RESEARCH ON CARBON EMISSIONS REDUCTION PATHS AND COOPERATION PROSPECTS IN CIVIL AVIATION SECTOR BETWEEN CHINA AND ITALY

2021 >>>

This project is undertaken by Institute of European Studies (IES) of Chinese Academy of Social Sciences (CASS) with cooperation of Italian Institute for Political, Economic and Social Studies (Eurispes) and is completed by scholars and experts from both China and Italy.

A Study on Carbon Emissions Reduction Paths and Cooperation Prospects in Civil Aviation Sector between China and Italy[1]

Introduction

As the global ecosystem crisis caused by climate change has accelerated in recent years, peaking carbon emissions and achieving carbon neutrality (hereinafter referred to as the Dual Carbon Goals) are gaining increasing recognition and consensus on a global scale. The Paris Agreement, the second legally binding climate treaty after the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC), was formally reached and entered into force in November 2016. In support of such global climate treaty and in consideration of economic growth model transformation, practice to reduce carbon emissions has been in full swing in many countries, ranging from government's macro-level planning to industry policies formulation and from low-carbon technology innovation in various fields to business management. Global carbon reduction actions pick up speed in 2021 because frequent extreme weather events made governments and people further perceive the havoc wrecked by climate change.

Civil aviation is a major transportation sector, as well as an important part and pillar of global economic and trade activities. Reducing carbon emissions from civil aviation has received extensive attention from the international community. In 2019, civil aviation accounted for 10% of global transportation carbon emissions and around 2~3% of global carbon emissions. Although the share is low, carbon emissions from civil aviation are increasing at an alarming rate to make into the fastest-growing sectors in the world. Between 2013 and 2019, the civil aviation sector saw its carbon emissions add by 29%, according to the International Civil Aviation Organization (ICAO), if measures are not taken, civil aviation will contribute to 25% of global carbon emissions by 2050. This highlights the high necessity and urgency of emissions reduction of this sector. In recent years, some progress has been made in energy conservation and emissions reduction through considerable efforts of the civil aviation sector worldwide. However, achieving carbon neutrality in this sector is still extremely challenging in the context of its globally rapidly expanding operation.

It is worth noting that civil aviation is a highly transnational source of carbon emissions. Hence, close coordination and cooperation between countries are indispensable for achieving emissions reduction targets. To this end, in recent years ICAO has played a vital role in guiding and coordinating global efforts to reduce emissions of this sector. In 2010, the 37th Session of the ICAO Assembly pledged the goal of achieving carbon neutral growth from 2020 onwards (CNG2020). Since then, ICAO has launched a basket of mitigation measures,

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including aircraft technology innovations, sustainable alternative fuels (SAF), fleet and facility operation improvements, and market-based mechanisms. At the 39th Session in 2016, the ICAO Assembly adopted a global market-based measure scheme for international aviation, in the form of the Carbon Offsetting and Reduction Mechanism for International Aviation (CORSIA), which affirmed the carbon neutral growth goal from 2020 onwards[2]. However, controversy has arisen from CORSIA implementation as major economies, at different stages of economic development and civil aviation, are divided on the target setting and specific implementation plan.

In view of the need for coordination and cooperation noted above, cross-national comparative study is of theoretical and practical significance to help China's civil aviation sector better achieve carbon reduction targets. As one of the developed countries and the third largest economy in the European Union, Italy has run well among the EU member states in the transition to green economy. In terms of energy transition, the share of renewable energy in the final energy consumption rose to 17.1% in 2014, fulfilling the EU's 17% target set for Italy, six years ahead of schedule. In terms of energy efficiency, Italy came top of the EU in recent years, performing evidently better than the EU as a whole, and also better than Germany and France. This is attributed to Italy's strict energy efficiency standards, white certificates, public sector thermal accounts, large-scale installation of smart meters, and so on. Eurostat data indicate that, Italy's energy consumption per 1,000 Euro of gross domestic product (GDP) was 97.37 kilograms of oil equivalent in 2019, far lower than the overall EU level (114.21 Euro) and much lower than that of Germany (103.07 Euro), France (112.8 Euro), and Spain (113.03 Euro). When it comes to energy conservation and emissions reduction in civil aviation, Italy has also rendered outstanding performance, not only carrying out many attempts in technology innovation, but also having rich experiences in mechanisms. Given this, a comparative study on carbon emissions reduction practice of the civil aviation sector in China and Italy can enlighten China's civil aviation sector as to find better ways to the Dual Carbon Goals based on national and industry conditions.

Besides, civil aviation sector is directly or indirectly involved in the seven priority areas of cooperation under the *China-Italy Action Plan for Strengthening Cooperation in Economy, Trade, Culture, and Science and Technology (2017–2020)*, such as environment and sustainable energies, aviation, infrastructure and transportation. In a phone conversation on September 7, 2021, Chinese President Xi Jinping and Italian Prime Minister Mario Draghi both expressed the importance of strengthening bilateral cooperation in the field of climate change and sustainable development. Therefore, conducting a comparative study on reduction of carbon emissions and exploring the pathways to cooperation in civil aviation sector between China and Italy will also be helpful for enhancing pragmatic cooperation towards a stronger comprehensive strategic partnership between the two countries in the new situation.

This study first reviews the plans and pathways achieving the Dual Carbon Goals for China's civil aviation sector and analyzed the plans and pathways of carbon emissions reduction for

[2] Initially, the average value of emissions in 2019 and 2020 was used to calculate CORSIA baseline. Considering the impact of COVID-19 on global civil aviation, the ICAO Council passed in July 2020 a proposal to use the value of emissions in 2019 instead, and will present the proposal to the 41st Session of the ICAO Assembly for deliberation.

Italy's civil aviation sector, then compares the pathways of the two countries' civil aviation sectors in the dimensions of international environment, technology innovation, and carbon market, and finally, outlines the prospects for cooperation between China and Italy in green and sustainable development of civil aviation sector.

I. Plans and Pathways to the Dual Carbon Goals for China's Civil Aviation Sector

1.1 Background and Challenges

On September 22, 2020, Chinese President Xi Jinping announced, at the General Debate of the 75th Session of the United Nations General Assembly, that "China will scale up its intended nationally determined contributions by adopting more vigorous policies and measures, and aims to have carbon dioxide (CO_2) emissions peak before 2030 and achieve carbon neutrality before 2060." The Dual Carbon Goals embody China's ambitious commitment to the Paris Agreement, and demonstrate China's responsibility as a large and responsible country. It is important for accelerating the green and low-carbon transformation of China's development models, promoting the global joint effort to effectively address climate change, and contributing to the green recovery of the global economy.

For China, which is still in the developing stage, the Dual Carbon Goals are a very challenging and systematic task. It requires not only top-level design, but also the coordination and enormous efforts of various departments and sectors. In 2019, carbon emissions from civil aviation sector stood at 103 million tons, accounting for about 1% of China's total carbon emissions. Although the share not high, such emissions expand quickly. China's civil aviation sector, currently ranking second in the world in terms of scale, has been developing rapidly. The average annual growth rates of total turnover, passenger transportation and freight transportation registered 11%, 10.7% and 4.6% respectively during the 13th Five-Year Plan period (2016–2020). Amid the heavy impact on global civil aviation brought by the COVID-19 outbreak in 2020, China's civil aviation sector is the first to rebound and China becomes the world's fastest-recovering and best-performing aviation market. Against this backdrop, the Dual Carbon Goals are by no means easy for such a rapidly developing sector.

On the whole, China's civil aviation sector faces multiple challenges in emissions reduction due to the special nature of the sector, the severe international environment and the tightening domestic requirements.

Firstly, the particularity of civil aviation sector determines that it's difficult for China to achieve the Dual Carbon Goals. Civil aviation is an important part of global economic activities, and moreover, it plays an irreplaceable role in enabling other economic activities. Hence, growth in carbon emissions from civil aviation is hard to reverse, while reduction of such emissions is inherently complex and multilateral due to the unique feature of cross-border operations. In addition, the inconsistency of interests among multiple links and various entities along the industrial chain involved in emissions reduction makes it difficult to achieve the Dual Carbon Goals.

Secondly, the severe international environment puts great stress on China's civil aviation sector. Carbon emissions from civil aviation have peaked in the developed economies such as

the United States and the EU. Unlike these counterparts, it is much more difficult for China's civil aviation sector to seek balance between development and emissions reduction. The existing CORSIA mechanism fails to leave proper development and emissions space for developing economies in target setting and implementation plan, which will probably increase the cost of mitigation for international aviation. In addition, the purchase of allowances to offset emissions has added the financial burden on developing economies for technology innovation in the sector, which is likely to cause competition imbalance in the global market. In short, global CORSIA application has exerted heavy pressure on civil aviation emissions reduction in developing economies such as China.

Thirdly, Chinese government's rising requirements for emission reduction also pose a huge challenge to the civil aviation sector. The Dual Carbon Goals implementation plan specific for civil aviation sector is under preparation. Requirements concerning emissions reduction of this sector will be further tightened with the introduction and continuous improvement of the plan and the prospective inclusion of civil aviation sector in the national carbon market. China's civil aviation sector is, currently in a stage of steady development, required to peak carbon emission within less than 10 years and achieve carbon neutrality within 40 years. The task is undoubtedly very arduous in such a period critical to both development and emissions reduction.

1.2 Policies and Implementation Progress

In spite of facing many challenges, China's civil aviation sector has always regarded energy conservation and emissions reduction as one of the priorities, and accomplished remarkable achievements over the past years. Aiming at achieving the Dual Carbon Goals, this sector is stepping up efforts to reduce carbon emissions.

The Civil Aviation Administration of China (hereinafter referred to as CAAC) is the primary agency that guides the energy conservation and emissions reduction in civil aviation sector in China. Its responsibilities mainly include proposing civil aviation development strategies and mid- and long-term plans; drafting proposals of laws, regulations and rules, as well as policies and standards concerning civil aviation; conducting civil aviation traffic management; overseeing and managing the construction and safe operation of civil airports; and regulating air transportation and general aviation market. The Energy Conservation and Emissions Reduction Office under the Department of Development Planning of CAAC is responsible for the comprehensive administration of energy conservation and emissions reduction in the civil aviation sector.

Under the guidance of CAAC and other departments concerned, China has accelerated efforts in energy conservation and emissions reduction of civil aviation in recent years. The country has issued various policy documents and plans, continuously optimized relevant systems and mechanisms, and taken measures concerning innovation, investment, and infrastructure, in order to improve green civil aviation development. At present, a comprehensive top-level framework for green and low-carbon development of civil aviation has taken shape, covering policy planning, evaluation indicators, green standards and measurement, reporting and verification of carbon emissions (MRV). In terms of policy planning, the five-year development plans set down the overall goals of energy conservation and emissions reduction,

and the special implementation plans address specific technologies and tasks. With regard to evaluation indicators, an indicator framework for high-quality development has been formed, which mainstreams energy conservation and emissions reduction. In terms of green standards, a series of standards and guidelines for airports have been introduced, ranging from planning and construction to energy efficiency evaluation. In addition, an initial MRV system for domestic and international carbon control has been established. It has been successfully applied to the verification of multi-annual domestic carbon emissions and to the reporting and verification of carbon emissions from 44 airlines in 2019 under CORSIA framework. Table 1 and Table 2 show the major policy documents and the objectives for energy conservation and emissions reduction of China's civil aviation sector.

Specifically, during the 11th and 12th Five-Year Plan periods (2006–2010, 2011–2015), focus was put on the application of energy-saving and emission-reduction technologies. In 2006, CAAC unveiled the *11th Five-Year Plan for Civil Aviation Development of China*, stating that China's civil aviation sector needs to "improve efficiency and reduce costs while taking account of resource conservation and environmental protection". In 2008, the National Development and Reform Commission (NDRC) issued, in conjunction with CAAC, the *Energy Conservation and Emissions Reduction Plan for Civil Aviation*, which required energy efficiency improvement, particularly by saving fuels and controlling emissions. In 2011, the *12th Five-Year Plan for Civil Aviation Development of China* published by CAAC put forward the development of "resource-saving and environment-friendly civil aviation". In the same year, the *Guiding Opinions on Accelerating Energy Conservation and Emission Reduction of Civil Aviation* made arrangements for work from 2011 to 2020. The State Council established, in 2012, the task of "effectively developing green and low-carbon aviation" in its *Several Opinions on Promoting Civil Aviation Development*. In response, the Ministry of Finance (MOF) and CAAC formulated the *Interim Measures for the Administration of Special Fund for Civil Aviation Energy Conservation and Emissions Reduction* in the same year, marking the establishment of the special fund for civil aviation energy conservation and emissions reduction. The *Project Endorsement Guidelines for the Special Fund for Civil Aviation Energy Conservation and Emission Reduction* was published in 2013 and updated in 2014 and 2015. These three guidelines, applicable to the years of 2013~2014, 2015, and 2016–2018 respectively, specified project contents and requirements in support of the large-scale application of energy-saving and emission-reduction technologies, and put in place an incentive mechanism for energy conservation and emission reduction. In 2013, the *Greenhouse Gas Emissions Accounting Methodologies and Reporting Guidelines for Civil Aviation Companies in China (for Trial Implementation)*, issued by NDRC, required covered civil aviation companies across the country to report and verify their carbon emissions annually as part of the preparations for inclusion in the national carbon market.

Table 1 China's Major policy documents for green and low-carbon civil aviation development

Year	Policy documents
2006	The 11th Five-Year Plan for Civil Aviation Development of China

2008	Energy Conservation and Emissions Reduction Plan for Civil Aviation
2011	The 12th Five-Year Plan for Civil Aviation Development of China
2011	Guidelines for Accelerating Energy Conservation and Emissions Reduction of Civil Aviation
2012	Several Opinions on Promoting Civil Aviation Development
2012	Interim Measures for the Administration of Special Fund for Civil Aviation Energy Conservation and Emissions Reduction
2013	Project Endorsement Guidelines for the Special Fund for Civil Aviation Energy Conservation and Emissions Reduction (2013–2014)
2013	Greenhouse Gas Emissions Accounting Methodologies and Reporting Guidelines for Civil Aviation Companies in China (For Trial Implementation)
2014	Project Guidelines for the Special Fund for Civil Aviation Energy Conservation and Emissions Reduction (2015)
2015	Project Guidelines for the Special Fund for Civil Aviation Energy Conservation and Emissions Reduction (2016-2018)
2017	The 13th Five-Year Plan for Civil Aviation Development of China
2017	The 13th Five-Year Plan for Energy Conservation and Emissions Reduction of Civil Aviation
2017	Opinions on Comprehensively and Deeply Promoting the Development of Green Transportation
2018	Implementation Opinions on Further Promoting the Green Development of Civil Aviation
2018	Three-Year Action Plan to Win the Blue Sky Protection Campaign
2018	Work Program for Civil Aviation to Implement the Three-Year Action Plan to Win the Blue Sky Protection Campaign
2018	Interim Measures for the Administration of Carbon Dioxide Emissions Monitoring, Reporting and Verification of Civil Aviation Flight Operations
2020	Notices on Several Matters on Regulating Carbon Emissions Verification Reports for Civil Aviation Flight Operations

2020	Outline of the Action Plan to Develop Four-Characteristics Airports in China (2020–2035)
2021	Outline of the 14th Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Long-range Objectives throughout the Year 2035
2021	Opinions on Deepening Civil Aviation Reform during the 14th Five-Year Plan Period
2021	The 14th Five-Year Plan for Deepening Civil Aviation Reform (2021–2025)

Source: Collected by the research team.

The civil aviation sector has accelerated the pace of carbon emissions reduction since green development was incorporated into the new development concepts at the 5th Plenary Session of the 18th Central Committee of the Communist Party of China (CPC) in 2015. During the 13th Five Year Plan period, the civil aviation sector's emissions reduction has highlighted the importance of the policy management system and the coordination of supporting industries. In 2017, CAAC unveiled the *13th Five-Year Plan for Civil Aviation Development of China* and the *13th Five-Year Plan for Energy Conservation and Emissions Reduction of Civil Aviation*. These two documents for energy conservation, emissions reduction, and climate change mitigation in these five years set the goal of "by 2020, reducing the five-year average of both energy consumption and CO_2 emissions per ton-kilometer by 4% at the minimum compared with the previous period". In order to further promote the development of green transportation, the Ministry of Transportation (MOT) circulated the *Opinions on Comprehensively and Deeply Promoting the Development of Green Transportation* in 2017, aiming to "initially build, by 2020, a well-deployed green transportation system that is eco-friendly, clean, low-carbon, intensive, and efficient", and specifically for civil aviation, "to reduce energy consumption per unit of transportation turnover by 7% from the 2015 level". On this basis, CAAC formulated the *Implementation Opinions on Further Promoting the Green Development of Civil Aviation* in 2018, which laid down the policies of "focusing efforts on energy saving and carbon reduction of aircrafts, and starting by improving the efficiency of air traffic management with the support of green airport construction". In order to resolutely fight against pollution and enhance air quality improvement, the State Council launched the *Three-Year Action Plan to Win the Blue Sky Protection Campaign* in 2018. The key task identified for civil aviation is to "accelerate the oil-to-electricity transition in airports, and vigorously promote shore power supply (alternative to Axillary Power Unit or APU) for aircrafts. Pertaining to this, CAAC developed the *Work Program for Civil Aviation to Implement the Three-Year Action Plan to Win the Blue Sky Protection Campaign*, which put forward specific requirements for energy conservation and pollution reduction. Apart from that, airlines are required to have monitoring plans approved and submit emissions reports and verification reports, according to CAAC's 2018 *Interim Measures for the Administration of Carbon Dioxide Emissions Monitoring, Reporting and Verification of Civil Aviation Flight Operations*. In 2019, CAAC made public the *Indicator Framework System for High-quality Development of Civil Aviation in China (For Trial Implementation)*, establishing an evaluation system for high-quality development of civil aviation sector that incorporates

energy and emissions indicators such as fuel consumption per ton-kilometer and energy consumption per passenger. In 2020, airlines began to conduct the verification of carbon emissions for 2019 in accordance with the CAAC's *Circular on Several Matters on Concerning the Regulation of Carbon Emission Verification Reports for Civil Aviation Flight Operations*. In the same year, the *Outline of the Action Plan to Develop Four-Characteristics Airports in China (2020–2035)* set forth the four core principles of airport construction. i.e., "safe, green, smart, and humanistic", further expanding the connotation of green development of civil aviation sector.

Table 2 China's objectives for energy conservation and emissions reduction in civil aviation sector

Policy documents	Target year	Target level
"The 11th Five-Year Plan for Civil Aviation Development of China (2006)	2010	Energy consumption per ton-kilometer is reduced by about 10%, and expected to reach 0.302 kilograms.
Energy Conservation and Emissions Reduction Plan for Civil Aviation (2008)	2015	Both energy consumption and CO_2 emissions per ton-kilometer are reduced by 15% from the 2005 levels.
The 12th Five-Year Plan for Civil Aviation Development of China (2011)	2015	The five-year average of both energy consumption and CO_2 emissions per ton-kilometer are reduced by 3% at the minimum over the previous five-year period.
Guiding Opinions on Accelerating Energy Conservation and Emission Reduction of Civil Aviation (2011)	2013	Both energy consumption and CO_2 emissions per ton-kilometer are reduced by 11% from the 2005 levels.
	2015	Both energy consumption and CO_2 emissions per ton-kilometer are reduced by 15% from the 2005 levels.
	2020	Both energy consumption and CO_2 emissions per ton-kilometer are reduced by 22% from the 2005 levels.
The 13th Five-Year Plan for Civil Aviation Development of China (2017), The 13th Five-Year Plan for Energy Conservation and Emission Reduction of Civil Aviation (2017)	2020	The five-year average of both energy consumption and CO_2 emissions per ton-kilometer are reduced by 4% at the minimum over the previous period, and expected to reach 0.281 kilograms and 0.889 kilograms respectively.

Opinions on Comprehensively and Deeply Promoting the Development of Green Transportation (2017)	2020	Energy consumption per unit of transportation turnover is reduced by 7% from the 2015 level.
Implementation Opinions on Further Promoting the Green Development of Civil Aviation (2018)	2020	The policy system, standard system, and evaluation system for green civil aviation are basically established.
	2035	The policy system, standard system, and evaluation system for green civil aviation are mature and complete.
	2050	The pattern of green civil aviation development and green travel is fully formed, with green management reaching international advanced level.

Source: Collected by the research team.

In March 2021, the *Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-range Objectives throughout the Year 2035*, adopted at the 4th Session of the 13th National People's Congress, required the civil aviation sector to "advance low-carbon transition at deep levels in fields such as transportation". Pursuant to this, CAAC issued the *Opinions on Deepening Civil Aviation Reform during the 14th Five-Year Plan Period* and the *Work Plan for Deepening Civil Aviation Reform during the 14th Five-Year Plan Period (2021–2025)*, which laid down the specific measures. At the moment, departments concerned are stepping up to develop the work plans and implementation pathways towards the Dual Carbon Goals for the civil aviation sector. Further improvement of related policies will provide a guarantee for achieving as scheduled the Dual Carbon Goals in the civil aviation sector.

Thanks to increasing efforts to reduce carbon emissions, substantial progress has been observed in China's civil aviation sector with respect to green and sustainable development.

In terms of energy consumption, fuel consumption per ton-kilometer fluctuated and showed a downward trend during 2005–2019. There was a sharp decline during the 11th Five Year Plan period, a volatile increase in the next five years, and a steady but slight decrease during the 13th FYP period. In 2019, fuel consumption per ton-kilometer was 0.285 kilograms, down 16.2% from the 2005 level, which means an annual increase of 1.08% in the overall fuel efficiency.

In terms of carbon emissions, CO_2 emissions per ton-kilometer fell from 0.926 kilograms in 2015 to 0.898 kilograms in 2019, the lowest level in history. In 2019, energy consumption per passenger stood at 0.898 kilograms of coal equivalent, and CO_2 emissions per passenger came to 0.553 kilograms, declines of 15.8% and 28.8% from the baselines (average of 2013–2015)

respectively.

As to construction of green airports, significant results have been reaped in airport pollution reduction, and smart airports have begun to yield results. In 2020, the utilization rate of bridge facilities reached 100%. Aviation fuel savings from equipment alternative to APUs have added up to more than 400,000 tons over the past three years, which is equivalent to nearly 1.3 million tons of carbon emissions reductions and 4,900 tons of various air pollutant emissions reductions. The share of electric vehicles within airports grew to 16.3% from 5% in 2018, and in Beijing Daxing International Airport, the share of new energy vehicles exceeded 80%, contributing greatly to the reduction of fuel vehicle exhaust emissions. Gasoline and diesel consumption intensity dropped evidently. In 2019, gasoline and diesel consumption shrank by 1,100 tons year on year while flights increased by 5.8% year on year. Some airports have harnessed new technologies such as Internet of Vehicles, big data, and micro energy storage to independently develop energy and equipment intelligent monitoring systems and optimize power supply and utilization efficiency. For example, Chengdu Shuangliu International Airport, Beijing Capital International Airport (BCIA) and Guangzhou Baiyun International Airport have applied smart energy storage technologies to micro-grid construction, providing referable experience for reducing the excessive electrical load of large airports and tapping the potential of existing power guarantee resources.

As to related industries, the performance of civil aviation in the Blue Sky Protection Campaign has created new opportunities for accelerating the integration of upstream and downstream industries and boosting the green development of related industries. From 2012 to 2018, there were totally 1,379 endorsed projects for the application of energy-saving and emission-reduction technologies in civil aviation. More than 100 projects were implemented to support the civil aviation sector in the Blue Sky Protection Campaign. With more attention paid to the actual needs of green civil aviation development, domestic equipment manufacturers scaled up input to continuously improve product performance, supplying products for green civil aviation development. For example, China Eastern Airlines has, in cooperation with domestic manufacturers, successfully developed the world’s first 35-ton pure electric container load and 50-ton pure electric pole-mounted aircraft tractor. Air China, BCIA and related equipment manufacturers have teamed up in technical projects and effectively addressed the technical challenge of safe and efficient equipment alternative to APUs to support new aircraft models (B787, A350, etc.). Therefore, the endogenous driving force for the green development of related industries has been significantly enhanced. In addition, a series of pioneering results have been achieved in the performance of equipment alternative to APUs and the research & development of heavy-duty new energy equipment specially for airports. In summary, China's civil aviation sector is moving steadily towards green development while pressing on with carbon emission reduction.

1.3 Experiences of Chinese Airlines Companies – Taking China Eastern Airlines as an Example[3]

The reduction of civil aviation carbon emissions requires high degree of linkage and collaboration between relevant government agencies, airlines, airports, research institutions,

[3] Data and information in this section come from CEA.

and consumers. Among them, airlines companies, as the principal operator, play an indispensable and crucial role in achieving the Dual Carbon Goals of China's civil aviation sector. After years of active exploration and development, Chinese domestic airlines such as Air China, China Eastern Airlines and China Southern Airlines have taken a range of measures to pursue green and low-carbon development in an active response of the State's call for energy conservation and emissions reduction. These measures include internal mechanisms for green and low-carbon development, technology innovation in support of energy conservation and emissions reduction, optimization of fleet routes and configurations, sustainable fuels, and active involvement in carbon market transactions and international exchanges and cooperation. Due to space limitations, this section takes China Eastern Airlines (hereinafter referred to as CEA) as an example to illustrate briefly the energy conservation and emissions reduction pathways and experiences of airlines.

In general, CEA keeps working in the aspects of technology and operation towards the four directions charted by ICAO, while improving the internal systems and mechanisms for green and low-carbon development. These four directions are related technological innovation, more efficient management of operations and facilities, SAF, and action involvement in carbon market.

First, CEA has set up an internal mechanism for green and low-carbon development. It establishes the organizational leadership for green and low-carbon development, improves the internal top-level policies design for pathways to the Dual Carbon Goals, and strengthens the measurement, monitoring, supervision and assessment of energy conservation and emissions reduction. A comprehensive system for green and low-carbon development of airlines has therefore been formed. In terms of organizational leadership, the overarching framework and organizational structure for green and low-carbon development is optimized. The Aviation Safety and Environment Committee under the Board of Directors conducts, on a regular basis, research and deliberation on major domestic and international environmental issues. The Leading Group for Comprehensively Promoting Energy Conservation and Environmental Protection of CEA is responsible for coordinating and advancing work in green, low-carbon, and circular development and the Dual Carbon Goals. In terms of system building, CEA strictly enforces national laws and regulations, and meanwhile, refines its own green and low-carbon development system that integrates energy conservation and environmental protection through the adoption of policy documents and regulatory requirements. Moreover, a comprehensive monitoring platform covering energy and environment has been put in place, and energy conservation and emissions reduction targets are set on an annual basis. In addition to supervision in the forms of self-inspection and cross-inspection, the assessment and accountability mechanism has been improved to reflect progress to the set targets in routine assessment at all levels and thereby force the implementation of major tasks.

Second, CEA has stepped up technological innovation in support of energy conservation and emissions reduction. It regards technology innovation as the primary force driving energy conservation and emissions reduction, and strengthens R&D cooperation and collaborative innovation in energy conservation and emissions reduction through stronger enterprise-university-research alliance. In terms of technology progress, new technologies have been used to refit aircraft wings and upgrade engine software and performance, so as to

reduce flight resistance and required thrust and raise engine fuel efficiency. Engine Care, which CEA has independently developed for intelligent engine cleaning, lowers engine maintenance costs and improves aviation fuel efficiency. The retrofit project aimed at exhaust treatment has been advanced, which adopts a technical plan that can simultaneously reduce the exhaust particulate matter and nitrogen oxide emissions based on the comparative analysis of ground vehicle exhaust data. With respect to collaborative innovation, the CEA R&D and Technology Application Center was established. An enterprise-university-research platform was created, integrating research institutions and ground support equipment (GSE) manufacturers, such as Shanghai Jiao Tong University, Civil Aviation University of China (CAUC), and Weihai Guangtai Airport Equipment Co., Ltd. The Equipment Joint Innovation Laboratory was founded by CEA and its partners, including Huadong Kaiya System Integration Co., Ltd, CAUC Airport College, and Beiqi Foton Co., Ltd. It makes use of research findings in new energy special vehicles to reduce GSE carbon footprint, thereby supporting environmental protection and carbon reduction in civil aviation industrial ecosystem.

Third, CEA has been optimizing the management of fleets, routes, operations and facilities. Efforts have been made in fleet optimization, route exploration and optimization, and efficient operations and facilities to comprehensively reduce energy consumption and carbon emissions. In terms of fleet optimization, B737-300, B767 and EMB145 have been completely removed, and newer fuel-efficient models such as A350, B787, A320neo and B737MAX have been introduced, to improve fleet fuel efficiency. As to route optimization, measures taken include shortening the flight distance, well matching aircraft types and routes, and continuously opening up new routes. This reduces fuel consumption and carbon emissions by enabling GSE sharing, improving efficiency, and shortening flight distance and flight time. In terms of efficient operations and facilities, fuel cost control is realized by saving fuels through aircraft weight reduction, route optimization, and single-engine taxiing. New navigation technologies have been introduced and applied, such as GBAS Landing System (GLS) and Head-Up Display System (HUD), and Continuous Climb Operation (CCO) and Continuous Descent Operation (CDO) have been verified and encouraged. While more energy-efficient bridge-mounted equipment has replaced APUs to provide power, cooling, and heat for aircrafts, ground vehicles are undergoing an oil-to-electricity transition to maximize fuel savings and carbon reduction.

Fourth, CEA has played an active role in the application, test flight and promotion of sustainable fuels. It stays at the forefront of the sector in the introduction of new energy technologies such as SAF into the commercial operation of flights. In 2013, CEA successfully completed the first test flight with China’s self-developed bio-aviation fuel. Before the test flight, meticulous preparations were made, including mixing ratio of bio-aviation fuel, temperature measurement during the cruise stage, influence of flight altitude, engine borescope inspection before and after the flight, and handling of special situations. Special research and test were also conducted in collaboration with aviation fuel suppliers such as Sinopec and AVIC, covering the airworthiness index, quality standard and testing, flight safety evaluation, economic evaluation, and storage and transportation of bio-aviation fuel. In addition, CEA has carried out active exchanges and extensive cooperation with the Second

Research Institute of CAAC on the R&D of domestic sustainable aviation fuels, laying a solid foundation for the large-scale commercial application and extension of China's self-developed SAF.

Finally, CEA has been active in carbon market transactions and international exchanges and cooperation. It has made full use of market mechanisms, such as carbon sinks and carbon offsets, to offset carbon emissions produced by airline operations. At the same time, CEA has actively strengthened green and low-carbon exchanges and cooperation with other international airlines. In terms of carbon market transactions, CEA has been an active player under the carbon emissions trading scheme (ETS) in the EU, China, Shanghai, and at industry levels. It has earnestly fulfilled its emissions reduction responsibility by continuously improving the management system, implementing the MRV system, surrendering allowances on schedule, engaging third-party verifiers to issue verification reports, and actively cooperating with CAAC in the national ETS survey. Besides, CEA is also exploring a series of carbon-neutral flights. It purchases carbon offset products such as forestry carbon sinks and renewable energies via the market, while attracting interactive participation from passengers. In terms of international exchanges and cooperation, CEA pays close attention to international green aviation development, actively participates in relevant international conferences, and conveys the attitude and appeals of Chinese airlines. In response to net-zero carbon target by 2050 set by the International Air Transport Association (IATA), CEA clearly stated that the related work should follow the basic principles of global climate governance and the principle of "common but differentiated responsibilities" and respective capabilities, and take full account of the varying development stages, scales and speeds of member companies.

II. Carbon Emissions Reduction Plans and Pathways of Italy's Civil Aviation Sector

Italian policies for the reduction of greenhouse gas emissions in its entire system of production and services and, in particular, in the specific sector of air transport, reflect both the commitments undertaken by the government within international institutions, and the commitments that are closely linked to its membership of the European Union, especially as a founding member state of the Union. As with international agreements, compliance with European rules and regulations is, consequently, an important aspect to consider in order to understand the value of the initiatives that Italy promotes at national level as a contribution to the organization of a sustainable air traffic systemin the short, medium and long term.

2.1 The Main Measures for Sustainable Air Transport of the EU

Within the European Union, the main elements that qualify the strategy and programs for the development of sustainable air mobility refer to the following main documents:

1）The Regulation for the establishment of a "Single European Sky". Since 2004, on the basis of the Framework Regulation (EC) n.549/2004, the European Union has acquired competences in the management of air traffic and, consequently, the decision-making process has moved from a system that essentially referred to the agreement between individual governments in favor of a system that has instead taken the decisions of the community authorities as its main reference. The objective of the EU is to reform "Air Traffic Management (ATM)" in Europe to cope with the sustained growth of air traffic and related

service operations in conditions of greatest possible safety, efficiency also in terms of costs, respect for the environment. This implies the defragmentation of the European airspace, the reduction of delays, the increase of safety standards and the efficiency of flights to reduce the environmental impact of aviation and the reduction of costs related to the provision of services. In the following years, the Regulation was progressively updated and adapted to better respond to the growing needs of sustainability.

2）SESAR Programme. Together with the approval of the Regulations for the "Single European Sky", in 2004 the EU launched the "Single European Sky ATM Research (SESAR)" program as a technological support tool for the implementation of the new project; SESAR is essentially the "technological pillar" as it has been defined. The goal of SESAR is to improve the performance of air traffic management (ATM) by modernizing and harmonizing the various ATM systems through the definition, development, validation and implementation of innovative, technological and operational ATM solutions. It aims to provide the Union with a high-performance air traffic control infrastructure by 2030 that will enable the development of safe and environmentally friendly air transport. The SESAR project includes three interconnected, continuous and evolving collaborative processes: the definition of content and priorities, the development of new technological systems, components and operating procedures of the SESAR concept, and the plans to implement the next generation ATM systems that contribute to achieving performance targets for the Single European Sky. The SESAR project was divided into three successive phases: a definition phase, a development phase and an implementation phase, for the period 2005-2020.

3)The EU strategy: "European Green Deal". At the end of 2019, the European Commission defined the "European Green Deal" strategy (COM(2019)640 final), the fundamental reference for the new EU policies on sustainability with a projection to 2030 and 2050. "This Communication –states the document - sets out a European Green Deal for the European Union (EU) and its citizens. It resets the Commission's commitment to tackling climate and environmental-related challenges that is this generation's defining task". The European Green Deal "is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use". And "This Communication presents an initial roadmap of the key policies and measures needed to achieve the European Green Deal… To deliver the European Green Deal, there is a need to rethink policies for clean energy supply across the economy, industry, production and consumption, large-scale infrastructure, transport, food and agriculture, construction, taxation and social benefits".

In the chapter dedicated to new policies for smart mobility, (point. N 2.1.5., COM(2019)640 final) the Commission intervenes specifically in the transport sector: "Transport accounts for a quarter of the EU's greenhouse gas emissions, and still growing. To achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050. Road, rail, aviation, and waterborne transport will all have to contribute to the reduction. Achieving sustainable transport means putting users first and providing them with more affordable, accessible, healthier and cleaner alternatives to their current mobility habits… In aviation, work on adopting the Commission's proposal on a truly Single European Sky will need to restart, as

this will help achieve significant reductions in aviation emissions… air quality should be improved near airports by tackling the emissions of pollutants by aeroplanes and airport operations."

4) The "Fit-for-55 Package". On July 14, 2021, The European Commission presented the package of legislative measures defined for the 55% reduction of greenhouse gas emissions by 2030 (COM(2021)550 final). Called "Fit-for-55 Package", the new provision developed by the Commission is a set of twelve interventions: directives, regulations and other measures. Among these measures, for example, the following initiatives are noteworthy for their importance: a new Social Fund for the Climate which will operate for the period 2025-2032; the update of the current Renewable Energy Directive which proposes to increase the overall binding target by 2030 from the current 32% to a new level of 40% of renewable energies in the EU energy mix; in the land transport sector, the revision of CO2 emission standards for new cars and vans; in the infrastructure sector, the strengthening of the Innovation Fund to finance the innovative projects and infrastructure needed to decarbonise the industry; the updating of the current Regulation on land use and forestry and the simultaneous commitment to promote a new forestry strategy

With regard to fuels and the civil aviation sector, the new EU provision states: "The Commission is proposing to promote the uptake of sustainable fuels in the aviation and maritime sectors complementing the ETS for the aviation and maritime sectors which makes polluting fuels more expensive for suppliers. The ReFuel EU Aviation to promote sustainable aviation fuel will oblige fuel suppliers to blend an increasingly high level of sustainable aviation fuels into existing jet fuel uploaded at EU airports, as well as incentivise the uptake of synthetic fuels, known as e-fuels. The upcoming zero emission aviation Alliance will complement this work to ensure market readiness for disruptive aircraft configurations (e.g., hydrogen, electric)". It should be noted that the reform of the "Emission Trade System-ETS", the market for emissions quotas in force for 15 years, intervenes to further strengthen an instrument that has so far proved very effective in reducing greenhouse gases.

2.2 How the Aviation Sector Achieves the Main Emissions Targets

In line with the Paris agreement, the air transport sector has for now renewed its objectives by aiming:1) to the stabilization of CO2 emissions (carbon neutral growth) at 2020 levels; 2) to the halving of CO2 emissions in 2050 compared to 2005 levels; to reach the "net-zero" aviation in the following decades (an ultimate goal for which the results of regulatory harmonization are expected).

With regard to the first target, the drastic reduction in activities caused by the COVID-19 pandemic has effectively stopped the growth of CO2 emissions. In this regard, there are various recovery hypotheses, which are being studied by ICAO, IATA and various national and supranational aviation authorities such as, for example, in Europe EUROCONTROL. Based on these studies, it is estimated that the levels of CO2 emissions recorded in the pre-COVID situation could be reached again in a time range from 2024 to 2030, depending on the scenarios, the geographical areas, the type of network of aircraft operators. But one thing is certain: CO2 emissions growth will have to occur without ever exceeding 2020 emissions levels globally.

With regard to the second target, mentioned above, it must be said that its achievement constitutes the great challenge of today and tomorrow. The halving (or even zeroing) of emissions in 2050 will only be possible through programmatic action that acts on the following “pillars”:

1) technological development by aircraft and engine manufacturers (supported by European programs such as “Clean Sky”)

2) increase in operational efficiency by aircraft operators, airport infrastructures and traffic control, the latter linked to the aforementioned European program “Single European Sky ATM Research (SESAR)”.

3) use of SAF. This item is linked to the following European directives: the directive of the European Parliament and of the Council on “Renewable Energy (REDII)” (11 December 2018), the document that regulates and obliges the member states of the European Union to achieve the objectives for exploitation of renewable energies by 2030; the “Refuel EU” directive (2021) which provides for two separate initiatives that will introduce an obligation to reduce the CO2 content, through blends, in aviation and maritime transport fuels; the “Emission Trade System (ETS)” emissions market reform directive (2021); all measures approved in previous years but which are currently undergoing a thorough review as part of the new system of measures that refer to the aforementioned “Fit-for-55 package”.

4) use of economic instruments for incentives to reduce emissions (Market Based Measures-MBM). In relation to this point it is useful to immediately distinguish the binding and mandatory schemes, such as the international program applied by ICAO from 1 January 2019 and entitled “Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)” and the European system “Emission Trade System (ETS) “, which have been implemented by national governments, with respect to the voluntary schemes according to which aircraft operators or passengers can contribute to balancing their environmental impact.

There are therefore many players in the field and much will have to be done also at the regulatory and governmental level to identify priorities, orient investments, act globally.

2.3 Italy and the Government’s New 2021 Strategy for the Civil Aviation Sector

In Italy, at the beginning of 2021, the Minister of Infrastructure and Sustainable Mobility indicated the policies for the development of air transport within the framework of the guidelines for Sustainable Mobility based on the new National Plan for Recovery and Resilience (PNRR). Thus the text of the ministerial document:

“It is essential that air transport is perfectly integrated into a coherent and harmonized transport network, capable of contributing to the reduction of the environmental impacts of the related infrastructures and promoting decarbonisation programs with the goal of zero emissions.

It is therefore necessary to encourage the renewal of fleets with the purchase/replacement of new generation aircraft, which are less polluting both for harmful emissions (CO2) and for noise.

It is then necessary to develop a new strategy for the use of minor airports currently not open to commercial traffic, the potential of which can be developed in terms of accessibility to territories and the promotion of tourist flows.

The traffic forecasts for the next 15 years are being updated and the National Airport Plan is being revised, in order to update the volumes and characteristics of the expected traffic and the development strategies that must be implemented. As part of the review of the National Airport Plan, a special section will be dedicated to defining the strategies underlying the development of the future freight transport network, in order to define the infrastructure needs and priorities for intervention in this sector.

It is clear that in updating the traffic forecasts and in identifying the methods and timing of implementation of the adaptation and development interventions of the airports, the impact on the airport sector of COVID-19 must be taken into account, which today entails a very strong reduction in passenger traffic volumes and the need to review the planning of some interventions to reduce travel times".

On 30 April 2021, the Prime Minister Mario Draghi sent the "National Recovery and Resilience Plan (PNRR)" to the European authorities, the extraordinary programmatic plan for the relaunch of the Italian economy developed in consistency with the guidelines of the "Recovery Fund" program of the European Commission defined, for the next period 2021-2026, as the "Marshall Plan" aimed at reviving the economy of the states of the Union from the serious crisis caused by the COVID-19 pandemic. On 22 June 2021, the Commission definitively approved the Italian plan which provides for interventions projected to 2023, 2026, 2030 and 2050. Following this approval by the Community authorities, the plan has thus become the fundamental tool for future development policies of Italy. The Italian PNRR plan, which has been defined by the government as "an epochal intervention", groups investment and reform projects into 16 Components, grouped in turn into 6 Missions. They are: 1. Digitization, innovation, competitiveness, culture and tourism 2. Green revolution and ecological transition 3. Infrastructures for sustainable mobility 4. Education and research 5. Cohesion and inclusion 6. Health. There are numerous interventions in support of the ecological transition of the Italian system.

With regard to the airport system and air traffic, the major interventions planned by the Italian government are contained in Mission No. 3 entitled "Infrastructures for sustainable mobility", the objectives of which are defined as follows: "The mission aims to build, by 2026, a more modern, digital and sustainable infrastructure system" from an environmental point of view. These objectives are further specified in Component No.2 of Mission No.3 in the following terms: "The interventions of Component No.2 are dedicated to improving the competitiveness, capacity and productivity of the logistics chain and air traffic. The general objectives of the Component are: Digitization of the logistics chain; Air traffic digitalization; Eco-sustainable management of air traffic". These strategic objectives are subsequently specified as follows: "The Component includes investments to manage air traffic in an eco-sustainable way and ensure the digitalization and optimization of airports."

With regard to the investments to be promoted, indicated in point "Investment no.3.2", the plan specifies: "Digital innovation applied to the air transport sector allows for an

improvement in aircraft sequencing, both in en-route airspace and in approaching airports, with consequent optimization and reduction of fuel consumption. The digital enhancement of the sector will involve both the development of new tools for the digitalization of aeronautical information, and the implementation of platforms and services for unmanned aircraft." And again: "The secure sharing of information will also allow the creation of a new generation communication backbone, able to connect the various operating sites of the flight assistance systems, guaranteeing coverage of cybersecurity requirements and connecting Air Navigation. Service Provider (ANSP) to other interested parties. The projects will concern: the development and connectivity of the Unmanned Traffic Management System (UTM), the digitization of aeronautical information, the creation of cloud infrastructures and virtualization of operational infrastructures, the definition of a new maintenance model, in addition to the secure sharing of information ... As regards the airport system, the investments included in the measure will produce positive impacts such as the development of new areas and production sectors induced by the digitalization and optimization of the logistics chain".

In summary, while supporting the digitization of airports and traffic control infrastructures with just 110 million euros, aimed at optimizing air flows and airport capacity, the Italian PNRR plan aims to intervene more decisively on integrated transport logistics and on intermodality of transport (maritime, railways and land), opening up to new forms of transport (Advanced Air Mobility, Unmanned Aerial Vehicles), to the strengthening of ports and airports, as well as to the renewal of the fleet of trains, vehicles and ships. All this is inevitably destined to have a significant impact on the Italian aviation sector and to influence its business model.

2.4. The Italian Operators in the Sector and the Prospects for Interventions in the Short-medium Term

Airline operators, in particular, have different levers to intervene both in the short-medium term and at a strategic level.

In Italy, the main players can mainly be traced back to the following airlines: Air Dolomiti, Air Italy, Alitalia,[4] Blue Panorama, Cargo Lux Italia, Neos Air, Poste air Cargo. Many of these companies are affected by corporate transformations and are engaged in related contractual initiatives (such as, for example, Alitalia, with its transformation into the new ITA company, Air Italy, Blue Panorama). Their situation reflects the deep crisis of the national sector, even in a context of continuous growth of the global and national air transport market (apart from the disastrous parenthesis of the crisis generated by the COVID-19 pandemic). Other airlines, on the other hand, are in a growth phase and linked to consolidated international partnerships (for example: AirDolomiti / Lufthansa, Cargo-Lux Italia, NeosAir / Alpitour) or active in the ever-expanding Cargo transport (for example: Poste Air Cargo, Cargo Lux Italia, the new born Alis Cargo).

By following a scheme of interventions articulated according to the main "pillars", in the short to medium term an aircraft operator can certainly act on the efficiency of flight and

[4] On October 15, 2021, the new publicly owned company Italia Trasporto Aereo (ITA) officially replaced the historic Italian company Alitalia, which ceased to exist after almost 75 years of activity.

ground assistance operations, on targeted maintenance interventions of aircraft and engines, on a careful management of the fleet both in terms of fittings and lightening, and in terms of operational use. Further actions can be introduced by training pilots in fuel efficiency and adapting navigation procedures. In some cases, the practice of working through the organization of transversal tables for comparison and collaboration has become widespread, in which aircraft operators participate together with airport managers and traffic control bodies; all this in order to reduce operating times respectively on the ground and in flight.

In this context in particular, the airline Alitalia had for some time adopted a company policy, called “Operational Fuel Efficiency Policy”, for the efficient management of JETA1 consumption by introducing all the best practices suggested by IATA. The policy, sponsored by top management, tends to involve all employees based on their skills and to guide all processes, both operational and marketing, on-board services, Corporate Social Responsibility (CSR) practices and efficient management of society, in order to achieve the goal of reducing consumption; this policy made it possible, for example in 2019, to obtain the result of a saving of more than 100,000 tons of CO2. The other national operators are also acting towards this goal in a more or less sophisticated way according to their maturity.

The related monitoring of emissions takes place, for all national operators, according to the mandatory monitoring schemes at national level defined and approved with the CORSIA, EU-ETS, UK-ETS, Swiss ETS programs, i.e., the economic measures known as “Market Based Measures (MBM)”. The mandatory nature of these schemes is based on precise European directives that have been implemented by national governments and converted into laws that an aircraft operator must comply with if it wants to be able to exercise his license. Among other things, it should be remembered that these regulations provide for criminal sanctions in the event of non-compliance, so large as to make the activity economically unsustainable (according to the European “Emission Trading Scheme (ETS)”, for example, it could be possible to impose a penalty of about one hundred million euros per year for a medium-sized airline).

As part of the complex and new European provision “Fit-for-55 Package” (2021), various developments are expected for the EU legislation on the ETS, both with regard to the inclusion of the maritime sector in the area of intervention of this provision, both to further reduce the emission quotas on the market (with further increases in the expected prices for the “European Union Allowance (EUA)” securities). One of the most innovative tools of the package concerns the “Carbon Border Adjustment (CBA)”, a carbon tax linked to the imports of certain non-European goods, aimed at avoiding penalizing European industries that are subject to the provisions of the ETS scheme, preventing the carbon leakage and to stimulate foreign producers to reduce their carbon footprint.

In Italy, the activities of technical regulation, certification and supervision in the civil aviation sector have been entrusted since 1997 to the “Ente Nazionale per l'Aviazione Civile” (National Civil Aviation Authority, hereinafter referred to as ENAC), a non-economic public body with regulatory, organizational, administrative, patrimonial accounting and financial autonomy, which operates under the control of the Ministry of Infrastructure and Sustainable Mobility. Within the scope of the competences entrusted, ENAC operates as a single authority.

With specific reference to environmental protection policies, ENAC provides for the implementation of circular letters and regulations aimed at limiting the environmental impact of airport systems and reducing noise and atmospheric pollution produced by aeronautical activities. With regard to international activities, ENAC represents Italy in the major international civil aviation organizations, such as ICAO, ECAC, EASA, EUROCONTROL, with which it maintains continuous dialogue and collaboration and in which it plays a role of primary importance. On the basis of the institutional mandate, in addition to the aspects highlighted so far, ENAC, among other things, regulates the procedures of airport services, the collection and analysis of data on aeronautical events, the development and implementation of international and national programs on flight safety, the promotion of a culture of safety and the human factor in aviation.

Of particular importance is the fact that the Italian body ENAC coordinates a national planning table for the reduction of emissions (known as the "Action Plan for Emission Reduction") which operates according to the guidelines, provisions and indications for monitoring approved by ICAO, an Italian working group in which the main national aircraft operators participate.

ENAC, which has always been sensitive to the issues of decarbonisation in the civil aviation sector and, more generally, climate change, essentially plays the role of catalyst for the initiatives implemented by the various public and private subjects involved in policies and initiatives aimed at respecting the principles and implementation of the objectives of environmental sustainability, in reducing energy consumption and reducing noise impact, representing Italy in the forums dedicated to this topic within ICAO.

The actors involved in air traffic control and airport management are also acting on the efficiency of operations in Italy: the National Flight Assistance Authority (hereinafter referred to as ENAV) and the Aeroporti di Roma company (ADR).

The ENAV is an Italian joint-stock company that operates as an exclusive provider of civil air navigation services in the airspace under Italian jurisdiction. The company is controlled by the Ministry of Economy and Finance (for a shareholding equal to 53.37% of the share capital) and is subject to the supervision of the ENAC and the Ministry of Infrastructure. and sustainable mobility. ENAV is the company that manages civil air traffic in Italy, guaranteeing safety and punctuality 24 hours a day for approximately 2 million flights a year, from the control towers of 45 airports and from the 4 Area Control Centers. The company provides air navigation services to its customers, the airlines flying in Italy. Considered for some time among the European "big five" for its excellent operational and innovation performance, ENAV is a fundamental component of the international "Air Traffic Management" system. It participates in research and development activities in coordination with the national and international control bodies of the sector and is one of the main players in the creation of the "Single European Sky". Since 2012, ENAV has launched a series of initiatives aimed at using its know-how also for the supply of commercial services on international markets, also proceeding in this direction with the establishment and/or acquisition of shares in other companies in the sector. In this process of progressive expansion, ENAV set up the company ENAV Asia Pacific (2012), based in Kuala Lumpur in Malaysia, for the provision of

aeronautical consulting services at the Malaysian Civil Aviation Department; acquired 11% of the company AIREON (2014) for the global space-based surveillance service; established in 2018 the company D-Flight (60% ENAV) for the development of solutions for the control of drone traffic; acquired 100% of the company IDS AirNav in 2019, for the supply of AIM and ATFM software solutions.

With regard to the commitments on environmental sustainability, which has always been the subject of particular attention, the Italian company ENAV has long since become a first-rate interlocutor in Europe, in particular with reference to the Community program "Single European Sky ATM Research (SESAR)"; moreover, among the first in Europe, it has implemented free routes ("Free Route Italia") above a certain altitude, allowing route cuts and savings in operating times and fuel for airlines. The ENAV company is also involved in the international project "BluMed", financed by the European Union and coordinated by Italy, which represents an important integration initiative with the neighbouring regions of the Mediterranean and the Middle East, through which it intervenes in creating an effective, safe and sustainable traffic control network. Finally, ENAV has committed to zeroing its direct emissions through CO2 reduction and Offsetting actions, by 2022.

Since 2011, the year of the first "Airport Carbon Accreditation (ACA)" certification, the company that manages the Rome Airports (hereinafter referred to as ADR) has constantly improved its carbon emissions, up to the achievement of an "Airport Carbon Accreditation (ACA)" defined in terms of "Neutrality" by" Airports Council International (ACI Europe)" (the Council representing over 500 airports in 46 European countries) which is equal to level 3+ for Leonardo da Vinci airport, in 2013, and for the Ciampino airport, in 2018. To actively combat climate change, ADR wanted to undertake the commitments and challenges that led the Rome airports of Ciampino and Fiumicino to obtain the "Airport Carbon Accreditation 4+ "Transition": this is the maximum level of certification introduced by the "International Council of European Airports (ACI Europe)" at the end of 2020. Rome's airports were the first in Europe and third in the world to reach this result.

The central point of the company's commitment is the "Environmental Sustainability Plan", a document drawn up annually and formally approved by the General Manager, which defines an articulated program of interventions and improvement objectives on the environmental performance of Roman airports. The Plan is inspired by the international guidelines defined by the General Assembly of the United Nations through the SDGs (Sustainable Development Goals), and is proposed as a tool aimed at correlating the environmental policy of ADR with the shared objectives, so that the company can contribute, on a local scale, to the achievement of these international objectives with its own program of actions and interventions. Attention to the environment has made it possible to obtain an improvement in performance in all environmental matrices: separate waste collection, energy production, saving and reuse of water.

The ADR pays particular attention to the management of third parties. Over time, the company has developed an articulated structure of operating procedures that regulate the behaviors to be adopted within the airport to ensure the best environmental performance. Consistently, an extensive program of checks has been activated on the management methods

of the most diverse activities that insist on the airport area to ensure full compliance with the defined rules. ADR in 2020 became part of the United Nations Global Compact, the largest international platform on sustainability, committed to the creation of a responsible business model focused on environmental protection, training of people and commitment to local development.

In November 2020, the ADR company joined the ALIGHT project, together with other large European airports, fuel manufacturers and universities. The project, which has the strategic objective of building the sustainable airport of the future, plans to test practicable solutions and intervene in the reduction of direct emissions through the use of renewable energy and smart energy and to introduce SAF in airport fuel logistics by 2024.

Furthermore, also in November 2020, the company ADR became the protagonist of an interesting initiative of green bond issues for 500 million euros, based on obtaining the ACA4 + certification, the highest in terms of reduction of greenhouse gases, as well as the anticipation to 2030 of the total elimination of its CO2 emissions. With this initiative, ADR was among the first airport companies in the world to make use of “sustainable” financial structures.

Again, in a short-medium term perspective, another fundamental lever available to operators in the sector is that of offsetting, which implies an action aimed at neutralizing the emissions of their flights through the purchase of securities equivalent to as many reductions in emissions arising from specific projects in other business initiatives and different geographical areas. These operations can take the form of an investment tout-court by the airline operator (for example, the Easy-jet company declared that it had balanced all the emissions in 2020 with a total cost of the order of 30 million pounds) or through the conscious and transparent involvement of its customers, often integrating the purchase of securities with loyalty initiatives.

As part of the involvement of its customers, the Italian airline Air Dolomiti, operating in the framework of the partnership with Lufthansa, proposes to its passengers to offset the emissions of its flights by contributing to emission reduction projects in the medium term or by supporting the purchase of SAF in the short term. The airline company Alitalia is evaluating between different projects aimed at integrating the needs to reduce its environmental impact with coherent communication strategies. There are no further initiatives among other civil aviation operators.

In the post-COVID situation, the emissions of the sector are well below the limits imposed by the ETS and CORSIA regulations. This fact has eliminated costs in “Market Based Measures (MBM)”, but this does not prevent operators from following the growing sensitivity of customers and from acting to promote voluntary offsetting operations, where customers, increasingly green-oriented, choose to travel or have their goods travel in “carbon-free” mode and, consequently, they opt for services provided by aircraft operators that guarantee a lower environmental impact.

Still in the short to medium term, another possibility of reducing one's environmental impact is that of using SAF. The current technical specifications (ASTM7566) allow the SAF to be

compared to JETA1 as long as the first meets precise criteria relating to both the feedstock of origin and the mixing percentages with the second. This therefore does not require any modification on board the aircraft.

Yet, there are still significant barriers and obstacles to the large-scale commercialization of SAF, in particular related to the price (still 3-5 times higher than that of fossil fuel) and the lack of airport infrastructure for in-to-plane distribution. Regarding the price, unfortunately the production technologies and the small number of producers do not allow phenomena of scalability; nor are there any Italian SAF producers given that the only candidate, the "Ente Nazionale Idrocarburi (ENI)" (National Hydrocarbon Corporation, ENI), currently subordinates its investments to government incentives. In any case, ENI announced on October 15, 2021 to be ready to start the production of alternative sustainable fuels for aviation, called "Eni biojet". In the same while ITA, taking its first flight just on October 15, started with a symbolic pilot project, in partnership with ENI and ADR, refueling the first 10 flights of the day with Jet fuel blended with SAF produced by ENI. After this first step, several more initiatives will follow in ITA Airways in next months based on the same partnership. With regard to logistics, there are still no Italian airports equipped to manage SAF from both a technical and commercial point of view. For the moment, any small quantities of SAF would reach Italian ports only by sea or road transport, with consequent increases in the cost of the in-to-plane product.

An alternative that would limit the costs of the logistic service is the Book & Claim mechanism, according to which an aircraft operator can purchase SAF from the manufacturer, which in turn will consider placing it on the physical market at the least expensive point for him, while guaranteeing transparency. in the chain of custody (from production to blending and, finally, to use). The issue of transparency and the risk of counting the same SAF on different CO2 reduction objectives (for example of several states or of air producers/operators), are critical factors to be governed.

The next regulatory developments related to the European measures defined in the aforementioned "Fit-for-55 Package" should intervene on these mechanisms by introducing new requirements; at the moment the Fit-for-55 package due to transparency constraints, is still lacking on welcoming the Book & Claim mechanism, while in this way lobbies are already pushing to consider it inside the regulatory framework, as an effective way to accelerate SAF production and utilization in EU. On the other hand, it is certain that obligations will be introduced to place a certain quantity of SAF on the market (2-5%) to accelerate their diffusion. Given that the price of SAF is higher than the fossil one, an increase in costs for aircraft operators is expected.

On the open problem of SAF, legislators can therefore make a difference by encouraging producers and probably introducing obligations for consumers. The ambition envisaged in the IATA framework would be to promote the transition from an almost negligible level of consumption recorded in 2020 to a level equal to more than 80% of the entire fuel demand in 2050. There is a long way to go seen that, according to IATA estimates for 2021, only 350,000 flights have boarded SAF in the world, for a demand of around 100 million litres, and approximately 7 billion USD in financial forward transactions.

In Italy, the demand for JetFuel in 2019 had reached just under 5 million tons, of which 2 million were imported from abroad. The prospects for SAF domestic production in the short to medium term do not seem to go beyond 5%.

In the recent past, the airline company Alitalia had participated in a table coordinated by the Boeing company for the production of SAF from refined tobacco oil by ENI, as part of an entirely Italian supply chain. But the imbalance between the small quantities of which it was dealt with and the substantial input investments made it impossible to start such a process.

Still on the subject of SAF, it should be remembered that in Italy the ENAC has set up a National Observatory on SAF called "Italian Sustainable Aviation Fuel Observatory - ITSAFO" which aims to contribute to the spread of biofuels in Italy through the activation of a permanent discussion table and dialogue between the parties involved, including representatives of the competent ministries, industrial producers, carriers, managers, research bodies and universities. The former Unione Petrolifera (Oil Union) also participates in the work of the Observatory, which is a member of the "Confederazione Generale dell'Industria Italiana" (General Confederation of Italian Industry - Confindustria) - the main business association representing manufacturing and service companies in Italy - and which has evolved its mission and changed its own name in the "Unione Energie per la Mobilità" (Energy Union for Mobility - UNEM), taking up the challenge of achieving climate neutrality on energy products in 2050.

As far as airlines are concerned, the Italian company AirDolomiti appears to be the most advanced Italian carrier in this context: in fact, it uses SAF mainly embarked at Frankfurt a.M. airport (Germany) and has included it in the voluntary offsetting framework by passengers. The Alitalia company was studying a pilot project for some corporate clients. There are no other initiatives by other aircraft operators. But a long way will have to be travelled before organizing a true Italian country system in this area.

A particular aspect of the problem concerns the passing on of the costs related to this operation from the airline operators to the passengers. Currently in Italy there is neither the definition of these guidelines nor the application of the related cost transfer mechanisms by air operators to passengers; on the other hand, the situation in the international arena is different, where this transfer seems to have become a practice, when this is allowed by the elasticity of demand.

2.5 The Italian Operators in the Sector and the Prospects for Interventions in the Long Term

In a long-term perspective, however, programmable interventions by aircraft operators require more conspicuous investments and a necessary corporate stability; for example, there is talk of fleet renewal, i.e. the replacement of old aircraft with new ones with more recent technology, with emission levels even lower by up to 30%. In parallel, the hypothesis of a remodelling of the short-haul network is being envisaged and the opportunity to use smaller aircraft is being considered by intercepting hybrid or electric propulsion technologies, ready in the next five years.

In this regard, by way of example, we can mention the contribution to a greener aviation that

comes from the technology developed by the Italian company TECNAM in collaboration with other leading international operators; a technology called P-Volt that involves the construction of a fully electric motor, for passenger aircraft and medium-haul flights, designed for maximum versatility and safety, powered by renewable energy.

Finally, it is possible to invest in a wide and widespread use of SAF for long-haul flights, where the "disruptive" technology of zero-emission propulsion is still a long way off. These investments would also go in the direction of reducing noise during take-off and landing, as well as the quality of the air in airports and neighboring areas.

The European Commission, through the complex provision "Fit-for-55 Package" is oriented to consider it as an "Important Project of Common European Interest (IPCEI)", according to the definition of strategic projects linked to particular objectives of the European Union, that relating to energy supply from fuels originating from renewable sources and with a low carbon content; as was the case for the projects already started relating to the production of batteries and hydrogen. All this gives hope that scale factors in SAF production will soon be achieved.

Instead, less mature technologies such as hydrogen propulsion and synthetic fuel will undoubtedly revolutionize the future of aviation, but it is very likely that they will actually enter service after 2050.

As part of the EU policy of the "European Green Deal", the strategic direction in favor of the identification and release of certification standards applicable to engines and aircraft of new generations is very well established. In parallel, consequently, in the post-COVID era, all governments are preparing structural interventions to fight climate change and guarantee regulatory stability to this end. The role of legislators is, and will be, fundamental to guide and incentivize the industry to operate in this direction.

As regards Italy, the situation of the aircraft fleets is currently the following: the company Alitalia, the former first Italian aircraft operator, had a fleet of about 100 aircraft with an average age of about 14 years, of which 15 aircraft Regional Jet with an average age of 9 years. The AirDolomiti company has a Regional Jet fleet with an average age of 9.5 years. The Blue Panorama airline, before the recent restart of its flights also from the Milan airport as well as from Rome, had a plan to replace the B737-800 aircraft with the Airbus A220 by 2025. The Neos Air company employs a fleet of approximately 13 aircraft including 6 new generation B787 Dreamliner aircraft. The nascent airline company ITA plans to use a fleet made up of 80% of new generation aircraft by 2024, reducing CO2 by 750.000 tons at the end of 2025; furthermore, it stated that environmental sustainability is one of the founding values of the company, permeating all business and transformation plans, and that every process and every activity will be designed to be sustainable, according to a governance dedicated to this general objective.

A last aspect, no less important and which goes beyond direct CO2 emissions, concerns the reduction of the use of plastic and the proper management of waste on board. EU Directive 2019/904 came into force in Europe which imposes a ban on the placing on the market of certain disposable plastics (e.g., cotton swabs, cutlery, plates, straws, stirrers) starting from 3

July 2021. In this case the transformation of on-board services will also be a decisive step; how the role of aware passengers and the cabin crew will be fundamental. The company Alitalia with its “FlyGreen” project has already begun in 2019 to “test the ground”, reducing the use of about 21 million single-use plastic pieces: but it seems to be only the beginning of a path to be completed.

III. Comparison of Carbon Emissions Reduction Pathways and Cooperation Prospects in Civil Aviation Sector between China and Italy

Technological innovation is the core driving force for pursuing carbon neutrality. ETS is an important market-based mechanism that supports energy conservation and emissions reduction in many industrial sectors, including civil aviation. As revealed in the preceding analysis, Chinese and Italian civil aviation sectors pursue a green transition driven by technological innovation, and actively participate in the internal and international carbon markets. In other words, they are striving for carbon emissions reduction targets through two pathways: technological innovation and market-based mechanism. This denotes that there is great potential for cooperation in energy conservation and emissions reduction between the two sides.

3.1 Technological Innovation

First, Chinese and Italian aerospace manufacturing sectors will step up innovation, and leverage existing technology upgrades and cutting-edge technological innovations to drive as the core force of carbon emissions reduction. Italy has strong capabilities in the development of complete aircraft engines. China has made a series of breakthroughs in recent years, despite the late start in aviation R&D. On the one hand, there are a number of new energy-saving and emissions-reduction technologies available in terms of engine performance improvement, model optimization, and fuel efficiency improvement. They have all been applied in Chinese and Italian civil aviation sectors. On the other hand, noticeable progress has been made in cutting-edge technological innovation through intensified R&D. On the whole, China and Italy each have their own strengths. Italy has strong engine development capabilities. It is also able to manufacture parts and components by means of 3D printing (such as AVIO Aero), but relatively weak in the development and innovation of medium and large civil aeroengines. Hence, it mainly supplies large components and core machines to international head enterprises (such as Rolls-Royce and Pratt & Whitney). China, as a late starter, lagged far behind in the aspect of engines and materials in the early days, but continues to strengthen innovation-oriented R&D in recent years. Relying on a complete industrial chain, China has successfully independently designed, developed, manufactured, and tested key models such as C919. The major technological breakthroughs embodied in C919, such as supercritical wing design, aluminum-lithium alloys and advanced composite materials, and high-bypass jet engine, can greatly reduce aircraft weight and air resistance and improve aircraft fuel efficiency, injecting innovative impetus to energy conservation and emissions reduction in civil aviation sector.

Second, Chinese and Italian civil aviation sectors have pushed forward the energy transition, primarily through the comprehensive utilization of SAF and the R&D of hydrogen energy technologies. Regarding SAF, Italy has already kicked off production, and China needs to

speed up. Regarding hydrogen energy, China has formed a more complete industrial chain, but both sides are facing the arduous task of promoting technological breakthrough and wide application.

In the short term, SAF have the disadvantages of high cost and insufficient production capacity. In the long term, the large-scale commercial application of hydrogen energy is not yet mature due to the lack of stability and safety. These are common problems faced by the energy transition of civil aviation sector in China and Italy. At the moment, the two sides are working actively to promote and apply SAF and hydrogen energy to civil aviation sector. Italy has begun the production of SAF, while China is still in the test flight stage and needs to increase investment in production. In Italy, a national observatory station has been set to support the application of SAF. ENI is investing heavily in the production of SAF, and ITA and Dolomites are also actively involved in test flight projects. In China, the production of SAF is apparently inadequate, with only test flight projects launched by Air China and CEA. In the future, it is necessary to provide more support for production and actively optimize production technology, so as to promote the wide application. As to hydrogen energy, China and Italy both have formulated a national strategy to support its development. China has taken the lead to foster a relatively complete industrial chain covering production, storage, filling, and application. In Italy, the Enel Group officially launched the green hydrogen energy business in 2021. On the whole, whether in China or Italy, the large-scale commercial application of hydrogen energy in civil aviation sector is still immature, and there is still a long way to go in the future.

Third, Chinese and Italian civil aviation sectors have endeavored to improve airlines operations and build green airports as important measures to reduce carbon emissions. In general, Italian airlines perform better in consumer engagement mechanism and green airport construction, while Chinese airlines have larger fleet size and faster fleet renewal.

In terms of efficient operations, both Chinese and Italian airlines have adopted innovative management measures to advance energy conservation and emissions reduction, with each having its own strengths. In terms of consumer engagement, Italian airlines launched voluntary passenger compensation programs earlier, which advises passengers to offset their personal carbon footprint by supporting the purchase of SAF, voluntarily canceling meals, and funding other environmental projects. In comparison, Chinese airlines have not yet formed a complete system for compensating passengers for energy conservation and emissions reduction. In terms of fleet renewal, larger fleet size and market size allow Chinese airlines to integrate eco-friendly models at a higher frequency and maintain a younger age of aircrafts. For example, at the end of 2019, Air China had a total of 699 passenger aircrafts with an average age of 6.96 years. CEA kept 734 passenger aircrafts with an average age of 6.4 years, but it also actively introduced A350 and other eco-friendly models. Italian airlines are relatively smaller in terms of fleet size, aircraft age, and fleet renewal. Regarding green airport construction, Italy has rendered more outstanding performance, and China still has more space for improvement. Only five airports in mainland China have achieved verification with Airport Carbon Accreditation (ACA), with the highest level of Level 3. Ciampino airport and Leonardo da Vinci airport in Rome-Italy have both obtained Level 4 certification. In the future, China needs to further optimize the green airport management system, expand the use

of renewable energies at the airport, and facilitate the centralized management of airport energy conservation and emissions reduction by building energy monitoring platforms and data analysis centers.

3.2 Market-based Mechanism

First, China and Italy both employ respective carbon markets as a key tool to reduce carbon emissions from civil aviation sector. The EU launched the carbon market as early as in 2015 and has rich experience so far. The EU ETS included civil aviation sector in 2012 and gradually reduces the free allowances for this sector, so airlines are forced to make a low-carbon transition. Italy as a member state joins the EU carbon market. China's national carbon market has just started, and should move faster to integrate civil aviation sector. Established in 2021, China's national carbon market currently covers power generation only, and will gradually include key industries such as civil aviation sector in the future. Due to differences in development stage, compared with the relatively mature EU carbon market, China's carbon market has certain gaps in laws and regulations, supervision and management, transaction scale and pricing mechanism, which implies greater potential for development and room for improvement. Therefore, it is necessary to consolidate the legal basis and improve the MRV mechanism of carbon market in a quick manner. Moreover, the market access and allowance allocation plan for civil aviation sector should be researched, so that an effective and reliable carbon emissions trading mechanism can be put in place to drive the reduction of carbon emissions reduction from civil aviation.

Second, China and Italy both support and respond actively to CORSIA under the framework of international carbon market, but CORSIA-related disputes have not been finally resolved. The two countries can actively promote international multilateral consultations to pursue the carbon neutral goal of civil aviation sector with a fair and effective international carbon market mechanism. China's massive civil aviation market is still expanding rapidly, so it is under huge pressure to take less than ten years to peak carbon emissions and achieve carbon neutrality in four decades. In view of this, China has not yet joined CORSIA's pilot phase and first phase[5]. In comparison, owning to early start, Italy as an EU member state has entered the pilot phase. The EU is now considering relevant policies to promote the coordinated implementation of EU ETS and CORSIA in the context of the European Green Deal. At present, the global civil aviation industry still needs time to fully recover from the impact of the COVID-19 epidemic, and the international civil aviation sector's carbon market still needs to be improved. This is the common external environment faced by both Chinese and Italian civil aviation sectors. In the future, China and Italy can coordinate and negotiate on strengthening the global carbon market mechanism for civil aviation sector under a multilateral framework, and facilitate the agreement of ICAO member states on specific CORSIA implementation plans. As such, they can contribute to the establishment of a fair and effective international carbon market.

[5] CORSIA comprises three implementation phases: the pilot phase (2021–2023), the first phase (2024–2026), and the second phase (2027–2035). In the pilot phase and first phase, offsetting requirements will only be applicable to flights between States that have volunteered to participate. The second phase will apply to States with an individual share of international aviation activities in revenue above 0.5% or States as part of the listed States that account for more than 90% activities of total revenue.

3.3 Prospects of China-Italy Cooperation in Green and Sustainable Development in Civil Aviation Sector

In spite of differences in development stages and concrete challenges, Chinese and Italian civil aviation sectors are both moving faster to tap the core role of technological innovation in driving carbon neutrality, and leverage the market mechanism to ensure cost-effective energy conservation and emissions reduction. Under these two common pathways, the prospects of cooperation in green and sustainable development are quite broad.

In terms of technological innovation, China and Italy can further promote the upgrades of existing technologies and breakthroughs in cutting-edge technologies applicable to civil aviation sector through cooperation in R&D and innovation. In particular, companies from the two sides are encouraged to carry out pragmatic cooperation in aircraft technological innovation, digital upgrade of civil aviation, and development and production of SAF and hydrogen energy. Besides, the two countries can further strengthen top-level design to stimulate international cooperation in R&D and innovation; actively create various carrier platforms such as industrial parks and joint laboratories; increase policy and financial support for innovation cooperation between multiple entities; and consolidate the base of talents for collaborative innovation, and expand the training, exchange and interaction of talents in energy conservation and emissions reduction.

In terms of market mechanism, China and Italy can promote the alignment of Chinese and EU carbon markets in an appropriate way, paving a solid foundation of rules and systems for cooperation in reducing emissions in civil aviation sector. The EU carbon market that Italy joins is relatively mature, while China’s national carbon market is still in its infancy period. The alignment between the two requires a certain degree of compatibility and consistency in emissions reduction requirements, pricing mechanism, international offset project recognition, and penalty mechanism. It is in these areas that cooperation between China and Italy is expected in the future. After civil aviation is included in China’s national carbon market, Chinese and Italian civil aviation sectors can conduct, on a regular basis, in-depth exchanges on participation in internal and international carbon markets.