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 8.5% reduction of fuel consumption and CO_2 emissions in 2040 compared to the baseline. Whilst the data to model the benefits of ATM improvements and sustainable alternative fuels may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall fuel efficiency, including the effects of new aircraft types and ATM-related measures, is projected to improve by 24% between 2010 and 2040. The potential of sustainable aviation fuels to reduce CO_2 emissions on a lifecycle basis is reflected in Figure 1. Market-based measures and their effects have not been simulated in detail, but will help reach the goal of carbon-neutral growth. As further developments in policy and technology are made, further analysis will improve the modelling of future emissions.

3.1 ECAC BASELINE SCENARIO AND ESTIMATED BENEFITS OF IMPLEMENTED MEASURES

3.1.1 ECAC Baseline Scenario

The baseline scenario is intended to serve as a reference scenario for CO_2 emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2016) and forecasts (for 2020, 2030 and 2040) were provided by EUROCONTROL for this purpose:

- European air traffic (includes all commercial and international flights departing from ECAC airports, in number of flights, revenue passenger kilometres (RPK) and revenue tonne-kilometres (RTK)),
- its associated aggregated fuel consumption,
- its associated CO_2 emissions.

The sets of forecasts correspond to projected traffic volumes in a scenario of "Regulation and Growth", while corresponding fuel consumption and CO_2 emissions assume the technology level of the year 2010 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, alternative fuels or market based measures).

Traffic Scenario "Regulation and Growth"

As in all forecasts produced by EUROCONTROL, various scenarios are built with a specific storyline and a mix of characteristics. The aim is to improve the understanding of factors that will influence future traffic growth and the risks that lie ahead. In the 20 year forecasts published by EUROCONTROL the scenario called 'Regulation and Growth' is constructed as the 'most likely' or 'baseline' scenario for traffic, most closely following the current trends. It considers a moderate economic growth, with some regulation particularly regarding the social and economic demands.
Amongst the models applied by EUROCONTROL for the forecast the passenger traffic sub-model is the most developed and is structured around five main group of factors that are taken into account:

- **Global economy** factors represent the key economic developments driving the demand for air transport.
- Factors characterizing the **passengers** and their travel preferences change patterns in travel demand and travel destinations.
- **Price of tickets** set by the airlines to cover their operating costs influences passengers' travel decisions and their choice of transport.
- More hub-and-spoke or point-to-point **networks** may alter the number of connections and flights needed to travel from origin to destination.
- **Market structure** describes size of aircraft used to satisfy the passenger demand (modelled via the Aircraft Assignment Tool).

Table 1 presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year

2016 serves as the baseline year of the 20-year forecast results[2] updated in 2018 by EUROCONTROL and presented here. Historical data for the year 2010 are also shown later for reference.

	Global Growth	***Regulation and Growth***	*Fragmenting World*
2023 traffic growth	High ➚	Base ➔	Low ➘
Passenger			
Demographics (Population)	Aging UN Medium-fertility variant	Aging UN Medium-fertility variant	Aging UN Zero-migration variant
Routes and Destinations	Long-haul ➚	No Change ➔	Long-haul ➘
Open Skies	EU enlargement later +Far & Middle-East	EU enlargement Earliest	EU enlargement Latest
High-speed rail (new & improved connections)	20 city-pairs faster implementation	20 city-pairs	20 city-pairs ter implementation.
Economic conditions			
GDP growth	Stronger ➚	Moderate ➔	Weaker ➘➘
EU Enlargement	+5 States, Later	+5 States, Earliest	+5 States, Latest
Free Trade	Global, faster	Limited, later	None
Price of travel			
Operating cost	Decreasing ➘➘	Decreasing ➘	No change ➔
Price of CO_2 in Emission Trading Scheme	Moderate	Lowest	Highest
Price of oil/barrel	Low	Lowest	High
Change in other charges	Noise: ➚ Security: ➘	Noise: ➚ Security: ➔	Noise: ➔ Security: ➚
Structure Network	Hubs: Mid-East ➚➚ Europe ➘ Turkey➚ Pt-to-pt: N-Atlant.➚➚	Hubs: Mid-East ➚➚ Europe&Turkey ➚ Pt-to-pt: N-Atlant.➚	No change ➔
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

Table 1. Summary characteristics of EUROCONTROL scenarios

Further assumptions and results for the baseline scenario

The ECAC baseline scenario was generated by EUROCONTROL for all ECAC States. It covers all commercial international passenger flights departing from ECAC airports, as forecasted in the aforementioned traffic scenario. The number of passengers per flight is derived from Eurostat data.
EUROCONTROL also generates a number of all-cargo flights in its baseline scenario. However, no information about the freight tonnes carried is available. Hence, historical and forecasted cargo traffic have been extracted from another

[2] Challenges of Growth 2018: Flight forecast, EUROCONTROL September 2018 (to be published)

source (ICAO[3]). This data, which is presented below, includes both belly cargo transported on passenger flights and freight transported on dedicated all-cargo flights.
Historical fuel burn and emission calculations are based on the actual flight plans from the PRISME data warehouse used by EUROCONTROL, including the actual flight distance and the cruise altitude by airport pair. These calculations were made for 98% of the passenger flights; the remaining flights in the flight plans had information missing. Determination of the fuel burn and CO_2 emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample. Fuel burn and CO_2 emission results consider each aircraft's fuel burn in its ground and airborne phases of flight and are obtained by use of the EUROCONTROL IMPACT environmental model. While historical traffic data is used for the year 2016, the baseline fuel burn and emissions in 2016 and the forecast years (until 2040) are modelled in a simplified approach on the basis of the historical/forecasted traffic and assume the technology level of the year 2010.
The following tables and figures show the results for this baseline scenario, which is intended to serve as a reference case by approximating fuel consumption and CO_2 emissions of European aviation in the absence of mitigation actions.

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[4] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[5] FTKT (billion)	Total Revenue Tonne Kilometres[5,6] RTK (billion)
2010	4.6	1,218	0.20	45.4	167.2
2016	5.2	1,601	0.21	45.3	205.4
2020	5.6	1,825	0.25	49.4	231.9
2030	7.0	2,406	0.35	63.8	304.4
2040	8.4	2,919	0.45	79.4	371.2

Table 2. Baseline forecast for international traffic departing from ECAC airports

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	0.0310	0.310
2016	46.28	146.26	0.0287	0.287
2020	49.95	157.85	0.0274	0.274
2030	61.75	195.13	0.0256	0.256
2040	75.44	238.38	0.0259	0.259
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

Table 3. Fuel burn and CO_2 emissions forecast for the baseline scenario

[3] ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016.
[4] Calculated based on 98% of the passenger traffic.
[5] Includes passenger and freight transport (on all-cargo and passenger flights).
[6] A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

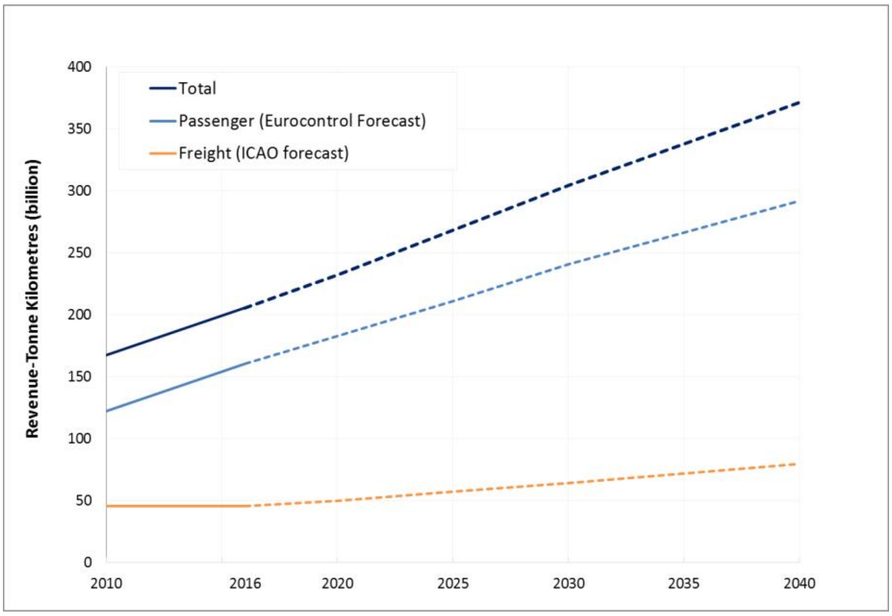


Figure 2. Forecasted traffic until 2040 (assumed both for the baseline and implemented measures scenarios)

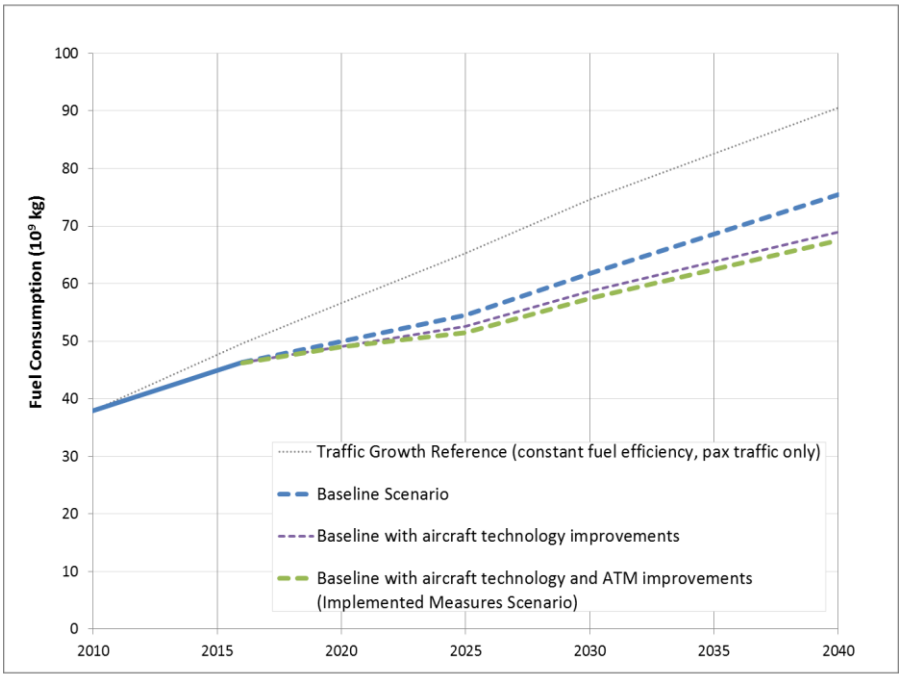


Figure 3. Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports)

3.1.2 ECAC Scenario with Implemented Measures, Estimated Benefits of Measures

In order to improve fuel efficiency and to reduce future air traffic emissions beyond the projections in the baseline scenario, ECAC States have taken further action. Assumptions for a top-down assessment of effects of mitigation actions are presented here, based on modelling results by EUROCONTROL and EASA. Measures to reduce aviation's fuel consumption and emissions will be described in the following chapters.

For reasons of simplicity, the scenario with implemented measures is based on the same traffic volumes as the baseline case, i.e. EUROCONTROL's 'Regulation and Growth' scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development, improvements in ATM/operations and alternative fuels are considered here for a projection of fuel consumption and CO_2 emissions up to the year 2040.

Effects of **improved aircraft technology** are captured by simulating fleet roll-over and considering the fuel efficiency improvements of new aircraft types of the latest generation (e.g. Airbus A320NEO, Boeing 737MAX, Airbus A350XWB etc.). The simulated future fleet of aircraft has been generated using the Aircraft Assignment Tool (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of the Aircraft Assignment Tool is performed year by year, allowing the determination of the amount of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 0.96% per annum is assumed to aircraft deliveries during the last 10 years of the forecast (2030-2040). This rate of improvement corresponds to the 'medium' fuel technology scenario used by CAEP to generate the fuel trends for the Assembly.

The effects of **improved ATM efficiency** are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. Regarding SESAR effects, baseline deployment improvements of 0.2% in terms of fuel efficiency are assumed to be included in the base year fuel consumption for 2010. This improvement is assumed to rise to 0.3% in 2016 while additional improvements of 2.06% are targeted for the time period from 2025 onwards[7]. Further non-SESAR related fuel savings have been estimated to amount to 1.2% until the year 2010, and are already included in the baseline calculations[8].

Regarding the **introduction of sustainable alternative fuels,** the European ACARE roadmap targets described in section B chapter 2.1 of this document are assumed for the implemented measures case. These targets include an increase of alternative fuel quantities to 2% of aviation's total fuel consumption in the year 2020, rising linearly to 25% in 2035 and 40% in 2050. An average 60% reduction of lifecycle CO_2 emissions compared to crude-oil based JET fuel was assumed for sustainable aviation fuels, which is in line with requirements from Article 17 of the EU's Renewable Energy Directive (Directive 2009/28/EC)[9]. The resulting emission savings are shown in Table 6 and Figure 4 in units of equivalent CO_2 emissions on a lifecycle (well-to-wake) basis[10].

For simplicity, effects of **market-based measures** including the EU Emissions Trading Scheme (ETS) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) on aviation's CO_2 emissions have not been modelled explicitly in the top-down assessment of the implemented measures scenario presented here. CORSIA aims for carbon-neutral growth (CNG) of aviation, and this target is therefore shown in Figure 4[11].

Tables 4-6 and Figures 3-4 summarize the results for the scenario with implemented measures. It should be noted that Table 4 shows direct combustion

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[7] See SESAR1 D72 "Updated Performance Assessment in 2016" document, November 2016, project B05, project manager: ENAIRE.

[8] See SESAR1 D107 "Updated Step 1 validation targets – aligned with dataset 13", project B.04.01, December 2014, project manager: NATS.

[9] According to article 17 of the EU RED (Directive 2009/28/EC), GHG emission savings of at least 60% are required for biofuels produced in new installations in which production started on or after 1 January 2017.

[10] CO_2e emissions of fossil-based JET fuel are calculated by assuming an emission index of 3.88 kg CO_2e per kg fuel (see DIN e.V., "Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)", German version EN 16258:2012), which is in accordance with 89 g CO_2e per MJ suggested by ICAO CAEP AFTF.

[11] Note that in a strict sense the CORSIA target of CNG is aimed to be achieved globally (and hence not necessarily in each world region).

emissions of CO_2 (assuming 3.16 kg CO_2 per kg fuel), whereas Table 6 and Figure 4 present equivalent CO_2 emissions on a well-to-wake basis, including those from fuel production. More detailed tabulated results are found in Appendix A.

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	0.0310	0.310
2016	46.24	146.11	0.0286	0.286
2020	49.03	154.93	0.0245	0.245
2030	57.38	181.33	0.0242	0.242
2040	67.50	213.30	0.0237	0.237
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

Table 4. Fuel burn and CO_2 emissions forecast for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

Period	Average annual fuel efficiency improvement (%)
2010-2016	-1.36%
2016-2020	-1.40%
2020-2030	-1.11%
2030-2040	-0.21%

Table 5. Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

Year	Well-to-wake CO_2e emissions (10^9 kg)				% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario			
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	Acft. techn. and ATM improvements + alternative fuels	
2010	147.3				NA
2016	179.6	*179.6*	*179.4*	179.4	-0.1%
2020	193.8	*190.4*	*190.2*	187.9	-3.0%
2030	239.6	*227.6*	*222.6*	199.5	-16.7%
2040	292.7	*267.7*	*261.9*	214.8	-26.6%
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of alternative fuels.					

Table 6. Equivalent (well-to-wake) CO_2 emissions forecasts for the scenarios described in this chapter

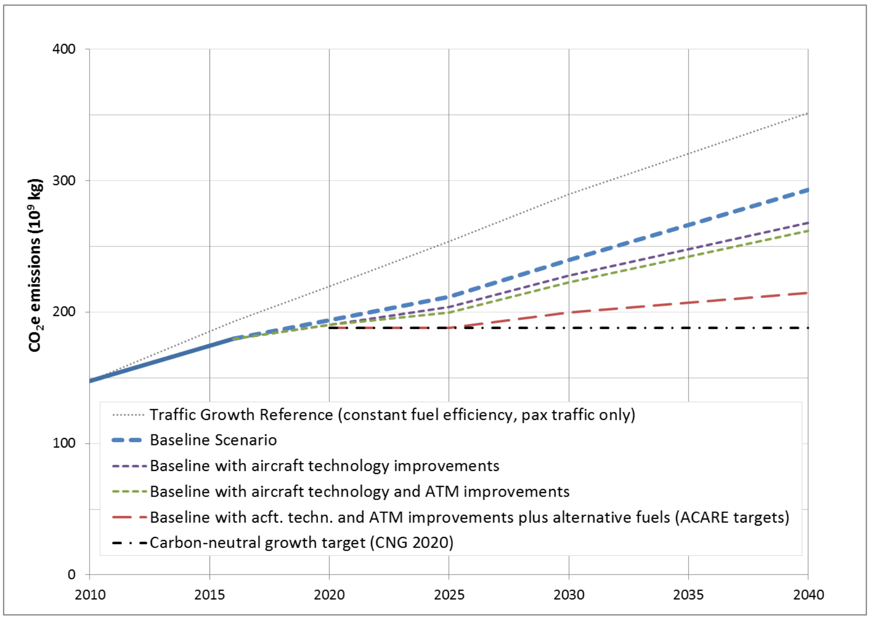

Figure 4. Equivalent (well-to-wake) CO_2 emissions forecast for the baseline and implemented measures scenarios

As shown in Figures 3-4, the impact of improved aircraft technology indicates an overall 8.5% reduction of fuel consumption and CO_2 emissions in 2040 compared to the baseline scenario. Whilst the data to model the benefits of ATM improvements and sustainable alternative fuels shown in Figure 4 may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall fuel efficiency, including the effects of new aircraft types and ATM-related measures, is projected to improve by 24% between 2010 and 2040.

Under the currently assumed aircraft and ATM improvement scenarios, the rate of fuel efficiency improvement is expected to slow down progressively until 2040. Aircraft technology and ATM improvements alone will not be sufficient to meet the post-2020 carbon neutral growth objective of aviation, nor will the use of alternative fuels even if Europe’s ambitious targets for alternative fuels are met. This confirms that additional action, particularly market-based measures, are required to fill the gap.

3.2 Actions taken collectively throughout Europe

3.2.1 Aircraft-related technology development

3.2.1.1 Aircraft emissions standards (Europe's contribution to the development of the aeroplane CO_2 standard in CAEP)

European Member States fully supported the work achieved in ICAO's Committee on Aviation Environmental Protection (CAEP), which resulted in an agreement on the new aeroplane CO_2 Standard at CAEP/10 meeting in February 2016, applicable to new aeroplane type designs from 2020 and to aeroplane type designs that are already in-production in 2023. Europe significantly contributed to this task, notably through the European Aviation Safety Agency (EASA) which co-led the CO_2 Task Group within CAEP's Working Group 3, and which provided extensive technical and analytical support.
The assessment of the benefits provided by this measure in terms of reduction in European emissions is not provided in this action plan. Nonetheless, elements of assessment of the overall contribution of the CO_2 standard towards the global aspirational goals are available in CAEP.

3.2.1.2 Research and development

Clean Sky is an EU Joint Technology Initiative (JTI) that aims to develop and mature breakthrough "clean technologies" for air transport globally. By accelerating their deployment, the JTI will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth.

Joint Technology Initiatives are specific large-scale EU research projects created by the European Commission within the 7th Framework Programme (FP7) and continued within the Horizon 2020 Framework Programme. Set up as a Public Private Partnership between the European Commission and the European aeronautical industry, Clean Sky pulls together the research and technology resources of the European Union in a coherent programme that contributes significantly to the 'greening' of global aviation.
The first Clean Sky programme (**Clean Sky 1 -** 2011-2017) has a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry. It aims to develop environmental friendly technologies impacting all flying-segments of commercial aviation. The objectives are to reduce aircraft CO_2 emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

What has the current JTI achieved so far?

*It is estimated that Clean Sky resulted in a reduction of aviation CO_2 emissions by more than 32% with respect to baseline levels (in 2000), which represents an **aggregate of up to 6 billion tonnes of CO_2 over the next 35 years***

This was followed up with a second programme (**Clean Sky 2** – 2014-2024) with the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. The current budget for the programme is approximately €4 billion.
The two Interim Evaluations of Clean Sky in 2011 and 2013 acknowledged that the programme is successfully stimulating developments towards environmental targets. These preliminary assessments confirm the capability of achieving the overall targets at completion of the programme.
Main remaining areas for RTD efforts under Clean Sky 2 are:

- **Large Passenger Aircraft**: demonstration of best technologies to achieve the environmental goals whilst fulfilling future market needs and improving the competitiveness of future products.
- **Regional Aircraft:** demonstrating and validating key technologies that will enable a 90-seat class turboprop aircraft to deliver breakthrough economic and environmental performance and a superior passenger experience.
- **Fast Rotorcraft:** demonstrating new rotorcraft concepts (tilt-rotor and compound helicopters) technologies to deliver superior vehicle versatility and performance.
- **Airframe:** demonstrating the benefits of advanced and innovative airframe structures (like a more efficient wing with natural laminar flow, optimised control surfaces, control systems and embedded systems, highly integrated in metallic and advanced composites structures). In addition, novel engine integration strategies and innovative fuselage structures will be investigated and tested.
- **Engines:** validating advanced and more radical engine architectures.
- **Systems:** demonstrating the advantages of applying new technologies in major areas such as power management, cockpit, wing, landing gear, to address the needs of a future generation of aircraft in terms of maturation, demonstration and Innovation.

- **Small Air Transport:** demonstrating the advantages of applying key technologies on small aircraft demonstrators to revitalise an important segment of the aeronautics sector that can bring key new mobility solutions.
- **Eco-Design:** coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship with intelligent Re-use, Recycling and advanced services.

In addition, the **Technology Evaluator** will continue to be upgraded to assess technological progress routinely and evaluate the performance potential of Clean Sky 2 technologies at both vehicle and aggregate levels (airports and air traffic systems). More details on Clean Sky can be found at the following link:
http://www.cleansky.eu/

3.2.2 Alternative Fuels

3.2.2.1 European Advanced Biofuels Flightpath

Within the European Union, Directive 2009/28/EC on the promotion of the use of energy from renewable sources ("the Renewable Energy Directive" – RED) established mandatory targets to be achieved by 2020 for a 20% overall share of renewable energy in the EU and a 10% share for renewable energy in the transport sector. Furthermore, sustainability criteria for biofuels to be counted towards that target were established[12]. Directive 2009/28/EC of the European Parliament and of the Council of 23/04/2009 on the promotion of the use of energy from renewable sources, details in its Article 17 that '*with effect from 1 January 2017, the greenhouse gas emission saving from the use of biofuels and bioliquids taken into account for the purposes referred to in points (a), (b) and (c) of paragraph 1 shall be at least 50 %. From 1 January 2018 that greenhouse gas emission saving shall be at least 60 % for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017'.*
In November 30, 2016, the European Commission (EC) presented a proposal to the EU Council and the European Parliament for a recast of the Renewable Energy Directive for 2030.
To promote the deployment and development of low carbon fuels, such as advanced biofuels, it is proposed to introduce after 2020 an obligation requiring fuel suppliers to sell a gradually increasing share of renewable and low-emission fuels, including advanced biofuels and renewable electricity (at least 1.5% in 2021 increasing to at least 6.8% by 2030).
To promote innovation the obligation includes a specific sub-quota for advanced biofuels, increasing from 0.5% in 2021 to at least 3.6% in 2030. Advanced biofuels are defined as biofuels that are based on a list of feedstocks; mostly lignocellulosic material, wastes and residues.
Aviation and marine sectors are explicitly covered in the proposal. In fact, it is proposed that advanced alternative fuels used for aviation and maritime sectors can be counted 1.2 times towards the 6.8% renewable energy mandate. This would provide an additional incentive to develop and deploy alternative fuels in the aviation sector.
In February 2009, the European Commission's Directorate General for Energy and Transport initiated the SWAFEA (Sustainable Ways for Alternative Fuels and

[12] Directive 2009/28/EC of the European Parliament and of the Council of 23/04/2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Article 17 Sustainability criteria for biofuels and bioliquids, at pp. EU Official Journal L140/36-L140/38

Energy for Aviation) study to investigate the feasibility and the impact of the use of alternative fuels in aviation.
The SWAFEA final report was published in July 2011[13]. It provides a comprehensive analysis on the prospects for alternative fuels in aviation, including an integrated analysis of the technical feasibility, environmental sustainability (based on the sustainability criteria of the EU Directive on renewable energy[14]) and economic aspects. It includes a number of recommendations on the steps that should be taken to promote the take-up of sustainable biofuels for aviation in Europe.
In March 2011, the European Commission published a White Paper on transport[15]. In the context of an overall goal of achieving a reduction of at least 60% in greenhouse gas emissions from transport by 2050 with respect to 1990, the White Paper established a goal of low-carbon sustainable fuels in aviation reaching 40% by 2050.

ACARE Roadmap targets regarding share alternative sustainable fuels:

Aviation to use:

- **at minimum 2%** sustainable alternative fuels **in 2020**;
- **at minimum 25%** sustainable alternative fuels **in 2035**;
- **at minimum 40%** sustainable alternative fuels **in 2050**

Source: ACARE Strategic Research and Innovation Agenda, Volume 2

As a first step towards delivering this goal, in June 2011 the European Commission, in close coordination with Airbus, leading European airlines (Lufthansa, Air France/KLM, & British Airways) and key European biofuel producers (Choren Industries, Neste Oil, Biomass Technology Group and UOP), launched the **European Advanced Biofuels Flight-path**. This industry-wide initiative aims to speed up the commercialisation of aviation biofuels in Europe, with the objective of achieving the commercialisation of sustainably produced paraffinic biofuels in the aviation sector by reaching an aggregated 2 million tonnes consumption by 2020.
This initiative is a shared and voluntary commitment by its members to support and promote the production, storage and distribution of sustainably produced drop-in biofuels for use in aviation. It also targets establishing appropriate financial mechanisms to support the construction of industrial "first of a kind" advanced biofuel production plants. The Biofuels Flight path is explained in a technical paper, which sets out in more detail the challenges and required actions[16].
More specifically, the initiative focuses on the following:

1. Facilitating the development of standards for drop-in biofuels and their certification for use in commercial aircraft,

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[13] http://www.icao.int/environmental-protection/GFAAF/Documents/SW_WP9_D.9.1%20Final%20report_released%20July2011.pdf

[14] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

[15] Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM (2011) 144 final

[16] https://ec.europa.eu/energy/sites/ener/files/20130911_a_performing_biofuels_supply_chain.pdf

2. Working together across the full supply chain to further develop worldwide accepted sustainability certification frameworks,
3. Agree biofuel take-off arrangements over a defined period of time and at a reasonable cost,
4. Promote appropriate public and private actions to ensure the market uptake of paraffinic biofuels by the aviation sector,
5. Establish financing structures to facilitate the realisation of 2nd Generation biofuel projects,
6. Accelerate targeted research and innovation for advanced biofuel technologies, and especially algae, and
7. Take concrete actions to inform the European citizen of the benefits of replacing kerosene with certified sustainable biofuels.

When the Flightpath 2020 initiative began in 2010, only one production pathway was approved for aviation use; renewable kerosene had only been produced at very small scale and only a handful of test and demonstration flights had been conducted using it. Since then, worldwide technical and operational progress in the industry has been remarkable. Four different pathways for the production of renewable kerosene are now approved and several more are expected to be certified soon. A significant number of flights using renewable kerosene have been conducted, most of them revenue flights carrying passengers. Production has been demonstrated at up to industrial scale for some of the pathways. Distribution of renewable kerosene through an airport hydrant system was also demonstrated in Oslo in 2015.
In 2016 the European commission tendered support and secretariat functions for the Flightpath 2020, which had so far depended on the initiative of the individual members. This €1.5m tender was won by a consortium run by SENASA, which started the work supporting the Flightpath at the end of 2016.

Performed flights using bio-kerosene

IATA: 2000 flights worldwide using bio-kerosene blends performed by 22 airlines between June 2011 and December 2015

Lufthansa: 1 189 Frankfurt-Hamburg flights using 800 tonnes of bio-kerosene (during 6 months period June - December 2011)

KLM: a series of 200 Amsterdam-Paris flights from September 2011 to December 2014, 26 flights New York-Amsterdam in 2013, and 20 flights Amsterdam-Aruba in 2014 using bio-kerosene

Air France: A series of 50 Paris – Toulouse flights evaluating SIP kerosene in 2014/2015

Since late 2015, bio kerosene is regularly available as a fuel blend at Oslo airport. Total throughput so far can be approximatively estimated at 2000 tonnes. Attribution to individual flights is no longer possible except on an accounting basis as the fuel is commingled in the normal hydrant fuelling infrastructure of the airport.

Production (EU)

***Neste** (Finland): by batches*

- Frankfurt-Hamburg (6 months) 1 189 flights operated by Lufthansa: 800 tonnes of bio-kerosene

- Itaka: €10m EU funding (2012-2015):ca. 1 000 tonnes

***Biorefly**: €13.7m EU funding: 2000 tonnes per year– BioChemtex (Italy)*

***BSFJ Swedish Biofuels**: €27.8m EU funding (2014-2019)*

3.2.2.2 Research and Development projects on alternative fuels in aviation

In the time frame 2011-2016, 3 projects have been funded by the FP7 Research and Innovation program of the EU.

ITAKA: €10m EU funding (2012-2015) with the aim of assessing the potential of a specific crop (camelina) for providing jet fuel. The project aims entailed testing the whole chain from field to fly and assessing the potential beyond the data gathered in lab experiments, gathering experiences on related certification, distribution and economic aspects. For a feedstock, ITAKA targeted European camelina oil and used cooking oil in order to meet a minimum of 60% GHG emissions savings compared to the fossil fuel jetA1.

SOLAR-JET: This project has demonstrated the possibility of producing jet-fuel from CO_2 and water. This was done by coupling a two-step solar thermochemical cycle based on non-stoichiometric ceria redox reactions with the Fischer-Tropsch process. This successful demonstration is further complemented by assessments of the chemical suitability of the solar kerosene, identification of technological gaps, and determination of the technological and economical potentials.

Core-JetFuel: €1.2m EU funding (2013-2017) this action evaluated the research and innovation "landscape" in order to develop and implement a strategy for sharing information, for coordinating initiatives, projects and results and to identify needs in research, standardisation, innovation/deployment and policy measures at European level. Bottlenecks of research and innovation will be identified and, where appropriate, recommendations for the European Commission will be made with respect to the priorities in the funding strategy. The consortium covers the entire alternative fuel production chain in four domains: Feedstock and sustainability; conversion technologies and radical concepts; technical compatibility, certification and deployment; policies, incentives and regulation. CORE-Jet Fuel ensures cooperation with other European, international and national initiatives and with the key stakeholders. The expected benefits are enhanced knowledge amongst decision makers, support for maintaining coherent research policies and the promotion of a better understanding of future investments in aviation fuel research and innovation.
In 2015, the European Commission launched projects under the Horizon 2020 research programme with production capacities of the order of several thousand tonnes per year.
In addition, in 2013 the Commission tendered the **HBBA study** (High Biofuel Blends in Aviation). This study analysed in detail the blending behaviour of fossil kerosene with bio kerosene produced by the various pathways either already approved or undergoing the technical approval process. It also analysed the impact of bio kerosene on various types of aircraft fuel seals, plus the effect of

different bio-kerosenes on aircraft emissions. The final report on this research was published in early 2017 and is available at:

https://ec.europa.eu/energy/sites/ener/files/documents/final_report_for_publication.pdf.

3.2.3 Improved Air Traffic Management and Infrastructure Use

The EU's Single European Sky Initiative and SESAR

3.2.3.1 SESAR Project

The European Union's Single European Sky (SES) policy aims to reform Air Traffic Management (ATM) in Europe in order to enhance its performance in terms of its capacity to manage larger volumes of flights in a safer, more cost-efficient and environmental friendly manner.

The initial SES aims with respect to the 2005 performance were to:

- Triple capacity of ATM systems,
- Reduce ATM costs by 50%,
- Increase safety by a factor of 10, and
- Reduce the environmental impact by 10% per flight.

SESAR, the technology pillar of the Single European Sky, contributes to the Single Sky's performance targets by defining, developing, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner.

Guided by the European ATM Master Plan, the SESAR Joint Undertaking (JU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe's air traffic management system and deliver benefits to Europe and its citizens. The SESAR JU research programme has been split into 2 phases, SESAR 1 (from 2008 to 2016) and SESAR 2020 (starting in 2016). It is delivering solutions in four key areas, namely airport operations, network operations, air traffic services and technology enablers.
The SESAR contribution to the SES high-level goals set by the Commission are continuously reviewed by the SESAR JU and are kept up to date in the ATM Master Plan.
Concerning the environmental impact, the estimated potential total fuel and CO_2 emission savings per flight are depicted below by flight segment:

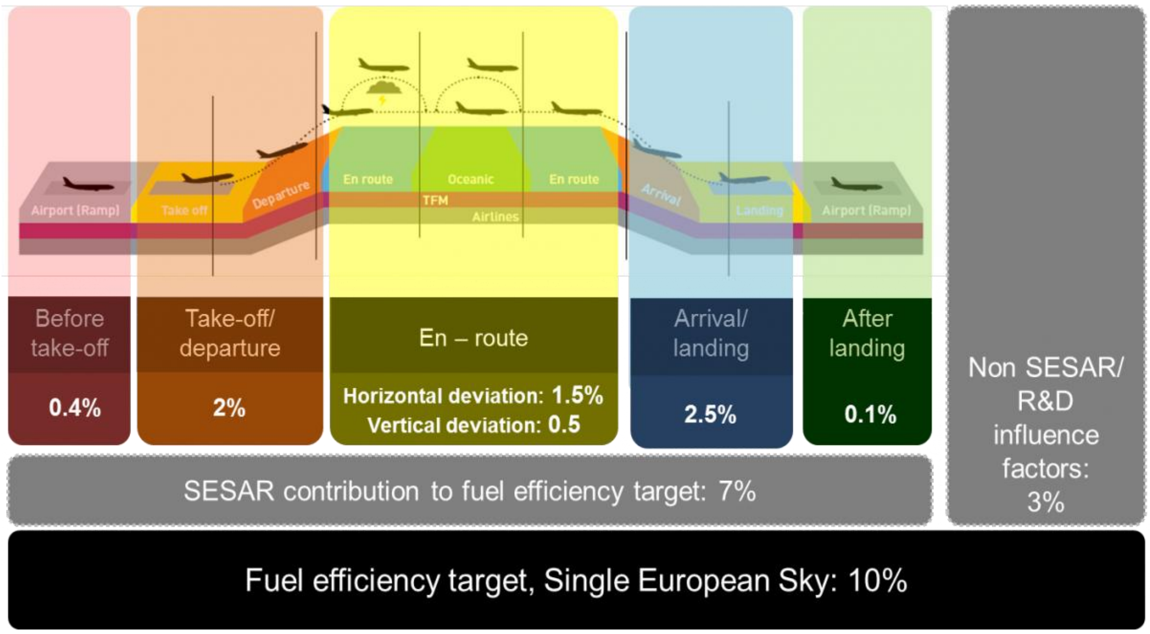


Figure 5

By the end of SESAR 1, the validation exercises conducted showed that the solutions identified could provide by 2024 (as compared to the 2005 baseline) 2.36% reduction per flight in gate-to-gate greenhouse gas emissions.

3.2.3.2 SESAR Research Projects (environmental focus)

During SESAR 1, environmental aspects were mainly addressed under two types of project: Environmental research projects, which were considered as a transversal activity and therefore primarily supported the projects validating the SESAR solutions, and secondly SESAR validation and demonstration projects, which were pre-implementation activities. Environment aspects, in particular fuel efficiency, were also a core objective of approximately 80% of SESAR 1's primary projects.

Environmental Research Projects:

The four Environmental research projects have been completed:

- Project 16.03.01 dealt with the "Development of the Environment validation framework (Models and Tools)");

- Project 16.03.02 addressed the "Development of environmental metrics";
- Project 16.03.03 dealt with the "Development of a framework to establish interdependencies and trade-off with other performance areas";
- Project 16.03.07 considered "Future regulatory scenarios and risks".

In the context of Project 16.03.01, a first version of the IMPACT tool was developed by EUROCONTROL providing SESAR primary projects with the means to conduct fuel efficiency, aircraft emissions and noise assessments, from a web-based platform, using the same aircraft performance assumptions. IMPACT successfully passed the verification and validation process of the ICAO Committee on Aviation Environmental Protection Modelling and Database Group CAEP. Project 16.06.03 also ensured the continuous development/maintenance of other tools covering aircraft greenhouse gas (GHG) assessment (AEM), and local air quality issues (Open-ALAQS). It should be noted that these tools were developed to cover the research and the future deployment phase of SESAR, as well as to support European states and agencies in conducting environmental impact assessments for operational or regulatory purposes.

In the context of Project 16.03.02, a set of metrics for assessing GHG emissions, noise, and airport local air quality were documented. The metrics identified by Project 16.03.02 will be gradually implemented in IMPACT.

Project 16.03.03 produced a comprehensive analysis of the issues related to environmental impact interdependencies and trade-offs.

Project 16.03.07 conducted a review of the then current environmental regulatory measures as applicable to ATM and SESAR deployment, and another report presenting an analysis of environmental regulatory and physical risk scenarios in the form of user guidance. It identifies both those concept of operations and Key Performance Areas which are most likely to be affected by these risks and the future operational solutions that can contribute to mitigating them. It also provides a gap analysis identifying knowledge gaps or uncertainties which require further monitoring, research or analysis.

Project 16.06.03, was the SESAR Environment support and coordination project which ensured the coordination and facilitation of all the Environmental research project activities whilst supporting the SESAR/AIRE/DEMO projects in the application of the material produced by the research projects. In particular, this project delivered an Environment Impact Assessment methodology providing guidance on how to conduct an assessment, which metrics to use, and dos and don'ts for each type of validation exercise with a specific emphasis on flight trials.

The above-mentioned SESAR 1 environmental project deliverables constitute the reference material that SESAR2020 should be using.

SESAR demonstration projects

In addition to its core activities, the SESAR JU co-financed projects where ATM stakeholders worked collaboratively to perform integrated flight trials and demonstrations of solutions. These aimed to reduce CO_2 emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 "green" projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE).

A total of 15 767 flight trials were conducted under AIRE, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3 150 kg of CO_2), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology. More information can be found at http://www.sesarju.eu

A key feature leading to the success of AIRE is that it focused strongly on operational and procedural techniques rather than new technologies. AIRE trials used technology that was already in place, but until the relevant AIRE project came along, air traffic controllers and other users hadn't necessarily thought deeply about how to make the best operationally use of that technology. For example, because of the AIRE initiative and the good cooperation between NAV Portugal and FAA, in New York and St Maria oceanic airspace lateral separation optimisation is given for any flight that requests it.

Specific trials were carried for the following improvement areas/solutions as part of the AIRE initiative:

a. Use of GDL/DMAN systems (pre-departure sequencing system / Departure Manager) in Amsterdam, Paris and Zurich,
b. Issue of Target-Off Block time (TOBT), calculation of variable taxiout time and issue of Target-Start-up Arrival Time (TSAT) in Vienna,
c. Continuous Descent Operations (CDOs or CDAs) in Amsterdam, Brussels, Cologne, Madrid, New York, Paris, Prague, Pointe-à-Pitre, Toulouse, and Zurich,
d. CDOs in Stockholm, Gothenburg, Riga, La Palma; Budapest and Palma de Majorca airports using RNP-AR procedures,
e. Lateral and vertical flight profile changes in the NAT taking benefit of the implementation of Automatic Dependent Surveillance-Broadcast (ADS-B) surveillance in the North Atlantic,
f. Calculation of Estimated Times of Arrival (ETA) allowing time based operations in Amsterdam,
g. Precision Area Navigation - Global Navigation Satellite System (PRNAV GNSS) Approaches in Sweden,
h. Free route in Lisbon and Casablanca, over Germany, Belgium, Luxembourg, Netherlands in the EURO-SAM corridor, France, and Italy,
i. Global information sharing and exchange of actual position and updated meteorological data between the ATM system and Airline AOCs for the vertical and lateral optimisation of oceanic flights using a new interface.

The **AIRE 1** campaign (2008-2009) demonstrated, with 1,152 trials performed, that significant savings can already be achieved using existing technology. CO_2 savings per flight ranged from 90kg to 1,250kg and the accumulated savings during the trials were equivalent to 400 tonnes of CO_2. This first set of trials represented not only substantial improvements for the greening of air transport, but generated further motivation and commitment of the teams involved creating momentum to continue to make progress on reducing aviation emissions.

Domain	Location	Trials performed	CO_2 benefit/ flight
Surface	Paris, France	353	190-1 200 kg
Terminal	Paris, France	82	100-1 250 kg
	Stockholm, Sweden	11	450-950 kg
	Madrid, Spain	620	250-800 kg
Oceanic	Santa Maria, Portugal	48	90-650 kg
	Reykjavik, Iceland	48	250-1 050 kg
	Total	**1.152**	

Table 7: Summary of AIRE 1 projects

The **AIRE 2** campaign (2010-2011) showed a doubling in demand for projects and a high transition rate from R&D to day-to-day operations. 18 projects involving 40 airlines, airports, ANSPs and industry partners were conducted in which surface, terminal, oceanic and gate-to-gate operations were tackled. 9 416 flight trials took place. Table 8 summarises AIRE 2 projects operational aims and results.
CDOs were demonstrated in busy and complex TMAs although some operational measures to maintain safety, efficiency, and capacity at an acceptable level had to be developed.

Project name	Location	Operation	Objective	CO_2 and Noise benefits per flight (kg)	Number of flights
CDM at Vienna Airport	Austria	CDM notably pre-departure sequence	CO_2 & Ground Operational efficiency	54	208
Greener airport operations under adverse conditions	France	CDM notably pre-departure sequence	CO_2 & Ground Operational efficiency	79	1 800
B3	Belgium	CDO in a complex radar vectoring environment	Noise & CO_2	160-315; -2dB (between 10 to 25 Nm from touchdown)	3 094
DoWo - Down Wind Optimisation	France	Green STAR & Green IA in busy TMA	CO_2	158-315	219
REACT-CR	Czech republic	CDO	CO_2	205-302	204
Flight Trials for less CO_2 emission during transition from en-route to final approach	Germany	Arrival vertical profile optimisation in high density traffic	CO_2	110-650	362

RETA-CDA2	Spain	CDO from ToD	CO_2	250-800	210
DORIS	Spain	Oceanic: Flight optimisation with ATC coordination & Data link (ACARS, FANS CPDLC)	CO_2	3 134	110
ONATAP	Portugal	Free and Direct Routes	CO_2	526	999
ENGAGE	UK	Optimisation of cruise altitude and/or Mach number	CO_2	1 310	23
RlongSM (Reduced longitudinal Separation Minima)	UK	Optimisation of cruise altitude profiles	CO_2	441	533
Gate to gate Green Shuttle	France	Optimisation of cruise altitude profile & CDO from ToD	CO_2	788	221
Transatlantic green flight PPTP	France	Optimisation of oceanic trajectory (vertical and lateral) & approach	CO_2	2 090+ 1 050	93
Greener Wave	Switzerland	Optimisation of holding time through 4D slot allocation	CO_2	504	1 700
VINGA	Sweden	CDO from ToD with RNP STAR and RNP AR.	CO_2 & noise	70-285; negligible change to noise contours	189
AIRE Green Connections	Sweden	Optimised arrivals and approaches based on RNP AR & Data link. 4D trajectory exercise	CO_2 & noise	220	25
Trajectory based night time	The Netherlands	CDO with pre-planning	CO_2 + noise	TBC	124
A380 Transatlantic Green Flights	France	Optimisation of taxiing and cruise altitude profile	CO_2	1 200+ 1 900	19
				Total	**9 416**

Table 8: Summary of AIRE 2 projects

The AIRE 3 campaign comprised 9 projects (2012-2014) and 5199 trials summarised in table 9.

Project name	Location	Operation	Number of Trials	Benefits per flight
AMBER	Riga International Airport	Turboprop aircraft to fly tailored Required Navigation Performance – Authorisation Required (RNP-AR) approaches together with Continuous Descent Operations (CDO),	124	230 kg reduction in CO_2 emissions per approach; A reduction in noise impact of 0.6 decibels (dBA).
CANARIAS	La Palma and Lanzarote airports	CCDs and CDOs	8	Area Navigation-Standard Terminal Arrival Route (RNAV STAR) and RNP-AR approaches 34-38 NM and 292-313 kg of fuel for La Palma and 14 NM and 100 kg of fuel for Lanzarote saved.
OPTA-IN	Palma de Mallorca Airport	CDOs	101	Potential reduction of 7-12% in fuel burn and related CO_2 emissions
REACT plus	Budapest Airport	CDOs and CCOs	4 113	102 kg of fuel conserved during each CDO
ENGAGE Phase II	North Atlantic – between Canada & Europe	Optimisation of cruise altitude and/or Mach number	210	200-400 litres of fuel savings; An average of 1-2% of fuel burn
SATISFIED	EUR-SAM Oceanic corridor	Free routing	165	1.58 t CO_2 emissions
SMART	Lisbon flight information region (FIR), New York Oceanic and Santa Maria FIR	Oceanic: Flight optimisation	250	3.13 t CO_2 per flight
WE-FREE	Paris CDG, Venice, Verona, Milano Linate, Pisa, Bologna, Torino, Genoa airports	Free routing	128	693 kg CO_2 for CDG-Roma Fiumicino; 504 kg CO_2 for CDG Milano Linate
MAGGO	Santa Maria FIR and TMA	Several enablers	100	The MAGGO project couldn't be concluded

Table 9: Summary of AIRE 3 projects

3.2.3.3 SESAR2020 Environmental Performance Assessment

SESAR2020 builds upon the expectations of SESAR1 and of the deployment baseline.
It is estimated that around 50.0m MT of fuel per year will be burned by 2025, ECAC wide, by around 10m flights. The SESAR2020 Fuel Saving Ambition (10%) equate to 500kg per flight or around 1.6 t CO_2 per flight, including:

- SESAR2020 Fuel Saving target for Solutions (6.8%) = 340kg/flight or 1 t CO_2/flight,
- SESAR 1 Fuel Saving performance (1.8%) = 90kg/flight or 283kg of CO_2/flight,
- SESAR Deployment Baseline Fuel Saving performance (0.2%) = 10kg/flight or 31kg of CO_2/flight,
- Non-SESAR ATM improvements (1.2%) = 60kg/flight or 189Kg of CO_2/flight.

It has to be noted that, while the SESAR 1 baseline was 2005, the SESAR2020 baseline is 2012.

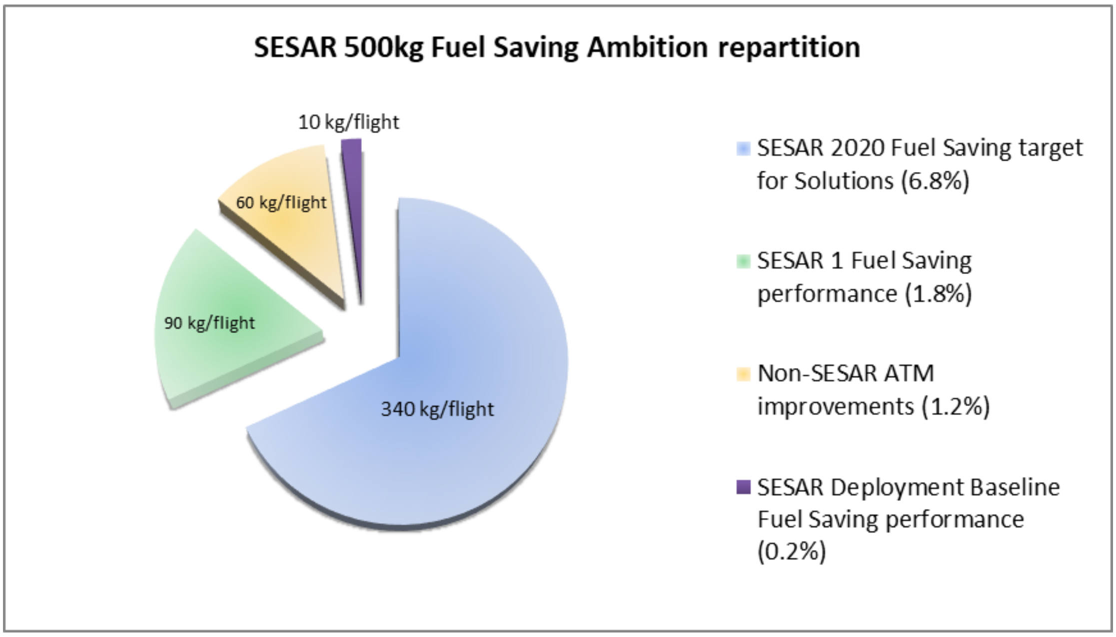


Figure 6

SESAR2020 has put in place a methodology that should allow a close monitoring of the expected fuel saving performance of each Solution, and of the overall programme. But, at this point of the SESAR2020 programme, it is too early to assess with a good level of confidence the gap between the expected fuel-saving benefit of each SESAR Solution and its demonstrated potential from the results of the validation exercises.
However, 30 out of the 85 SESAR2020 Solutions have the potential to generate fuel savings. Table 10 provides the Top 10 Solutions with the biggest expected fuel saving potential:

Solution	Short description + Fuel saving rational	Operational environment (OE/ Sub-OEs) benefitting
PJ.07-01 Airspace User Processes for Trajectory Definition	This Solution refers to the development of processes related to the Flight Operation Centre (FOC) aimed at managing and updating the shared business trajectory, and fully integrating FOCs in the ATM Network processes. These processes respond to the need to accommodate individual airspace users' business needs and priorities without compromising the performance of the overall ATM system or the performance of other stakeholders. This will also ensure continuity in the Collaborative Decision Making process throughout the trajectory lifecycle. The benefits will come through anticipation and choice of the optimal route and reduction of vertical inefficiencies, which will reduce costs and fuel burn. No real impact on airport is expected.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower for: Terminal High, Medium, Low Complexity En-route High, Medium Complexity
PJ.10-01C Collaborative Control	This Solution refers to coordination by exception rather than coordination by procedure and is facilitated by advanced controller tools, reducing the need for coordination agreements, fewer boundary constraints and the ability to combine sectors into multisector planner teams. The existence of clear procedures for collaborative control reduces the need for coordination and results in a more streamlined method of operation close to a sector boundary. This may bring a reduction in the number of level-offs and, thus, bring a partial improvement in fuel efficiency.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower for: Terminal High, Medium, Low Complexity En Route High, Medium Complexity
PJ.10-02b Advanced Separation Management	This Solution aims to further improve the quality of services of separation management in the en-route and TMA operational environments by introducing automation mechanisms and integrating additional information (ATC intent, aircraft intent). Controller tools will enable earlier and more precise detection and resolution of conflicts. This will reduce the need for vectoring and enable de-confliction actions to be taken earlier and through the usage of closed clearances. Those will be managed more proactively on-board, and benefit fuel efficiency. Clearances issued by the ATCOs may, in some situations, take into account aircraft derived data related to airline preferences, bringing an improvement in fuel efficiency.	Mainly for: Terminal Very High Complexity En-route Very High Complexity Some benefit but much lower: Terminal High, Medium, Low Complexity En-route High, Medium Complexity
PJ.09-03 Collaborative Network Management Functions	This Solution allows for network management based on transparency, performance targets and agreed control mechanisms. The work enables a real-time visualisation of the evolving Airport Operation Plan (AOP) and Network Operating Plan (NOP) planning environment (such as demand pattern and capacity bottlenecks) to support airspace user and local planning activities. Thanks to this Solution, the increased efficiency of the performance of the system due to more optimised trajectory with airlines preference will result in fuel burn reductions.	Mainly for: En-route Very High Complexity Some benefit but much lower for: Terminal very High, High, Medium Complexity En-route High, Medium Complexity Airport very large, large, medium
PJ.01-02 Use of Arrival and Departure	This Solution brings near real time traffic management to the TMA, taking advantage of predicted demand information provided by arrival and departure management systems from one or multiple airports.	Mainly for: Terminal Very High Complexity En-route Very High

Management Information for Traffic Optimisation within the TMA	This will allow the identification and resolution of complex interacting traffic flows in the TMA and on the runway, through the use of AMAN and DMAN flow adjustments and ground holdings. Traffic optimisation obtained thanks to this Solution will reduce the need for tactical interventions and will result in more efficient flights, and increased flight efficiency will save fuel.	Complexity Some benefit but much lower for: Terminal very High, High, Medium, Low Complexity En-route High, Medium Complexity
PJ2-01 Wake turbulence separation optimization	This Solution refers to the use of downlinked information from aircraft to predict wake vortex and determine appropriate wake-vortex minima dynamically, thereby optimising runway delivery. Wake turbulence separation optimization should reduce airborne delays due to arrival capacity limitations linked to wake separations. For major airports that are today constrained in peak hours, the use of: - optimised wake category scheme or pairwise separations can either be translated into added capacity (as described above) or additional resilience in case of perturbation. - time based separation will reduce the effect of a headwind on the arrival flow rate and thus increase the predictability of the scheduling process. On less constrained airports, significant improvement can also be observed by employing reduced separation applied on a time based separation basis in the specific runway configuration or wind conditions responsible for a large part of the airport delay. This increases the flexibility for Controllers to manage the arrival traffic due to the separation minima reduction. The weather dependant reduction of wake separation, considering the allowable increase of throughput, is expected to be a major mitigation of delay and to provide for an increase in the flexibility for Controllers to manage the arrival traffic due to the reduction in the required wake separations. The reduction of delay will generate fuel saving.	Mainly for: Airports and TMAs with High and Medium complexity. • Any runway configuration. • Airports with mainly strong headwinds. • Capacity constrained airports or airports with observed delay.
PJ.09-02 Integrated local DCB processes	This Solution sees the seamless integration of local network management with extended air traffic control planning and arrival management activities in short-term and execution phases. The work will improve the efficiency of ATM resource management, as well as the effectiveness of complexity resolutions by closing the gap between local network management and extended ATC planning. The increased efficiency of the performance of the system due to more optimised trajectory with airlines preference will result in fuel burn reductions.	Mainly for: Airport Very large Some benefit but much lower for: Terminal very High, High, Medium Complexity En-route very High, High, Medium Complexity Airport large, medium
PJ.01-03 Dynamic and Enhanced Routes and Airspace	This Solution brings together vertical and lateral profile issues in both the en-route and TMA phases of flight, with a view to creating an end-to-end optimised profile and ensuring transition between free route and fixed route airspace. The Solution will be supported by new controller tools and enhanced airborne functionalities. Significant fuel efficiency benefits are expected from Continuous Descent (CDO) / Continuous Climb Operations (CCO) in high density operations. CDO / CCO permit closer correlation of the actual with optimal vertical profile, to take into account the preference of the Airspace User for the most efficient	Mainly for: Terminal Very High Complexity Some benefit but much lower for: Terminal High, Medium Complexity

	climb / descent profile for the flight. Implementation of enhanced conformance monitoring / alerting by both ground and airborne systems reduce the likelihood of ATCO intervention in the climb / descent, so reducing the potential for tactical level offs.	
PJ.02-08 Traffic optimisation on single and multiple runway airports	This Solution refers to a system that enables tower and approach controllers to optimise runway operations arrival and/or departure spacing and make the best use of minimum separations, runway occupancy, runway capacity and airport capacity. Imbalances known more than 3 hours ahead allow to re-planning inbound traffic from the originating airport or reconsider Airport Transit View (ATV) on behalf of airlines reducing delays due to airport constraints up to 20%. Planning runway closures or runway changes in the optimum periods of the day will minimize the time spent re-routing air and ground traffic during the execution phase. Sharing this information with the different actors will provide the NOP with more accurate forecasts for arrival and departure time in order to coordinate the subsequent target times. There should be some fuel gains as a direct consequence of improved predictability, both for departures and arrivals (less variability ==> less patch stretching, holdings ...).	Mainly for: Terminal Very High Complexity • Single and Multiple runways • Preferably Congested large and medium size airports
PJ.08-01 Management of Dynamic Airspace configurations	This Solution refers to the development of the process, procedures and tools related to Dynamic Airspace Configuration (DAC), supporting Dynamic Mobile Areas of Type 1 and Type 2. It consists of the activation of Airspace configurations through an integrated collaborative decision making process, at national, sub-regional and regional levels; a seamless and coordinated approach to airspace configuration, from planning to execution phases, allowing the Network to continuously adapt to demand pattern changes in a free route environment) and ATC sector configurations adapted to dynamic TMA boundaries and both fixed and dynamic elements. This solution increased efficiency enabling optimised flight trajectories and profiles with the end result being reduced fuel burn, noise and CO_2 emissions. Advanced Airspace Management should decrease Airspace Users fuel consumption and reduce flight time. Optimised trajectory and a more direct route as a result of enhanced situation awareness through real airspace status update and seamless civil-military coordination by AFUA application.	Mainly for: En-route Very High Complexity Some benefit but much lower for: En-route High, Medium Complexity

Table 10: Summary of SESAR2020 projects offering the greatest potential fuel savings

3.2.4 Economic/Market-Based Measures

ECAC members have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The 31 EEA states in Europe have already implemented the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap and trade approach to limit CO_2 emissions. It was the first and is the biggest international system capping greenhouse gas emissions. In the period 2012 to 2018 EU ETS has saved an estimated 100 million tonnes of intra-European aviation CO_2 emissions.

3.2.4.1 The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is the cornerstone of the European Union's policy to tackle climate change, and a key tool for reducing greenhouse gas emissions cost-effectively, including from the aviation sector. It operates in 31 countries: the 28 EU Member States, Iceland, Liechtenstein and Norway. The EU ETS is the first and so far the biggest international system capping greenhouse gas emissions; it currently covers half of the EU's CO_2 emissions, encompassing those from around 12 000 power stations and industrial plants in 31 countries, and, under its current scope, around 500 commercial and non-commercial aircraft operators that fly between airports in the European Economic Area (EEA). The EU ETS Directive has recently been revised in line with the European Council Conclusions of October 2014[17] that confirmed that the EU ETS

[17] http://www.consilium.europa.eu/en/meetings/european-council/2014/10/23-24/

will be the main European instrument to achieve the EU's binding 2030 target of an at least 40% domestic reduction of greenhouse gases compared to 1990[18] .
The EU ETS began operation in 2005; a series of important changes to the way it works took effect in 2013, strengthening the system. The EU ETS works on the "cap and trade" principle. This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants, other installations and aircraft operators in the system. Within this cap, companies can sell to or buy emission allowances from one another. The limit on allowances available provides certainty that the environmental objective is achieved and gives allowances a market value. For aviation, the cap is calculated based on the average emissions from the years 2004-2006. Aircraft Operators are entitled to free allocation based on an efficiency benchmark, but this might not cover the totality of emissions. The remaining allowances need to be purchased from auctions or from the secondary market. The system allows aircraft operators to use aviation allowances or general (stationary installations) allowances to cover their emissions.
By 30th April each year, companies, including aircraft operators, have to surrender allowances to cover their emissions from the previous calendar year. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or sell them to another company that is short of allowances. The flexibility that trading brings ensures that emissions are cut where it costs least to do so. The number of allowances reduces over time so that total emissions fall.
As regards aviation, legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[19]. The 2006 proposal to include aviation in the EU ETS, in line with the resolution of the 2004 ICAO Assembly deciding not to develop a global measure but to favour the inclusion of aviation in open regional systems, was accompanied by a detailed impact assessment[20]. After careful analysis of the different options, it was concluded that this was the most cost-efficient and environmentally effective option for addressing aviation emissions.
In October 2013, the Assembly of the International Civil Aviation Organisation (ICAO) decided to develop a global market-based mechanism (MBM) for international aviation emissions. Following this agreement the EU decided to limit the scope of the EU ETS to flights between airports located in the European Economic Area (EEA) for the period 2013-2016 (Regulation 421/2014), and to carry out a new revision in the light of the outcome of the 2016 ICAO Assembly. The temporary limitation follows on from the April 2013 'stop the clock' decision[21] adopted to promote progress on global action at the 2013 ICAO Assembly.

[18] Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0410

[19] Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0101

[20] http://ec.europa.eu/clima/policies/transport/aviation/documentation_en.htm

[21] Decision No. 377/2013/EU derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/LexUri ServLexUri Serv.do?uri=CELEX:32013D0377:EN:NOT

The European Commission assessed the outcome of the 39th ICAO Assembly and, in that light, made a new legislative proposal on the scope of the EU ETS. Following the EU legislative process, this Regulation was adopted in December 2017[22].

The legislation maintains the scope of the EU ETS for aviation limited to intra-EEA flights. It foresees that once there is clarity on the nature and content of the legal instruments adopted by ICAO for the implementation of CORSIA, as well as about the intentions of other states regarding its implementation, a further assessment should take place and a report be presented to the European Parliament and to the Council considering how to implement CORSIA in Union law through a revision of the EU ETS Directive. This should be accompanied, where appropriate, by a proposal to the European Parliament and to the Council to revise the EU ETS Directive that is consistent with the Union economy-wide greenhouse gas emission reduction commitment for 2030 with the aim of preserving the environmental integrity and effectiveness of Union climate action.

The Regulation also sets out the basis for the implementation of CORSIA. It provides for European legislation on the monitoring, reporting and verification rules that avoid any distortion of competition for the purpose of implementing CORSIA in European Union law. This will be undertaken through a delegated act under the EU ETS Directive.

The EU ETS has been effectively implemented over recent years on intra-EEA flights, and has ensured a level playing field with a very high level of compliance[23]. It will continue to be a central element of the EU policy to address aviation CO_2 emissions in the coming years.

The complete, consistent, transparent and accurate monitoring, reporting and verification of greenhouse gas emissions remains fundamental for the effective operation of the EU ETS. Aviation operators, verifiers and competent authorities have already gained wide experience with monitoring and reporting; detailed rules are prescribed by Regulations (EU) N°600/2012[24] and 601/2012.[25]

The EU legislation establishes exemptions and simplifications to avoid excessive administrative burden for the smallest operators of aircraft. Since the EU ETS for aviation took effect in 2012 a *de minimis* exemption for commercial operators – with either fewer than 243 flights per period for three consecutive four-month periods or flights with total annual emissions lower than 10 000 tonnes CO_2 per year applies. This means that many aircraft operators from developing countries are exempted from the EU ETS. Indeed, over 90 States have no commercial aircraft operators included in the scope of the EU ETS. In addition, from 2013 flights by non-commercial aircraft operators with total annual emissions lower

[22] Regulation (EU) 2017/2392 of the European Parliament and of the Council of 13 December 2017 amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.350.01.0007.01.ENG&toc=OJ:L:2017:350:TOC

[23] Report on the functioning of the European carbon market, COM(2017) 693 final, https://ec.europa.eu/commission/sites/beta.../report-functioning-carbon-market_en.pdf

[24] Commission Regulation (EU) No 600/2012 of 21 June 2012 on the verification of greenhouse gas emission reports and tonne-kilometre reports and the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0600&from=EN

[25] Regulation (EU) No 601/2012 of the European Parliament and of the Council of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012R0601

than 1 000 tonnes CO_2 per year are excluded from the EU ETS. A further administrative simplification applies to small aircraft operators emitting less than 25 000 tonnes of CO_2 per year, who can choose to use the small emitters' tool rather than independent verification of their emissions. In addition, small emitter aircraft operators can use the simplified reporting procedures under the existing legislation. The recent amendment to extend the intra-EEA scope after 2016 includes a new simplification, allowing aircraft operators emitting less than 3 000 tCO_2 per year on intra-EEA flights to use the small emitters' tool.
The EU legislation foresees that, where a third country takes measures to reduce the climate change impact of flights departing from its airports, the EU will consider options available in order to provide for optimal interaction between the EU scheme and that country's measures. In such a case, flights arriving from the third country could be excluded from the scope of the EU ETS. This will be the case between the EU and Switzerland following the agreement to link their respective emissions trading systems, which was signed on 23rd November 2017. The EU therefore encourages other countries to adopt measures of their own and is ready to engage in bilateral discussions with any country that has done so. The legislation also makes it clear that if there is agreement on global measures, the EU shall consider whether amendments to the EU legislation regarding aviation under the EU ETS are necessary.

Impact on fuel consumption and/or CO_2 emissions

The environmental outcome of an emissions trading system is determined by the emissions cap. Aircraft operators are able to use allowances from outside the aviation sector to cover their emissions. The absolute level of CO_2 emissions from the aviation sector itself can exceed the number of allowances allocated to it, as the increase is offset by CO_2 emissions reductions in other sectors of the economy covered by the EU ETS.

With the inclusion of intra-European flights in the EU ETS it has delivered around 100 MT of CO_2 reductions/offsets between 2012 and 2018. The total amount of annual allowances to be issued will be around 38 million, whilst verified CO_2 emissions from aviation activities carried out between aerodromes located in the EEA has fluctuated between 53.5 MT CO_2 in 2013 and 61MT in 2016. This means that the EU ETS is now contributing more than 23 MT CO_2 of emission reductions annually[26], or around 100 MT CO_2 over 2012-2018, partly within the sector (airlines reduce their emissions to avoid paying for additional units) or in other sectors (airlines purchase units from other ETS sectors, which would have to reduce their emissions consistently). While some reductions are likely to be within the aviation sector, encouraged by the EU ETS's economic incentive for limiting emissions or use of aviation biofuels, the majority of reductions are expected to occur in other sectors.
Putting a price on greenhouse gas emissions is important to harness market forces and achieve cost-effective emission reductions. In parallel to providing a carbon price which incentivises emission reductions, the EU ETS also supports the reduction of greenhouse gas emissions through €2.1bn fund for the deployment of innovative renewables and carbon capture and storage. This funding has been

[26] Report on the functioning of the European carbon market, COM(2017) 693 final, https://ec.europa.eu/commission/sites/beta.../report-functioning-carbon-market_en.pdf

raised from the sale of 300 million emission allowances from the New Entrants' Reserve of the third phase of the EU ETS. This includes over €900m for supporting bioenergy projects, including advanced biofuels.

In addition, through Member States' use of EU ETS auction revenue in 2015, over €3.5bn has been reported by them as being used to address climate change. The purposes for which revenues from allowances should be used encompass mitigation of greenhouse gas emissions and adaptation to the inevitable impacts of climate change in the EU and third countries. These will reduce emissions through: low-emission transport; funding research and development, including in particular in the field of aeronautics and air transport; providing contributions to the Global Energy Efficiency and Renewable Energy Fund, and measures to avoid deforestation.

In terms of its contribution towards the ICAO global goals, the states implementing the EU ETS have delivered, in "net" terms, a reduction of around 100 MT of aviation CO_2 emissions over 2012-2018 for the scope that is covered, and this reduction will continue to increase in the future under the new legislation. Other emission reduction measures taken, either collectively throughout Europe or by any of the 31 individual states implementing the EU ETS, will also contribute towards the ICAO global goals. Such measures are likely to moderate the anticipated growth in aviation emissions.

Estimated emissions reductions resulting from the EU-ETS

Year	*Reduction in CO_2 emissions*
2012-2018	*100 MT*

Table 11: Summary of estimated EU-ETS emission reductions

The table presents projected benefits of the EU-ETS based on the current scope (intra-European flights).

3.2.4.2 The Carbon Offsetting and Reduction Scheme for International Aviation

In October 2016, the Assembly of ICAO confirmed the objective of targeting CO_2-neutral growth as of 2020, and for this purpose to introduce a global market-based measure for compensating CO_2 emissions above that level, namely Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The corresponding resolution is A39-3: Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme.

According to the Assembly Resolution, the average level of CO_2 emissions from international aviation covered by the scheme between 2019 and 2020 represents the basis for carbon neutral growth from 2020, against which emissions in future years are compared. In any year from 2021 when international aviation CO_2 emissions covered by the scheme exceed the average baseline emissions of 2019

and 2020, this difference represents the sector's offsetting requirements for that year.
CORSIA is divided into 3 phases[27]: There is a pilot phase (2021-2023), a first phase (2024-2026) and a second phase (2027-2035). During CORSIA's pilot phase and the first phase, participation from states is voluntary. The second phase applies to all ICAO Member States.

CORSIA Implementation Plan Brochure (© ICAO)

Exempted are States with individual share of international aviation activities in RTKs, in year 2018 below 0.5 per cent of total RTKs and States that are not part of the list of States that account for 90 per cent of total RTKs when sorted from the highest to the lowest amount of individual RTKs. Additionally Least Developed Countries (LDCs), Small Island Developing States (SIDS) and Landlocked Developing Countries are exempted as well.
CORSIA operates on a route-based approach. The offsetting obligations of CORSIA shall apply to all aircraft operators on the same route between States, both of which are included in the CORSA. Exempted are a) emissions form aircraft operators emitting less than 10 000 tCO_2 emissions from international aviation per year, b) emissions from aircraft whose Maximum Take Off Mass (MTOM) is less than 5 700 kg, and c) emissions from humanitarian, medical and firefighting operations.
According to the "Bratislava Declaration" from September 3rd 2016 the Directors General of Civil Aviation of EU Member States and the other Member States of the European Civil Aviation Conference declared their intention to implement CORSIA from the start of the pilot phase provided certain conditions were met. This shows the full commitment of the EU, its Member States and the other Member States of ECAC to counter the expected in-sector growth of total CO_2 emissions from air transport and to achieving overall carbon neutral growth.

[27] Further information on https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx

3.2.5 EU Initiatives in Third Countries

3.2.5.1 Multilateral projects

At the end of 2013 the European Commission launched a project with a total budget of €6.5 million under the name "*Capacity building for CO_2 mitigation from international aviation*". The 42-month project, implemented by the ICAO, boosts less developed countries' ability to track, manage and reduce their aviation emissions. In line with the call from the 2013 ICAO Assembly, beneficiary countries will submit meaningful State action plans for reducing aviation emissions. They then and received assistance to establish emissions inventories and pilot new ways of reducing fuel consumption. Through the wide range of activities in these countries, the project contributes to international, regional and national efforts to address growing emissions from international aviation. The beneficiary countries are the following:

Africa: Burkina Faso, Kenya and Economic Community of Central African States (ECCAS) Member States: Angola, Burundi, Cameroon, Central African Republic, Chad, Republic of Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, Sao Tome and Principe.

Caribbean: Dominican Republic and Trinidad and Tobago.

Preceding the ICAO Assembly of October 2016 sealing the decision to create a global MBM scheme, a declaration of intent was signed between Transport Commissioner Violeta Bulc and ICAO Secretary General Dr Fang Liu, announcing their common intention to continue cooperation to address climate change towards the implementation of the ICAO Global Market Based Measures. On adoption of a decision by the ICAO Assembly on a GMBM, the parties intended to jointly examine the most effective mechanisms to upgrade the existing support mechanism and also to continue similar assistance, including cooperation and knowledge sharing with other international organisations, with the aim of starting in 2019.

The "Capacity building for CO_2 mitigation from international aviation" has been of enormous value to the beneficiary countries. A second project has been initiated by the European Commission aimed at assisting a new set of countries on their way to implementing the CORSIA. Further details will be published upon signature of the contract with the different parties.

Additionally, initiatives providing ASEAN Member States with technical assistance on implementing CORSIA have been initiated in 2018 and will possibly be extended further in 2019. The ARISE plus project dedicates an activity under result 3 - *'strengthened national capabilities of individual ASEAN Members States and aligned measures with ICAO SARPs'*. To achieve this, the project will support workshops in 2018 on capacity building and technical assistance, especially for the development or enhancement of actions plans. This will provide a genuine opportunity to pave the way for the effective implementation of further potential assistance and foster States readiness for their first national aviation emission report at the end of 2019.

EASA is also implementing Aviation Partnership Projects (APPs) in China, South Asia and Latin America (including the Caribbean) as well as projects funded by DG NEAR and DG DEVCO in other regions. This can enable the EU to form a holistic view of progress on CORSIA implementation worldwide.

In terms of synergies, the South Asia and South East Asia environmental workshops could engage with key regional stakeholders (ICAO Asia Pacific office, regulatory authorities, airline operators, verification bodies), and thereby assess the level of readiness for CORSIA on wider scale in the Asia Pacific region. This preparatory work would help focus the subsequent FPI CORSIA project and create economies of scale in order to maximise the benefits of the project, which needs to be implemented within an ambitious timescale.

3.2.6 Support to voluntary actions

3.2.6.1 ACI Airport Carbon Accreditation

This is a certification programme for carbon management at airports, based on carbon mapping and management standards specifically designed for the airport industry. It was launched in 2009 by ACI EUROPE, the trade association for European airports.

The underlying aim of the programme is to encourage and enable airports to implement best practice carbon and energy management processes and to gain public recognition of their achievements. It requires airports to measure their CO_2 emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party.

This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). It is also officially supported by the United Nations Environmental Programme (UNEP). The programme is overseen by an independent Advisory Board.

At the beginning of this reporting year (May 2016) there were 156 airports in the programme. Since then, a further 36 airports have joined and 3 have withdrawn, bringing the total number of airports at the end of this reporting year (May 2017) to 189 covering 38.1 % of global air passenger traffic.

In 2017, for the first time, airports outside Europe achieved the highest accreditation status: 1 airport in North America, 5 in Asia-Pacific and 1 in Africa have been recognised as carbon neutral. European airports doubled their pledge and set the bar at 100 European airports becoming carbon neutral by 2030 from the 34 currently assessed to be carbon neutral.

Airport Carbon Accreditation is a four-step programme, from carbon mapping to carbon neutrality. The four steps of certification are: Level 1 "Mapping", Level 2 "Reduction", Level 3 "Optimisation", and Level 3+ "Carbon Neutrality".

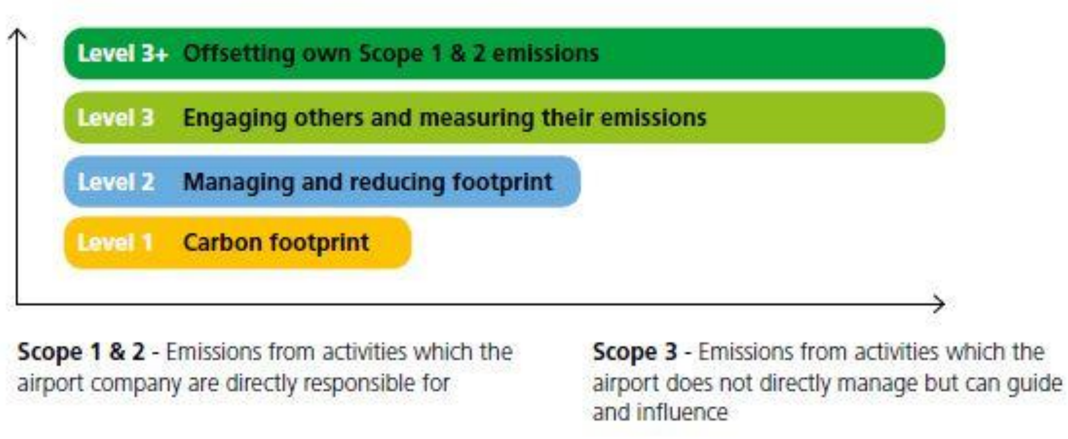


Figure 7: Four steps of Airport Carbon Accreditation

Levels of certification (ACA Annual Report 2016-2017)

One of its essential requirements is the verification by external and independent auditors of the data provided by airports. Aggregated data are included in the *Airport Carbon Accreditation* Annual Report thus ensuring transparent and accurate carbon reporting. At level 2 of the programme and above (Reduction, Optimisation and Carbon Neutrality), airport operators are required to demonstrate CO_2 reductions associated with the activities they control.
For historical reasons European airports remain at the forefront of airport actions to voluntarily mitigate and reduce their impact on climate change. The strong growth momentum was maintained for the reporting year which ended with 116 airports in the programme. These airports account for 64.8% of European passenger traffic and 61% of all accredited airports in the programme this year.

Anticipated benefits

The Administrator of the programme has been collecting CO_2 data from participating airports over the past five years. This has allowed the absolute CO_2 reduction from the participation in the programme to be quantified.

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Total aggregate scope 1 & 2 reduction ($ktCO_2$)	51.7	54.6	48.7	140	130	169	156	155
Total aggregate scope 3 reduction ($ktCO_2$)	360	675	366	30.2	224	551	142	899

Table 12: Emissions reduction highlights for the European region

	2015-2016	2016-2017
Aggregate emissions offset, Level 3+ (tCO_2)	222	252 218

Table 13: Emissions offset for the European region

The table above presents the aggregate emissions offset by airports accredited at Level 3+ of the programme. The programme requires airports at Level 3+ to offset their residual Scope 1 & 2 emissions as well as Scope 3 emissions from staff business travel.

Variable	**2013 -2014**		**2014-2015**	
	Emissions	**N. of airports**	**Emissions**	**N. of airports**
Aggregate carbon footprint for 'year 0'[28] for emissions under airports' direct control (all airports)	2.04 MT CO_2	85	2.09 MT CO_2	92
Carbon footprint per passenger	2.01 kg CO^2		1,89 kg CO_2	
Aggregate reduction in emissions from sources under airports' direct control (Level 2 and above)[29]	87.4 ktonnes CO_2	56	139 ktonnes CO_2	71
Carbon footprint reduction per passenger	0.11 kg CO_2		0.15 kg CO_2	
Total carbon footprint for 'year 0' for emissions sources which an airport may guide or influence (level 3 and above)[30]	12.8 MT CO_2	31	14.0 MT CO_2	36
Aggregate reductions from emissions sources which an airport may guide or influence	224 ktonnes CO_2		551 ktonnes CO_2	
Total emissions offset (Level 3+)	181 ktonnes CO_2	16	294 ktonnes CO_2	20

Table 14: Summary of Emissions under airports direct control

Its main immediate environmental co-benefit is the improvement of local air quality. Costs for the design, development and implementation of *Airport Carbon Accreditation* have been borne by ACI EUROPE. *Airport Carbon Accreditation* is a non-for-profit initiative, with participation fees set at a level aimed at allowing for the recovery of the aforementioned costs.

[28] 'Year 0' refers to the 12 month period for which an individual airport's carbon footprint refers to, which according to the Airport Carbon Accreditation requirements must have been within 12 months of the application date.

[29] This figure includes increases in CO_2 emissions at airports that have used a relative emissions benchmark in order to demonstrate a reduction.

[30] These emissions sources are those detailed in the guidance document, plus any other sources that an airport may wish to include.

The scope of *Airport Carbon Accreditation,* i.e. emissions that an airport operator can control, guide and influence, implies that aircraft emissions in the LTO cycle are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions during the LTO cycle. This is consistent with the objective of including aviation in the EU ETS as of 1 January 2012 (Directive 2008/101/EC) and can support the efforts of airlines to reduce these emissions.

3.3 APPENDIX A

Detailed results for ECAC Scenarios

1. BASELINE SCENARIO (technology freeze in 2010)

a) International passenger and cargo traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[31] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[32] FTKT (billion)	Total Revenue Tonne Kilometres[32, 33] RTK (billion)
2010	4.6	1,218	0.20	45.4	167.2
2016	5.2	1,601	0.21	45.3	205.4
2020	5.6	1,825	0.25	49.4	231.9
2030	7.0	2,406	0.35	63.8	304.4
2040	8.4	2,919	0.45	79.4	371.2

Note that the traffic scenario shown in the table is assumed for both the baseline and implemented measures scenarios.

b) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.28	146.26	179.6	0.0287	0.287
2020	49.95	157.85	193.8	0.0274	0.274
2030	61.75	195.13	239.6	0.0256	0.256
2040	75.44	238.38	292.7	0.0259	0.259
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

[31] Calculated based on 98% of the passenger traffic for which sufficient data is available.
[32] Includes passenger and freight transport (on all-cargo and passenger flights).
[33] A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

2. IMPLEMENTED MEASURES SCENARIO

2A) EFFECTS OF AIRCRAFT TECHNOLOGY IMPROVEMENT AFTER 2010

Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2010 included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.28	146.26	179.6	0.0286	0.286
2020	49.08	155.08	190.4	0.0270	0.245
2030	58.65	185.34	227.6	0.0247	0.247
2040	68.99	218.01	267.7	0.0242	0.242
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

2B) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AFTER 2010

Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2010:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.24	146.11	179.4	0.0286	0.286
2020	49.03	154.93	190.2	0.0245	0.245
2030	57.38	181.33	222.6	0.0242	0.242
2040	67.50	213.30	261.9	0.0237	0.237
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

2C) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AND ALTERNATIVE FUELS

Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements as well as alternative fuel effects included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	37.98	120.00	147.3	0.0310	0.310
2016	46.24	146.11	179.4	0.0286	0.286
2020	49.03	154.93	187.9	0.0245	0.245
2030	57.38	181.33	199.5	0.0242	0.242
2040	67.50	213.30	214.8	0.0237	0.237
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of alternative fuels.					

4. NATIONAL MEASURES IN ITALY

4.1 Historic emissions and baseline

In order to better control the Italian share of CO_2 emissions, Italy has established a national baseline for international aviation, fuel consumption and traffic.
With the aim of quantifying the traffic data under Italian responsibility for the baseline, the following assumptions have been taken into consideration.
Italy is a full member of the EU and, consequently, every EU registered operator is free to operate domestic flights within Italy, as well as international intra-European flights.
As per ICAO definition of "international flight", international intra-European flights are always considered "international" and, therefore, the competent authority, overviewing non-Italian operators, is the National Aviation Authority, who registered these operators.
The main caution consideration arising from this situation is to avoid the double counting of emissions from non-Italian airlines operating international intra-European flights.
Italy has decided to adopt the IPCC methodology to differentiate international and domestic aviation operations: a flight departing from an Italian airport and arriving in another Italian airport is always considered domestic, regardless of the nationality of the air operator.
However there are three different possibilities of counting the CO_2 emissions:

- If the flight is operated by an Italian airline, its emissions are included in the Italian national baseline, regardless of inbound or outbound flights.
- If the flight is operated by a non-Italian airline, and connects Italy to the State where the operator is registered, its emissions are included in the baseline of the State where such operator is registered.
- If the flight is operated by a non-Italian airline and connects Italy to a State other than the one where the operator is registered, then only the outbound flight emissions are included in the Italian national baseline; the inbound flights are counted by the Authority of the State from where the flight originates.
- If the flight is operated under 5th freedom, only emissions of the outbound flights are considered.

In this latter case, non-Italian airlines report the quantity of CO_2 emissions to Italy on voluntary basis.
The table below shows, in accordance with the above IPCC definition, the international percentage of the passengers transported:

- from Italian airports;
- to Italian airports by Italian airlines only.

It is to keep in mind that:

- Data from airlines transporting less than 100.000 passenger a year have not been considered;
- Italian Cargo airlines have been included.

Furthermore, the baseline does not consider neither traffic data from carriers whose licenses were withdrawn or suspended by Italian Civil Aviation Authority in the last five years, nor flights operated by aircraft with less than 20 seats capacity.

	Airline	Nationality	IPCC 2017 Intern Pax	IPCC % Share
1	Ryanair	Ireland	12.223.544	36,6
2	Alitalia	Italy	9.614.368	28,8
3	Easyjet	UK	4.344.687	13,0
4	Wizzair	Hungary	1.831.069	5,5
5	Vueling	Spain	1.200.790	3,6
6	Blue Panorama Airlines	Italy	1.198.774	3,5
7	Air Italy	Italy	1.124.735	3,4
8	Neos	Italy	1.095.064	3,3
9	Volotea	Spain	290.668	0,9
10	Eurowings	Germany	133.924	0,4

Table 1 (Passenger data – IPCC definition)

As shown in the table above, the percentage of international IPCC traffic falling under the direct control of Italy is below the threshold of 50%. Since there is no obligation for non-Italian airlines to report the quantity of CO_2 emissions to Italy, it is not always easy to gather such information. For this reason Italy will foster appropriate actions at EU level to facilitate the collection of these data.

The tables below show the emissions of CO_2 for the airlines operating in Italy, according to the IPCC definition of international flights. Data have been rounded to facilitate reading.
The baseline table is divided in two sub-tables.
Sub-table 2A refers to the airlines that are under direct control of ENAC, the Italian Civil Aviation Authority; sub-table 2B refers to the foreign airlines operating in Italy.
The forecast for future years, represented in terms of international RTK, fuel consumption and CO_2 emissions is the result of the methodology defined by ICAO in the "*Guidance on the development of States Action Plans on CO_2 Emissions reduction activities*" applied to Italian data (however using the IPCC definition).

Italian Airlines	Total RTKs (tonne-kilometres)	Total fuel (litres)	Total CO_2 emissions (metric tonnes)	International RTKs (tone-kilometres)	International fuel (litres)	International CO_2 emissions (metric tonnes)
2014	5.279.750.000	2.108.370.000	5.330.000	4.340.350.000	1.626.940.000	4.110.000
2015	5.204.550.000	2.039.530.000	5.160.000	4.387.550.000	1.623.200.000	4.100.000
2016	5.477.270.000	2.142.640.000	5.420.000	4.659.810.000	1.725.980.000	4.360.000
2017	5.635.400.000	2.172.450.000	5.490.000	4.857.480.000	1.765.950.000	4.460.000
2018	5.910.810.000	2.258.560.000	5.700.000	5.142.050.000	1.851.070.000	4.670.000
2019	6.540.110.000	2.498.410.000	6.310.000	5.687.230.000	2.056.960.000	5.190.000
2020	7.171.700.000	2.737.050.000	6.910.000	6.280.550.000	2.278.370.000	5.750.000
2021	7.690.520.000	2.879.980.000	7.270.000	6.779.620.000	2.411.050.000	6.080.000

Sub-table 2A (data from Italian airlines) – IPCC definition

Italian Airlines	Total RTKs (tonne-kilometres)	Total fuel (litres)	Total CO_2 emissions (metric tonnes)	International RTKs (tone-kilometres)	International fuel (litres)	International CO_2 emissions (metric tonnes)
2014	2.689.100.000	1.029.870.000	2.600.000	1.930.540.000	733.440.000	1.850.000
2015	2.948.540.000	1.124.580.000	2.840.000	2.120.510.000	796.870.000	2.010.000
2016	3.084.660.000	1.196.150.000	3.020.000	2.224.540.000	859.600.000	2.170.000
2017	3.518.330.000	1.360.430.000	3.440.000	2.569.860.000	991.090.000	2.500.000
2018	3.709.040.000	1.432.210.000	3.620.000	2.718.910.000	1.050.360.000	2.650.000
2019	3.892.600.000	1.500.250.000	3.790.000	2.882.960.000	1.115.060.000	2.820.000
2020	4.102.860.000	1.582.830.000	4.000.000	3.049.260.000	1.181.050.000	2.980.000
2021	4.347.340.000	1.678.810.000	4.240.000	3.246.280.000	1.258.980.000	3.180.000

Sub-table 2B (data from non-Italian airlines) IPCC definition

Notes:
1. Based on data available in July 2018.
2. Data can not be compared directly to the previous edition of the action plan, since it did not break up the results according to the nationality of the airline.

4.2 National actions for sustainable development of Air Transport

Since Civil Aviation is an essential component of the development of the global economy, all the environmental actions of the present CO_2 emissions reduction plan try to find a balance among the needs of mobility of the population, the industry growth and an environmentally sustainable growth. The emissions reduction must be pursued through the adoption of appropriate technological, operational, infrastructural and economical measures.
To obtain sound results, the measures identified by ICAO must be applied in a coordinated manner by all the stakeholders involved, under the supervision of National Civil Aviation Authorities. This supervision involves an objective complexity due to the multitude of stakeholders and to the difficulty of collecting consistent measurable and complete data, to refer them to a common base year and to test the goal achieved by each proposal within an appropriate timing.
In any case, looking at Italian targets of emissions reduction, it must be underlined that Italy joins the group of the most developed countries in the field of air transport, both in Europe and worldwide, for airport infrastructures, configuration of the airline's fleet and optimization of ATM.
Italy has already made several significant steps torward an environmental sustainable civil aviation, with actions individually taken by aeronautical operators and through an active participation in European programmes.
Even though, in accordance with Resolution A38-18, National Action Plans should incorporate information on activities that aim at addressing CO_2 emissions only from international aviation, Italy considers the aviation sector as a whole. Therefore, the Italy's Action Plan provides information on measures affecting both domestic and international operations and on emissions deriving from airport and/or ground support equipment operations.
Italy is at the forefront in this field and is in a prime position in fulfilling the expectations for global emissions reduction, since policies and strategies for sustainable development of air transport have been already implemented.

4.2.1 Aircraft technology and Flight operations

Aviation is a small but important contributor to climate change. Aircraft are estimated to contribute for roughly 3,5% of the total radioactive forcing (a measuring unit of climate change) produced by all human activities. This percentage, which excludes the effects of possible changes in cirrus clouds, is expected to grow.
CO_2 emissions from air transport represent roughly 2% of total global CO_2 emissions. Fuel burning is responsible for the GHG increase and, on the other hand, the fuel price is one of the major drivers in the determination of profitability in aviation industry. The implementation of a fuel efficiency policy has been pushed forward as a consequence of the oil cost growth in the last decade. A consequence of this fuel efficiency policy is the CO_2 emissions reduction. Since 2009 some Italian airlines have been adopting several measures for fuel saving, in order to prevent a more significant downgrade, to avoid a worsening of the global economic crisis, as well as in application of the ETS system.
The basket of selected and implemented measures comprises:

Aircraft Related Technology Development

- From 2009 to 2017 Italian airlines phased out most of their old aircraft (MD80; B737 old generation; B767 etc.) with new and more fuel efficient aircraft. The reduction of fuel consumption can be estimated around 20% compared to consumption of MD80 aircraft and 10% compared to consumption of B737 old generation. In absolute terms, Italian airlines saved every year CO_2 emissions equivalent to about 1000 tonnes per aircraft phased out. After the phase out of the majority of the old aircraft, and with the entrance into their fleet of new aircraft, the average age of the Italian airlines fleet is now quite low;
- Winglets have been installed on some long range aircraft with an estimated fuel saving of about 6% per modified aircraft;
- Engines replacement has been accomplished on long range aircraft with new and more efficient engines;
- Some Italian airlines have already introduced in their long haul fleet the latest models of Boeing 787, resulting in a 20% savings of CO_2 emissions compared to the aircraft model previously operated;
- Some foreign airlines operating in Italy (in the domestic, intra-EU and extra-EU market), introduced the latest models of Boeing 737 Max and Airbus 320 Neo with geared turbofan engines, saving 15% CO_2 emissions compared to the aircraft model previously operated.

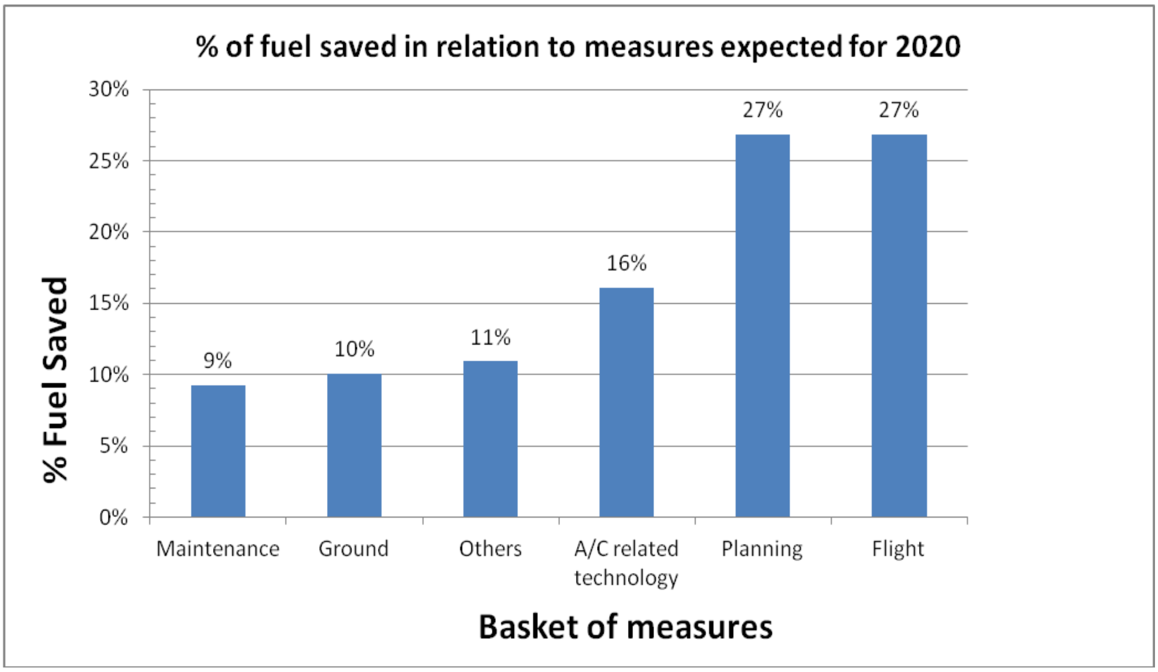
Improvement of Air Traffic Management

- The Actualized Operation Flight Plan has been implemented in order to establish fuel quantity based on actualized updated information en route and on arrival;
- As much extent as possible the En Route Optimization, in coordination with pertinent Air Navigation Service Provider, has been implemented;
- The following more efficient operations procedures have been implemented:
  - Cost Index and Climb Profile Optimization in order to calculate economy climb, cruise and descent speeds based on aircraft performance parameters;
  - Extra fuel Optimization based on Actualized Operation Flight Plan;
  - Estimated Zero Fuel Weight Optimization based on load plan;
  - Final Zero Fuel Weight Calculation Optimization;

- Single Engine Taxi;
- Weight Reduction by: Light weight trolleys, less catering equipment, magazine, tires Change, new life vest, paperless cockpit, ULD, coffee makers, entertainment system water load reduction, etc.;
- Weigh & Balance optimization for best cruise profile;
- Reduced Flap on Landing;
- Optimization in APU operation on ground and maximization in the using of the GSE;
- MEL & CDL reduction in order to resolve malfunction causing air traffic limitation (cruise speed, flight level, etc.);
- Engines Wash in order to restore engine fuel burning efficiency;
- Close in re-fleeting and Fleet Optimization Operation in order to perform the best fleet type assigned to a given flight close to departure to better accommodate the anticipated increase or shortfall in demand.

The implementation of such measures was planned in phases, the first of which started in 2009 and was completed in 2014. At the moment the aviation sector has been consolidating the results achieved, and additional improvements are expected by 2020 and beyond.
In the next future the replacements of the remaining old aircraft, i.e., are foreseeable. Looking forward to the future, up to 2050, it is not simple to predict the evolution, because several factors could affect this forecast.
The following charts show, limited to international activities and to Italian civil operators involved in international flights, the fuel burnt, the CO_2 emissions and the quantification of the effects after the implementation of the selected measures, as well as the expected results up to 2020:

In the following picture an estimation of the fuel allocation saved in relation to the implemented measures is showed:



It is important to note how the optimization of flight plan activities and flight procedures and routes plays a relevant role in CO_2 emissions reduction.
It is also important to underline the role of the aircraft related technology on the fuel saving. The obtained result is basically related to the replacement of the MD80 fleet. Now the Italian fleet is relatively young but, looking forward in the future years (2020 to 2050), Italy will have the opportunity to introduce the new aircraft with better fuel efficient system (B737 max; Airbus NEO series, B787 Dreamliner, etc…) with an estimated efficiency of roughly 20%.

4.2.2 Alternative Fuels

Aviation has an important role to play in greenhouse gas emissions as well as noise and local air quality issues. The continuous increase of air passenger transport generates an increasing use of hydrocarbon fuel with excessive emission of CO_2 and NOX (greenhouse gases, pollutants and noise). It is well known that commercial aircraft operations impact the atmosphere by the emissions of greenhouse gases and greenhouse gas precursors, and also through the formation of contrails and cirrus clouds.

Efforts in green technologies have to be collected and prospected in three major lines: Air vehicle, Air Transport System and Sustainable Energies.

The introduction of alternative fuels will contribute significantly to creating an effective and sustainable framework for the growing aviation industry. Cultivating energy crops that do not compete with food can open up new agro-economic perspectives; research on promising feedstocks such as algae and the development of advanced biorefinery technologies can also contribute to create economic opportunity for Italy.

From 2020, global aviation should experience CO_2 neutral growth; by 2050, net CO_2 emissions should be reduced by 50% compared to the base year 2005. These goals have been set by the airline members of IATA. Increasing the share of aviation biofuel is essential in order to reach these goals. This is because, unlike other modes of transport, new forms of propulsion such as electric or H_2 systems cannot be realized for aviation in the coming decades.

To realize the transition to a competitive energy system, it is necessary to overcome a number of challenges, such as increasingly scarce resources, growing energy needs and climate change.

Italy is strongly committed, both in the EU and in the world context, in trying to create the conditions for the development of a sustainable aviation biofuels competitive market.

Within the EU Horizon 2020, Italy is the coordinating Country for the following research projects:

Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels

The main objective of BECOOL (EU) and BioVALUE (Brazil) projects is to strengthen EU-Brazil cooperation on advanced lignocellulosic biofuels. Information alignment, knowledge synchronization, and synergistic activities on lignocellulosic biomass production logistics and conversion technologies are key targets of both projects and will bring mutual benefits. Both projects are structured in three main pillars covering in a balanced way the whole range of activities of the biofuels value chain (biomass production, logistics, conversion and exploitation). The BECOOL consortium is composed by 14 partners from universities, research institutes, large industries/SMEs, from 7 EU countries. Together with improved logistics, the establishment of the BECOOL innovative cropping systems will enable to increase biomass feedstock availability by at least 50% without negatively impacting food production, soil quality, and customary land uses. The improvements in gasification process efficiency of new feedstocks will allow to achieve an optimal gas quality from non-conventional sources (e.g. lignocellulosic crops and residues). The use of energy carrier in gasification will allow to overcome a major logistics barriers for low-energy density feedstock, while the valorization of lignin-rich residues will dramatically improve the energy efficiency of the overall value chain. Technological breakthroughs on pre-treatment, hydrolysis and enzymatic saccharification and fermentation steps will increase the competitiveness of biochemical advanced ethanol. The cross-project model benchmarking, carried out between EU and Brazil, will decrease present limitations on growth, logistics and process academic models, making them more reliable, opening opportunities for business, new jobs, reduced land pressure, and enhanced environmental benefits in EU and Brazil.

BIOmethane as SUstainable and Renewable Fuel (BIOSURF)

The objective of BIOSURF is to increase the production and use of biomethane (from animal waste, other waste materials and sustainable biomass), for grid injection and as transport fuel, by removing non-technical barriers and by paving the way towards a European biomethane market.

The main pillars of BIOSURF project are:

- to develop a value chain analysis from production to use depending on the territorial, physical and economic features (specified for different areas, i.e., biofuel for transport, electricity generation, heating & cooling);
- to analyse, compare and promote biomethane registering, labelling, certification and trade practices in Europe, in order to favour cooperation among the different countries and cross border markets on the basis of the partner countries involved;
- to address traceability, environmental criteria and quality standards, so aiming at reducing GHG emissions and indirect land-use change (ILUC); at preserving biodiversity and at assessing the energy and CO2 balance; at identifying the most prominent drivers for CO_2 emissions along the value chain as an input for future optimization approaches;
- to exchange information and best practices all along Europe concerning biomethane policy, regulations, support schemes and technical standards.

Advanced sustainable BIOfuels for Aviation

Decarbonising and reducing aviation dependence on fossil fuel requires biofuels. BIO4A will produce at least kt of sustainable biojet for its use in aviation at commercial scale for accelerating its deployment within the aviation sector, increasing their attractiveness. BIO4A targets HEFA pathway from wastes, aiming at increasing the Technology Readiness Level for the full value chain. BIO4A aims at demonstrating the full value chain, enabling a production capacity of 2-300 kt/y of biojet in a First Of A Kind new biorefinery in France. The fuel will be distributed using the existing infrastructures and conventional aircraft fuelling systems for commercial flights. Special attention will be directed to the supply of sustainable feedstock, focusing on waste streams. In parallel, long-term R&D work will address marginal land in EU MED (low ILUC biofuels). Relevant environmental (inc. GHG and energy balance), economic and social data (inc. health and safety issues, impacts and benefits) will be assessed against targets. Since the current main barrier to the commercial production of biojet is the price gap, BIO4A will explicitly address performance and cost targets vs. relevant key performance indicators. The final goal is to prove the business case, identifying potential issues of public acceptance, market or regulatory risks and barriers (feedstock, technological, business, process) along the entire value chain, taking advantage of previous projects and proposing potential mitigation solutions. Offtake agreements have been signed with KLM and Airfrance. Additional off-take agreements could also be signed to open the participation to more airlines. Regulatory framework is also limiting today the development of the sector and an additional goal is recommendations to policies makers. The proposal will be defined at EU/National level, involving the major sector stakeholders and opening with a profitable dialogue with Member States and the EC.

Improving Photosynthetic Solar Energy Conversion in Microalgal cultures for the production of Biofuels and High Value Products

Solar Energy is the most abundant renewable energy source available for our planet. Light energy conversion into chemical energy by photosynthetic organisms is indeed the main conversion energy step, which originated high energy containing fossil deposits, now being depleted. By the way, plant or algae biomass may still be used to produce biofuels, as bio-ethanol, bio-diesel and bio-hydrogen. Microalgae exploitation for biofuels production have the considerable advantages of being sustainable and not in competition with food production, since not-arable lands, waste water and industrial gasses can be used for algae cultivation. Considering that only 45% of the sunlight covers the range of wavelengths that can be absorbed and used for photosynthesis, the maximum photosynthetic efficiency achievable in microalgae is 10%. On these bases, a photobioreactor carrying 600 l/m-2 would produce 294 Tons/ha/year of biomass of which 30% to 80%, depending on strain and growth conditions, being oil. However this potential has not been exploited yet, since biomass and biofuels yield on industrial scale obtained up to now were relatively low and with high costs of production. The main limitation encountered for sustained biomass production in microalgae by sunlight conversion is low light use efficiency, reduced from the theoretical value of 10% to 1-3%. This low light use efficiency is mainly due to a combined effect of reduced light penetration to deeper layers in highly pigmented cultures, where light available is almost completely absorbed by the outer layers, and an extremely high (up to 80%) thermal dissipation of the light absorbed. This project aims to investigate the molecular basis for efficient light energy conversion into chemical energy, in order to significantly increase the biomass production in microalgae combining a solid investigation of the principles of light energy conversion with biotechnological engineering of algal strains.

Other projects ongoing in Italy related to Alternative Fuels are:

FREE
The FREE Coordination (Coordination of Renewable Sources and Energy Efficiency) is an Association that currently gathers, as Members, 26 Associations in whole or in part active in these sectors, as well as a wide range of Bodies and Associations that have asked to join as Adherent (without decision-making roles). The FREE Coordination aims at promoting the development of renewables and energy efficiency in the context of an environmentally sustainable social and economic model, the decarbonisation of the economy and the cutting of climate-altering emissions, by launching a more coherent action by the Associations and Entities that are part of it also towards all institutions.

ISAFF
It is a National Forum that gathers Alternative Fuel Stakeholders from Industry, Universities, Fuel Producers, with the goal of promoting Research & Development activities on Biofuels in Italy. Activities are ongoing under the aegis of ENAC.

ENI
The Italian National Energy Company currently produces Biofuel in a fuel plant in Northern Italy (Porto Marghera). The fuel is for automotive use, but the same technology is easily adaptable for aviation purposes.

BIOREFLY
It is a FP7 of the European Commission. The purpose consists of establishing in medium term a bio-kerosene plant in Southern Italy (Puglia region).

Alitalia
Alitalia, the major Italian air carrier, for several years has been a proactive sponsor of many projects, whose aims were to develop a National sustainable biojet fuel:

- 2009: MoU was signed with Solena with the aim at developing a project to convert Rome’s area urban wastes into biofuel;
- 2011: an Action Plan was signed with Sunchem, whose target is the usage of Toboil (tobacco seeds oil) as an alternative aviation fuel;
- 2013: Alitalia is one of the first minute members of ISAFF, Italian Sustainable Aviation Fuel Forum, which has, as one of the main objectives, the development of a production, logistics and distribution system for the new biofuels.

Biofuel from Microalgae project
During 2017 ENAC assigned funds to a consortium of Italian Universities (Universities of Rome, Verona and Florence) to develop a research intended to produce aviation biofuel from microalgae. Microalgae appear to be one of the best raw materials for their possible production in Italy, given the essentially sunny climate present on most of the peninsula.
The main problems for the positive outcome of the research project are however represented by the environmental and energy balances. In fact, in order to ensure

the economic viability of the biofuel production chain from microalgae, it is necessary to significantly reduce energy consumption along the whole chain; this is one of the main objectives of the research project in question: the research aims firstly at selecting in laboratory high-fat and low-energy strains for oil extraction. The ongoing study is also aimed at identifying the optimal cultivation processes, ensuring high productivity for long periods and for large volumes, also focusing efforts on the water/biomass separation process and on the oil extraction processes, which are particularly high energy consumption processes.
The project is divided into two phases:

- the first phase, identification of microorganisms optimized for the different phases of the process and the production of a small quantity of oil (to be completed by 2018);
- the second phase (lasting 3-4 years), dedicated to the construction of a pilot plant to produce biofuel in a small-demonstrative scale quantity.

It is due to note that a wide scale usage of biofuels has been up to now strongly limited by:

- Economic burdens: Biojet premiums vs fossil jet fuel prices are unaffordable for airlines and the drop of crude oil price has widen that gap;
- Lack of sustainable feedstock crops, with a stable and a wide range production and without competition with food;
- Limited refining capacity: Italy is the first European country where a traditional refinery was converted in a Green Refinery (ENI’s Porto Marghera refinery).

Notwithstanding the above considerations, the medium term outlook for biofuels seems to be optimistic:

- Increase of refining capacity: ENI’s Porto Marghera green refinery is expected to raise its production and Gela refinery is also going to be converted into a green refinery;
- Growth of awareness and concrete involvement at policymakers level to support the constitution of an Italian sustainable aviation biofuel supply chain, e.g. encouraging the usage of unused fields for biojet feedstock crops and setting up a system of incentives to make it sustainable for the whole industry.

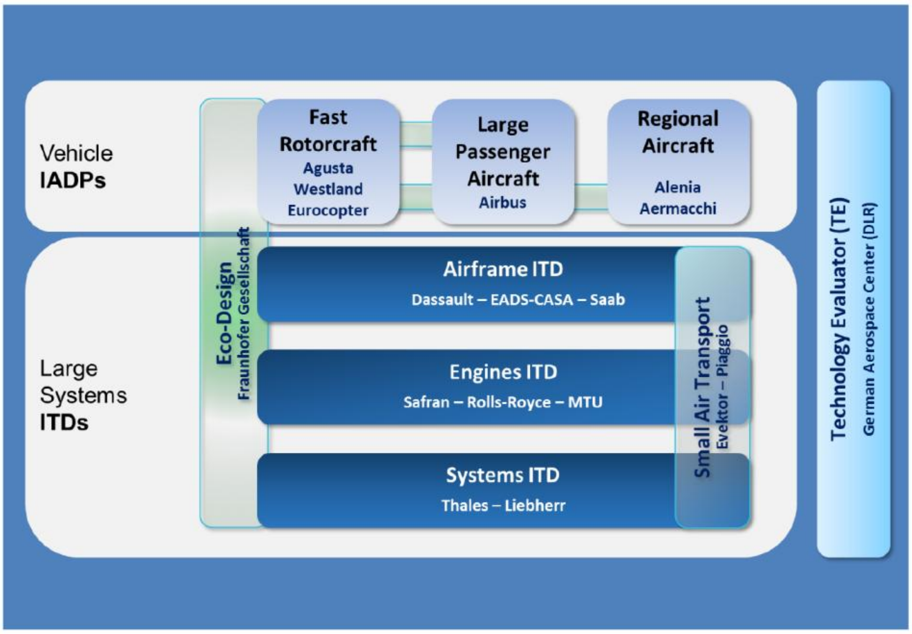
4.2.3 National Research and Development

Industries like Alenia Airmacchi, Agusta Westland (Leonardo), SelexES, Piaggio, research centers such as CIRA and CNR and several Universities are heavily involved in several programmes related to environmental objectives for CO_2 emissions reduction, to obtain less perceptive noise per operation and to reduce NOx emissions.
The Strategic Research Agenda Italia recognizes the European objectives in the CO_2 reduction programmes. The Strategic Research and Innovation Agenda (SRIA) is the new strategic roadmap for aviation research, development and innovation developed by ACARE that accounts for both the evolution of technology as well as radical changes or 'technology shocks'.
With reference to Clean Sky’s environmental objectives and the formulated targets, the first assessments performed early 2012 and early 2013 strongly underlined that Clean Sky was on the right track. In particular, short/medium range commercial aircraft (which is the backbone of the air transport system) could reduce CO_2 emissions up to 30%.

Clean Sky Concept Aircraft	Noise area (take off)	CO_2	NO_X
Low Sweep Biz-Jet (Innovative Empennage)	-68%	-32%	-28%
High Sweep Biz-Jet	-36%	-22%	-26%
TP90 (Regional Turbo-prop)	-48%	-23%	Up to -43%
GTF130 (Regional Jet – Geared Turbo-fan)	-75%	-23%	Up to -46%
Short-Medium Range / CROR Engine	Up to -37%	Up to -30%	N/A
Long Range / 3-shaft Advanced Turbo-fan	Up to -28%	Up to -20%	Up to -21%
Single Engine Light	-47%	-30%	-70%
Twin Engine Light	Up to -53%	-26%	-70%

Clean Sky assessment results

Clean Sky 2, born within H2020 EU Framework for research and innovation, is the natural continuation to the achieved progress in Clean Sky.
In the Clean Sky 2 Programme, Italian industries have been fully involved as per the scheme below:



The regional aircraft are a key element of Clean Sky and Clean Sky 2, providing essential building blocks towards an air transport system that respects the environment. In Clean Sky 2 the Regional Aircraft technologies, aimed at CO_2 reduction of emissions, will be pursued by the synergy between two CS2 platforms namely:

- Airframe ITD, with a relevant Alenia Aermacchi participation, will prepare the building blocks of the critical technologies then integrated and further maturated in the Regional Aircraft IADP such as low weight/high strength primary structure materials, eco-compatible and low weight materials for cabin systems;

- Regional Aircraft IADP, with the Italian leadership of Alenia Aermacchi, will bring the integration of technologies aimed at the reduction of the environmental impact, namely CO_2 reduction for the regional aircraft share, to a further level of complexity and maturity than currently pursued in Clean Sky.

The goal is to integrate and validate, at aircraft level, advanced technologies for regional aircraft useful for the CO_2 emissions reduction as well as to drastically de-risk their integration on future products.
In Clean Sky 2 Alenia Aermacchi will use the following demonstration programmes of the regional IADP to implement the technologies targeting CO_2 reduction:

- A Flying Test-bed using modified existing regional TP a/c for demonstration campaigns of air vehicle technologies such as wing structure with integrated systems, propulsion items, flight dynamics;
- Three Large Integrated Ground Demonstrators - i) full-scale fuselage and cabin including associated systems; ii) flight simulator; iii) iron bird - to fully and completely demonstrate low weight materials for fuselage structures, low weight eco-compatible materials for cabin, mission trajectory solutions and more effective flight controls solutions leading to a CO_2 reduction.

Full-scale demonstrations are essential to validate the insertion of breakthrough technologies on regional aircraft entering into service from 2025. To increase synergies and cross fertilization across the different ITDs and IADPs, some of technologies will be shared with other CS2 ITDs, namely Airframe for the low weight materials, Eco-Design for the low emission material and Systems and Engine ITD for the engine and on-board systems.
The Clean Sky 2 activities are distributed in all Regional Aircraft demonstrators and Airframe ITDs. In the following list a detail of content and technologies considered for application:

- FTB1 - Innovative Wing and Flight Controls (Regional IADP) the wide scope is the integration and flight testing of technologies suitable to regional aircraft applications for a new generation wing and advanced flight control systems. The technologies contributing to CO_2 reduction envisaged to be integrated in this demonstrator are:
  - Smart materials allowing morphing of control surfaces and then drag and CO_2 emissions reduction;
  - Electromechanical actuators applied to primary control surfaces reducing weight and power consumption then again less fuel burnt and lower CO_2 emissions;
  - Movable winglet to improve aerodynamic effectiveness, reduce drag and in turn reduce fuel consumption and CO_2 emission;
  - Control surfaces with a dedicated control for load control in order to reduce weight and in turn fuel burnt and CO_2 emission;
- Full-scale innovative fuselage and passenger cabin (Regional IADP) - the technologies, that will be integrated in the demonstrator, will be:
  - Low weight and eco-compatible material for cabin systems;
  - Low weight structural material with SHM feature to reduce weight thus fuel burnt and CO2 emissions;
- Flight Simulator (Regional IADP) - starting from the Clean Sky GRA Flight Simulator: an advanced Flight Simulator will be set up and used to demonstrate new avionics features allowing a more efficient trajectory for CO_2 reductions;

- Iron Bird (Regional IADP) - Virtual and Physical "Iron Birds" will also be an important part of the Regional A/C Ground Demonstration Programme. It will be used to optimize and validate the systems modification of the Flying Test Bed leading to the weight reduction and to the definition of optimal aircraft trajectory for CO_2 reduction.

The Agusta Westland (Leonardo)'s involvement into the Clean Sky programme is related to the "Fast Rotorcraft Technology Demonstrator", based on new NextGenCTR tilt-rotor concept.
The Fast Rotorcraft Technology Demonstrator has the primary objective in obtaining environmental benefits through a new efficient technology which uses the concept of high speed transportation solutions with a minimal infrastructure footprint.
This will be accomplished by means of:

- design, manufacturing and testing of a full scale technology demonstrator;
- analytical form through the technology evaluator efforts which are integral part of the CS2 programme.

The first flight of the technology demonstrator is planned for 2021.
The estimation of CO_2 emissions reduction, based on the application of the Fast Rotorcraft Technology, is still under evaluation. The benefits strongly depend on the final choice of aircraft configuration and on the supporting technological solutions as well as on the possibility of effective insertion within the future airspace and ATM and market requirements.
Alenia Aermacchi and SelexES are involved in the Air Traffic Management within the Single European Sky (SES) initiative and the SESAR programme.

Alenia Aermacchi is basically involved in:

- Taxi phase: the analysis of excess taxi time indicates that at least at the largest and most heavily utilized network hubs, there may be scope to reduce taxi times and hence improve fuel efficiency. In this phase, Alenia is committed in the development of an Airport Navigation Function (ANF) software for providing the capability of taxi routing during the airport surfaces operations as well as the on-ground traffic alerts, managed in cooperation with pilots and ATC controllers that will significantly improve the safety aspects and speed-up the taxi runway procedures reducing the fuel consumption;
- Terminal Maneuvre Area (TMA): the analysis of the Arrival Sequencing and Merging area (ASMA) indicator shows that queue management within the 40Nm radius of arrival airports could contribute to excess fuel burn per flight across the European network. Some Alenia Aermacchi initiatives are in progress in the integration of advanced services enabled by the Ground Based Augmentation System (GBAS), and on new approaches concepts (vertical profile, curved approach & runway approach) integrated in the Flight Management System on board the aircraft that will assist the pilot in the implementation of more efficient approaches to the airport. These functions, that were developed and validated in-flight using the real improved operation procedures, demonstrated the capability to reduce the fuel consumption, as a consequence of a better flight profile, but also due to the reduction of the holding procedures;
- En-route: The analysis of the En-route horizontal flight/fuel efficiency shows excess fuel burn beyond the 40Nm radius of origin/destination airports across the European network. The development of the "Airborne initial 4D for trajectory management", with an important contribution of Alenia Aermacchi, will allow a continuous synchronization of the aircraft trajectories between air traffic controllers and pilots allowing to fly the most fuel-efficient flight route, optimizing airspace usage.

Selex ES:

- is engaged in providing means for a more efficient Aircraft Navigation System aimed mainly at pursuing the environmental goals promoted by Clean Sky European Project as assessed in the Strategic Research Agendas (SRA1 and SRA2) and confirmed in the Challenge 3 of the Strategic Research and Innovation Agenda (SRIA) and the "Report of the High Level Group on Aviation Research - Flight Path 2050 – Europe's Vision for Aviation";
- is involved in the Work Package 3 - Management of the Trajectory and Mission - dealing with the task of providing the pilot with an aid in the choice of the best trajectory to follow in case of an unexpected (or differently expected) events, in particular weather events, forcing the pilot to change the Reference Flight Plan assessed before the take-off;
- its task in Clean Sky programme is related to the optimization of the path for minimum pollution by means of clear, accurate and timely knowledge of the environmental situation and the provision of a Decision Support System (DSS) identifying, selecting and suggesting the most suitable actions to counteract the change, as a valid help to the pilot for the success of the flight together with the maximum reduction in induced pollution, saving the safety constraints.

Unexpected weather events are one of the major causes of disruptions leading to heavier fuel consumption. In this frame, Selex ES developed two cooperating technologies concerning the improvement of presently available airborne weather radar performances to identify weather situation (Advanced Weather Radar = A-WXR), and the algorithms to optimize flight routes in presence of unforeseen weather – but not only weather – hazardous situations (Trajectory Optimizer, shortly Q-AI = Quasi-Artificial Intelligence, where "Quasi" means that the Optimizer does not replace pilot's skill, but pilot is always the main stakeholder in the decisional loop) and to display the results to the pilot to improve his/her situation awareness and help him/her in decision making process.
To reach this gate the A-WXR and the Q-AI have been integrated in two different flight simulators: the Alenia Aermacchi Green Aircraft Simulator, emulating the ATR72 regional aircraft, and the IDS company's simulator, emulating the A320 aircraft and the ATC.
Preliminary data referred to the cruise phase indicate that a benefit in the CO_2 emissions reduction of about 2% to 5% could be obtained. Such data are derived as a mean from many flight extracted by Flight Aware as well as simulating unexpected weather events on the aircraft route.

SESAR Very Large Demonstration Projects: Free solutions

The Flexible Airspace Management and Free Route is one of the six of the so-called Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan (Commission Implementing Rule (EU) 716/2014), which provides for the implementation (by FL 310+) of Direct Routing operations (by 1 January 2018) and operations Free Routing (by 1 January 2022).
In this context ENAV, Italy's main Air Navigation Service Provider, has decided to follow up the activity carried out in 2013 with the SESAR WE-FREE project, by developing a new project – also thanks to the technical/operational and co-financing opportunities offered by the SESAR JU - called FREE Solutions (Free Route and Environmental Efficient Solutions).
FREE Solutions aims at completing, between 2015 and 2016, a cycle of demonstration flights in operating cross-FAB environment (Blue Med and FABEC specifically) to prove the feasibility and applicability of Direct Routing/Free Routing concepts and the definition of technical and operational requirements essential for the implementation of the Free Routing. It is carried out in collaboration with a significant group of ANSP and Airspace User. The project was launched under the guidance of ENAV, in September 2014. Just six months after, the first set of

demonstration flights was successfully completed. Two weekends have been dedicated to the trials and more than 120 flights were operated by project partner airlines on point-to-point connection between European airports with optimized City-Pairs routes. A first analysis of the data collected during this session confirms and enhances the preliminary expectations: each day 1450Kg of fuel on average were saved, resulting in lower emission CO_2 equal to 4400Kg.
Other demonstration flights are dedicated to the identification of specific Direct Routes and to a Free Route specific Airspace Area (FRA), trans-national and multi-FAB, where users can plan their routes indicating just an entry point, an exit point and a limited (or null) set of intermediate points, freeing themselves from the current network of ATS routes.

4.2.4 New Technologies from Italian Industry

Leonardo's Aircraft Division has been engaged for years in initiatives focused on sustainability and on reduction of both direct and indirect GHC emissions and in environmental impact:

- Solutions, architectures and aircraft configurations to reduce fuel and energy consumption covering all phases including the aircraft decommissioning;
- Electrification of board (more/all electric) and propulsion systems, which, in parallel with the evolution of the enabling technologies, allows a significant reduction of fuel and emissions consumption in the field of air transport, contributing to achieve the ICAO ambitious targets;
- New manufacturing processes with low environmental impact: additive manufacturing to reduce production scraps (increase of "buy to fly ratio"); thermoplastic matrix composites and "Out of Autoclave" forming processes; composite material recycling; monitoring and traceability of hazardous substances (REACh, RoHS, Conflict Minerals, etc.).

In the following box the main actions already undertaken by the Aircraft Division or about to start:

MORE EFFICIENT REGIONAL TURBOPROP AIRCRAFT WITH LOW ENVIRONMENTAL IMPACT

In the framework of **Clean Sky 1** programme, carried out in the years 2008-2016, Leonardo achieved important results in terms of environmental impact reduction of regional aircraft with turboprop engine:

- for turboprop aircraft with 90 seats, CO_2 reduction by 25% in comparison with aircraft in service in 2000;
- for turboprop aircraft with 130 seats, CO_2 reduction by 27% in comparison with aircraft in service in 2000;

Such objectives have been achieved by the development, additional studies and architectures, validation by in-flight or on-the-ground demonstrations of advanced technologies applied to materials and structures, advanced aerodynamics, electrification of some aircraft systems along with a more efficient air traffic management system. The results were confirmed by in-flight demonstrations using a ATR72 and by full scale demonstrations using a flight simulators, which have validated:

- the use of multifunctional structural materials able to reduce structural weight as well as noise in passenger cabin;
- "more electric" aircraft systems to validate advanced system architectures;
- structural configurations of fuselage and wing through innovative composite materials, produced with manufacturing techniques with low energy consumption, which lighten the structure.

In the framework of **Clean Sky 2** programme, started in 2014 in Horizon 2020 and still ongoing, Leonardo has been developing further challenging objectives aimed at reducing turboprop aircraft environmental impact and at making them even more competitive and energetically efficient:

- for turboprop aircraft with 90 seats, CO_2 reduction by 35-40% in comparison with aircraft in service in 2014;
- for turboprop aircraft with 130 seats, CO_2 reduction by 19-25% in comparison with aircraft in service in 2014

Such objectives are pursued through the use of the most advanced technologies applied to materials, structures, aerodynamics and through a further electrification of the aircraft systems. The validation will be achieved by on-the-ground full-scale tests simulating the complexity of the real cases and in-flight tests which will encompass:

- one entire section of fuselage made from a very innovative composite material and using architectural structures aimed at demonstrating the reduced weight, while maintaining the competitiveness of the production process;

- Wing and its innovative control systems (movable winglet and newly designed leading edge) capable of increasing flight efficiency, cutting consumptions and reducing noise produced by aircraft;
- Control and electricity supply systems of aircraft able to allow a further electrification of aircraft at a higher power level.

A NEW AIR TRAFFIC MANAGEMENT SYSTEM

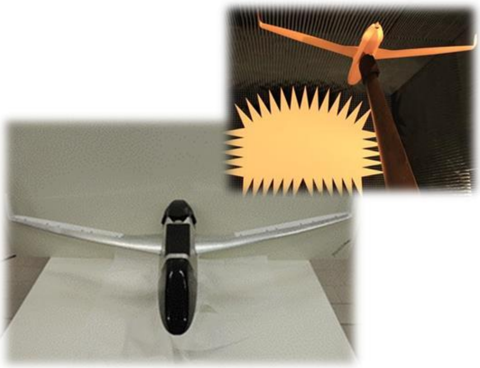
Within **SESAR** programme, Leonardo pursued the emissions reduction by the development and validation of technologies allowing a more efficient use of civil and military aircraft in the framework of the air traffic management system called “Single Sky”, currently under definition and development in EU, integrating these technologies in flight simulators and carrying out in-flight demonstrations on ATR72 and C-27J.

During the second phase of SESAR programme, called **SESAR 2020**, started in 2014 in Horizon 2020 EU and still ongoing, Leonardo has been going on with the development of innovative technological solutions for a more efficient integration of civil and military aircraft in the new air traffic management system, by carrying out demonstrations using manned and unmanned flight simulators.

HYBRID/ELECTRIC PROPULSION AIRCRAFT

The push towards the hybrid/electric propulsion is fostered by ICAO challenging objectives, aimed at reducing the environmental impact, not achievable by the incremental evolution of the traditional engines.
This approach will represent the first step towards a *revolution of air transport*, especially in short- and medium-haul routes, since this imposes a relevant change in aircraft technical management and an update of airport infrastructures. The following innovative initiatives have been launched by Leonardo’s Aircraft Division:

TIVANO – Innovative Technologies for next-generation General Aviation Aircraft



Leonardo coordinated the national research projects “TIVANO” whose aim was to develop new technologies suitable for specific aircraft to be applied to “more electric” systems and hybrid propulsion, for the purpose of improving the efficiency of aircraft systems and propulsion.
Special attention was paid to a new electrical propulsion technology for ground operations – a “green taxi” concept - complementary to the normal propulsion able to reduce noise and air pollution in airport areas. The study further explored also a new “Tail-less” configuration, with a high efficiency wing and high aspect ratio wing, developing new methods of aerodynamic and aero-elastic optimization, to maximize the capacity of persistence, so that the weight of the wing and the emissions of the aircraft will be reduced.
The results will lead to further studies on hybrid/electric propulsion architectures and will include higher/bigger size class aircraft.

PROSIB – Propulsion and hybrid systems for fixed- and rotor-wing aircraft (expected launch in 2018/19)

The aim of the project, headed by Leonardo in the framework of PNR 2015-2020, is to develop specific technologies for both ATR-42 regional aircraft, on which the distributed hybrid/electric propulsion is planned to be introduced by 2035, and VTOL (Vertical Take Off and Landing) rotorcraft per Urban Mobility. Feasibility studies, laboratory tests and key enabling technologies implementation in cooperation with universities, research centres and national SMEs are forseen.

OPTIMISATION AND INNOVATIVE CONFIGURATIONS

Leonardo collaborates with European universities and research centers to develop advanced multidisciplinary optimisation techniques for non-conventional aircraft configurations as essential instruments for a further refinement of the analysis on emissions reduction:

AGILE headed by DLR, in the framework Horizon 2020: Leonardo takes part to this project along with many other international organizations with the goal to develop and validate multi objective analysis methodologies.

PARSIFAL in the framework of Horizon 2020: Leonardo is an Advisory Board member together with Airbus, Alitalia and the airport operators "Toscana Aeroporti" and "Milano Aeroporti".

PARSIFAL, headed by Pisa University, studies, with modular approach applied to several classes of aircraft, configurations such as PrandtlPlane, in order to maximize the aerodynamic benefits and to reduce aircraft weight, consumption and emissions with no impact on airports for what concerns the amount of space required and their infrastructure needs. In other words, an airplane with the same wingspan of an A320 or a B737 could have the load capacity of a higher class airplane, such as an Airbus A330 or a Boeing B767, but a fuel consumption of lower class airplane.

INTEGRATED SIMULATION – Simulation as eco-friendly technology

The use of simulation technologies in the activities of development and qualification of platforms and for training purpose, allows Leonardo to decrease the overall number of flight hours with real aircraft and therefore to reduce significantly polluting emissions and costs.
Flight simulators have been continuously improving and updating to reproduce real aircraft behaviours and operative scenarios. This permits to modify training programmes so that up to 50% flight time training can be performed by simutators, reducing flight time training with real aircraft and consequently CO_2 and NOx emissions around airport area.

NEW TECHNOLOGICAL PROCESSES

- **Patent** of a new **method for recycling scraps** of prepregs composite materials in order to reduce the production of brand new materials. The patent will allow a great reduction of CO_2 emissions caused by the production of new prepregs composite materials, including the case where, thanks to the new material, less extreme performance of the original material is required.

  EP 2 197 643 B1

  EUROPEAN PATENT SPECIFICATION

  A METHOD FOR RECYCLING SCRAPS OF PREPREG MATERIALS

  VERFAHREN ZUM RECYCELN VON ABFALLSTOFFEN VON PREPREG-MATERIALIEN

  PROCEDE DE RECYCLAGE DE DECHETS DE MATERIAUX PREIMPREGNES

  The patent consist of a process that transforms the wastage of continuous fiber prepreg (unidirectional and woven) into a recycled material which is also prepreg, but has broken fibers of sufficient length to maintain high mechanical properties with near-isotropic characteristics. This material can be stratified and hot-formed and polymerized using conventional vacuum-bag technology.
- **Monitoring/traceability of harmful substances** (REACh, RoHS, Conflict Minerals, ecc.) and qualification of alternative eco-friendly processes. Leonardo has always paid particular attention to the characteristics of materials used and accurately monitors them through a specific management tool, in accordance with the legislation on hazardous materials (REACh Management) and considering the direct and especially indirect impacts that these processes have on CO_2 emissions production.
- **Eco-friendly processes:** several processes are under testing and qualifying phase with the aim to avoid the use of harmful substances banned by the recent European Decrees according to the following table:

Existing	Future	Benefits
Chromic Acid Anodizing on Aluminum Alloy	Tartaric Sulphuric Acid Anodizing on Aluminium Alloy	testing stage completed: -20% CO_2 emissions
Chemical Conversion Coating of Aluminium Alloys	Chemical Conversion Coating Chromate Free	testing stages to be completed by 2020
Hard Chromium Plating	Thermal Spray (HVOF)	
Electrolytic Cadmium Plating	Zinc-Nickel Plating	
Vacuum Cadmium on Steel	Ion Vapour Deposition on Steel	
Conversion Coating of Magnesium Alloys	Conversion Coating Chromate Free of Magnesium Alloys (Ardrox 1769)	
Passivation of Corrosion Resistant Steels	Passivation of Corrosion Resistant Steels with Citric Acid	
Wash primer	Wash primer chromate free	
Bonding Primer and Chromated Primer	Bonding Primer and Primer Chromate Free	

4.2.5 Air Traffic Management

4.2.5.1 ENAV S.p.A.

ENAV S.p.A. is the main Italian Air Navigation Service Provider for civil air traffic.
It ensures the safety and punctuality of around 1.8 million controlled flights per year on an airspace measuring more than 750,000 sq.km. and peaks of more than 6,575 flights per day during summer (2017).
ENAV mission is to guarantee the safety and punctuality for millions of passengers flying in Italy’s skies. In line with its vision, ENAV contributes to the growth of national and international air transport based on efficiency and innovation.
ENAV Group consists of ENAV S.p.A., Techno Sky, ENAV Asia Pacific, ENAV North Atlantic and ESSP.

- **Techno Sky** - responsible for operational management, support, maintenance and hardware/software development of entire range of systems and equipment used to provide flight assistance services.
- **ENAV Asia Pacific** - based in Kuala Lumpur - launched with the objective to manage all ENAV's commercial activities in that area.
- **ENAV NORTH ATLANTIC** - based in the United States with 12.5% of share capital of Aireon, is in charge of the planning, funding and installation of the first global satellite surveillance service for air traffic control.
- **ESSP** - with 16.6% stake in the company, ENAV provides the European satellite navigation service EGNOS.

Formerly fully controlled by the Ministry of Economy and Finance and supervised by the Ministry of Infrastructures and Transport, ENAV was transformed into a publicly controlled joint-stock company on 1st January 2001.
On 26th July 2016, ENAV was publicly listed and changed its legal form from a single member company to a joint-stock company. The Italian Economy and Finance Ministry holds 53.4% stake in ENAV. The Company is also supervised by the Italian Ministry of Infrastructure and Transport.
ENAV can count on about 4,200 employees. The Company provides control and support to allow approaches, departures and landings from the 45 Control Towers spread over the National territory, and en-route services from the four Area Control Centres located in Brindisi, Milan, Padua and Rome. Thanks to its operational units and advanced technical facilities, ENAV provides around-the-clock air traffic services ensuring air traffic flow and regularity, with absolute safety.
ENAV has its legal HQs in Rome and operating facilities throughout the National territory. Professional training and continuous professional development for Air Traffic Controllers, Air Traffic Assistance Specialists, Meteorologists and Flight Inspection Pilots are carried out through its Academy based at Forlì.
Thanks to its long-standing experience in Aeronautical Consulting & Design, Flight Inspection, Training, Maintenance & Engineering and Met Services, ENAV plays an outstanding role providing operational services and solutions worldwide.
In addition, ENAV has a leading role in key international partnerships and programmes such as the BLUE MED Functional Airspace Block, SESAR Deployment Manager, BLUEGNSS, 4-Flight/Coflight. The Company, through acknowledged experts, actively contributes to the work of international institutions and organisations such as ICAO, the European Commission, Eurocontrol, EASA and EUROCAE as well as the trade association CANSO (Civil Air Navigation Services Organisation).
ENAV strategy and cooperation activities aim at developing synergies with the major ATM stakeholders to continuously improve the safety and quality of services provided and to explore the opportunities offered by the technology innovation for the benefit of all customers and finally the wider aviation community.

4.2.5.2 ENAV Flight Efficiency Plan

One of ENAV's objectives is to contribute to lowering the environmental impact related to flight operations. To this regard, in accordance with the international guidelines, ENAV promotes wide-ranging initiatives to decrease the amount of greenhouse gases.
In winter 2008/2009, the Company released its first three-year action plan, which is annually monitored and reviewed. Moreover, ENAV has in place structural initiatives, mainly addressed to airlines, aimed at increasing cooperation and sharing operational suggestions with Airspace Users to elaborate operational solutions. The information exchange has followed-up important feedbacks to fine-tune ENAV FEP initiatives.
Since ENAV FEP first publication, thanks to a continuous process of review and improvement of the air navigation system, projects and measures had been set to ensure greater airspace accessibility delivering increased route availability, designing airspace portions and new operational procedures that enabled a more efficient use of terminal areas and approaches by using P-RNAV routes (Precision Area Navigation) and Continuous Descent Operations.
Under the framework of the National Performance Plan endorsed according to Reg. (EU) 390/2013, ENAC monitors ENAV FEP because of its environmental relevance.
The implemented measures have allowed considerable savings in terms of fuel consumption and GHG emissions thus producing their positive effects year after year.
Focusing on the last 5 years implementations, it is worthwhile to mention three major projects which also considered the objective to increase capacity and cost-efficiency performance while maintaining and/or increasing safety performance and reaching the performance requirements defined by Reg. (EU) 691/2010: the Italian Airspace Reorganization, the Free Route Italy, the PBN Implementation in Italy, and the Airport-Collaborative Decision Making.
The Italian Airspace Reorganization project has involved all Italian Area Control Centres (ACCs), reviewed the preexisting airspace structure and improved the network usability with a flight efficiency-oriented solution. Besides having achieved shorter routes, it has mainly enabled improvements in flight profiles, by gradually free up higher flight levels for most domestic city pairs and some cross-border connections.
The Flexible Airspace Management and Free Route is one of the six of the so-called Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan (Commission Implementing Rule (EU) 716/2014), which provides for the implementation (by FL 310+) of Direct Routing operations (by 1 January 2018)

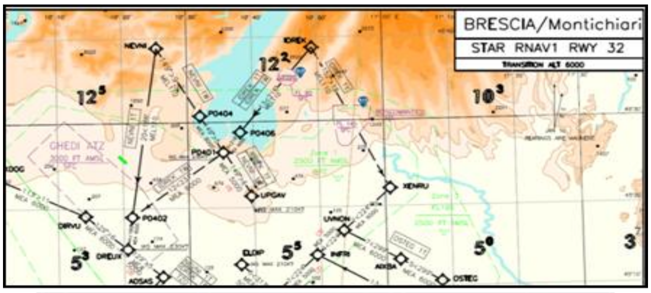
ENAV FEP 10 years' Achievements Timeline

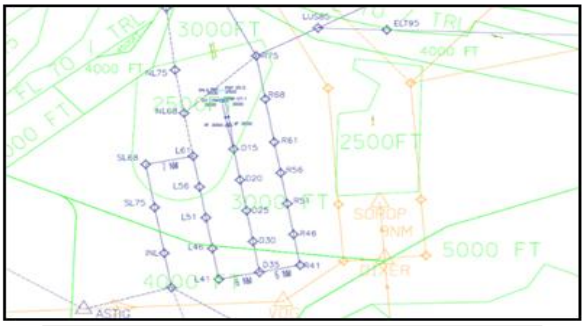
and operations Free Routing (by 1 January 2022).
In this context ENAV decided to follow up the activity carried out in 2013 with the R&D SESAR WE-FREE project, by developing a new project – also thanks to the technical/operational and co-financing opportunities offered by the SESAR JU - named FREE Solutions (Free Route and Environmental Efficient Solutions) and aimed to demonstrating the feasibility and support implementation of a plannable user-preferred route. Through a wide campaign of live trials, the operational impact was assessed with a view to de-risk the implementation of the main concepts addressed towards the deployment phase.
ENAV implemented the **Free Route operations in the Italian airspace (FRAIT)** above FL335, on 8th December 2016, achieving the third phase of a multiannual programme, the **Free Route Italy** project, started in 2013.
Phase 1, in mid-December 2013, enabled the availability of dedicated direct and near direct routings for overflights operating at night and during the weekends in the Italian airspace above FL335 and the extension of the temporal availability of some ATS routes.
Phase 2, in January 2015, lowered the dedicated routing. FRAIT operations offer capability for optimal trajectories 24/7 in the Italian Airspace above FL305 as of 24th May 2018.
Within FRAIT aircraft may freely fly a direct path and an optimal vertical profile between a pair of defined Entry Point and Exit Point, without reference to an ATS Route Network. FRAIT operations are available for overflights as well as for arriving and departing traffic.
Ad hoc continuous training sessions and some technological upgrades to the ATC systems have been accomplished to provide ATCOs with tools to manage traffic in Free Route airspace.
Positive results and feedbacks received from Airspace Users who have benefitted from FRAIT, confirm the fulfillment of their expectations in terms of flight trajectory optimisation.

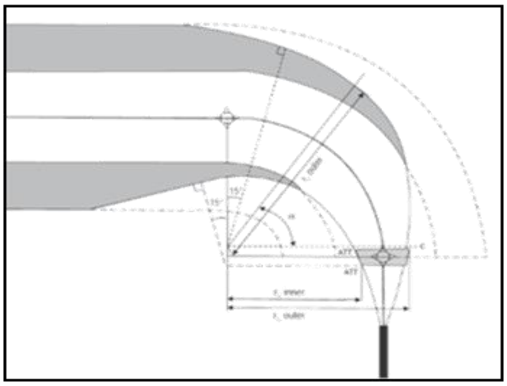
In **2017** the expectations on FRAIT implementation in terms of environmental performance have been confirmed. FRAIT, along with some adaptations to route availability below FL335 and new IFPs for Firenze, Brindisi and Pescara - that account for about 1% of total performance – have allowed short distances with less fuel consumption and CO_2 Emissions:

Distance reduced = 8,600 mln Km
Fuel saved =30 mln Kg
CO_2 avoided=-95 mln Kg

The PBN procedures optimize the use of Airspace, allowing a more efficient design and use of Instrumental Flight Procedures (IFPs) in the Terminal Area, which often support reduced flight times, fuel consumptions and CO_2 emissions, as well as increasing airspace capacity and optimizing the cost of navigation infrastructure.







According to the ICAO Resolution A37-11 in 2012, ENAC and ENAV prepared - with the contribution of the major stakeholders (AM, Alitalia, Agusta-Leonardo, etc.) - and issued the **PBN Implementation Plan Italy**.
ENAV FEP collects and monitors also the interventions defined to fully deploy Performance Based Navigation which are envisaged in the PBN Implementation Plan Italy.
Nowadays several major Italian airports are provided with P-RNAV SIDs/STARs and RNAV APCH procedures and other new IFPs and optimizations are planned for the next years.
In cooperation with airport operators and airspace users, ENAV has undertaken the deployment of the **A-CDM** (Airport Collaborative Decision Making) for the Italian main airports. The project is intended to enhance the efficiency of airport operations, by improving the departure sequences and taxi-times (-out and -in).
At the end of March 2018 five Italian airports - Rome Fiumicino, Milan Malpensa, Milan Linate, Venice and Naples - implemented Full A-CDM with data sharing among Air Traffic Control, Airport Operators, Airspace Users and Network Manager Operational Centre.
Air Traffic Controllers skilled in delivering efficient ground operations along with automation represent enabling factors for the reduction of apron and taxiway congestion while still guaranteeing the traffic flows and the airspace users' needs. In a number of other airports, a basic system for automatic data exchange managed by ENAV is available.
Ad-hoc ATCO training courses which are more focused on efficiency contribute to further deliver performance improvements. In fact, one of the cornerstones of the Flight Efficiency Plan consist in rising air traffic controllers' awareness since they can give a mighty contribution for fuel savings both to in-flight and on-the-ground operations. The principles of flight efficiency and their environmental implications were planned to be part of all recurrent trainings for ATCOs ever since ENAV first FEP edition.
Below the main achievements and improvements in the Air Space and Traffic Management of the last decade in Italy through the running of Flight Efficiency Plan are displayed.
The following table recaps the main actions achieved since 2008 split over the four lines of action:

ENAV FEP 10 years' achievement	
En-Route Airspace Design and Network Availability	▪ FRAIT from FL335 to FL660 ▪ Review of CDR classification following the implementation of military areas with high flexible use, Ionian and Sicilian areas ▪ Route availability maintenance and improvements ▪ Free route in Italy (FRI): first and second phases (2013-2015) ▪ Route realignments, changes in lower/upper limits, or time availability Redesign of the Italian Airspace and ACC Airspace Reorganization (2014) ▪ Improvements in flight profile Italy from/to Tunisia, from/to Spain, from/to France. ▪ Summer season two more hours clear of RAD constraints every day ▪ Reorganization of route network for Milan and Rome U/FIRs ▪ Increase of hourly network availability in winter seasons ▪ Reorganization of route network portion over ALG, BZO, FRZ and Verona ▪ User preferred flight level through raising or removal of level capping for city pairs ▪ Dedicated direct routings, available night-time or H24, improvements from NGT-WE to H24. ▪ Conversion of DCTs into ATS routes and time extension of their availability ▪ Implementation of new routes, extensions, realignments and direct routings in Italian airspace
Design and use of Terminal Areas	▪ Implementation of BRINDISI, MILANO, PADOVA and ROMA CTAs ▪ Withdraw of PADOVA and BRINDISI TMAs ▪ Review of ROMA and MILANO TMAs ▪ Implementations of P-RNAV SIDs/STARs: LIPX, LIRF, LIMZ, LIPZ, LIEO, LIPE, LIPX, LICJ, LIRQ ▪ Publication of an ad-hoc AIC describing the implementation of CDO ▪ New IFPs (STAR or SID or IAP or ICP): LIBC, LIBP, LIPY, LIPO, LIRZ, LIMP, LIMZ, LICA, LIRA, LIRF, LIRQ, LIME, LIMF, LIMZ ▪ Implementation of RNAV APCH for LIEA, LIBR, LIMC, LIRA, LIRF, LIRQ, LIML LIME, LIPE, LIPZ ▪ Reorganization of SIDs for LIRF and LICJ ▪ Review of Initial Climb Procedures and SIDs for LIMP, LIPZ ▪ Reorganization of LICJ, LIPY, LIPE, LIME, and LIRF CTRs and related IFP
Airport Operations	▪ Optimization and automation of the apron management of LIMC, LIML, LIME, LIMF, LIPE, LIPZ, LIRN, LICJ, LIEA, LIMJ, LIRQ, LIEO, LIBD, LICC and LICA. ▪ Full A-CDM Airports: Roma Fiumicino, Milano Malpensa, Venezia, Milano Linate and Napoli ▪ In several other airports, a basic system for automatic data exchange managed by ENAV is available.
Operational staff awareness	▪ Around 1000 people - ab initio ATCOs, advanced ATCOs and FISO students - have attended modules on flight efficiency at ENAV's Academy ▪ Managerial dedicated workshops for all ENAV's ATS Units ▪ 44.540 hours on flight efficiency provided to ATCOs during continuous training

The following table recaps the actions planned in Flight Efficiency Plan for the years 2018-2020, split over the four lines of action.

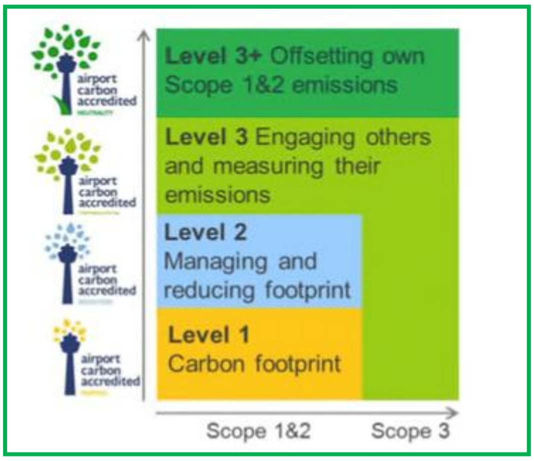
Flight Efficiency Plan for the years 2018-2020	
En-Route Airspace Design and Network Availability	**Plan 2018 – 2020** ▪ Free Route in Italy: ○ FRAIT inferior limit lowering to FL305 (May 2018) ○ FRAIT Integration with FRA ML and FRA GR ▪ Review of CDR classification following the implementation of military areas with high flexible use, Third phase: Sardinia area ▪ Re-Classification military areas above FL335 in AMC manageable and application of AUP/UUP process for Airspace Management ▪ Coordination with FAB Blue Med Partners to improve both intra-FAB and trans-FAB route network; Implementation of intra-FAB BM DCTs for selected routings ▪ Network optimization based on traffic demand and harmonization of new RAD implementations
Design and use of Terminal Areas	**Plan 2018 – 2020** ▪ New P-RNAV SIDs/STARs: LIEA, LICA, LIRA, LIRN, LIMJ, LIBD, LICJ_SID ▪ Improvements on P-RNAV SIDs/STARs: LIEO, LIME, LIPZ [LIPX] ▪ Implementations of RNP Approach procedure: LICJ, LIRN, LIMJ, LIMF, LICR, LIMZ, LIMP, LIPB, LICA, LIEA, LIPY, LIPE, LIBC, LICG, LIBP, LIPR, LIBG, LIMG, LIBD, LICD, LIRZ, LIPO, LIPQ, [LIEO, LIPX, LICC] ▪ New implementations STAR TROMBONI P-RNAV: LICJ, LIMC, LIML, LIMF
Airport Operations	**Plan 2018 – 2019** ▪ Implementation of A-CDM - Local and Full - with SW support for automatic data exchanging among ATC, AOP, Airlines, NMOC and related operational procedures for Napoli e Bergamo
Operational Staff Awareness	**Plan 2018** ▪ Ab initio and advanced ATCO students will follow around 130 hours on flight efficiency. ▪ ATCOs continuation training will include around 4.000 hours focused on flight efficiency

The table below shows a detail of the measures that ENAV is in progress to implement according to FEP Plan Edition 2018, relevant to measures described within the ICAO DOC 9988 Guidance on the Development of States' Action Plans on CO_2 Emissions Reduction Activities:

DOC 9988 MEASURES	2018	2019	2020	COMMENTS
1 - CDO	Implemented on tactical base			
2 - PBN STAR	LICJ, LIEA, LICA, LIRA	LIRN	LIMJ, LIBD	
	LIEO, LIME	LIPZ		Optimisation
3 - CCO	Implemented on tactical base			
4 - PBN SID	LICJ, LIEA, LICA, LIRA	LIRN	LIMJ, LIBD	
	LIEO, LIME	LIPZ		Optimisation
5 – ACDM (NON US VERSION)	LIRN	LIME		
7 - WAKE-RECAT (DEPARTURES)	N/A			N/A
8 - WAKE-RECAT (ARRIVALS)	N/A			N/A
9 - AMAN/(RSEQ)				Extended AMAN LIRF 2019, LIMC 2019
10 - FULLY UTILIZE ADS-B SURVEILLANCE				N/A
11 - RADIUS TO FIX PBN PROCEDURES				LIMC, LIRF
12 - RNP AR APCH(ARRIVALS)	LICJ, LIRN, LIMJ, LIMF, LICR, LIMZ, LIMP, LIPB, LICA, LIEA, LIPY, LIPE, LIBC, LICG, LIBP, LIPR, LIBG	LIMG, LIBD, LICD, LIRZ, LIPO	LIPQ	
13 - A-SMGCS PEAK - (DEPARTURES)	L1 implemented at LIMC; L2 by 2020. L1 implemented at LIML; L2 by 2020 L1 at LIPZ by 2020. L1 implemented at LIRF; L2 by 2020			
14 - A-SMGCS LOW VIS -(DEPARTURES)				
15 - A-SMGCS NIGHT - (DEPARTURES)				

4.2.6 Airports and Infrastructure Use

For a long time now, airport operators have undertaken initiatives and measures aimed at reducing CO_2 emissions and remarkable improvements have been already implemented, both through actions launched at national level and with the attendance to European certification programmes.
Nowadays more airports are committed to decreasing air pollution and greenhouse gases emissions through the continuous research on energy efficiency and the use of renewable resources. This is witnessed by numerous certifications and the most important and recognized one is the Airport Carbon Accreditation (ACA), as shown in para. 3.2.6.1.
The aim of Airport Carbon Accreditation is to encourage and enable airports to implement best practices in carbon management, with the ultimate objective of carbon neutrality. Airports can participate at four progressively stringent levels of accreditation: 1. Mapping; 2. Reduction; 3. Optimisation; and 3+. Neutrality. Airport Carbon Accreditation focuses on CO_2 emissions, which represent the large majority of airport emissions. Airports may include emissions of other greenhouse gases (GHGs) on a voluntary basis, as an example of best practice.
Accreditation provides the opportunity for airports to gain public recognition for their achievements, promotes efficiency improvements, encourages knowledge transfer, raises an airport's profile and credibility, encourages standardization, and increases awareness and specialization.



Independent third party verification by an approved verifier is an essential component of the programme. Airport Carbon Accreditation is developed in line with the GHG Protocol and ISO 14064 principles, as it sets the framework and management system to develop the carbon footprint and to identify projects to reduce emissions.
Similarly to the provisions of the GHG protocol, emissions are classified into scopes:

- Scope 1: direct emissions that occur from sources that are owned and/or controlled by the airport.
- Scope 2: indirect emissions from the generation of purchased electricity, steam, heat or cooling consumed by the airport.
- Scope 3: all other indirect emissions, which are a consequence of the activities of the airport, but occur from sources not owned and/or controlled by the company.

Note on Calculation of Scope 2 Emissions: Location and Market Based Approach. The programme has adopted the GHG Protocol Scope 2 Guidance according to which there are two ways of reporting scope 2 emissions: location based and market based. The location based approach reflects the average electricity emissions of the country or region where the airport is located and uses an average emission factor specific to the grid on which the energy consumption occurs. The market-based approach reflects the emissions from the electricity sources and products that have been purposefully chosen and, under strict conditions, allows for the use of an emission factor that is directly associated with the type of electricity purchased.
Achieving Reductions & the Three-Year Rolling Average. Based on the Airport Carbon Accreditation programme, an airport must demonstrate annually emission reductions against a three-year rolling average for the specific type of target it has selected (i.e., absolute or intensity). This works as follows: The year being reported (i.e., Year 0 emissions) should be compared with the arithmetic mean (i.e., average) emissions of Years -1, -2 and -3. If an airport joining or upgrading to level 2 or beyond does not have complete historical data to enable it to calculate the full three-year average, it may compare Year 0 emissions with Year -1 or the average of Years -1 and -2 emissions. As soon as three years of historical data become available, the airport shall compare its Year 0 emissions to the rolling three year

average. Airports entering the programme directly at level 2 or above must verify any historical carbon footprints they are using for comparison against Year 0.

4.2.6.1 National Context

ENAC asked airport operators for a complete picture of the measures taken under their direct responsibility to reduce CO_2 emissions and the following data represent the Italian "state of play".

Airports are committed to becoming cleaner and more efficient. In the middle of a complex web of aircraft movements, technical operations and surface access transport, airports can address the issue of CO_2 emissions in several ways. These include better insulation and energy efficiency, switching to green energy sources, investing in hybrid, electric or gas-powered service vehicles, encouraging employees, passengers and visitors to use public transport, working with airlines and air traffic management to reduce runway taxiing times, implementing green landing processes and much more.

In Italy, several airport operators have joined the Airport Carbon Accreditation programme with a total of 11 airports which manage 75% of total passenger traffic occurred in 2017.

The following table represents the distribution of Italian airports on the basis of the four level of Airport Carbon Accreditation and their levels of passenger traffic.

Airport	***Total passenger 2017***	***Level of Certification***
CIA	5.885.812	**NEUTRALITY**
FCO	40.971.881	
LIN	9.548.363	
MPX	22.169.167	
TSF	3.015.057	
VCE	10.371.380	
NAP	8.577.507	**OPTIMISATION**
BGY	12.336.137	**REDUCTION**
BLQ	8.198.156	
VRN	12.336.137	
CAG	4.157.612	**MAPPING**

It is important to underline that **4 airport operators, managing 6 major airports and representing more than the 52% of the national passenger traffic in 2017, are carbon NEUTRAL**.

With reference to the CO_2 emissions per passenger in the last three years, at national level it has been estimated a total index as follows:

Year	2015	2016	2017
Average of the total tons of CO_2 emissions per passenger	**0,00166**	**0,00157**	**0,00135**

The data above show how the actions, investments and initiatives developed by the airport operators have had a positive impact in term of CO_2 emissions reduction which have steadily decreased.
The overall initiatives undertaken by Italian airport operators also include airports which are not certified within the ACA programme and which have realized, in any case, initiatives with the aim of reducing CO_2 emissions.
The first 16 Italian airports classified per passenger traffic - which represent 90% of the total air traffic in Italy, namely more than 157 million of passengers - have already promoted, in different ways and timing, one or more of the following items:

- measures aimed at improving the lightings efficiency , such as the installation of Light Emitting Diode and automatic brightness control systems:
- actions aimed at improving the efficiency of the power plants (electricity/heating/cooling) through cogeneration, trigeneration or installation of high efficiency air treatment units (ATU);
- energy efficiency retrofits and/or installation of building envelope components with high performance in terms of thermal transmittance;
- measures of green procurement;
- personnel training, which includes training courses initiatives to raise awareness for airport personnel on environmental matters for proper energy use;
- adoption of management protocols and organizational instruments to improve management; and
- planning of measures to improve energy efficiency of airport infrastructures.

Some airports are also planning to install photovoltaic plants and to use photocatalytic materials for road areas by 2020.

4.2.6.2 Focus on the major airport operators

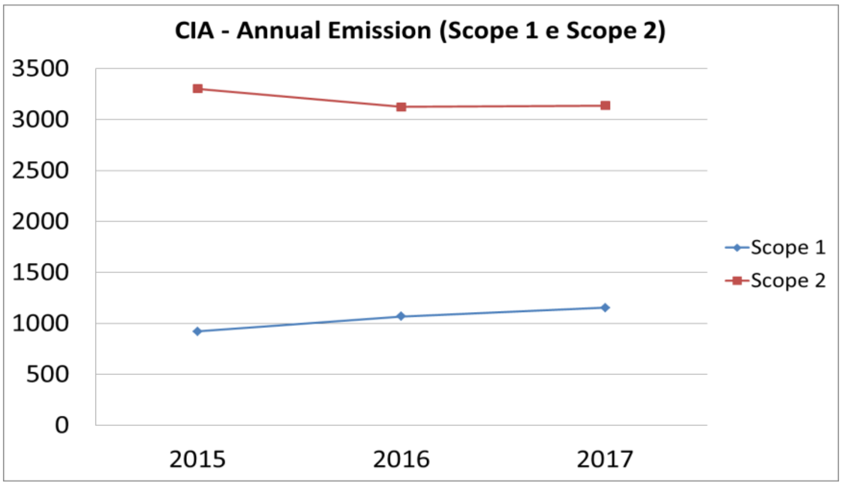
Aeroporti di Roma (ADR) – Fiumicino and Ciampino Airports

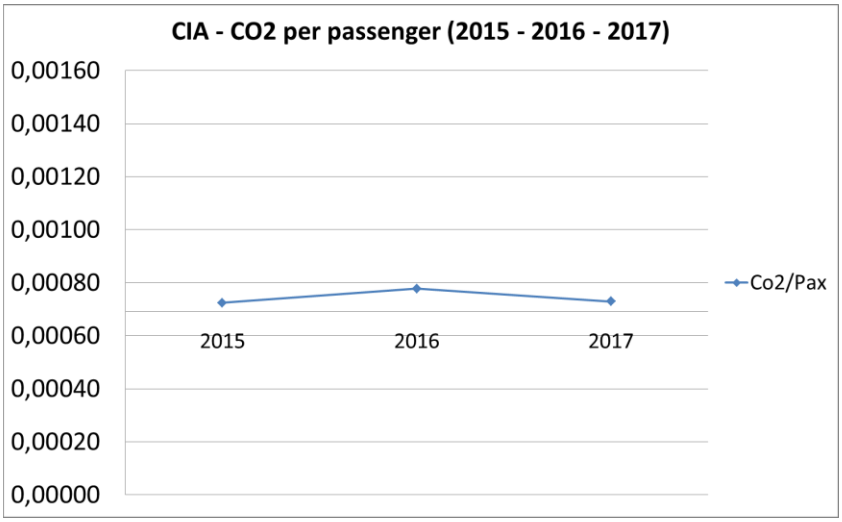
Aeroporti di Roma SpA has been committed to quantifying the CO_2 emissions related to the operation of the airport operators and to the activities that gravitate around the Rome airport system since 2011, through the voluntary adhesion to the Airport Carbon Accreditation scheme proposed by ACI Europe.
Aeroporti di Roma joined the scheme in its experimental phase, which involved only European airports, and continued in the certification path that led to the achievement of the Carbon Neutral levels of excellence in both airports (Fiumicino and Ciampino).
The use of the ACA certification at the highest level is integrated with other related management tools that have been implemented by the company for a long time now; in particular, until 2016 practices and procedures of the ACA were integrated in the environmental management system, while in 2017, following the new technical and organisational infrastructure, carbon performance management is included in energy management system procedures in a holistic approach aimed at integrating management systems.
The interventions envisaged by the ACI Europe programme include the reduction of discharges produced by land transport, the increase in renewable energy used and the reduction of energy waste in buildings.

Quantification of emissions

The request for a detailed analysis is aimed at obtaining a picture of the status quo updated to the last three years, in order to identify the actions to be undertaken in the fight against Climate Change, in line with the most recent European policies on the matter and, dynamically and proactively, to meet the challenges of "green communication" in the near future.
The study is conducted annually with the final aim of being used as a management tool within the ISO 50.001 certified SGE, already applied in ADR, and as a primary requirement for accreditation to the Airport Carbon Accreditation scheme, which resumes the methodology for the quantification of greenhouse gases, defined as "Carbon Footprint", defined by the UNI EN ISO 14064: 2012 standard and the guidelines of the GHG Protocol.
Through the use of appropriate indicators, internal and external comparisons are possible both for management and marketing purposes.

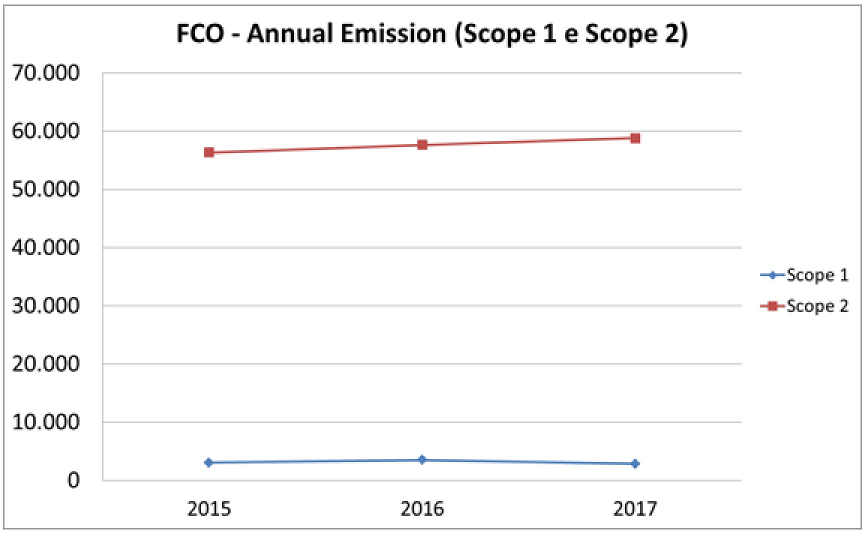
Rome Ciampino Airport - 2015-2017

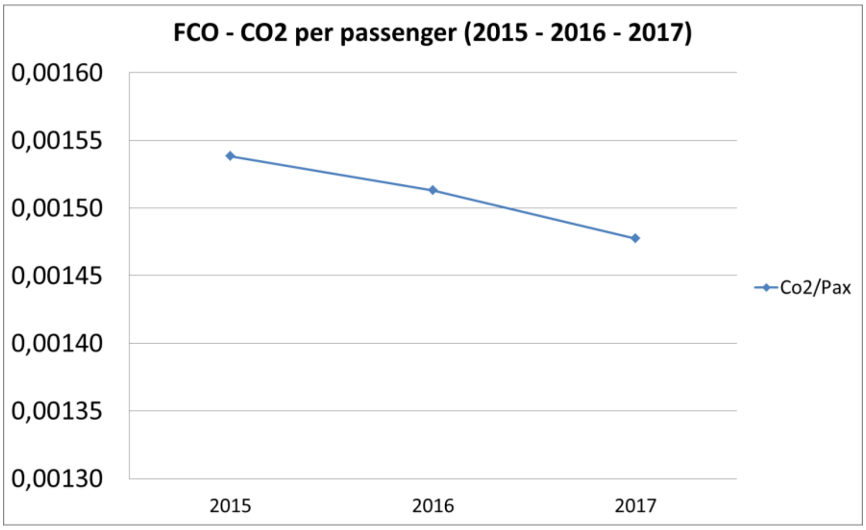




* in Summer 2016 the runway was closed so the passenger number is much lower than in 2015 and 2017.

Rome Fiumicino Airport - 2015-2017





The greatest contribution of the emissions under control of airport operators is given by "Scope 2", i.e. the energy purchased.
Rome Fiumicino and Ciampino airports have been certified ISO 50001 since 2012 and several energy efficiency projects are planned annually.
The continuous decrease in specific consumption is due to a series of energy efficiency measures, investments for the reduction of specific consumption and investments in infrastructure.
Since 2011, the first year of ACA certification, Aeroporti di Roma has constantly improved its carbon performance expressed with the $KgCO_2$/pax indicator related to the directly controlled emissions (Scope 1 + Scope 2).
As for the indirect emissions that cannot be directly controlled, ADR has encouraged the reduction of emissions through a stakeholder engagement plan, in which shared actions are valued, that can lead to an improvement in carbon performance.
Among the initiatives aimed at obtaining a CO_2 emissions reduction in the period 2011-2017, it is important to mention the following:

Directly controlled emissions

- Maintenance actions linked to energy savings which led to a reduction of around 36 GWh (-20%) in electrical energy consumption compared to the natural trend defined as business as usual;

- Use of electricity for Fiumicino, mainly coming from the power station of Fiumicino energy (subsidiary company of ADR), which produces electricity with an emission factor about 10% lower than the emission factor related to the grid (or national energy mix);
- Use of energy efficiency criteria in the design and construction of new infrastructures, C pier and terminal for FCO and general aviation terminal for CIA;
- Installation and use of energy from renewable sources through the installation of photovoltaic, wind and Smart Grid in FCO;
- Training and awareness of employees on energy saving and incentive policy on the use of public transport to reach the airport;
- Use of electric and hybrid cars to partially replace the ADR vehicle park on the air- and landside.

Not directly controlled emissions

- The joint action of ADR and ENAV (Italian Air Navigation Service Provider) led to the implementation of the Airport Collaborative Decision Making (A-CDM) operational procedure aimed at improving air traffic management through a greater exchange of information among all stakeholders (airport operators, handlers, airlines, air traffic controllers, CFMU- Central Flow Management Unit). As for Carbon, the reduction in TAXI time (one of the largest emission sources in absolute terms) and the reduction of the environmental impact of third-party operators were the main stakeholder engagement programmes;
- Improvement of traffic and ease of access to the airport by public transport. Over the years, with the increase in passengers, the construction of specific stalls was necessary for the arrival of buses with municipal, regional and inter-regional origins, both to Fiumicino and Ciampino Airports, which has led to an increase in passengers (and employees) who have chosen to use public transport instead of private car;
- Introduction of free floating carpooling in collaboration with Eni Enjoy and Car2go partners for passenger access to the airport;
- Specific training on energy saving at all the sub-concessionaires who lease commercial areas.

Beyond carbon neutrality: focus on future actions

In the next few years ADR intends to continue to maintain the level of Carbon Neutrality.
However, the process of continuous improvement to achieve the highest levels of certification in the Airport Carbon Accreditation scale will focus on improving the performance of the individual emission sources with regard to their significance.

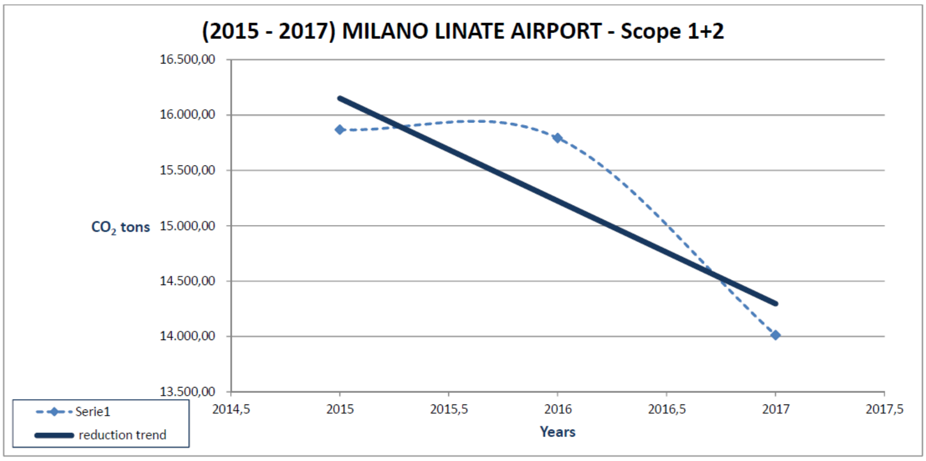
SEA Milan – Malpensa and Linate Airports

SEA (Società per Azioni Esercizi Aeroportuali) Group manages Milano Malpensa and Milano Linate airports under a 40-year agreement signed by SEA and ENAC in 2001. It is one of the ten biggest airport operators in Europe for goods and passenger traffic, while it is the second-biggest in Italy for the number of passengers handled and the biggest in the country for goods transported.
SEA's mission is entrenched in the responsibility to provide impetus to this growth in a manner that is sustainable, broadly shared and respectful to all.
Milano Malpensa and Milano Linate make up an airport system that guarantees civilians and economic operators an extensive network of links with Italy, Europe and

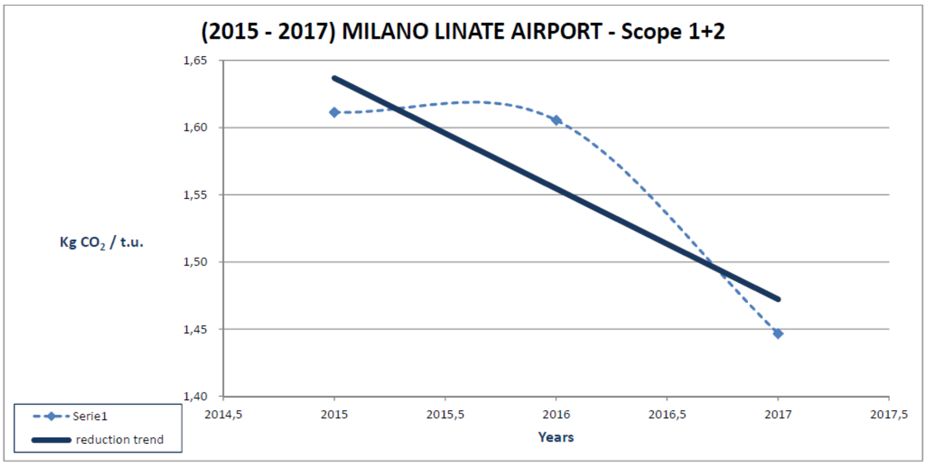
the rest of the world, thus contributing to the economic and social development of the North of Italy and the country as a whole.
Through SEA Energia (a wholly-owned subsidiary of SEA), the Group owns two co-generation plant, mainly meeting the energy needs of Linate and Malpensa airports, providing electricity, heat and district cooling.
SEA is certified UNI EN ISO 14001, ISO 50001, UNI EN ISO 9001, BS OHSAS 18001. It is also accredited ACI Europe Airport Carbon Accreditation at level "3+ Neutrality" for the reduction of CO_2 emissions.
SEA joined the Programme at the very beginning when it was launched in 2009 by ACI Europe, reaching the level of Optimisation, the first time in Italy, for both Milano Linate and Milano Malpensa airports. In 2010, among the first European airports, it was accredited level 3+ Neutrality, having mapped and reduced its Scope 1 and 2 emissions, comprised Scope 3 emissions, developed a Stakeholder engagement plan as well as offset its residual Scope 1 and 2 emissions for both airports.
Taking into consideration the due adjusting of the three-year rolling average resulting from the natural evolution of an airport in terms of investments and divestments, from 2009 (when SEA joined the ACA Programme) to 2017, it has been reducing its Scope 1+2+3 emissions of 24.4% for Linate and 39.7% for Malpensa, in absolute terms.
If considering the target expressed in tonnes of CO_2 per equivalent passenger, those reductions accounted for 33.9% for Linate and 54.9% for Malpensa.
Focusing on SEA emissions under Scope 1 and 2, i.e. emissions for which the airport has ownership/control, the last 3 years have been characterized by the following reductions:

Linate

Reduction in absolute terms: 11.7% tonnes of CO_2

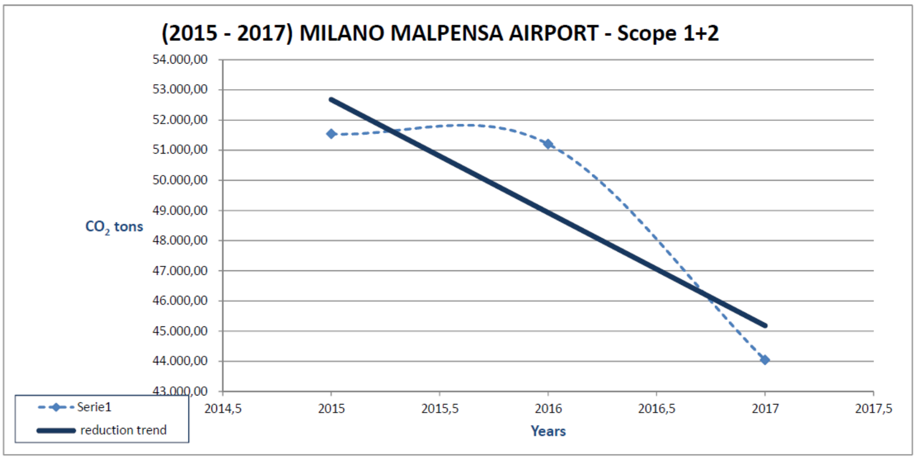


Reduction in Kg of CO_2 per traffic unit: 10,2%

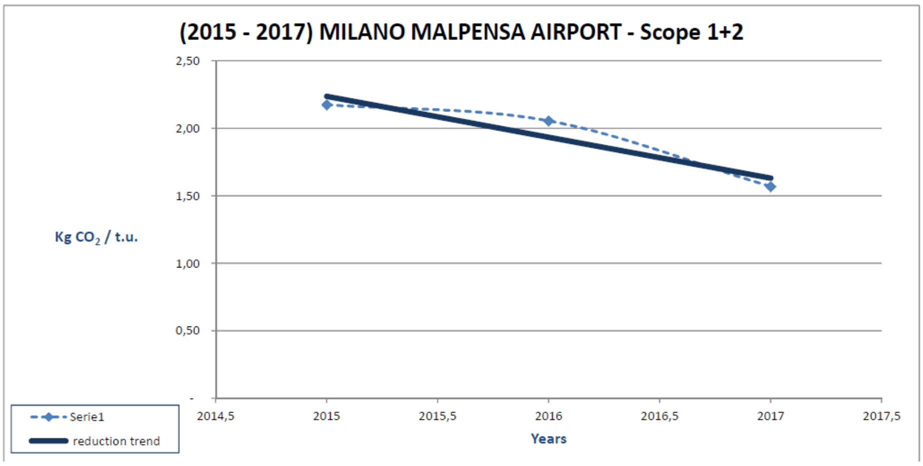


Malpensa

Reduction in absolute terms: 14.5% tonnes of CO_2



Reduction in Kg of CO_2 per traffic unit: 27,9%



This reduction in emissions is the result of a series of specific actions, together with a policy commitment to GHG, carbon and energy reduction formally stated from the company top management within SEA integrated Environmental and Energy Management Systems, certified ISO 14001 and 50001, as well as targeted savings measures adopted by the company, including under current institutional arrangements (Contratto di Programma ENAC-SEA).
Just to mention the most relevant ones:

- Optimization of the lightning system through the installation of LED lamps;
- Further optimization of the conditioning power station;
- Further improvement in energy consumptions management, through the implementation of new software and methodologies;
- An increasing use of renewable energy sources.

SEA future actions towards the reduction of CO_2 emissions

SEA Milan Airports will continue to voluntary commit to maintaining its accreditation at level 3+ Neutrality within the Airport Carbon Accreditation Programme.
As to the reduction of the emissions under its direct control, an investment plan has been presented for both Linate and Malpensa Airports, for the period 2016-2020, compliant with the objectives and targets stated in the Contratto di Programma

ENAC-SEA, which includes, among others, projects on HVAC System, Thermal plants, Electrical installation, and Management interventions.
Within the future actions related to the stakeholders' engagement (i.e. All SEA Departments, Air Traffic Control, ENAC, Surrounding Municipality, etc.) the plans defined for the two airports of Milano Linate and Milano Malpensa involve aspects such as:

- Decrease in the emissions of airport ground movements;
- Maintenance and improvement of SEA Certified Energy Management System;
- Low CO_2 emissions in the maintenance and management of airport infrastructures;
- Adoption of design concepts aimed at reducing carbon emissions in the construction of new airport infrastructures;
- Design and use of terminal areas;
- Support to the Apron Management Services;
- Raising awareness on energy saving;
- Contribution to design new solutions for low-emission mobility;
- Projects for green, energy efficiency, low carbon emissions at local and at international/European level;
- Organization of workshops and exchange of best practices on topics related to water and energy saving;
- Involvement of third parties in behaviours and awareness on energy efficiency and low carbon emissions.

SAVE – Venice Airport

Venice Marco Polo Airport is the unmatched airport of reference in the North-East of Italy and it is the main gateway for long distance access.
SAVE S.p.A., the company managing the airport, is strongly engaged in reducing its levels of pollution, and Venice Airport has achieved "Neutrality 3+" level within the Airport Carbon Accreditation, that requires neutralizing remaining direct carbon emissions by offsetting.
Since achieving complete carbon neutrality is challanging without external help, the ACA certification programme gives the possibility to look for carbon offsetting in the final stage, for example investing in renewable energy facilities which replace those powered by fossil fuels.
In fact, in Marco Polo Airport, since 2016 some of the offsets has came from the project named "Za Hung Hydropower Project" submitted to the Markit Environmental Registry. This project is based on the Voluntary Carbon Standard (VCS), created to ensure the credibility of voluntary compensatory investments. This standard requires projects to meet exact requirements such as the concreteness of the offsetting, their measurability and permanence, independent verifications; the offset quotas are used only once.
Moreover. in 2017 the company decided to support two projects very similar to each other:

- "Jari / Amapà REDD + Project" is registered in the APX VCS Registry and is based on the methodologies used by VCS;
- ii) "Portel-Para REDD Project in Brazil": the planting of trees is associated to each carbon offset.

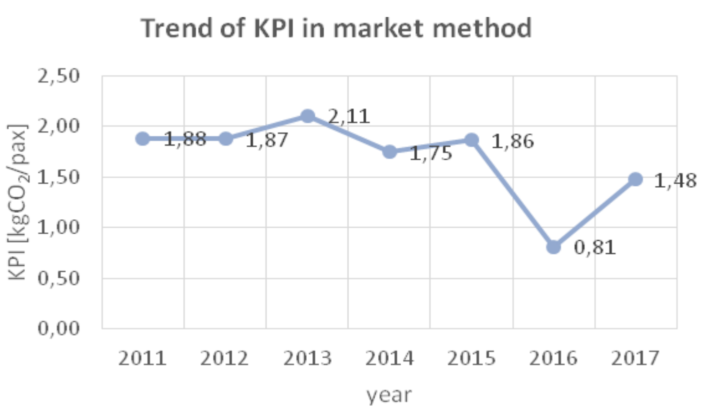
In January 2015 Venice Airport became a fully implemented A-CDM airport following the connection to the Network Manager Operations Centre and the exchange of live data via DPI messaging and certified its Energy Management System according to UNI CEI EN ISO 50001.
In the same year some initiatives in terms of energy efficiency have been carried out such as:

- the installations of air blades on some doors, the substitution of two chillers and the inclusion of a supervisor to switch off the lights in the multistorey car park;
- the replacement of several lamps with LED technology, especially in terminal areas;
- the change of the Baggage Handling Systems engines, saving 339 tons of CO_2 in 2016.

Furthermore, in the last years the airport operator has replaced at least two vehicles per year by purchasing eco-friendly cars (currently there are 7 hybrid and 2 full electric cars) and it was incremented the number of stands provided with fixed GPU 400 Hz.
The 2017 electricity, hot and chilled water needs were met in large part with the new trigeneration plant which entered service in February 2017. The plant consists of two internal combustion engines powered by natural gas, each one capable to produce 2 MWe of electric power and 1.9 MWt of thermal power. The engines also can feed two absorption refrigeration units of 1.5 MWf each.
This, in traditional condition, leads to a reduction of 4600 tCO_2 per year.
This has also led to an increase in the self-production of electricity (about 65%), but at the same time to an increase in CO_2 emissions because from May 2016 the company has opted to obtain a supply of electricity from 100% renewable sources, going to neutralize its scope 2 emissions according to Market method described in GHG Protocol Scope 2 Guidance.
However, the airport also owns an emissions inventory and has planned a reduction of CO_2 emissions by 30% below 2011 level by 2030, purpose that is fully achieved through the market method.
Here below a table summarizing CO_2 emissions from 2015 and Venice Airport KPI [$kgCO_2$/pax].

	2015	**2016**	**2017**
Scope 1 *[tCO_2]*	2.636	3.246	15.311
Scope 2 *[tCO_2]*	13.671	4.575	0
pax	8.751.028	9.624.748	10.371.380
KPI *[$kgCO_2$/pax]*	1,86	0,81	1,49

Table 1 *– Carbon Footprint in the last 3 years*



To understand the Venice Airport KPI trend from its base year, the following diagram shows very well the most impact actions taken since 2016 (purchase of 100% renawable electricity) and 2017 (trigeneration plant).

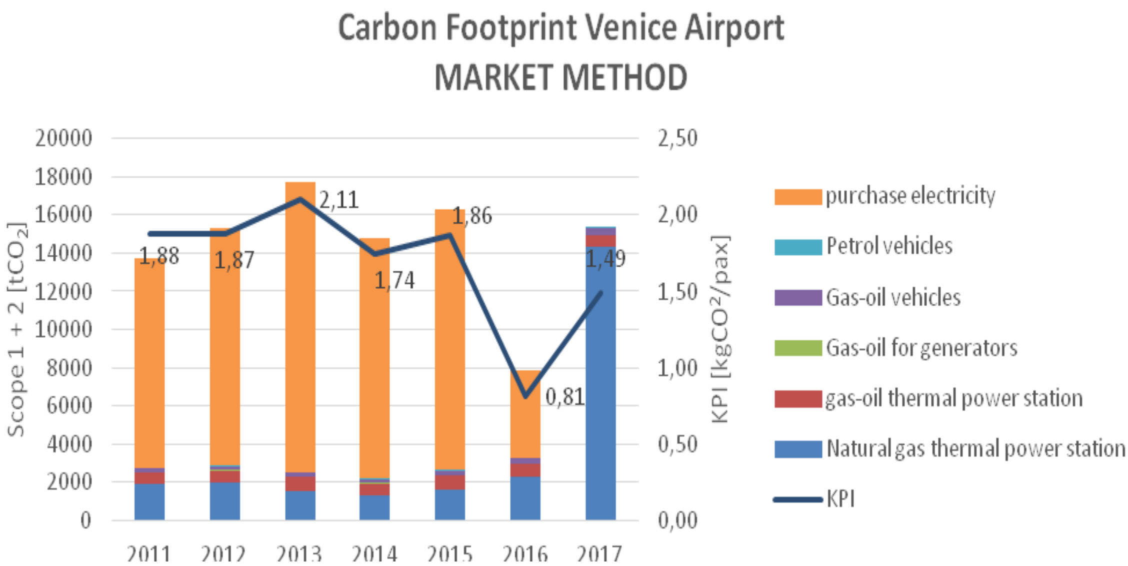


Figure 1 *– Carbon Footprint from 2011-2017*

FUTURE PROJECTS

According to the expected increase of passenger traffic in Venice Airport in the future, its area is affected by various projects aimed at guaranteeing an adequate level of service to passengers.

Below, some project goals:

- use of local materials with characteristics of environmental compatibility and energy efficiency, such as wood for parts of the roof and for the flooring, in continuity with the existing terminal;
- use of the most appropriate systems to achieve the highest environmental and energy sustainability of the building: acoustic and thermal insulation, use of solar panels, enhancement of natural light, reduction of energy consumption, use of drinking water, etc.

One of the main projects that will end in 2021 is the redevelopment of the flight infrastructures.

The current layout and the type of aircraft serving the airport cause, during the high season, incremental delays at take-offs, with a considerable quantity of waiting aircraft. The situation is similar for landing operations.

Here below there is the comparison between the current layout and the future one. The changes consist of:

- Increase of the holding bay on head 04;
- Addition of speed-exits;
- Construction of taxiway TN;
- Construction of taxiways dedicated to F codes;
- Extension second runway.

Figure 2 *- actual layout*

Figure 3 *- layout in 2021*

Further actions for the improvement of air quality will be focused on the efficiency of aircraft operations during LTO cycle: from 2021 it will be required to minimize the use of reverse and, for all the narrow body aircraft, taxing with a single engine.

4.2.7 Capacity Building, Buddy and other initiatives

In the framework of ICAO Buddy Program initiatives, Italy has initiated in 2018 a partnership with the Republic of Madagascar; both countries will work together to improve their CO_2 emission reduction Action Plans.
Italy also decided to finance the ICAO Capacity Building Programme for CORSIA; ICAO will use these funds to train personnel of Member States needing assistance for the CORSIA programme.
In preparation for CORSIA, Italy also launched a national programme to disseminate information to the air operators involved in CORSIA.

4.2.8 Emission Trading System (ETS)

Since January 1 2012, emissions deriving from air transport are included in the EU system of exchange of GHG emissions, named ETS, as regulated by the EU Directive 2003/87/CE.
The provisions related to civil aviation in the ETS, which have been implemented since January 1, 2013 for air carriers administrated by Italy, were endorsed by Legislative Decree n. 30 dated 13 March 2013, as national application of EU Directive 2009/29/CE which superseded Directive 2003/87/CE in order to improve and make more extensive the EU system of exchange of GHG.
Legislative Decree n. 30/2013 entered into force on April 5, 2013.
As provided for by the Decree, the National Committee for the management of the provisions of Directive 2003/87/CE and for supporting the management of the project activities related to the Kyoto Protocol (ETS Committee) undertakes the function of Competent Authority for the national implementation of the ETS system in air transport as well.

The Committee is composed of representatives of the Ministry for Environment, Safeguard of Territory and Sea, the Ministry for the Economic Development, the Ministry for Infrastructures and Transport and ENAC.
The Ministry for Economy and Finance, the Ministry for the European Policies and the Conference for the relations between State and Regions participate in the Committee in a consulting role.
The following table shows the amount of emissions in 2016 and 2017 recorded by air carriers administrated by Italy within the EU ETS (domestic and intra-EEA flights):

Year	*Total number of aircraft operators for which Italy is responsible as administering Member State*	*Total emissions of flights carried out by aircraft operators for which Italy is the administering Member State (t CO_2)*	*Total emissions of domestic flights carried out by aircraft operators for which Italy is the administering Member State (t CO_2)*
2016	20	1.987.546	1.076.437
2017	25	1.906.174	1.050.658

Part of ETS auction proceeds is earmarked for research initiatives to reduce green-house gas emissions in air transport. For this purpose the following projects have been activated:

- Biofuel from microalgae project, intended to the construction of a pilot plant to produce biofuel in a small-demonstrative scale quantity (ENAC);
- Cooperation agreement between Public Administrations and Research and Development Centres for production and use of biofuels in Civil Aviation (Ministry for Environment, Safeguard of Territory and Sea, Italian Air Force, ENEA and CNR);
- Research project for the implementation of a counting system for aircraft CO_2 emissions aimed at estimating the trend of the future emissions (ENAC).

5. List of abbreviations

ACARE – Advisory Council for Research and Innovation in Europe

ACARS – Aircraft Communications Addressing and Reporting System

ACA – Airport Carbon Accreditation

ACC – Area Control Centres

ACCAPEG – Aviation and Climate Change Action Plan Expert Group

ACI – Airports Council International

APER TG - Action Plans for Emissions Reduction Task Group of the ECAC/EU Aviation and Environment Working Group (EAEG)

EAER – European Aviation Environmental Report

AEM – Advanced Emission Model

AIRE – The Atlantic Interoperability Initiative to Reduce Emissions

ANS – Air Navigation Service

ATC – Air Traffic Control

ATM – Air Traffic Management

BAU – Business as Usual

CAEP – Committee on Aviation Environmental Protection

CCD – Continuous Climb Departures

CDA – Continuous Descent Approach

CDM - Collaborative Decision Making

CDA – Continuous Descent Approach

CDO - Continuous Descent Operations

CNG – Carbon neutral growth

CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation

CPDLC – Controller-Pilot Data Link Communications

EASA – European Aviation Safety Agency

EC – European Commission

ECAC – European Civil Aviation Conference

EEA – European Economic Area

EFTA – European Free Trade Association

EU – European Union

EU ETS – the EU Emissions Trading System

FAB – Functional Airspace Block

FANS – Future Air Navigation System

FP7 - 7th Framework Programme

GHG – Greenhouse Gas

GMBM – Global Market-based Measure

Green STAR – Standard Arrival

Green IA – Initial Approach

HVO – Hydro-treated Vegetable Oil

ICAO – International Civil Aviation Organisation

IFR – Instrumental Flight Rules

IPCC – Intergovernmental Panel on Climate Change

IPR – Intellectual Property Right

JTI – Joint Technology Initiative

LTO cycle – Landing/Take-off Cycle

MBM – Market-based Measure

OFA - Operational Focus Area

RED – Renewable Energy Directive

RNAV – Area Navigation

RNP AR – Required Navigation Performance Authorization Required

RNP STAR – Required Navigation Performance Standard Arrival

RPAS – Remotely Piloted Aircraft

RPK – Revenue Passenger Kilometre

RTD – Research and Innovation

SES – Single European Sky

SESAR – Single European Sky ATM Research

SESAR JU – Single European Sky ATM Research Joint Undertaking

SESAR R&D – SESAR Research and Development

SWAFEA – Sustainable Ways for Alternative Fuels and Energy for Aviation

SWIM – System Wide Information Management

TMA - Terminal Manoeuvring Area

ToD – Top of Descent

UNEP – United Nations Environmental Programme

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