CLEAN DEVELOPMENT MECHANISM

CDM-MP68-A02

Draft Large-scale Methodology

AM00XX: Electric taxiing systems for airplanes

Version 01.0

Sectoral scope(s): 07

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. At its eighty-first meeting, the Board requested the Meth Panel to conduct a gap analysis with a view to identifying methodologies needed for the aviation and other transport sectors that are currently not available and to develop top-down methodologies based on the outcome of this gap analysis.

2. At its eighty-second meeting, the Board considered the concept note and agreed on the development of methodologies in the areas of aviation, renewable energy, electrification and household energy supply.

3. The Meth Panel at 67th meeting launched a call for public input on the draft methodology. The call was open from 10 July to 08 August 2014; one input was received from the International Civil Aviation Organization (ICAO).

2. Purpose

4. Developed top-down in collaboration with the ICAO, the methodology aims to cover project activities that implement and operate electric-taxiing (e-taxi) systems in commercial airplanes.

3. Key issues and proposed solutions

3.1. Radiative Forcing Index

5. The methodology anticipates slightly greater fuel consumption en route due to the increased weight of the airplane after installing the e-taxiing devices. These emissions are considered as leakage emissions. However, emissions from aircrafts' engines in the upper troposphere and lower stratosphere are considered to have different climate impact than the emissions on the ground. According to the IPCC Special Report "Aviation and The Global Atmosphere": "The climate impacts of the gases and particles emitted and formed as a result of aviation are more difficult to quantify than the emissions; however, they can be compared to each other and to climate effects from other sectors by using the concept of radiative forcing."

6. An index aiming to measure radiative forcing to evaluate the role of aviation in climate change was introduced by IPCC: **the radiative forcing index** (RFI), which is defined as the ratio of total radiative forcing to that from CO_2 emissions alone. Total radiative forcing induced by aircraft is the sum of all forcings, including direct emissions (e.g., CO_2, soot) and indirect atmospheric responses (e.g., CH_4, O_3, sulfate, contrails). RFI is a measure of the importance of aircraft-induced climate change other than that from the release of fossil carbon alone by airplanes. RFI as applied by NASA and ICAO models ranges between 2.2 and 3.4 for their various scenarios for subsonic aviation (IPCC, 1999, Aviation and The Global Atmosphere, section Table 6-1).

7. The application of the RFI to this methodology is not recommended for the following reasons:

   (a) The effects of the radiative forcing are not considered in the “2006 IPCC guidelines for national GHG inventories” or in the “Monitoring and Reporting Guidelines for Emissions from Aviation Activities by the Commission of the European Communities”.

   (b) The RFI is not used in GHG inventories submitted to the UNFCCC secretariat, based on the review of selected inventories.

   (c) IPCC (IPCC, 2007, WGI, section 2.10.4, p 215) recommends that “the RFI should not be used as an emission metric since it does not account for the different residence times of different forcing agents”.

   (d) In the case of short-distance (most of domestic) flights, majority of the fuels are consumed during landing and take-off, which take place at near ground-level, rather than upper troposphere or lower stratosphere.

8. In addition, stakeholder inputs from ICAO suggested that “the scientific community has not yet reached consensus on the use of RFI or other such multipliers to quantify the non-CO_2 effects of aircraft emissions. Until the scientific community reaches a general agreement on this issue, ICAO strongly recommends that the methodology only consider CO_2 emissions from aviation.”

4. Impacts

9. The draft methodology, if approved, would widen the coverage of CDM into the aviation sector.

5. Subsequent work and timelines

10. The methodology is recommended by the Meth Panel for consideration by the Board at its eighty-seventh meeting. No further work is envisaged.

6. Recommendations to the Board

11. The Meth Panel recommends that the Board adopt this final draft methodology, to be made effective at the time of the Board’s approval.

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1. Introduction

1. The following table describes the key elements of the methodology.

Table 1. Methodology key elements

Typical projects	Implementation and operation of e-taxi systems in commercial airplanes
Type of GHG emissions mitigation action	Energy efficiency. Switch to energy-efficient technology

2. Scope, applicability, and entry into force

2.1. Scope

2. The methodology applies to project activities that implement and operate electric-taxiing (e-taxi) systems in commercial airplanes.

2.2. Applicability

3. Domestic flights of commercial airplanes operating e-taxi systems between two airports in the host country are eligible to claim emission reductions using this methodology.

4. In addition, the percentage share of commercial airplanes operating an e-taxi system is equal to or less than 20 per cent in the total number of commercial airplanes registered in the host country.

5. The applicability conditions included in the tools referred to below also apply.

2.3. Entry into force

6. The date of entry into force is the date of the publication of the EB 87 meeting report on 27 November 2015.

3. Normative references

7. The methodology also refers to the latest approved version of the following methodological tools:

   (a) The methodological tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period";

   (b) The methodological "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

8. For more information regarding the approved methodologies and the tools as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved>.

4. Definitions

9. The definitions contained in the Glossary of CDM terms shall apply.

10. For the purpose of this methodology following definitions applies

(a) **Auxiliary power unit (APU)** - a device on an airplane that provides energy for functions other than propulsion, including proving power to start the main airplane engines, running accessories while the engines are shut down;

(b) **Commercial airplane** - an airplane used to carry cargo or passengers for payment;

(c) **Domestic flight** - a flight stage operated within the boundaries of a country by an air carrier in that country or between the territories of a country including those accessed through international waters or flying over the territory of another country;

(d) **Electric taxiing (e-taxi) system** - a system that moves an airplane along the ground before take-off or after landing with electric motors powered by APU instead of requiring airplane engines;

(e) **Operational cycle**- a operational cycle for a project activity is defined to include two periods:

(i) from switching e-taxi equipment on for vacating runway after landing until switching e-taxi equipment off after arriving at a gate; and

(ii) from switching e-taxi equipment on for leaving the gate until switching e-taxi equipment off at a holding point of runway for the next take off.

(f) **Taxiing time** - The total time during an operational cycle.

Table 2. Operational cycle and taxiing means

	Taxi in		**Taxi out**	
	Baseline	e-taxi	Baseline	e-taxi
Start of taxiing	Vacating runway by engine thrust	Vacating runway by e-taxi	Start of movement by engine thrust or by tractor	Start of movement by e-taxi
End of taxiing	Stop at gate/stand		Arrival at holding point to runway for the take-off	

5. Baseline methodology

5.1. Project boundary

11. The spatial extent of the project boundary encompasses the geographical area of the airports where the project airplanes operate e-taxi systems.

12. The greenhouse gases and emission sources included in the project boundary are shown in Table 3.

Table 3. Emission sources included in or excluded from the project boundary

Source		Gas	Included	Justification/explanation
Baseline	Emissions from combustion of fossil fuels by airplane engines, APUs and tractors during taxiing without e-taxi	CO_2	Yes	Main emission source
		CH_4	No	Minor emission source
		N_2O	No	Minor emission source
Project activity	Emissions from combustion of fossil fuels in APUs during taxiing with e-taxi	CO_2	Yes	Main emission source

5.2. Procedure for the selection of the most plausible baseline scenario and demonstrate additionality

13. The CDM project activities are automatically additional.

14. This simplified procedure is valid for three years from the date of entry into force of Version 1.0 of the methodology on 27 November 2015; before the end of this period, the CDM Executive Board will reassess the validity of these simplified procedures and extend or update them if needed. Any update of the simplified procedures does not affect the projects that request registration as a CDM project activity or a programme of activities by 26 November 2018 and apply the simplified procedures contained in version 1.0 of the methodology.

5.3. Baseline emissions

15. In the absence of e-taxi, airline operators implement multi-engine taxi, single-engine with APU running taxi, and sometimes a mix of above as the standard operating procedures (SOPs) in their operation manuals. Some airline operators may use tractors to tow airplanes from gate to holding point of runway at specific airports. However, tractors are always required if the airplane needs to push backwards away from its gate.

16. The SOPs depicting the operation of airplane engine, APU or tractor during taxiing without e-taxi system, shall be identified ex ante, as applicable to each project airplane and each project airport. If the applicable SOPs are updated during the crediting period, the SOPs valid for the monitoring period shall be referenced. The inclusion of each airplane's engine or APU for each operational cycle in the baseline emissions shall be justified accordingly.

17. If the SOP provides more than one option to include engines and APU, the most conservative combination shall be used. For example, if SOP allows performing taxiing with two main engines or with one main engine and APU, the latter combination shall be used.

18. Baseline emissions are determined for all airplanes in the project activity and include the following sources:

(a) CO_2 emissions from combustion of fossil fuel used by engines of the project airplanes, if taxiing with any airplane engine running;

(b) CO_2 emissions from combustion of fossil fuel used by APUs of the project airplanes, if taxiing with APU running;

(c) CO_2 emissions from the tractors, if used for a pushback and/or a tow to runway.

19. The baseline emissions are calculated as follows:

$$BE_y = \sum_1^i \left[(\sum_1^j SFC_{BL,j,i,y}) \times T_{PJ,i,y} \times NCV_y \times EF_y + BE_{TR,i,y} \right]$$ Equation (1)

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2e)
$SFC_{BL,j,i,y}$	=	Specific fuel consumption by engine or APU *j* without e-taxi during operational cycle *i* (t/hour)
$T_{PJ,j,i,y}$	=	Taxiing time during operational cycle *i* in year *y* (hour)
i	=	Operational cycle of the project airplane in year *y*
j	=	Engine or APU *j* of the airplane
EF_y	=	CO_2 emission factor for the fossil fuel used by commercial airplanes in year *y* (tCO_2/GJ)
NCV_y	=	Net calorific value for the fossil fuel used by commercial airplanes in year *y*(GJ/ mass or volume unit)
$BE_{TR,i,y}$	=	Baseline emissions from the use of tractors during the operational cycle *i* in year *y*

20. Index *j* is to account for the applicable combination, as prescribed in an airplane's SOP, of main engines and APU that would have been used to taxi the airplane for the operational cycle *i* in the absence of the e-taxi system. If the engine or APU is only used during part of the taxiing operation cycle, it may be excluded or the taxiing time shall be adjusted accordingly. For example, the applicable SOP may contain instructions to use one main engine and an APU for the entire operation cycle *i*. In that case, *j=1* would correspond to the main engine, while *j=2* would correspond to the APU.

21. Equation 1 is provided for one airplane. In case more than one airplane is included in the project activity, total annual baseline emissions shall be determined as the sum of baseline emissions per airplane for the same period.

5.3.1. Baseline emission from using tractors (optional)

22. Determination of emissions occurring from the use of the tractor in the baseline is optional, i.e. the project participants may consider the baseline emissions due to the use of tractor as zero if no data are available. If emissions occurring from the use of the tractor in the baseline are included, the following guidance shall be applied.

23. For the fuel-powered tractors, there are two options to calculate baseline emissions from using the tractor:

$$BE_{TR,i,y} = \sum_{1}^{i} SFC_{TR,i,y} \times T_{TR,i,y} \times NCV_{TR,y} \times EF_{TR,y}$$ Equation (2)

$$BE_{TR,i,y} = \sum_{1}^{i} FC_{TR,i,y} \times NCV_{TR,y} \times EF_{TR,y}$$ Equation (3)

Where:

$SFC_{TR,i,y}$	=	Specific fuel consumption rate of the tractor during the operational cycle *i* in year *y* (t/hour)
$T_{TR,i,y}$	=	Time the tractor was used during the operational cycle *i* in year *y* (hour)
$FC_{TR,i,y}$	=	Fuel consumption of the tractor during the operational cycle *i* in year *y* (t)
$NCV_{TR,y}$	=	Net calorific value of the fuel used by the tractor in year *y* (GJ/mass or volume unit)
$EF_{TR,y}$	=	CO_2emission factor of the fuel used by the tractor in year *y* (tCO_2/GJ)

24. For the electricity-powered tractors baseline emissions should be calculated by applying the latest version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". Total electricity consumption of the tractor during all the applicable operational cycles in year *y* should be assigned to the parameter $EC_{BL,k,y}$ while applying the tool.

5.4. Project emissions

25. Project emissions are the emissions associated with consumption of fossil fuel to run APU during taxiing within each operational cycle.

26. Project emissions are given by:

$$PE_y = \sum_{1}^{i}\left[\left(\sum_{1}^{j} SFC_{PJ,j,i,y}\right) \times T_{PJ,i,y}\right] \times NCV_y \times EF_y \times AF$$ Equation (4)

Where:

PE_y	=	Project emissions in year *y* (tCO_2e)
$SFC_{PJ,j,i,y}$	=	Specific fuel consumption by APU *j* with e-taxi during operational cycle *i* (t/hour)
$T_{PJ,j,i,y}$	=	Taxiing time during operational cycle *i* in year *y* (hour)
i	=	Operational cycle of the project airplane in year *y*
j	=	APU *j* of the airplane
EF_y	=	CO_2emission factor for the fossil fuel used by commercial airplanes in year *y* (tCO_2/GJ)
NCV_y	=	Net calorific value for the fossil fuel used by commercial airplanes in year *y* (GJ/ mass or volume unit)
AF	=	Net to gross adjustment factor. Set as 1.08[1]

5.5. Leakage

27. No leakage is expected to occur in this type of projects

5.6. Emissions reduction

28. The emission reduction achieved by the project activity shall be calculated as the below:

$$ER_y = BE_y - PE_y$$ Equation (5)

Where:

ER_y	=	Emission reductions in year y (tCO2e)
BE_y	=	Baseline emissions in year *y* (tCO_2e)
PE_y	=	Project emissions in year *y* (tCO_2e)

[1] The net to gross adjustment factor is introduced to account for uncertainty associated with: (a) climate impact of additional emissions from the project aircrafts' engines during the landing/take-off cycle and cruise due to the increased weight of the airplane after installing the e-taxiing devices; (b) possible longer taxiing time in the project scenario due to the e-taxi equipment speed limitations; (c) possible longer taxiing time of other airplanes and associated with this additional emissions due to the congestion at taxiway caused by low taxiing speed of the project airplane.

5.7. Changes required for methodology implementation in 2nd and 3rd crediting periods

29. Refer to the tool “Assessment of the validity of the original/current baseline and to update of the baseline at the renewal of the crediting period”.

30. In addition, no emission reductions can be claimed if at the beginning of the second crediting period and the third crediting period the percentage share of commercial airplanes operating an e-taxi system is high than 20 per cent in the total number of commercial airplanes registered in the host country.

5.8. Data and parameters not monitored

Data / Parameter table 1.

Data / Parameter:	$\boldsymbol{SFC_{BL,j,i,y}}$
Data unit:	t/hour
Description:	Specific fuel consumption by engine or APU *j* without e-taxi during operational cycle *i*
Source of data:	Engine or APU design fuel consumption provided by manufacturer
Measurement procedures (if any):	
Monitoring frequency:	At the start of the crediting period
QA/QC procedures:	
Any comment:	Fuel consumption for the idle mode of an engine should be used by default.

Data / Parameter table 2.

Data / Parameter:	$\boldsymbol{SFC_{TR,i,y}}$
Data unit:	t/hour
Description:	Specific fuel consumption rate of the tractor during the operational cycle *i* in year *y*
Source of data:	Design fuel consumption provided by manufacturer
Measurement procedures (if any):	
Monitoring frequency:	At the start of the crediting period
QA/QC procedures:	
Any comment:	Fuel consumption for the idle mode of an engine should be used by default.

6. Monitoring methodology

6.1. Data and parameters monitored

Data / Parameter table 3.

<table>
<tr><th>Data / Parameter:</th><th>NCV_y</th></tr>
<tr><td>Data unit:</td><td>GJ/mass unit</td></tr>
<tr><td>Description:</td><td>Net calorific value (energy content) of fuel type in year y</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>Values provided by the fuel supplier in invoices</td><td>If data is collected from airlines</td></tr>
<tr><td>Regional or national average default values</td><td>If values are reliable and documented in regional or national energy statistics/energy balances</td></tr>
<tr><td>IPCC default values at the lower limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td></td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Monitoring frequency:</td><td></td></tr>
<tr><td>QA/QC procedures:</td><td>-</td></tr>
<tr><td>Any comment:</td><td>The gross calorific value (GCV) of the fuel can be used, if gross calorific values are provided by the data sources used. Make sure that in such cases also a gross calorific value basis is used for CO_2 emission factor.</td></tr>
</table>

Data / Parameter table 4.

Data / Parameter:	EF_y
Data unit:	tCO_2/GJ
Description:	CO_2e emission factor for the fossil fuel used by the airplane in year *y*

<table>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>Values provided by the fuel supplier in invoices</td><td>If data is collected from airlines</td></tr>
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<tr><td>Measurement procedures (if any):</td><td></td></tr>
<tr><td>Monitoring frequency:</td><td></td></tr>
<tr><td>QA/QC procedures:</td><td></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Data / Parameter table 5.

<table>
<tr><td>Data / Parameter:</td><td>$\mathbf{NCV_{TR,y}}$</td></tr>
<tr><td>Data unit:</td><td>GJ/mass unit</td></tr>
<tr><td>Description:</td><td>Net calorific value (energy content) of fuel used by the tractor in year y</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>Values provided by the fuel supplier in invoices</td><td>If data is collected from airlines</td></tr>
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</table></td></tr>
</table>

Measurement procedures (if any):	-
Monitoring frequency:	
QA/QC procedures:	-
Any comment:	The gross calorific value (GCV) of the fuel can be used, if gross calorific values are provided by the data sources used. Make sure that in such cases also a gross calorific value basis is used for CO_2 emission factor.

Data / Parameter table 6.

<table>
<tr><td>Data / Parameter:</td><td>$EF_{TR,y}$</td></tr>
<tr><td>Data unit:</td><td>tCO_2/GJ</td></tr>
<tr><td>Description:</td><td>CO_2e emission factor for the fuel used by the tractor in year y</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
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<tr><td>Measurement procedures (if any):</td><td></td></tr>
<tr><td>Monitoring frequency:</td><td></td></tr>
<tr><td>QA/QC procedures:</td><td></td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>

Data / Parameter table 7.

Data / Parameter:	$FC_{TR,i,y}$
Data unit:	T
Description:	Fuel consumption of the tractor during the operational cycle *i* in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	

Any comment:	

Data / Parameter table 8.

Data / Parameter:	$\boldsymbol{T_{TR,i,y}}$
Data unit:	Hour
Description:	Time the tractor was used during the operational cycle *i* in year *y*
Source of data:	
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	

Data / Parameter table 9.

Data / Parameter:	$\boldsymbol{SFC_{PJ,j,i,y}}$
Data unit:	t/hour
Description:	Specific fuel consumption by APU *j* with e-taxi during operational cycle *i*
Source of data:	Quick Access Recorder
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / Parameter table 10.

Data / Parameter:	$\boldsymbol{T_{PJ,j,i,y}}$
Data unit:	Hour
Description:	Taxiing time during operational cycle *i* in year *y*
Source of data:	Quick Access Recorder or airlines records
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	Switching on and switching off e-taxi equipment shall be used as a control points.

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Document information

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01.0	23 October 2015	MP 68, Annex 2 To be considered by the Board at EB87. This draft methodology was available for public input from 10 July to 8 August 2015. It received one input.

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