Aircraft on the Ground CO_2 Reduction Programme

Developed by Sustainable Aviation
with support of the Clinton Climate Initiative
and administered by the UK's Airport Operators Association

Overview and Invitation to UK Airports

The Aircraft on the Ground CO_2 Reduction (AGR) Programme has been developed through Sustainable Aviation – a coalition of UK aviation stakeholders spanning aircraft and engine manufacturers, airlines, airports and the principal air navigation service provider.

It has a simple objective – to contribute towards CO_2 emission reductions from aircraft ground operations at UK airports through collaborative action taken by airports and their stakeholders.

While aircraft ground operation CO_2 emissions are small relative to air operations they are still significant and this study shows that there are real opportunities to achieve material reductions.

These reductions are estimated to be in the order of 20% per movement for ground based aircraft activity today with potential for even greater efficiency improvements in the future. To put this into context this work has estimated that the savings today at Heathrow are in the order of 100,000 tonnes of CO_2 per annum compared to a notional do nothing case.

To support UK airports in taking steps to deliver these savings, the AGR programme has developed a menu of pragmatic and effective "action steps" for airports to deploy in concert with the wider aviation community.

This best practice document represents a first step towards the full realisation of these CO2 savings on the ground. AOA member airports will trial the guidance over a twelve month period, examining how best to implement the "action steps" identified in this document, and further developing the aviation industry's understanding of and ability to manage CO2 emissions on the ground.

1. Introduction

1.1 Background and Objectives

The Aircraft on the Ground CO_2 Reduction (AGR) Programme has been developed through Sustainable Aviation – a coalition of UK aviation stakeholders spanning aircraft and engine manufacturers, airlines, airports and the principal air navigation service provider.

The AGR Programme forms part of a suite of work programmes run through Sustainable Aviation aimed at reducing the environmental impacts of aviation to help deliver its vision:

> "*Our vision for 2020 and beyond is the UK aviation industry meeting the needs of society for air travel and transport, while removing or minimising any negative impacts on the local and global environment and maximising its contribution to the UK economy*"

The AGR Programme has a simple objective – to deliver the tools to achieve CO_2 emission reductions from aircraft ground operations at UK airports.

While aircraft ground operation CO_2 emissions are small relative to air operations they are still significant and this study shows that there are real opportunities to achieve reductions.

Airports will work together through the Airport Operators Association to implement the full range of "action steps" identified by the programme. They will share their experiences and findings.

In so doing this programme breaks new ground for the aviation industry, involving different sectors in a way that has not been done so far either in the UK or elsewhere.

1.2 Approach

The approach for delivering CO_2 emission reductions from aircraft ground movements is simple and pragmatic and relies on a series of practical "action steps" and initiatives that can be facilitated by UK airports, engaging and working collaboratively with their stakeholders.

Identification of the action steps has been facilitated through a "trial case" at Heathrow Airport with the help and support of The Clinton Climate Initiative who oversaw and project managed technical studies feeding into the final programme. Key Sustainable Aviation stakeholders involved in developing this programme included:

- Manchester, Heathrow and Stansted Airports
- British Airways, Virgin Atlantic and bmi
- Rolls-Royce
- NATS
- A|D|S (formerly SBAC)
- The consultancy ENTEC

The programme has benefited and builds on work carried out by industry experts and airports and which has led to the production of the Departures Code of Practice, the first two interim parts of which are published on Sustainable Aviation's website[1]. This is a voluntary code of best practice looking at a wider set of environmental issues of aircraft operations.

[1] See www.sustainableaviation.co.uk

2. Context

Carbon emissions at airports take many forms.

These range from emissions over which airports have direct control – e.g. energy used by airport terminals and buildings and airport vehicles, to those emissions which airports can influence but have no financial or contractual responsibility. This covers for example emissions from aircraft and from passenger and staff travel to the airport.

Heathrow's carbon footprint[2] has been used to provide context to the development of this programme and is reproduced below. The footprint excludes carbon dioxide emissions from en-route departures (e.g. the aircraft operations while at altitude between airports). For context it can be noted that the Department for Transport (DfT) quantified the total aircraft emissions for Heathrow flights as 17.1m tonnes in 2005[3].

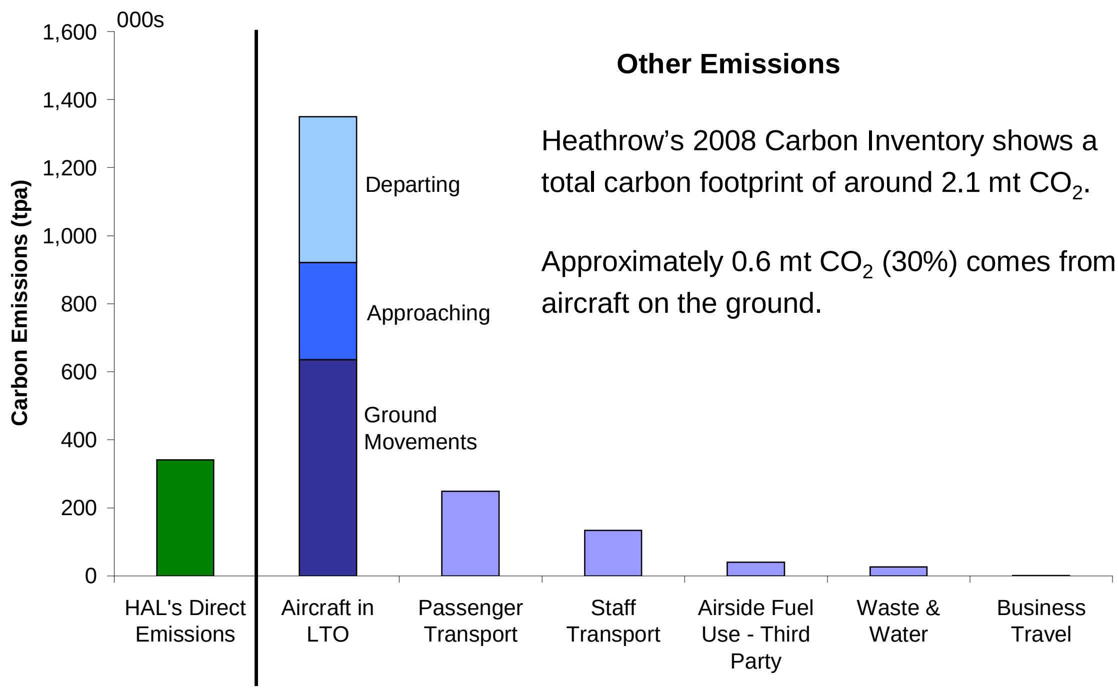

Figure: Heathrow Airport's Carbon Footprint 2008

The focus of this programme is on steps to reduce CO_2 emissions from aircraft ground movements (and this can form part of an airport's wider environmental programme).

In simple terms this broadly means reducing emissions from aircraft taxiing and reducing the use of auxiliary power units (APUs, see 3.2.2) whilst aircraft are being prepared on stand for departure or following arrival.

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[2] Note that the departing and approaching emissions are quantified up to a height of 3000ft. This is consistent with ICAO's definition of the emissions certification reference Landing and Take off (LTO) cycle.

[3] Department for Transport, "UK Air Passenger Demand and CO_2 Forecasts", January 2009.

At Heathrow the figure shows how significant these emissions are - contributing 30% of the total footprint - and are in total nearly twice the emissions Heathrow directly controls (approximately 0.34mt CO_2).

These emissions, whilst not directly controlled by the airport operator, are intrinsically linked both to the services and infrastructure offered by airports and to the operational practices in place at airports subject of course to safety requirements.

As such they offer an opportunity (whilst working within operational and safety requirements) for airports to work with airlines and other airport stakeholders to identify and to deliver pragmatic and practical steps that taken together can cut airports' and aviation's carbon footprint.

3. Benefits of the Programme

3.1 Introduction

Action steps and initiatives that will reduce CO_2 emissions from aircraft on the ground at airports have been identified through workshops facilitated by this programme as well as desktop research, including the Departures Code of Practice.

These have been drawn together into two "modules" of action steps that airports can deliver with the support of their stakeholders to achieve CO_2 and financial savings, described below.

3.2 Programme Modules

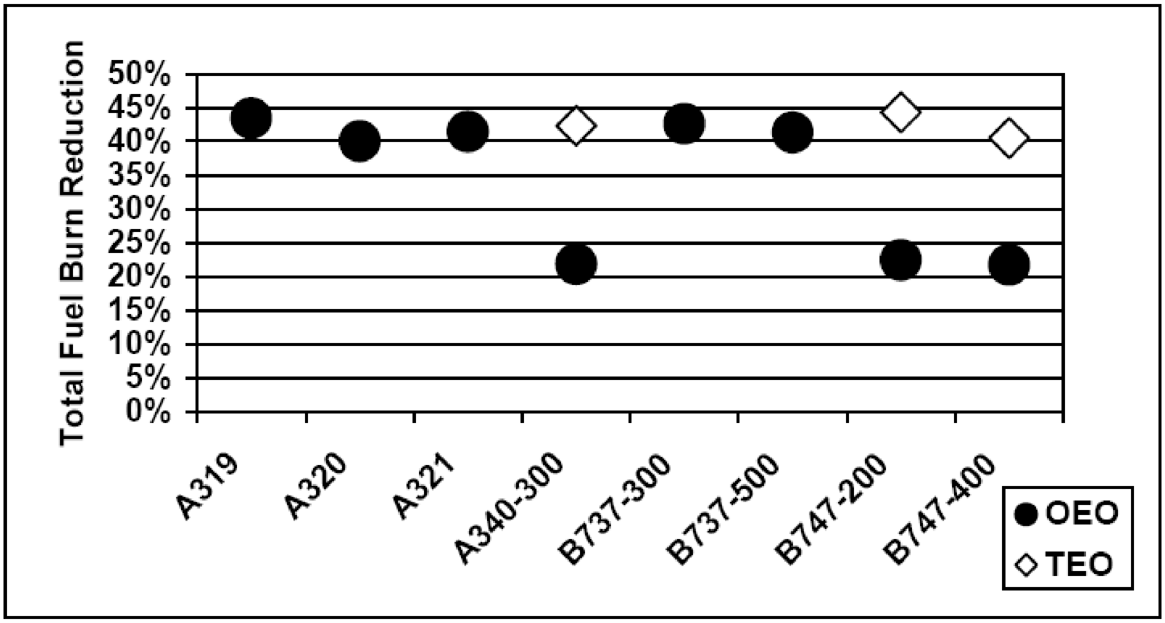
3.2.1 Taxiing

Aircraft engines, even at idle or minimal power settings, produce some forward thrust, which is used to taxi the aircraft whilst on the ground. Because of this, taxi-in, hold and even taxi-out may, under certain conditions, be completed with one or more of those engines (as appropriate) not operating.[4]

If an engine can be shut down during the taxi-in or, on a departure, is not started after pushback until the aircraft is in an advanced stage of the taxi-out for takeoff, then such a procedure, under current operating procedures, has the potential to reduce fuel burn and CO_2 emissions. For taxi-in operations a saving of between 20-40% per aircraft movement has been estimated (see Figure)

It should be noted that the interim Departures Code of Practice 1st Interim Report has examined the specific opportunities under which such a procedure is possible and identified constraints which flight crew and airport operators need to consider, for example crew workload, aircraft systems, jet blast issues and negotiating runway crossings, which mean that realisation of the full potential of this procedure is not always possible[5].

[4] Note that on some aircraft types, manufacturers or operators mandate that the APU must be run when taxiing with a main engine not operating, mainly for systems back-up purposes and, occasionally, to supply systems normally powered by the inoperative engine.
[5] see www.sustainbleaviation.co.uk



Figure[6]: Reported stabilised fuel flow reductions for taxi with one engine (OEO) and two engines (TEO) shut down, from IATA 2005 study – APU fuel burn not included.

3.2.2 Auxiliary Power Units (APUs)

APUs are small gas turbines normally mounted in the rear fuselage of most transport category aircraft.

They are used to power electrical systems on board, to run air circulation and conditioning systems and to supply bleed air for starting main engines before or during push back. (They may also be required to power pneumatic systems on some aircraft types where this is unavailable from the main engines, for instance when one or more main engines are not operating.)

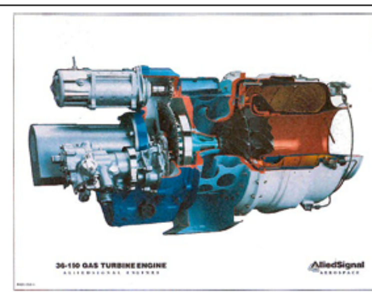
Hamilton Sundstrand APS 3200 APU for A320 family	Hamilton Sundstrand APS 500R APU for ERJ 135/140/145	Honeywell 36-150CX APU for Do328
		

Figure: Example APU for commercial aircraft

[6] Source: Departures Code of Practice.

In many cases, the electrical and air conditioning loads normally supplied by an APU can be efficiently supplied instead by ground based systems, which use grid electricity generated at a higher efficiency and thus have a much lower carbon intensity and will in general offer a much lower cost per kWhr.

Use of aviation jet fuel in APUs is, to put it simply, expensive and inefficient. It therefore leads to a simple ground power hierarchy which if followed can save fuel, money, CO_2 and NO_X emissions as follows:

1. Airport Terminal, or ground based facilities such as FEGP and PCA, should always be used where provided. (described further below),

2. When they are not available, GPUs and air-conditioning units should be used as these provide a reduction in fuel, emissions and noise over APUs,

3. When FEGP, PCA or GPUs are not available, on-board APUs and associated generators and air bleeds should be used.

4. If none of the above are available, the main engine driven generators and air bleeds should be used **as a last resort**.[7]

GROUND POWER (FEGP AND GPU)

Supply of 'fixed electrical ground power' (FEGP) at the stand is a primary substitute for electrical supply from an aircraft's APU[8]. An electrical supply cable is plugged into the underside of the aircraft and draws its power from the airport's electrical supply.

Figure: Example use of FEGP at Stansted airport

This system converts grid electricity to power suitable for supply (3 phase 400Hz), through standardised connectors, to the aircraft.

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[7] Source, Departures Code of Practice 2nd Interim Report. See www.sustainableaviation.co.uk
[8] FEGP can not however substitute for pneumatic power requirements or be used to heat and cool the aircraft.

Mobile ground power units (GPUs), which often run on diesel fuel, are also a better substitute where fixed systems are not present, are inoperable or cannot supply sufficient power to completely satisfy the aircraft’s requirements.

Preconditioned Air (PCA)

FEGP can not substitute the APU where air-conditioning is required in the cabin. Therefore to restrict the use of the APU for this purpose a ground supply of cooled or heated air to the cabin air-conditioning systems is necessary.

This is termed “preconditioned air” (“PCA”). Some airports are able to supply this air either from their central energy plant or through decentralised, gate mounted chiller/heater units on or near each airbridge.

Figure: Example of Preconditioned Air

3.3 Benefits of APU Substitution

There are clearly opportunities for reducing the time APUs are run at airports through substitution of the APU’s appropriate function (be this electrical power and or air conditioning) by airport based support systems. This has both environmental benefits for airports and operators (reduced CO_2, NO_x and noise) as well as in general financial savings through the saving of fuel burn by the APU.

The exact potential for savings is complex and dependent on a multitude of factors ranging from the availability of ground based systems at an airport, weather conditions and the flight schedules and local operating procedures in place[9].

[9] See also the Departures Code of Practice –2nd Interim Report for a fuller description of these variables and operational issues for flight crew, ground handlers and airport operators

Due to this large number of variables an exact calculation of saving potential is problematic. However this programme has sought to identify a broad level of saving potential based on published evidence described further below.

3.3.1 European Emissions Reduction Potential Study

A comprehensive study [10] looking at a selection of major European airports[11] has estimated the existing and future potential for APU substitution by ground powered systems such as FEGP and PCA to reduce aircraft ground emissions.

The study examined three scenarios:

- Unrestricted use of APUs (baseline)
- Currently realised reduction potential
- Future emission reduction potential

Annex A provides a summary of key assumptions made.

Using the three scenarios and assumptions the study has estimated that, compared to a do nothing scenario, European airports[12] are realising emission reductions through APU substitution with FEGP and PCA of up to 40% today with potential to go further in the future (see Figure).

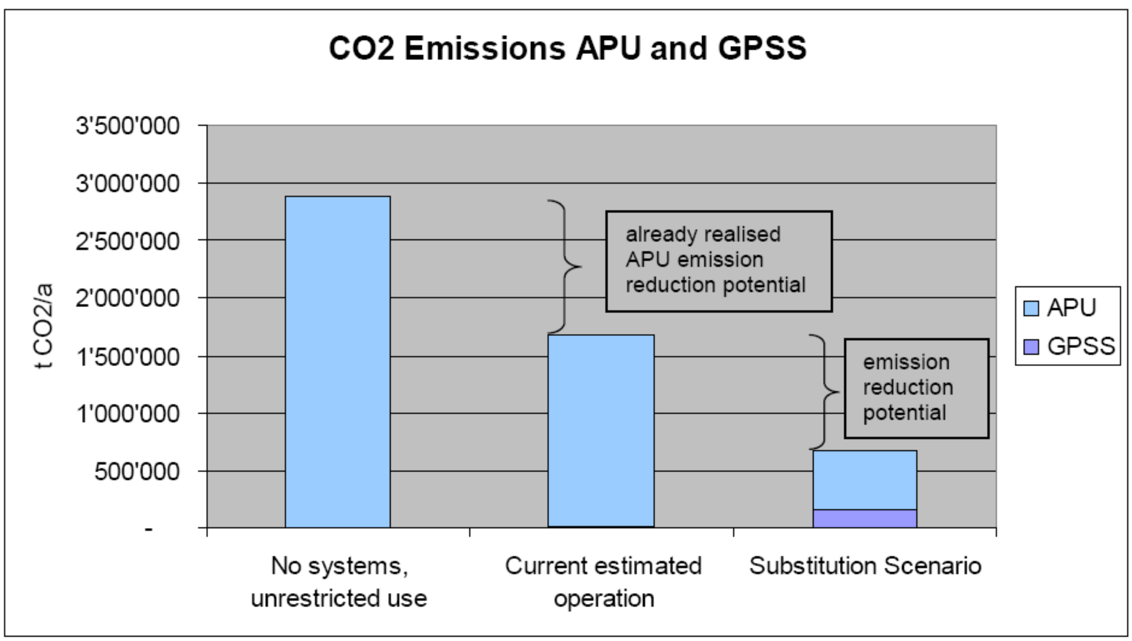


Figure: CO_2 savings from FEGP and PCA[13] substitution for APU

[10] Emission Reduction Potential by Replacing Aircraft APU with GPSS, E Fleuti, Zurich Airport. 7/12/07.
[11] Amsterdam Schiphol, Athens, Copenhagen, Frankfurt, Heathrow, CDG, Warsaw and Zurich.
[12] The airports studied generally have FEGP and PCA fitted on their stands, which is not necessarily true for all airports within the UK.
[13] Also known as Ground Powered Support Systems (GPSS) outside the UK.

3.3.2 Departures Code of Practice Interim Report 2

The Departures Code of Practice group also examined the scale of benefits potentially achievable through substitution of APUs by FEGP and or PCA.

Broadly this study highlighted that a Boeing 747 APU used roughly 6 times more fuel than a GPU supplying the same load[14], which in turn generates more CO_2 than FEGP.

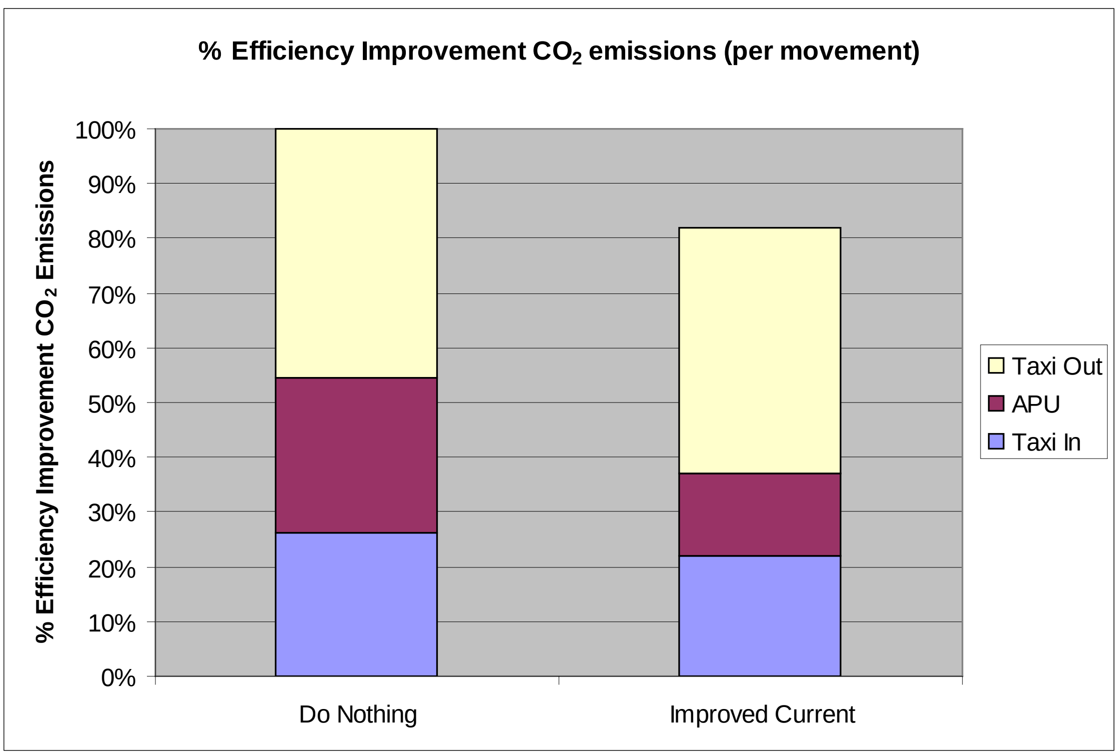
3.4 Summary of Savings

The potential CO_2 savings from reduced engine taxiing and APU substitution have been modelled using the Heathrow footprint by the Clinton Climate Initiative using two scenarios:

Do Nothing: Assumes no action and is a do nothing scenario.

Improved current: Takes into account known practices to use less than all engines on taxiing in and predicted current levels of FEGP and PCA use for APU substitution.

The key assumptions underlying these scenarios are summarised in Annex B.



[14] Ref: ICAO Workshop on the Aviation Operational Measures for Fuel and Emissions Reduction, Ottawa, Canada, 2002.

If Heathrow is taken as representative the results suggest that UK Airports today are delivering **efficiency savings in the order of 20% per movement** versus a do nothing scenario.

The study also looked at the potential for greater efficiency improvements in the future and concluded that these were significant, although detailed airport by airport studies are required to confirm this potential.

To put this into context the calculations carried out for Heathrow show that initiatives already taking place at Heathrow are saving approximately 100,000 tonnes of CO_2 per annum against a notional do nothing case.

Looking globally IATA has estimated that the global savings potential are in the order of 6 million tonnes CO_2 annually.

4. The AGR Programme

The AGR programme is a menu of pragmatic and effective "action steps" that airports can take, working with the wider aviation community to deliver CO_2 savings of the form identified above, now and in the future.

The action steps have been designed to be sufficiently broad in nature to ensure they can be practically translated into airport specific actions by a wide spectrum of UK airports - be they large or small. The actions are also presented as a menu rather than a prescriptive list – this allows airports to subscribe to those actions that are meaningful and practical at any one time to their own specific circumstances.

Therefore it is for individual airports to assess if and how to interpret the actions and to compile these into a bespoke programme that is effective and operational for the airport in question.

The AGR programme presents the action steps identified across 2 modules and 3 phases below.

It is envisaged that additional modules will be developed through this programme under the leadership of the Sustainable Aviation initiative.

	Phase		
Modules	Measurement	Plans, Assess and Deliver	Monitor and review
Reduced engine taxiing			
Reduced use of Auxiliary Power Units			

4.1 Reduced Engine Taxiing Module

Module	No	Phase	Action Step	Responsible party/parties
Taxi	1	Measure	Collect data from airlines on rates of reduced engine taxi currently employed, disaggregated by aircraft type.	Airport/Airlines
	2	Plan, Assess and Deliver	Work with airlines and the Air Navigation Service Provider to assess the suitability of different aircraft types for reduced engine taxi having regard to the specific operational challenges of the airport in question.	Airport/Airlines/NATS
	3		Influence manufacturers to consider and if appropriate revise and promote recommended practices for their aircraft to enable the use of reduced engine taxi by airlines.	Airport/Manufacturers
	4		Encourage airlines to revise and update standard operating procedures to encourage take up of reduced engine taxiing in line with latest manufacturer's guidance.	Airport/Airlines
	5		Encourage take up of reduced engine taxiing procedures through appropriate updating of the Aeronautical Information Publication (AIP).	Airport
	6		Take steps to encourage airlines to sign up to the guidance contained in the Departures Code of Practice.	Airport
	7		Investigate opportunities for Collaborative Decision Making (CDM) to increase take up for reduced engine taxiing.	Airport
	8		Evaluate the suitability of the airport infrastructure for reduced engine taxi and build feasible alterations to better facilitate the use of reduced engine taxi into short, medium and long term development plans as appropriate.	Airport
	9		Work with the Air Navigation Service Provider and airlines to investigate the feasibility of and options for taxi routes to optimise the potential for environmental objectives including reduced engine taxi, taking into account necessary trade-offs.	Airport/NATS
	10	Monitor and review	Form or expand existing working groups comprising the airport operator, airlines and the Air Navigation Service Provider to share information on best practice and procedures relating to reduced engine taxi and to monitor usage.	Airport/Airlines

4.2 Reduced use of Auxiliary Power Units Module

Module	No	Phase	Action Step	Responsible party/parties
APU	1	Measure	Collect comprehensive data on rates of current APU usage.	Airport
	2		Collect comprehensive data on the rates of FEGP and PCA availability.	Airport
	3	Plan, Assess and Deliver	Establish an FEGP performance standard and take steps to provide FEGP capable of adequately supporting power requirements of aircraft systems for all relevant aircraft types, and thus can effectively substitute (with Pre-Conditioned Air (PCA)) for APU use.	Airport
	4		Take steps to provide PCA capable of adequately meeting the requirements of all relevant aircraft types, and thus which can effectively substitute for APU use in terms of air conditioning requirements.	Airport
	5		Encourage the implementation of an adequate financial charging structure to encourage use of FEGP and PCA where practicable.	Airport
	6		Review and update local operating rules to minimise the permitted APU running times and develop a hierarchy for the use of energy sources with a view to promoting the use of FEGP and PCA.	Airport
	7		Encourage reduced APU usage by publishing the APU running restrictions in the Aeronautical Information Publication (AIP).	Airport
	8		Encourage airlines to revise and update airline standard operating procedures to ensure use of FEGP and PCA in preference to use of APUs wherever possible.	Airport/Airlines
	9		Examine opportunities for CDM to provide additional opportunities for reduced usage of APUs.	Airport/NATS
	10		Develop and run awareness and education programmes with airline/airport personnel on the benefits of reduced APU use and alternative systems available.	Airport/Airlines
	11	Monitor and review	Work with ground handlers and airport engineers to encourage the use of PCA and FEGP in line with best practice and to encourage continuous improvement in terms of operating and usage of the facility.	Airport/Ground Handlers

5. Joining the Programme and Reporting Progress

This Sustainable Aviation work programme has shown that by taking pragmatic steps airports can deliver significant CO_2 reductions today and in the future. The assessment illustrates that:

- **UK Airports today are delivering efficiency savings in the order of 20% per movement for ground based aircraft activity versus a do nothing scenario.**

- **Looking into the future even greater efficiency improvements are possible, although detailed airport by airport studies are required to confirm this potential.**

To help facilitate savings of this nature the AGR Programme will be administered by the AOA who will provide support and recruit airports wishing to implement elements of the programme.

Airports can participate in the AGR programme by notifying the AOA. The AOA will work with the airport to identify:

- Specific, timebound and measurable action steps to implement.
- Robust description of the airport's proposal for reporting progress.

Participating airports will work together to monitor and report on progress to the AOA. This will focus on the actions they have taken and, where feasible, quantifying the savings achieved in as far as this is possible.

The results from these airport progress reports will be compiled and presented by the AOA within the Sustainable Aviation progress report every 2 years.

Individual airports are also encouraged to report progress annually through their own Corporate Responsibility reports or similar.

ANNEX A: SUMMARY ASSUMPTIONS EUROPEAN STUDY

A1: Methodology

To estimate the energy use and emission reduction potential, three questions were answered:

1. What are the total estimated APU fuel use and emissions without any alternative systems or restrictions at these selected airports and in Europe in total?
2. What are the estimated actual APU and GPSS fuel/energy use and emissions when considering available stationary systems (not GPU), their usage and eventually implemented restrictions?
3. What would be the remaining APU and GPSS fuel/energy and emissions after reasonably substituting APU operation by GPSS operation?

A2: Unrestricted APU Emissions in Europe (Baseline)

The first assessment establishes a baseline or do nothing case. It assumes that there is no APU substitution and their use is not restricted beyond 3.0 hours per wide-body aircraft operation and 1.2 hours per narrow-body aircraft.

A3: Estimation of Currently Realised Reduction Potential

Study results show that the use of APU at the selected European airports is heterogeneous with clear examples of APU emission reductions through both the installation of PCA and FEGP and the use of operating restrictions. The assessment has assumed 90% of wide body aircraft use APUs for 2 hours and 75% of narrow body aircraft use APUs for 0.9 hours.

A4: Emission Reduction Potential

The following assumptions have been made:

- 90% of wide-body aircraft can be serviced by PCA and or FEGP over the full turn-around time, as they are mostly parked at stands connected to a pier or terminal building which can easily accommodate PCA and or FEGP.
- The remaining wide-body aircraft may be using their APU, but an operational restriction is in place that limits the use to maximal 0.8 hour per rotation.
- 70% of narrow-body aircraft can be serviced by PCA and or FEGP over the full turn-around time. As many aircraft are parked on open or remote stands, the systems might not be easily available or might still be diesel powered GPU to some degree.
- The remaining narrow-body aircraft may use their APU, but only in connection with an operational restriction of 0.5 hour of APU time per rotation.
- Emissions related to the production of the required energy for the PCA/FEGP is factored in using average conversion factors (Törner, Anna, Eurelectric; www.eurelectric.com. December 2006).

ANNEX B: MODELLING ASSUMPTIONS

B1: Reduced Engine Taxiing.

The model is based on three types of aircraft:

- "**WB4**": wide bodied (long haul) four-engine aircraft (eg, A380, B747, A340)
- "**WB2**": wide bodied (long haul) two-engine aircraft (eg, B777-200, A330, B767)
- "**NB**": narrow bodied (short haul) aircraft, all of which are two-engine (eg, A319, A320, A321, B737)

In constructing the scenarios the following reductions and frequencies are applied.

			Aircraft type		
			WB4	WB2	NB
		% movements			
		% emissions			
		APU needed during taxi?	No	Yes	Yes/No
CASE	PHASE	VARIABLE			
"Baseline (inventory) Case"	Taxi in	Assumed frequency (% of total movements)	0	0	0
		Effect (% reduction)	0	0	0
	Taxi out	Assumed frequency (% of total movements)	0	0	0
		Effect (% reduction)	0	0	0
"Current Case"	Taxi in	Current frequency (% of total movements)	60	20	55
		Effect (1.5 engines off for WB4) (% reduction)	30	30	40
	Taxi out	Current frequency (% of total movements)	10	0	10
		Effect (% reduction)	25	25	35

B2: MODELLING FOR PCA AND FEGP

Carbon intensity of FEGP and electrically powered PCA: 480 g/kWhr.[15]

Current case assumes:

- FEGP used for 90% of the total APU runtime in inventory - *0.9.
- PCA used for 25% of the total APU runtime in inventory - *0.25.

[15] See "Fuel Mix Disclosure Data Table", Department for Business Enterprise and Regulatory Reform: http://www.berr.gov.uk/energy/markets/electricity-markets/fuel-mix/page21629.html.