Greening European ATM's ground infrastructure:
What could ANSPs achieve over the next decade?

If aviation is to achieve its ambitious decarbonisation goals, as the sector takes on the challenge of achieving carbon neutrality by 2050, all emissions sources need to be considered. This Think Paper argues that there is considerable potential to 'green' the ground infrastructure of European air traffic management (ATM) – its control towers, control centres, offices and other essential ground facilities – over the next decade.

In this Think Paper we make a very first assessment of the extent of Europe's ATM ground infrastructure, and use this to assess its potential to contribute to the overall goal of aviation decarbonisation.

We ask:

- How much electricity does Europe's ATM ground infrastructure consume, and how many tonnes of CO_2 emissions are generated as a result?
- What initiatives are air navigation service providers (ANSPs) already taking to reduce their energy consumption?
- What impact would switching to renewable energy have on the carbon footprint of ATM ground facilities?

We conclude that **decarbonising European ATM's ground infrastructure** could deliver **large potential emissions savings on an annual basis,** providing strong support to aviation's overall decarbonisation goals.

For this to happen, ANSPs would need to **seize the right moment in their investment cycles** to replace energy-inefficient equipment, and to **accelerate the switch to renewable energy sources.**

MAIN FINDINGS

- European ANSPs are estimated to consume **1,140GWh** of electricity annually, roughly equivalent to 55% of the annual electricity consumption of Malta.

- Decarbonising this ground infrastructure by switching to and investing in renewable energy over the next decade could save **311K** tonnes of CO_2 equivalent emissions annually, summing up to over **6.2M** tonnes overall by 2050.

- Improving the energy efficiency of all ground infrastructure over the next 10 years will be both a challenge and a window of opportunity if successfully linked to investment cycles.

- Progress has already been made by some ANSPs towards switching to renewable energy contracts, or greening their facilities, which serve as best practice for their peers.

FOUNDING MEMBER
SESAR JOINT UNDERTAKING

NETWORK MANAGER

How much air navigation services (ANS) infrastructure is actually out there?

European ATM has an **extensive air navigation services infrastructure that is largely organised along State boundaries,** as Figure 1 sketches out:

FIGURE 1: PAN-EUROPEAN ANS NETWORK [1]

37 air navigation service providers (ANSPs)

62 area control centres (ACCs)

279 terminal area & airport approach control facilities

406 airports with ATC services (most with a control tower)

A recent EUROCONTROL Economic Perspective study[2] estimated that there are in addition **well over 6,000 CNS (communications, navigation and surveillance) ground-based facilities across Europe** (see Figure 2). **Further optimisation of the European CNS infrastructure clearly has the potential to reduce energy consumption and emissions**, and the need to estimate such savings has led to the development of this Think Paper.

FIGURE 2: ESTIMATED CNS FACILITIES IN EUROPE

SERVICE	SES Area	ECAC Area
COM	588	891
NAV	2797	3694
SUR	1720	2059
TOTAL	**5105**	**6644**

Can we estimate the electricity consumption of the facilities that make up the ATM/CNS ground infrastructure?

This Think Paper makes a series of assumptions based on an assessment of the scope of the known or estimated infrastructure – with some caveats based on the nature of the main types of facility.

On the communications side, many facilities have to be kept in a specific temperature range to function

as guaranteed, requiring air conditioning which adds additional power consumption. Thus, for a communications antenna, its power use is likely to be substantially less than its air conditioning unit. On the other hand, the power consumption of a primary radar station emitting electromagnetic pulses, including all the electronics and rotating elements, will be substantially greater than any air conditioning it may require.

For communications equipment in particular, it may be impossible for an ANSP to isolate the power consumption of an antenna if it is located on top of a building operated by a third party. This could be the case at an airport, where such antennae could be on terminal buildings or other facilities. An ANSP could also benefit from siting equipment at secure facilities controlled by government departments, but thus with no visibility on the energy consumed.

For navigation and surveillance facilities, their nature as single-purpose installations only developed for and operated by air traffic control should make it easier to calculate individual energy consumption; this information is not however publicly available, since facilities' performance requirements are generally covered in confidential supplier contracts.

Estimating ANSPs' energy consumption therefore requires a different approach. Some ANSPs do publish annual aggregated energy consumption data, and this Think Paper uses this to develop a ballpark figure.

We looked at a large sample of ANSPs' annual and sustainability reports, finding four ANSPs – ENAV, NATS, NAVIAIR and skyguide – reporting their overall electricity consumption, as per Figure 3.

FIGURE 3: TOTAL REPORTED ELECTRICITY CONSUMPTION OF SELECTED ANSPs*

ANSP	2020 consumption
ENAV	67.0 GWh
NATS	60.0 GWh**
NAVIAIR	6.8 GWh
Skyguide	11.0 GWh

*Notes: *See ANSP reports at 3, 4, 5 & 6*
**2019-2020 data

"This Think Paper takes a different approach to estimating ANSPs' energy consumption, to develop a first-ever ballpark figure"

A recent article[7] has estimated that the ATC towers at two medium-sized airports, together handling approximately 80,000 air traffic movements annually, could together expect to generate 170 tonnes of CO_2 equivalent emissions. The ATC towers at the airports in question, Larnaca and Paphos on Cyprus, averaged almost 300MWh of electricity consumption annually. If this is representative of airports with roughly 40,000 annual movements, an ANSP running 10 such towers may require 3GWh of electricity to operate them.

However, **an ANSP's carbon footprint is wider than its area control centres (ACCs) and control towers (TWRs), with headquarters and regional offices to be taken into account as well as CNS infrastructure.**

We estimate that a medium-sized ANSP running one or two ACCs, up to ten airport towers, an HQ and regional offices, as well as CNS and other facilities, could consume somewhere in the range of 20GWh of electricity annually. **Actual consumption will also be influenced by geography and climate, as well as the number of staff employed, which can be thought of as a proxy for the built office space and, by extension, ANSPs' energy consumption.**

However, ANSPs vary considerably in terms of number of ACCs, towers and staff, as Figure 4 reveals.

FIGURE 4: 10 LARGEST ANSPs IN TERMS OF STAFF COMPLEMENT [8]

COUNTRY	ANSP	#ACCs	#TWRs	#Staff
France	DSNA	5	75	7622
Turkey	DHMI	2	51	6894
Germany	DFS	4	16	5095
United Kingdom	NATS	3	14	4312
Ukraine	UkSATSE	4	16	4287
Spain	ENAIRE	5	21	3944
Italy	ENAV	4	16	3063
Poland	PANSA	1	15	1899
Greece	HCAA	1	18	1650
Romania	Romatsa	1	16	1613

In order to estimate total energy consumption across European ANSPs, we clustered them according to the numbers of their ACCs, TWRs and staff, and used a combination of linear fit and expert judgement to allocate an average annual consumption to the ANSPs in each cluster as follows: Very large – 110GWh; Large – 65GWh; Medium-large – 30GWH; Medium – 20GWh; Medium-Small – 15GWh; Small – 12GWh.

Manual adjustments were applied where the number of ACCs, TWRs or staff were outside the ranges defining a cluster, resulting in a small number of ANSPs being reallocated. Figure 5 shows the final clustering.

FIGURE 5: EUROPEAN ANSPs CLUSTERED ACCORDING TO ACCs, TWRs & STAFF

CLUSTER	ACCs	TWRs	STAFF	SERVICE PROVISION	TOTAL
Very large	2-5	>50	>5000	France, Turkey	2
Large	2-5	15-25	2000-5000	Germany, Italy, Spain, Ukraine, United Kingdom	5
Medium-large	1-2	15-20	1000-2000	Greece, Norway, Poland, Romania, Sweden	5
Medium	1-2	10-15	750-1000	Austria, Belgium & Luxembourg, Bulgaria, Croatia, Czech Republic, Finland, Georgia, Hungary, Ireland, Netherlands, Portugal, Serbia & Montenegro, Switzerland, EUROCONTROL (incl. MUAC)	14
Medium-small	1	5-10	400-750	Bosnia & Herzegovina, Denmark, Slovakia	3
Small	1	<5	<400	Albania, Armenia, Cyprus, Estonia, Latvia, Lithuania, Malta, Moldova, North Macedonia, Slovenia	10

The next step was to calculate the CO_2 equivalent emissions that are generated at the point of electricity production. In carbon accounting, these are known as "Scope 2" emissions, which are "indirect greenhouse gas emissions associated with the purchase of electricity, steam, heat, or cooling. Although Scope 2 emissions physically occur at the facility where they are generated, they are accounted for in an organisation's inventory because they are a result of the organisation's energy use"[9]. We used the average EU emissions factor of 253g CO_2e/kWh published by the European Environment Agency to convert energy consumption into emissions, and applied it to all clusters, leading to the estimates shown in Figure 6.

FIGURE 6: EUROPEAN ANSP CLUSTERING IN TERMS OF ESTIMATED AVERAGE ENERGY CONSUMPTION & CO_2e EMISSIONS

CLUSTER	Estimated average energy consumption (GWh)			Estimated average CO_2e emissions (t)	
	No. of ANSPs	Annual per ANSP in cluster	Total	Annual per ANSP in cluster	Total
Very large	2	110	220	27830	55660
Large	5	65	325	16445	82225
Medium-large	5	30	150	7590	37950
Medium	14	20	280	5060	70840
Medium-small	3	15	45	3795	11385
Small	10	12	120	3036	30360
TOTAL	39	N/A	1140	N/A	288420

Note: "Very Large" clusters France with 5 ACCs and Turkey with 2. However, their estimated consumption and emissions are assumed to be similar, as their similar total staffing levels as per Figure 4 are assumed to require a similar amount of physical space.

The estimated annual average consumption of 1,140GWh is roughly equivalent to 55% of Malta's annual energy consumption[10], meeting the needs of a population of 525,000[11] and a significant tourist industry.

Using the "carbon intensity" of each country's power generation based on data published annually by the European Environment Agency[12], we can further refine our figure of **288K** tonnes by calculating the "CO_2 equivalent" (CO_2e) emissions of the local electricity production sources (renewable, nuclear, oil, gas, coal). This yields a new figure of just over **311K tonnes CO_2e** – which, if it can be fully decarbonised, would represent a sizeable achievement that will contribute to greening European aviation.
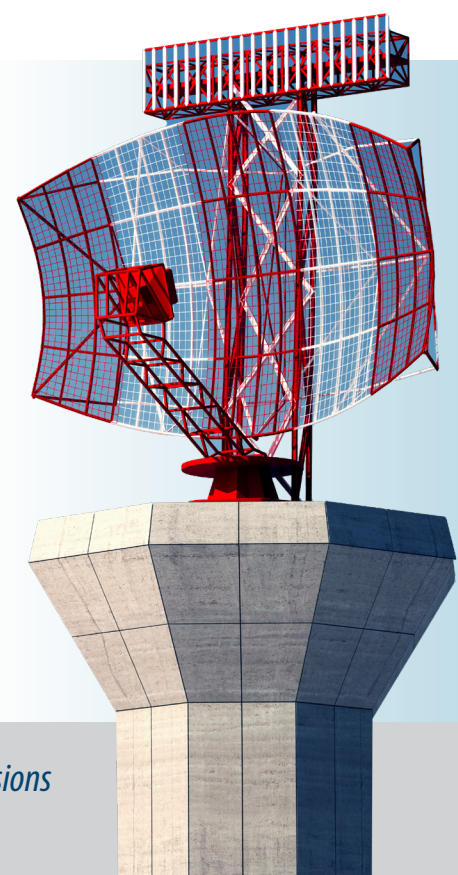
"Fully decarbonising Europe's ATM ground infrastructure CO_2e emissions would significantly contribute to greening European aviation"

## What are European ANSPs already doing to reduce their energy consumption?

Figure 7 lists some of the energy-reducing initiatives under way across Europe's ANSPs.

**FIGURE 7:** SELECTED ENERGY-SAVING INITIATIVES AT 6 EUROPEAN ANSPs

Austrocontrol	DSNA	ENAV
• 1.5GWh cut in electricity consumption over the past 5 years via measures such as deactivating its energy-intensive Buschberg radar station as a result of deploying a wide-area multilateration surveillance system[13] • Innovative reuse of decommissioned facilities, with its Freistadt VOR antenna platform repurposed as a mounting system for a photovoltaic array, and the electricity generated now used to power a communications antenna	• Innovative renewable energy solution planned for remote sites, producing electricity by hydrogen fuel cells, which are themselves powered by photovoltaic solar panels. This replaces the diesel generators typically used at such locations, reducing CO_2 emissions by 60% and lowering maintenance costs, while maintaining reliability and continuity. The Sarlat-la Canéda pilot was inaugurated on 14 September 2021[14] and aims to be the blueprint for similar installations at up to 20 SSR Mode S surveillance stations and 80 VHF (R/T) radio stations[15]	• Peripheral site trial at the Brancasi TBT radio centre to use hydrogen fuel cells in place of automatic backup generators to generate electricity. Rolling this out to all ENAV's peripheral sites will save an estimated 10 GWh and 5,000 tCO_2e annually • Photovoltaic electricity plants already installed at 5 facilities including ENAV HQ, with plans to roll them out to 6 control towers, 2 radio centres and its training centre by the end of 2022[16]

NATS	NAVIAIR	Skyguide
• 3.0GWh/month reduction in energy consumption over 13 years (2006: 8.0GWh; 2019: 5.0GWh), with NATS committed to reducing its CO_2 emissions to zero by 2050[17] • 10% reduction in electricity consumption 2020-2021 due to changing work patterns, and will continue to scale back the buildings in its portfolio and realise more energy savings from those it continues to occupy[18]	• 0.2GWh reduction in electricity consumption at its Copenhagen facilities, from 5.7GWh in 2017 to 5.5GWh in 2018. This drop was the result of replacing cooling machinery with new, more energy-efficient equipment, shutting down the local cooling systems and putting phase one of a new groundwater cooling system into service • Carbon footprint is measured to set CO_2 emissions reduction targets, with a reduction in energy consumption and increased use of renewables in its energy mix[19] • Overall energy consumption reduction target of approximately 500 MWh[20]	• 1.6GWh reduction in total energy consumption (2006: 14.5GWh; 2020: 12.9GWh) • 1.0GWh reduction in fuels for transport and heat (2006: 3.0GWh; 2020: 2.0GWh), with electricity consumption reducing from 11.5GWh to 11GWh over that period, and now 100% renewable[6] • Energy-efficient lighting & cooling machines • New energy-efficient data centre employing passive cooling[21]

In addition to energy-saving initiatives, some ANSPs have also cut back on their required infrastructure, deploying remote towers which allow aerodrome Air Traffic Control or Flight Information Services to be provided from a remote location. These are estimated to consume roughly 70% less electricity than a conventional aerodrome tower[7], also costing less to operate, while maintaining an equivalent level of operational safety.
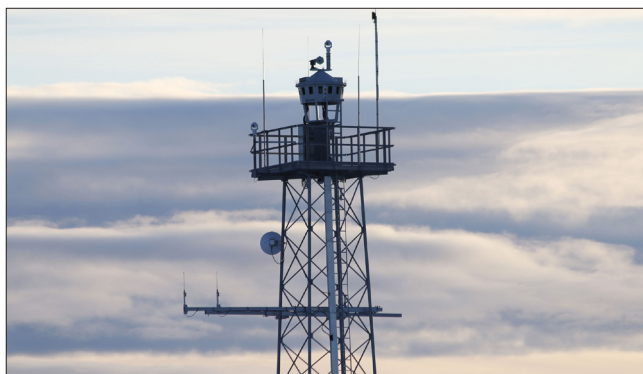
Saab on-site camera tower, Sälen
© Saab
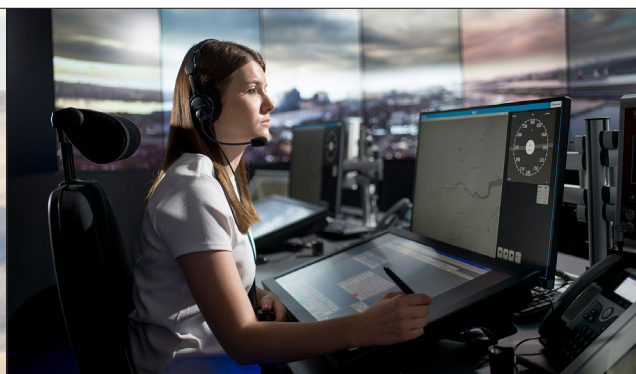
London City Digital Tower
© NATS

Moving to a zero carbon ATM infrastructure

The first step to take on the road to reducing an organisation's carbon footprint is to generate a baseline. EUROCONTROL and EASA have established a Working Group on ATM/ANS Environmental Transparency, one of whose tasks covers how ANSPs calculate their environmental footprints, allowing ANSPs to show improvements over time[22]. The results of that work should provide a clearer picture of ANSPs' energy consumption and greenhouse gas emissions.

The EUROCONTROL Network Manager's Operational Excellence Programme contains two work streams looking at how the CNS infrastructure should evolve, including its energy efficiency and carbon footprint. The data being gathered will be shared with the Environmental Transparency Working Group.

The estimates of 1,140GWh of energy consumption and 311KtCO$_2$e emissions published in this Think Paper only cover electricity consumption, but most ANSPs also use fossil fuels in their energy mix, something that the EUROCONTROL-EASA work should also factor into carbon footprinting. In addition, not all airports have ATC delivered by their national ANSPs: approach and terminal control is the one area of ANS provision that is open to competition and so there are several providers whose activities are not covered here. It is possible, therefore, that this Think Paper's initial estimates of total European ATM-related electricity consumption and CO$_2$ equivalent emissions are too low.

## Switching to renewable energy supplies

The share of renewables in EU energy production has been increasing gradually, from 10% in 2005 to 20% in 2019, with a target of 32% in 2030[23]. Solar power alone generated almost 10% of EU energy needs in summer 2021[24]. The energy reduction measures discussed above are important steps by ANSPs on the path to achieving net zero greenhouse gas emissions.

Encouragingly, a number of ANSPs are further down that path, and have chosen as a matter of policy to decarbonise their electricity supplies completely, as the following examples show:

- skeyes, the Belgian ANSP, has used 100% green electricity since 2015[25], and has approved the installation of a solar farm at its main site adjacent to Brussels airport[26].

- DFS, as well as optimising its navigation and radar infrastructure to reduce energy consumption and emissions, is expanding its use of photovoltaic facilities[27].

- NATS purchased renewable electricity for over 96% of total electricity consumed in 2020-2021 (up from 93% in the previous reporting year). This is an example of a portfolio of activities that led to NATS being identified as a European Climate Leader by the Financial Times in 2021 for its environmental performance since 2014.[28]

- ENAV plans to switch to renewable sources to reduce its emissions from purchased energy by 96% by 2022 compared with 2019[29], and has initiated an energy efficiency upgrade plan to reduce its consumption by 30% by 2030[30].

- EUROCONTROL's Brussels facilities have been running on renewable energy for several years, and the roof on the new EUROCONTROL Network Operations Centre (currently under construction) will accommodate over 600 photovoltaic panels[31].
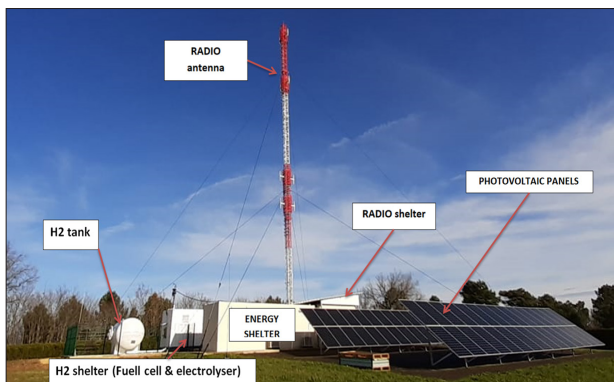
Sarlat-la Canéda radio antenna renewable energy emergency power supply (photo courtesy of DSNA).

If all ANSPs could follow these examples - by boosting their energy efficiency, installing renewable energy plants at their facilities, and switching to renewable energy supply contracts, and other green investment - **then ATM's ground infrastructure could potentially be progressively decarbonised over the next decade.** Moreover, as renewable energy becomes increasingly price-competitive, it is possible that **such a move could actually reduce ANSPs' operating expenditures in the medium term.**

Conclusions

The actions taken by European ANSPs to reduce their environmental impact by delivering more efficient airspace solutions are paralleled by a growing number of initiatives to reduce the carbon footprints generated by their energy consumption; but more can be done.

The estimates in this Think Paper are a first attempt to quantify the total potential emissions saving that greening Europe's ATM ground infrastructure could achieve over the course of the next decade, and are designed to stimulate decision-making in the years ahead.

MAIN FINDINGS

- European European ANSPs are estimated to consume **1,140GWh** of electricity annually, roughly equivalent to 55% of the annual energy consumption of Malta.

- Decarbonising this ground infrastructure by switching to and investing in renewable energy over the next decade could save **311K** tonnes of CO_2 equivalent emissions annually, summing up to almost **6.2M** tonnes overall by 2050.

- Improving the energy efficiency of all ground infrastructure over the next 10 years will be both a challenge and a window of opportunity if successfully linked to investment cycles.

- Progress has already been made by some ANSPs towards switching to renewable energy contracts, or greening their facilities, which serve as best practice for their peers.

"Improving energy efficiency of ground infrastructure is both a challenge and a window of opportunity if linked to investment cycles"

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