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THE CHALLENGES OF A SUSTAINABLE AIRPORT PLATFORM

ADP INGÉNIERIE

A member company of Groupe ADP

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1. Introduction

1.1 Global Context

As the world struggles to emerge from an unprecedented health crisis, lifestyles and habits will change dramatically. The COVID-19 pandemic has put pressure on health systems throughout the world, negatively affected all economic stakeholders, and taken a toll on morale and everyone's way of life.

The crisis resulted in a sudden and in some cases "brutal" interruption of human activities, with strict lockdown measures forcing people to remain at home to prevent the spread of the virus. While this exceptional slowdown was difficult for organizations and individuals, it also allowed everyone to take a step back and reduce the influence of human activities on the environment. This forced pause did in fact have several positive effects on the environment, including a significant reduction in the pollutant emissions visible from space (evidenced by comparison of maps of nitrogen oxides emissions in France in March 2019 and March 2020).

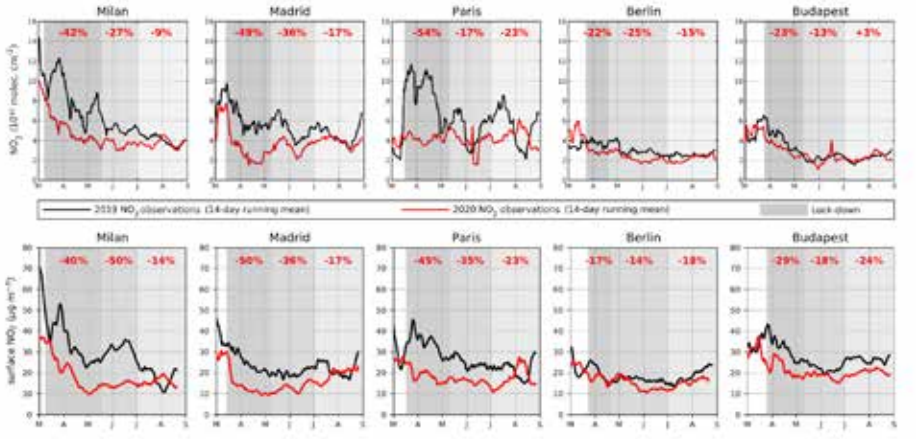

Figure 1: Nitrogen dioxide concentrations observed over five major European cities - esa.int

This spectacular drop in pollution even resulted in rare scenes of cities emptied of tourists (view of Piazza San Marco in Venice, figure 2), and previously unseen wildlife returning to inhabited land (rorquals sighted off Marseille, figure 3, wild boar in the streets of Barcelona, and a cougar wandering the streets of Santiago). Despite the economic turmoil, the crisis reduced human pressure on nature, which in turn demonstrated its capacity for rapid regeneration and rebirth in urban settings.

Figure 2: The deserted Saint Mark's Square - March 18th, 2020 - AFP

In 2020, CO2 emissions dropped by over 2.5 billion tonnes compared to 2019, for an annual emissions reduction of 5%. This reduction was particularly significant in the road and airport transport sectors (over 70% less air traffic in the world in 2020).

Figure 3: Whales off Marseille - April 2020 - Facebook screenshot / Parc National des Calanques

This drop in emissions had a temporary and short-term positive impact on the planet but will not be enough to bring global emissions down to a level compatible with warming below 2°C or even 1.5°C by 2100, as hoped by signatory countries of the 2015 Paris Agreement. Despite this decline in emissions, 2020 was one of the hottest years since the pre-industrial era. 2020 had the second hottest month of March in terms of thermometer readings since 1880 (according to a publication by NASA and Columbia University in the city of New York). According to the Guardian and Carbon Brief, the trajectory of warming consistent with 2°C could only be achieved through a continuous and sustained 5% annual drop in emissions until 2030. This is why lasting and far-reaching changes are needed in order to confirm the trend observed in 2020 and limit global warming.

This unprecedented crisis, while having disastrous effects on the economy and health systems, could be an accelerator of the ecological transition needed to mitigate global warming, which could have equally devastating consequences. The airport sector has been committed to fighting global warming for many years now and has even been a driving force in the ecological transition of the entire aerospace sector.

1.2 Considering sustainability criteria in the earliest project phases

For over twenty years, the aviation sector has been taking steps to reduce its environmental impacts, with decisions taken as early as 2000 through the European "Horizon 2020" programme to reduce fuel consumption, CO2 and NOx emissions (by over 50%) and noise levels (< 65 Lden at airport boundaries). The ICAO (International Civil Aviation Organization), ATAG (Air Transport Action Group) and ACI (Airports Council International) have all made voluntary commitments to reduce the sector's impacts on the environment.

In the "green" transformation of the aviation sector, airports play a leading role, as demonstrated by the resolutions taken by ACI Europe in June 2019:

- Call for the entire industry and Member States to establish a concrete roadmap for carbon neutral growth beginning in 2020;

- Net-zero carbon emissions from airport operations under the control of airports by 2050, and maximum reduction of absolute emissions (including all stakeholders) with carbon capture and storage projects;

- Incentives for countries to accelerate their transition to renewable energy.

Airports must continue to take the lead in pursuing a new "green deal" by integrating environmental impact management into every aspect of their activities, all stages of the airport life cycle, by the operator and all the various stakeholders.

We know that the aviation sector has faced intense media pressure regarding sustainable development issues. The exemplary nature of airports in terms of environmental and health impacts will be key in achieving the sustainable development of the activities and the acceptability of the entire aviation sector.

Sustainable development of airport activities must be designed based on a comprehensive approach that includes social, economic, ecological and health aspects. This is how Groupe ADP approaches its client relationships.

Figure 4: Airport Carbon Accreditation (ACA) program launched in 2009 by ACI Europe and then extended to other regions of the world, with 211 airports committed to carbon neutrality by 2050.

2. Three pillars of the sustainable airport

2.1 A rich social fabric

Airports are major sources of employment, both locally and in neighbouring communities. Their development is associated with high employability in terms of direct (airport professions) and indirect jobs (linked to the supply chain), as well as employment related to household activities, administration, and as a catalyst for other activities (tourism).

For example, the business activity of Paris-Charles de Gaulle airport accounted for 403,000 jobs in 2016 (Utopies Report, 2017), making it the 5th most populated French city, not counting the 66 million passengers who transited through the airport that same year (76 million in 2019).

These figures clearly demonstrate the key role that airports play in local employment. They are above all spaces through which individuals transit and where others work. We must therefore facilitate links with the local communities, companies and workforce, who must be the first to benefit from these activities.

This rich social fabric is cultivated through a healthy, safe, pleasant and fulfilling environment that contributes to the well-being of the population. Building on the experience of its airports, Groupe ADP is helping to devise the WELL certification for airports, which will enable the measurement and improvement of comfort and well-being indicators for this type of infrastructure. WELL certification should soon be available for airports, allowing them to certify the levels of comfort, health and employee well-being (for all stakeholders) in the airport environment and help to improve these key indicators.

2.2 A driver of economic development

Airports are exceptional in terms of job creation because they create and accelerate economic activity. One of an airport operator's

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responsibilities is to maintain the appeal of the area for local and international companies in order to attract them to the region. It must therefore identify the types of industries that could benefit from the local characteristics and ecosystem and foster their development. The operator could base this action

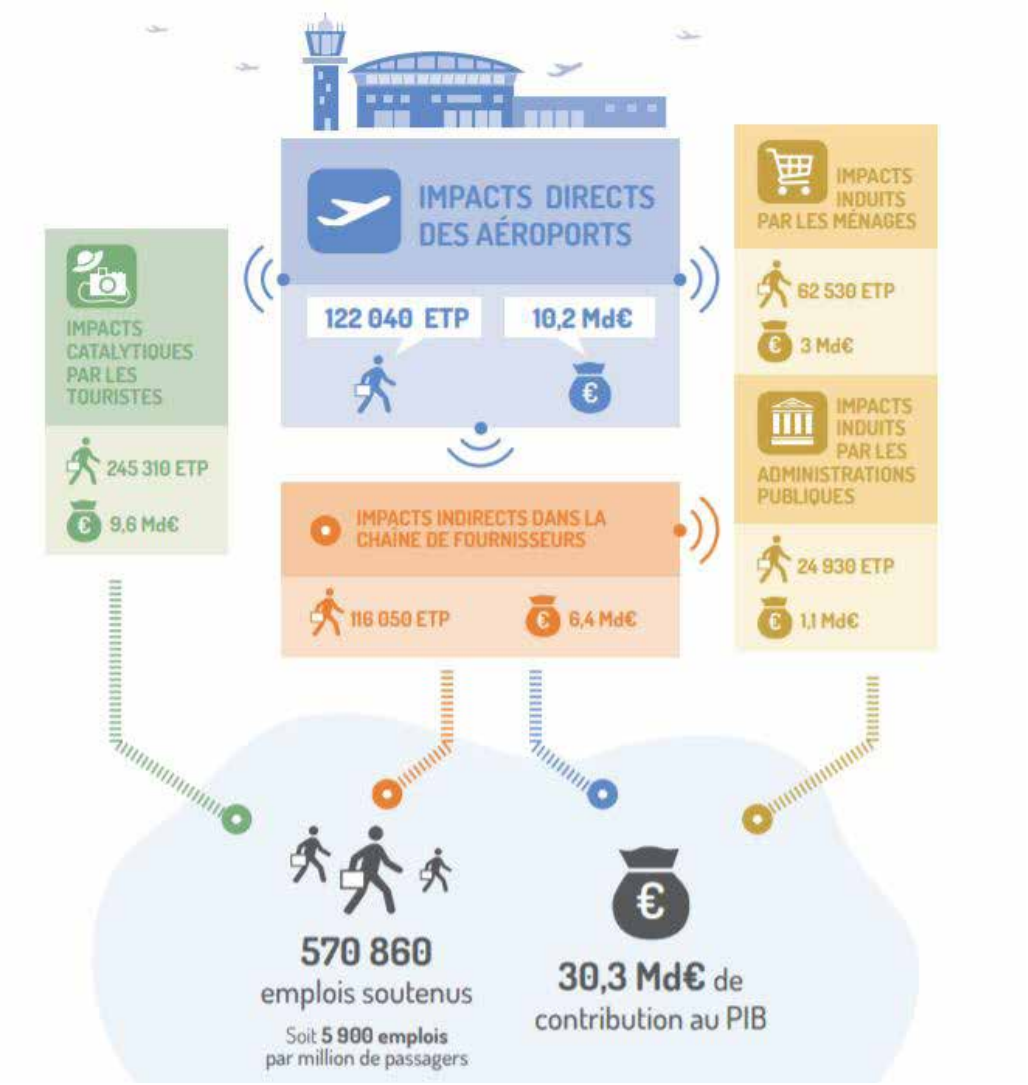

Figure 5: Socio-economic impact study of PARIS-CHARLES DE GAULLE, PARIS-ORLY and PARIS-LE BOURGET airports - 2017

on "airport urbanism" principles by matching the specific needs of airport users with the neighbouring communities, to pursue urban development projects near the airport.

The increase in economic stakeholders in the aerotropolis surrounding the airport helps to generate non-aeronautical income while improving the attractiveness of the area and stimulating traffic. Aerotropolis Atlanta (110 million passengers in 2019) is a valuable example in terms of attractiveness, with major stakeholders from a wide range of sectors–including agri-food, film, logistics and bioscience–located near the airport.

Airports can be a strategic catalyst for the economic and social development of a region, potentially leading to the creation of an economic area centred around the airport, known as an Airport city.

2.2.1 Airport City

Depending on the type of airport, the expectations of neighbouring communities, and its integration into the region, the development surrounding the airport can be based on a multi-industry approach (like the Atlanta example) or have a more targeted focus (tourism, cargo logistics, business travel).

The growing number of examples of Airport cities around the world (Amsterdam Schiphol, Dubai, Hong Kong, Paris CDG, Chicago) demonstrates the benefits of diversifying non-aeronautical activities and generating other sources of income during periods of aviation industry crisis, like the one we are currently experiencing.

The development of these Airport cities generally leads to the creation of true multimodal platforms combining all possible land and air connections: rail transport, metros, trams, shuttles, buses, taxis, hybrid bicycles, personal-use vehicles, soft mobility–even Urban Air Mobility in the future. Airports

must offer flexible connections between the various forms of transport in order to ensure sustainable development of the airport city.

Groupe ADP is a recognized partner in the development of airport cities, capable of offering support in a variety of areas:

- Support for public consultation and identification of the issues facing local communities;

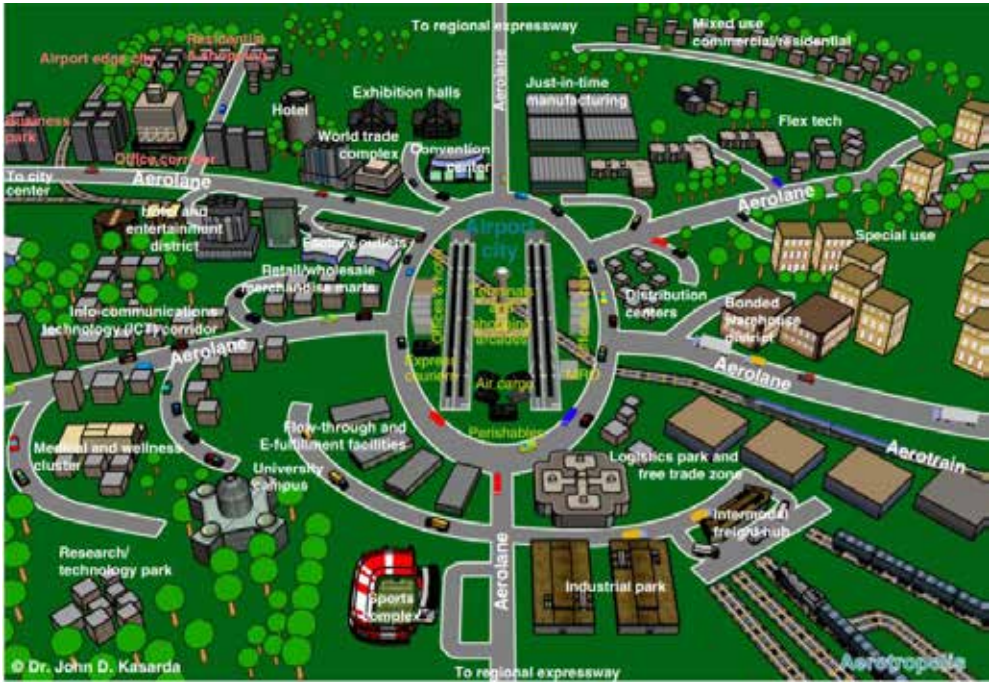

Figure 6: Compact vision of the airport city (aerotropolis according to Dr. John Kasarda)

- Characterization of the airport area and selection of the most promising business activities based on the issues facing the community and the airport profile;

- Advice on the urbanization of sites and coordination of the various transport routes;

- Optimization of traffic flows inside and outside of the airport to improve transfer efficiency;

- Development of "smart" or digital solutions for improving the passenger experience;

- Signage clarification and guidance for individuals;

- Reduction of emissions from land transport (source of nearly 30% of airport emissions).

Thanks to Groupe ADP's 360-degree understanding of airport operations, many references throughout the world, and the experience of its urban architects and town planners, it is able to provide assistance in the implementation of development plans for airport cities, while respecting the priorities and needs of clients and local communities and improving the passenger experience and the impacts of these activities on the environment.

2.2.2 Airport innovation for sustainable development

The airport environment is also the base for innovative projects that will transform the sector and thoroughly decarbonise the activities:

- UAM (Urban Air Mobility): by 2030, the futuristic travel portrayed in "The Jetsons" cartoon could become a reality, with flying taxis and electric aircraft flying over cities. The dream of intra-urban air routes to ease congestion in overcrowded cities is about to come true. Many major stakeholders are making considerable efforts to accelerate the development of Urban Air Mobility: Airbus, Lilium, Volocopter, Bell, eHang and Hyundai.

The concepts and experiments are increasing: several devices have already completed manned test flights. Considerable creativity has also gone into the ground infrastructure needed to accommodate these aircraft: our teams are working on the Vertiport concept. The objective is to be operational for an experiment during the 2024 Olympic Games in Paris.

Experiments in actual flight conditions will even begin as early as June 2021 at the Pontoise-Cormeilles site in Vexin, with the involvement of many industry stakeholders, to prepare a demo eVTOL (electric vertical

take-off and landing vehicle) for the 2024 Olympic Games.

- Renewable energy:

o Airports generally cover vast areas of land, with large roof surfaces, car parks and vacant land, making them ideal sites for developing renewable energy. It is now possible to develop photovoltaic solar installations while still complying with air traffic requirements. Solar plants are rapidly growing around the world, with constant increases in capacities (as evidenced by Cochin Airport in India, JFK in the US, Kansai in Japan, and many others).

Other types of renewable energy, such as wind, geothermal energy and biomass are starting to develop (in compliance with air traffic constraints), which is gradually promoting energy independence and the decarbonisation of airports.

o Aviation of the future is also gradually preparing for the energy transition by developing more efficient aircraft which can be powered by SAF (Sustainable Aviation Fuels). Synthetic fuel "gigafactories" are being built to produce SAF on a large-scale (e.g., NESTE projects in Rotterdam and Singapore). This transition to SAF will accelerate over time with the strengthening of the CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) market mechanism, aimed at increasing pressure on airlines to force them to reduce their kerosene consumption.

o Hydrogen should also gradually move into the airport environment, with many potential applications: airside ground service equipment (GSE), light and heavy vehicles, auxiliary power units (APU), low-carbon rescue services and, in a more distant future, aeronautical propulsion. Recent announcements by the French government and Airbus demonstrate the important role hydrogen will play in the future of the airline industry. Likewise, at European level, the European Commission launched the European Clean Hydrogen Alliance, an initiative aimed at developing

and deploying hydrogen as a viable and competitive energy source on a global scale in Europe. This initiative aims to support the implementation of a hydrogen strategy to help Europe achieve carbon neutrality through the development of a full and accessible hydrogen value chain.

Figure 7: UAM project for the 2024 Olympics and future Airbus hydrogen aircraft

- Contactless solutions:

Airports have also integrated multiple innovations to improve the passenger experience and ensure compliance with safety and security rules, as well as health measures to lessen the risk of spreading the virus.

Some innovations will be implemented quickly in airports: "contactless" technology at security checkpoints, automatic management for luggage and border police, "smart" controls and boarding systems for travellers (by time slot), smart mobile applications to facilitate passenger transfers and prevent queues, and other solutions that could facilitate the movement of people within the airports.

2.2.3 The core of inter- and intra-urban connectivity

In addition to driving economic development in their regions, airports offer an open door to the world and create connection points between cities, countries and various transport networks. They form true multimodal platforms, enabling the seamless and efficient transfer of individuals from their point of departure to their final destination.

A sustainable airport must be designed in a way that ensures flexibility for users and multiple connections through inter and intra-urban rail networks, collective or individual road transport, soft mobility (providing bicycles) and, in the future, flying taxis (otherwise known as eVTOLs, for electric vertical take-off and landing vehicles) which represent a serious alternative for intra-urban travel in the medium-term.

The logic behind airport travel solutions must focus on providing all the possible options to enable users to define their ideal itinerary towards their final destination based on efficiency, cost and a reduced carbon footprint. A network of low-carbon mobility solutions will greatly reduce emissions from the transport of people around the airport (indirect scope 3 emissions) and therefore improve the air quality for neighbouring communities.

For airports in the Ile-de-France region in 2018, mobility (access to airports for staff and passengers using light vehicles) accounted for nearly 30% of the airports' total emissions. Groupe ADP has initiated a vast greening project for the vehicle fleet used by staff. New Grand Paris metro stations and the CDG Express will also help to reduce emissions from passenger transport.

Groupe ADP has recognized expertise in developing these multimodal platforms and urban facilities surrounding the airports, through its multiple references in France (Orly, Toulouse-Blagnac) and around the world (Abidjan, Bahrain, Jeddah, Guangzhou Baiyun and Karbala).

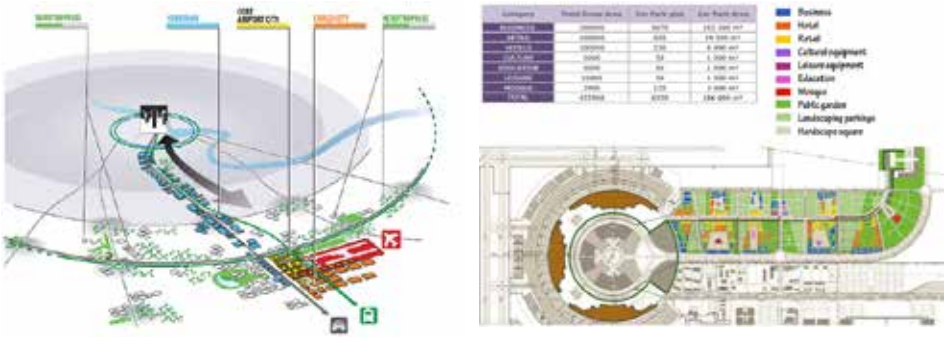

Figure 8: Airport City Concept

2.3 Reduction of environmental impacts and development of natural landscapes

The social and economic development of airports can only be achieved through the responsible management of environmental risks, aimed at minimizing the impacts of the airport's activities on the environment and neighbouring communities.

A rapid and massive ecological transition involving all countries and economic stakeholders will be required in order to meet the commitments of the 2015 Paris Agreement. Because the consequences

of climate change are becoming more visible; many populations, cities and infrastructure have already been affected by unprecedented climate-related disasters, which are expected to occur with increasing frequency and intensity:

o Massive fires in Australia, California and Brazil, resulting in the loss of a huge reserve of biodiversity;

o Increased tropical storm intensity resulting in devastating hurricanes (in 2019, Dorian in the Caribbean and Idai in Mozambique, Amphan in India in May 2020);

o Increased torrential rain events causing flooding and landslides;

o Accelerated ice melt and permafrost thaw, resulting in rising sea levels and the risk of losing coastal regions around the world.

Airports are already committed to fighting global warming, but they must continue to develop in a sustainable manner in order to reduce the carbon footprint of infrastructure and the impacts of their activities on the environment.

Figure 9: Airports submerged by the sea (typhoon in Kansai, Sept. 2018 - air-journal), rivers breaking their banks (floods in Chennai, Dec. 2015 - les Echos), mega-fires (Australia, California, 2019 - Shane Chalker, Reuters), tornadoes in Antalya airport, Jan 2019 - lematin.ch)

Groupe ADP offers a complete range of services to help airport authorities develop sustainable and resilient facilities, from the initial strategic planning phase to the detailed infrastructure design phase, and the adaptation of existing infrastructure and processes. These services are suitable for airports of all sizes and contexts.

2.3.1 Bioengineering or Nature Based Solutions

Airports generally cover large areas: the world's 20 largest airports are all over 2,300 ha and are mainly located in the United States (8 out of the 20), the Middle East (home to the world's largest airport, King Fahd Airport in Saudi Arabia, with an area of 78,000 hectares) and South East Asia (47,000 ha for Daxing Airport, inaugurated in September 2019).

Today, however, airports are increasingly being developed on smaller areas, and with a desire to respect the specific characteristics of the surrounding environment, and even reintroduce the natural environment, in order to:

• Create carbon sinks and redevelop biodiversity: by choosing specific vegetation with suitable maintenance, it is possible to develop biodiversity that is "compatible" with air navigation, while limiting "wildlife hazards".

In France, the Aérobiodiversité organization has developed unique expertise in plant selection and late mowing practices based on a participatory science. This approach was tested at Groupe ADP airports in the Ile-de-France region.

• Adopt natural water and soil management and treatment:

o Plants are carefully selected and positioned so as to create a natural solution for treating glycol-contaminated storm water (like the filter marsh at Orly);

o Reduction of impervious surfaces and increased ground absorption capacity to reduce the volume of storm water to be treated;

o Drainage swales positioned along car parks and runways to help filter runoff containing oil residue;

o Specific plants which also help to clean land contaminated by harmful

products.

• Improve air quality and reduce carbon emissions: natural spaces located near places of transit aimed at cooling the air in these areas (reducing heat island effects) and improving air quality or cleaning up pollution; These green spaces also create carbon sinks that absorb some of the CO2 emitted by airport activities;

• Take advantage of unused areas to create gardening activities (urban gardening concept) or for beautification projects (flower garden, apiaries, indoor gardens) to improve the health and well-being of airport users.

Relatively small investments can significantly improve the sustainability of the facilities.

Group ADP has references in each of these areas and can provide assistance in any type of greening project with various objectives. These solutions are not mere ideals, they are immediately available and fully achievable in our current environment.

Figure 10: Orly filtering marshes, urban cultures on airport sites, participatory science study on biodiversity (Aerobiodiversity)

2.3.2 Carbon emissions management

Groupe ADP can help airports calculate their emissions (scope 1, 2, and 3), identify and implement actions to reduce emissions (development of a carbon action strategy or plan) and pursue certification for continuous emission reduction (e.g., Airport Carbon Accreditation).

As the subsidiary of an international airport group that is fully committed to managing its emissions (with the target of net-zero emissions by 2050) and many international references, Groupe ADP can provide support in the development of action plans for reducing emissions, including building energy efficiency, conducting studies on the potential of renewable energies, development of low-carbon landside and airside mobility, optimization of aircraft taxiing times and runway electrification to replace auxiliary power units.

Groupe ADP has also been a signatory to the Syntec climate charter for the industry since 2019. The adoption of this charter demonstrates the group's commitment to reducing the environmental impacts of its activities, both in terms of its projects, by proposing ecologically responsible solutions, in the sustainable reduction of its carbon footprint, and the commitment of all of its staff members to climate action.

2.3.3 Energy and carbon efficiency of buildings

Airport design often favours expansive sites and large facilities for the sake of passenger comfort and the visual impression they create. The quest for massive volume is often at the expense of energy efficiency. With rising energy costs and efforts to fight global warming, airports could achieve significant energy savings simply by reducing the volume of their facilities and integrating bioclimatic design principles.

More sustainable building design could make the most of the weather conditions, thus reducing the energy supply needed and the energy bill for buildings: optimization of natural ventilation and natural light,

efficiency of the facades or glass walls, choice of materials, layout of the rooms, energy recovery, efficient HVAC system.

The integration of effective and virtuous design principles will significantly reduce energy consumption, resulting in a reduction of emissions and the overall carbon footprint for the life cycle of the buildings.

Reflection on the types of materials and their origins will allow for improved "carbon efficiency" for buildings, which will become a major requirement for future thermal regulations for buildings, with the French environmental regulation RE2020 set to enter into force in 2021. This new regulation will introduce major changes in design choices and methods and Groupe ADP is prepared to assist its clients in this ecological transition for buildings.

At existing airports, a wide range of energy efficiency measures can be implemented: optimization of insulation, protection of exposed facades, lighting improvements, centralized and "smart" energy management, improvement of HVAC system efficiency.

Groupe ADP has recognized expertise in the design of bioclimatic terminals with architects who master all the environmental performance tools. A team of thermal engineers works alongside designers to validate the architectural choices through dynamic thermal modelling and assess the energy efficiency gains and the comfort level for those using the spaces. This organizational model enables Groupe ADP to pursue ambitious levels of efficiency, resulting in savings for clients.

All of these sustainable design choices can be supported by an environmental certification process (HQE, BREEAM, LEED, ESTIDAMA), with qualified and recognized experts available to guide the implementation of very high-quality projects in terms of environmental standards.

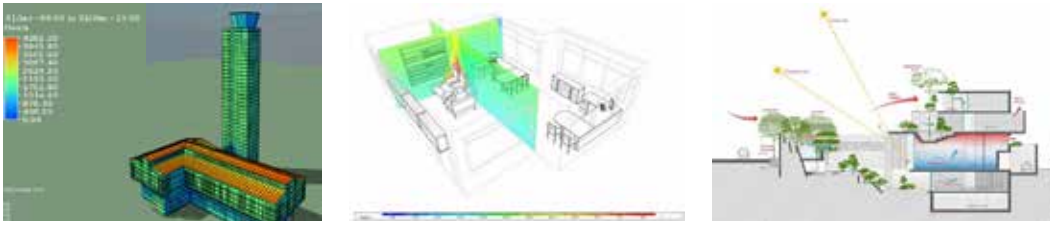

Figure 11: Building energy performance simulation - CFD model - IES software

2.3.4 Energy Master Plan

Airports are major consumers of energy, with needs comparable to those of entire cities and peak power demand that reaches very high levels (due to air conditioning during heatwaves, for example). The creation of an energy master plan (or overall energy plan) allows for a review of the current and future energy requirements and sets up a promising energy supply scenario. This optimal energy supply plan can include the identification of energy efficiency measures (improvement of facades, insulation, lighting optimisation, energy management), the use of innovative energy systems (heat pumps, solar air-conditioning, efficient HVAC equipment, installation of a heating network with storage capacity), and development of the renewable energy potential on the site (e.g., solar photovoltaic or wind production combined with storage using batteries or hydrogen).

Different energy supply scenarios can be studied, with a comparison of their economic and environmental performance and planned investments, taking into account the scheduled airport development deadlines.

This reflection prior to energy production makes it possible to:

- Develop production means suited to the airport's current and future needs:

- Secure the energy supply in order to ensure continuity of service for vital functions (such as security systems and telecommunications with air navigation);

- Combine environmental performance with economic and operational performance. The means of production can be used in conjunction with building energy management systems (BEMS) or smart grids with connected smart meters, which can optimize management of the energy networks.

Smart-grids are a major source of energy efficiency gains, providing flexibility in the operation of the electricity grid and improving its availability. They also reduce the risk of power failures, which can have

Figure 12: Renewable energies applicable to airports (photos ©Groupe ADP and Shutterstock)

far-reaching consequences in an airport. In Atlanta, for example, in 2017, following a fire in an electrical substation, over 1,400 Delta Airline flights had to be cancelled, which led to a loss of $50 million. Smart-grids ensure electricity supply for the airport's essential functions. Today, numerous smart-grids have been installed around the world, including at several airports in the United States (Pittsburgh, Cincinnati, Atlanta) and Europe (London City, Schiphol and Hamburg).

2.3.5 Virtuous management of environmental resources

Due to the increasing scarcity of environmental resources and the need to handle environmental impacts responsibly, airports must implement virtuous systems for managing energy, biodiversity, water and waste. The actions addressing energy and waste are already described in sections 2.4.1, 2.4.3 and 2.4.4.

A water management plan must be implemented in order to reduce consumption and recover/recycle/reuse this increasingly scarce resource as much as possible.

This plan can be based on the following principles, which are applicable during renovation periods and the entire building life cycle:

- Recover storm water from paved surfaces (roofs of buildings, car parks); once this water is collected and partially treated, it can be used for specific purposes on-site (such as for toilets, cleaning cars, or watering green spaces);
- Reduce water flow rates in toilets (timed self-closing taps, hand sensors, dual flush toilets) and in water used for cleaning or watering plants;
- Increase permeable surfaces (to reduce the volume of leakage flow to be treated) to promote soil absorption (reduced risk of overloading buffer tanks).

Water systems can also be viewed as systems for producing energy, with the integration of innovative pico hydro turbines for decentralized energy production, while minimizing the impacts of runoff for the system.

In terms of waste, the volumes generated can also be significantly reduced while also promoting recycling and a circular economy by promoting the following principles:

- Better management of waste streams: development of a selective waste sorting system, with treatment methods adapted to each waste stream;

- Incentives for sorting and recovering waste; innovative start-ups offer smart boxes facilitating waste management, such as machines for collecting plastic bottles and cans and a "solar cube" machine that encourages recycling by collecting waste in exchange for discount coupons for shops;

- Development of a circular economy, in which waste is sorted, recycled and reused locally. For example, at the airport in Lille, once technicians' clothes are worn out, they are recovered and recycled into insulation panels for the airport.

An increasing number of airports prohibit the use of plastic bottles, like in San Francisco, where, as of July 2019, the only bottles permitted for sale are those made of glass, compostable materials or recycled aluminium. Travellers can fill their water bottles at over 100 water fountains located throughout the airport.

Many airports have also made commitments to maintain high recycling rates, such as in Brussels (50% of waste are recycled in 2023), and Groupe ADP, where over 45% of non-hazardous waste is recycled (2020) in buildings, and a recovery rate of 70% was achieved for construction waste.

Responsible and economical management of environmental resources must therefore be factored in at the design phase and integrated into the entire airport life cycle. This will avoid additional costs linked to pollution problems, high operating costs (excessive consumption of water, waste collection challenges) and will improve acceptability (airport perceived as committed to reducing its environmental impacts).

2.3.6 Noise and Emissions Modelling

As was previously mentioned, the acceptability of airport activities requires responsible and rigorous management of its harmful effects on the environment and the neighbouring communities. Noise is an immediate harmful effect, directly linked to airport activities, which affects the quality of life of these communities.

By using data on current and forecasted traffic, and taking the airport's physical characteristics into account, it is possible to model noise exposure plans, which quantify noise pollution and create a map of the most exposed areas. Based on these studies, a sound management plan can be defined, indicating recommendations for operational (adaptation of flight frequency and procedures) and technical mitigation (sound management programme) in order to support urban development near the airports.

Models with varying degrees of complexity can also be developed to simulate pollutant emissions (CO2, NOx and fine particles) near the airports. Total emissions by type of pollutant can be determined, as well as mappings of the dispersion of pollutants in the air. The areas most affected can be identified and sensitivity studies can be conducted on the type of aircraft, flight procedures, and flight restrictions to be implemented to reduce the impacts of these emissions.

2.3.7 Resilience and adaptation study

Airport mapping models can be developed to study the resistance of the facilities to extreme weather conditions and their resilience to risks related to climate change.

Facilities can now be accurately modelled (using digital twin technology, BIM or geographic information systems) and climate change impact studies can be conducted in order to simulate the following:

- Extreme weather conditions, in order to identify vulnerable areas and

define protective solutions aimed at reducing tangible and intangible risks. These solutions could include a drainage channel, dyke, mangroves, greening projects, structural reinforcement.

- The effects of very high temperatures on infrastructure. This makes it possible to define suitable materials, thus preventing expansion and distortion problems in specific areas;

- The cooling effects of plants, to optimize the location and size of green spaces and improve the comfort of airport users;

- The propagation/dispersion of pollutants, smoke plumes from fires, to identify risk areas and implement procedures/systems for mitigating the impacts.

These specific studies measure the infrastructure's resistance to risks related to climate change and make it possible to implement suitable solutions aimed at protecting weak areas, improving the overall resilience of the facilities, and creating sustainable airports.

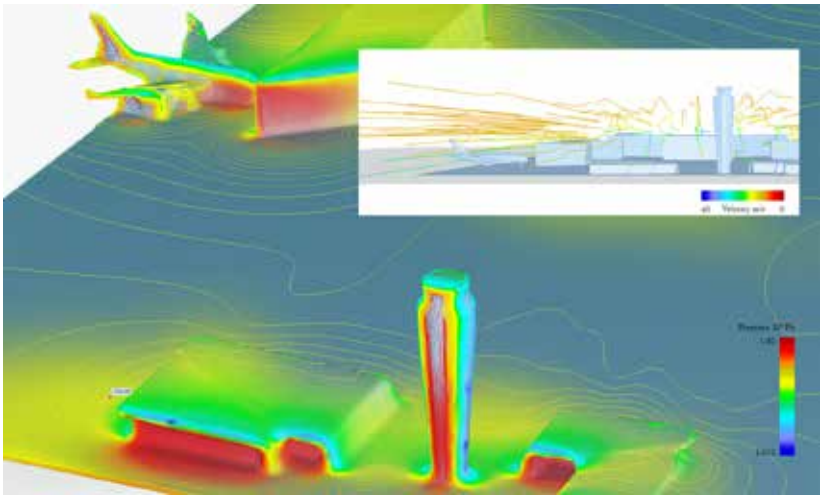

Figure 13: Vulnerability zone studies and Infrastructure resilience

3. Conclusion

A sustainable airport must manage the impacts and harmful effects of its activities on the environment and neighbouring communities in a responsible and virtuous manner. All the developments planned in the context of strategic ground plans can also integrate a sustainable approach by involving all the stakeholders and assessing all the possible impacts on the environment. The sustainable approach must be incorporated into every phase of the life cycle of the facilities, including design-construction, operation and decommissioning phases.

Development of this type of airport can be achieved through a balanced and systemic approach based on the 3 pillars of sustainable development:

1. Integration of the social issues facing passengers, employees, stakeholders and neighbouring communities;
2. Economic attractiveness and diversification of activities in urban development areas near the airport;
3. Management of environmental impacts, harmful effects of airports, and health risks.

A balanced consideration of all of these factors will enable the sustainable development of the airport, while maintaining its economic and social attractiveness.

Many of these actions can be implemented without major investments, especially if they are integrated early in the reflection stage. Some can even generate additional income (as is the case for the sale of electricity produced on-site back to the network, the recycling of waste, and the rental of spaces for non-aeronautical activities), which helps to make the facilities cost-effective, while improving the airport's integration in its environment.

The COVID-19 crisis brought global economic growth to a standstill. As the world struggles to find a way out of this major crisis, the environment has demonstrated its capacity for regeneration, as evidenced by improved air quality and a gradual restoration of biodiversity. This unprecedented crisis can also be used to accelerate the ecological transition that is needed in all industrial sectors.

Because, despite reduced global emissions of CO2 in 2020 (compared with the continuous increase observed in previous years), the realities of global warming have not gone away. The concentration of CO2 in the atmosphere has never been as high (417 ppm measured in May 2020, the highest value reached since the pre-industrial era) and record-high temperatures were experienced throughout the world.

The "forced" reduction of emissions caused by the COVID-19 pandemic in 2020 marked a change in the trend of human carbon emissions, which, if maintained long-term at lower levels, could potentially slow down climate change. If all the industrial stakeholders and countries strengthen and continue their efforts towards ecological transition, the objectives of the Paris Agreement could potentially be achieved (warming below 2°C above pre-industrial levels by the end of the century).

This crisis also required all sectors to quickly adopt health risk management practices by introducing new standards aimed at more effectively preventing the spread of any new infection.

Airport activities have been greatly affected by the drop in activity. It is hard to estimate the future pace of recovery. According to the forecasts, 2019 traffic levels will not be reached before 2025 or even 2027. Given this context, green growth could take over from past activities, and enable airports to return to growth founded on an environmentally responsible value chain.

Protecting the environment and neighbouring communities are among the major concerns of the airport sector, as evidenced by the commitments made over the past 20 years to reduce emissions and manage the airports' harmful effects.

Despite the drastic decline in investments due to the crisis, airports will still need to devote a major portion of their recovery efforts to green growth, in addition to their usual maintenance costs for existing infrastructure. This effort, marked by ecological transition, will allow them to return to their pre-crisis traffic levels more easily, while ensuring their acceptability and achieving their environmental goals. The current health crisis must once again allow airports to demonstrate their resilience and ability to adapt, in order to resume their lasting and essential role in driving economic and social development in local territories.

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