

Cost impacts of ICAO's GMBM

Briefing paper

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Summary

- **Aim of the Paper:** To estimate the cost impacts of introducing a global market-based mechanism (GMBM) in the International Civil Aviation Organisation (ICAO) per developing country region, particularly Africa, Asia and Latin America / Caribbean.
- **Approach:** Scenario analysis
 - Cost impacts are estimated using the AERO modelling system (AERO-MS);
 - Offset supply is estimated using the CDM pipeline of registered offset projects.
- **Assumptions**
 - Carbon neutral growth 2020 (CNG2020)
 - 3 scenarios: Business-as-usual (BaU), GMBM without (BC0-100) and GMBM with Route-Based Differentiation (BC0-100 with RBD)
 - 4 route groups differentiated based on CO₂ per GNI/cap (Figure 2)
 - Allocation of offset obligation: 100 % sectoral rate
 - Route group D: no offset obligation (Lowest Emission States, LES)
 - Route group C: 50 % offset obligation
 - Route group B: 75 % offset obligation
 - Route group A: required to offset all remaining emissions to comply with CNG2020
 - Economic assumptions:
 - Carbon price (US\$ 2012 per t CO₂): US\$ 8 (2020), US\$ 15 (2030), US\$ 20 (2035)
 - Cost pass-through of offset costs to passengers: 100 %
 - Demand price elasticities: IATA/InterVISTAS
 - Impacts are aggregated over the period of 2021 to 2035
 - Offset pipeline aggregated by ICAO regions:
 - Only registered projects
 - Offset unit (CER) supply is adjusted according to actual issuance (-15%).
- **Results**
 - GMBM-induced costs were with RBD 20 % lower on average, in Africa they were even 32 % lower.
 - Offset supply from these regions amounts to 3.1 Gt CER.
 - The threshold price, beyond which revenues of these regions would be higher than the GMBM-induced costs on average, ranges from 3.7 US\$/t to 4.6 US\$/t, depending on whether the GMBM's offset obligations are with or without RBD; with RBD the threshold prices are as follows (Table 4):

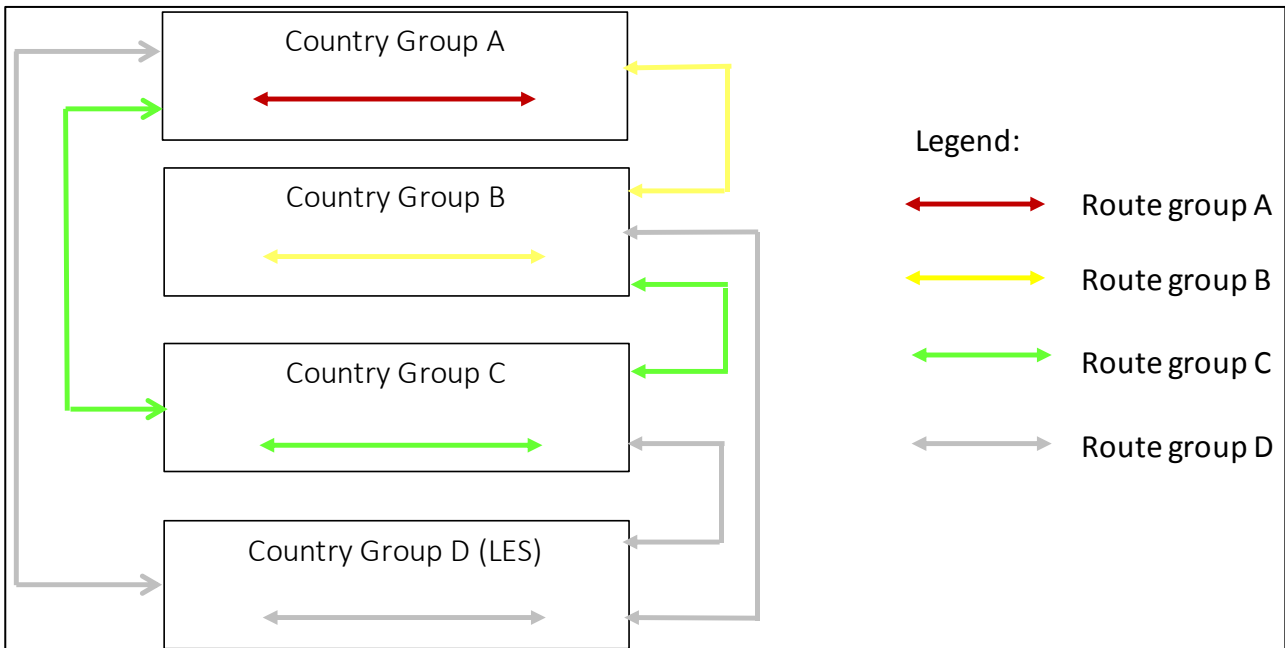
• Africa:	12.00 US\$/t
• Asia:	3.48 US\$/t
• Latin America / Caribbean:	3.45 US\$/t
 - On average, the three developing country regions can generate 3.4 times more offset units than would be required to cover the offset demand from the respective region; if the RBD were introduced, the supply-demand ratios are as follows (Table 5):

• Africa:	1.3 times
• Asia:	4.5 times
• Latin America / Caribbean:	4.4 times
 - Even if the cost of generating offsets equalled the offset price, the regions could net-benefit from introducing the GMBM because revenues from selling offset units would exceed the costs of purchasing offset units for the GMBM.

1. Specification of GMBM options

As a first step four country groups are defined. For this analysis we have used the grouping of countries based on the metric CO₂ versus GNI/Cap. The grouping of countries based on this metric is presented in Figure 1. Based on the 4 country groups, 4 route groups are defined. The relation between the 4 country groups and the 4 route groups is presented in Figure 1.

Figure 1: Relation between country groups and route groups



Source: Authors' own illustration

Two options for a Global Market Based Measure (GMBM) for international aviation are considered. Both options are a global offset scheme with carbon neutral growth for international aviation from 2020 onwards. The difference between the two options is the consideration of Route-Based Differentiation (RBD) and a redistribution of offset obligations. The characteristic of the main design elements for the two options are presented in Table 1 below, in which the following also applies:

- In both GMBM options in any year of the period of 2021-2035, operators have to offset the sectoral growth rate of CO₂ emissions (i.e. growth rate related to level of emissions in 2020). This implies that in any year fast- and slow-growing operators have to offset the same rate of their CO₂ emissions. Within the scope of the international discussions the option with a 100 % sectoral rate to be offset is referred to as the “Basic Calculation with 0 % individual rate and 100 % sectoral rate (BC0-100)”.
- In both options, routes to and from the Lowest Emission States (LES) are fully exempted from offset obligations for the period of 2021-2035. The LES are the same as country group D (Figure 2). Routes to and from the LES are route group D (see Figure 2).
- For the BC0-100 option (no RBD) operations on route groups A, B and C need to offset 100 % of their emission growth from 2020 onwards.
- For the option with a RBD operation on route group B, only 75 % of their emission growth from 2020 onwards needs to be offset. Operations on route group C only need to offset 50 % of their emission growth from 2020 onwards.

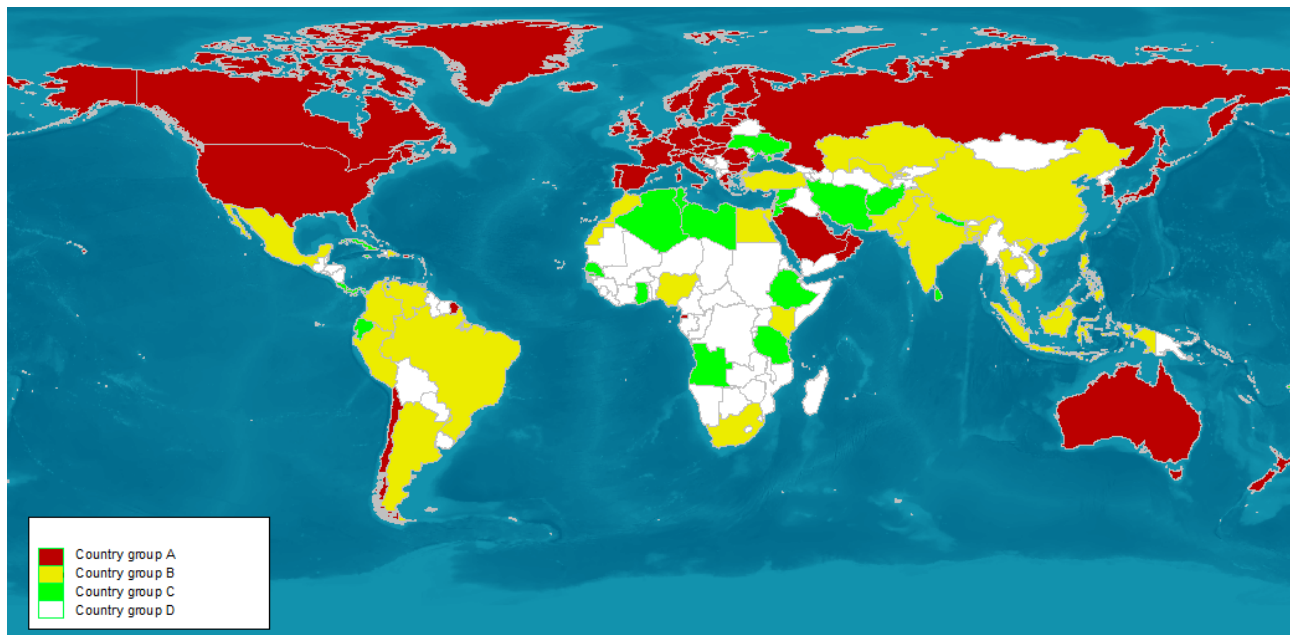
- For the option with a RBD, a redistribution of offset obligations takes place. Route group A has an additional obligation to compensate for the more lenient offset obligation of route groups B and C. The additional obligation for route group A is specified in such a way that there is carbon neutral growth across route groups A, B and C.

Table 1: Specification of design elements for two options for GMBM

Design elements	Options for GMBM	
	BC0-100	BC0-100 with RBD
Individual / sector rate	100 % sectoral rate	100 % sectoral rate
Exemption of lowest emission states	Yes	Yes
Route-based differentiation	No	Yes
Redistribution	No	Yes

Source: Authors' own compilation

Figure 2: Country groups based on CO₂ versus GNI/Cap



Source: Authors' own illustration

2. Approach for impact assessment of GMBM options

The cost impacts of the two GMBM options are assessed for the entire compliance period (2021-2035). Firstly, we assessed the impacts for the 4 route groups. Secondly, we assessed the impacts for the operators from three developing regions:

- Africa;
- Asia (excluding the Middle East; Japan and Korea; and the Asian part of Russia);
- Latin America / Caribbean.

For the impact assessment, use is made of the AERO Modelling System (AERO-MS).¹ The basic analysis principle of the AERO-MS is that the model first assesses future economic and environmental quantities for the aviation industry based on a Business-as-Usual (BaU) scenario. In a subsequent model run, a policy option for the reduction of aviation emissions is specified. By comparing the results of the run with and without the policy option in place, the impacts of the policy options are assessed. The BaU scenario used in this study is the CAEP/9 most likely growth scenario and a moderate aircraft technology scenario (CAEP 2013; FESG 2012). This scenario is referred to hereafter as the BaU scenario.

The most important assumptions underlying the impact assessment are:

- Carbon price: IEA 2013 low carbon price of US\$ 8 in 2020; US\$ 15 in 2030 and US\$ 20 in 2035 (prices per ton CO₂ expressed in year 2012 US\$).
- Pass-through rate: 100% pass-through to consumers of the costs for operators for buying emission offset units.
- The costs for operators for buying emission offsets on any route group are passed through to the passenger and cargo demand on that particular route group. It is thus assumed that there is no (additional) cross subsidization between route groups as a result of the GMBM options.
- The price elasticities of demand are based on an IATA/InterVISTAS report (IATA 2008).

3. Impacts per route group

Table 2 shows how the CO₂ emissions in the period of 2021-2035 for 4 route groups are covered in the case of the two GMBM options. The table shows that in both options for all route groups the CO₂ emission threshold (D) is far below the aviation CO₂ emissions in 2021-2035 with the GMBM option in place (C). The difference is covered by offsets bought by the aviation industry (E) in order to meet the emission threshold. The total amount of offsets to be bought by the aviation sector is the same for the 2 options (3,188 megatons of CO₂ emissions for the period of 2021-2035). The reduction of emissions within the aviation sector (B) for both options amounts to about 47 megatons of CO₂ emissions. This reduction follows from the pass-through of the offset costs and the resulting reduction in demand. The reduction in demand is generally small and will lead to a limited reduction in the number of flights and related emissions. Hence, for both options, the main mechanism for reaching the emission threshold will be to buy emission offsets from outside of the aviation sector. To a much lesser extent, airlines will be able to lower their actual emission levels.

¹ The AERO-MS is a model that has been CAEP-approved for over 15 years already and was last updated in 2014. The European Aviation Safety Agency (EASA) holds the IPR for the AERO-MS. EASA has granted permission for the use of the AERO-MS for the project within which this analysis is carried out.

Table 2: Covering of international aviation CO₂ emissions by route group for 2021-2035 period and costs for buying offsets (for BC0-100 with and without RBD)

	Unit	RG A	RG B	RG C	RG D	All
BC0-100						
Cumulative CO₂ emissions 2021-2035						
A. BaU CO ₂ emissions	Mt	5,112	6,088	787	410	12,396
B. Reduction in aviation sector	Mt	21	23	3	0	47
C. Aviation CO ₂ emissions (A-B)	Mt	5,074	6,095	779	402	12,349
Covering of CO₂ emissions 2021-2035						
D. CO ₂ emission threshold	Mt	3,729	4,460	569	402	9,161
E. Emissions offset	Mt	1,344	1,634	210	0	3,188
F. Total (D+E)	Mt	5,074	6,095	779	402	12,349
Financial impacts						
G. Costs for buying emissions offsets	US\$ bn	21.1	25.9	3.3	0.0	50.4
H. Costs as % of BaU revenues	%	0.35 %	0.42 %	0.36 %	0.00 %	0.37 %
BC0-100 with RBD						
Cumulative CO₂ emissions 2021-2035						
A. BaU CO ₂ emissions	Mt	5,112	6,088	787	410	12,396
B. Reduction in aviation sector	Mt	29	17	2	0	48
C. Aviation CO ₂ emissions (A-B)	Mt	5,083	6,071	785	410	12,349
Covering of CO₂ emissions 2021-2035						
D. CO ₂ emission threshold	Mt	3,226	4,845	680	410	9,161
E. Emissions offset	Mt	1,857	1,226	105	0	3,188
F. Total (D+E)	Mt	5,083	6,071	785	410	12,349
Financial impacts						
G. Costs for buying emissions offsets	US\$ bn	29.3	19.4	1.7	0.0	50.4
H. Costs as % of BaU revenues	%	0.49 %	0.31 %	0.18 %	0.00 %	0.37 %

Source: Authors' own calculations

Since both GMBM options do not include an offset obligation for route group D, the options do not result in a full carbon neutral growth (CNG) for international aviation from 2020 onwards. According to the BaU scenario, route group D is responsible for 3.3 % of the growth of international aviation in the period of 2021-2035. Hence, 96.7 % of the emission growth in the period of 2021-2035 is covered by both GMBM options.

Table 2 also shows the costs of the airline industry for buying the emission offsets. For both options, these costs amount to US\$ 50.4 billion for the period of 2021-2035 (in US\$ of year 2012). For both options, the total costs for buying offsets across all route groups amount to about 0.4 % of the expected airline revenues in the period of 2021-2035. For the option BC0-100 the costs as a

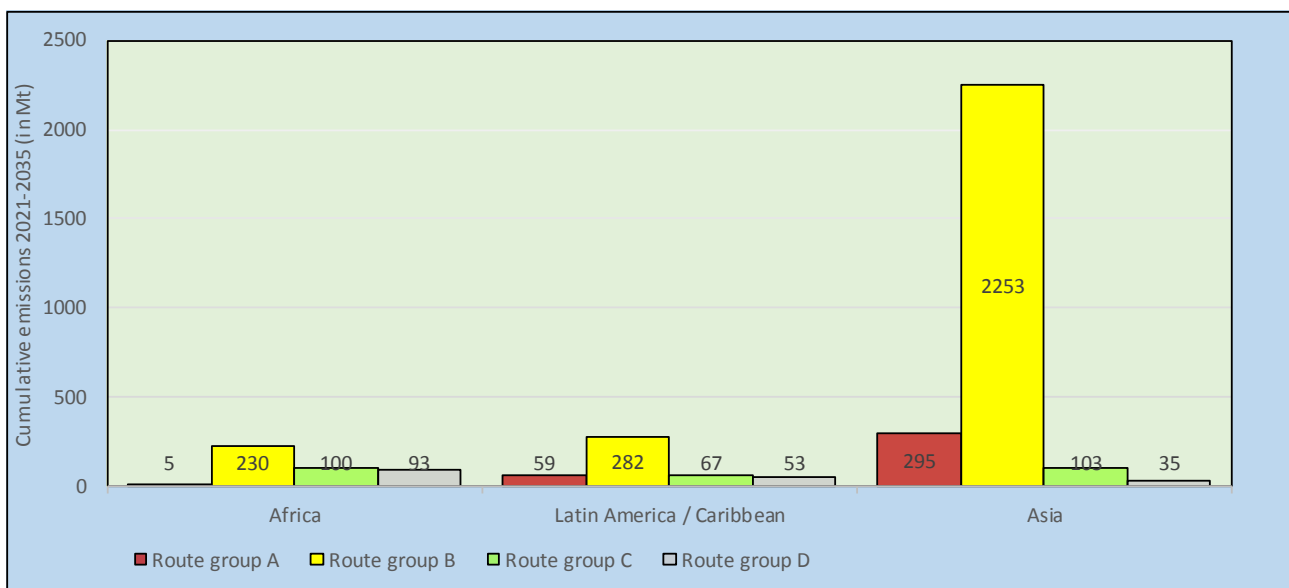
percentage of BaU revenues are fairly constant across the route groups A, B and C. For the option with RBD, the situation is different. Due to the more lenient offset obligations, the costs for buying offsets as a percentage of BaU revenues are reduced for route groups B and C and increased for route group A.

The distribution of the absolute costs for buying offsets across route groups is different for the two GMBM options. In the BC0-100 option, the costs for buying emission offsets for operations on route group A amount to US\$ 21.1 billion (yellow cells in Table 2). In the case of the option with RBD, these costs total US\$ 29.3 billion (orange cells in Table 2). Hence, the additional costs for route group A of the route-based differentiation and related redistribution of emission reduction obligations total US\$ 8.2 billion for the period of 2021-2035. Due to the more lenient level for route groups B and C in the option with RBD, the costs for buying emission offsets for these route groups are reduced relative to the costs in the case of the option without RBD (compare dark and light blue cells in Table 2).

4. Impacts per operator region

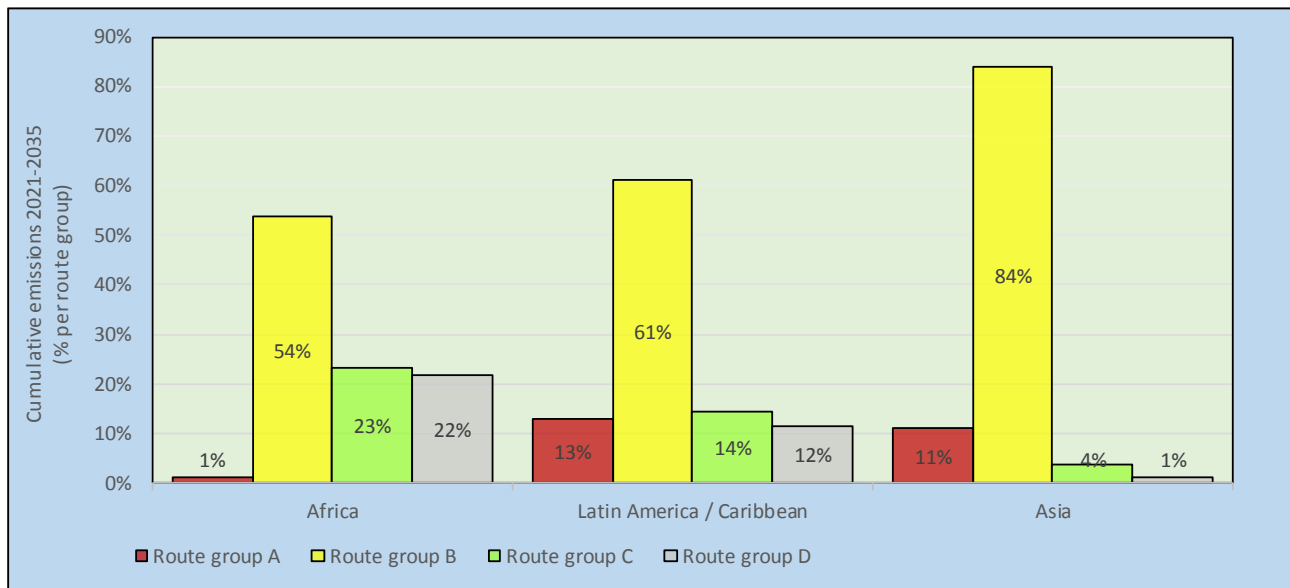
For the operators from the three developing regions, the cumulative BaU emissions from international aviation over the period of 2021-2035 per route group are calculated using the AEROMS (Figure 3). The figure shows that total emissions are clearly highest for the Asian operators. The emissions for the other two operator regions have a very similar order of magnitude to each other. Figure 4 shows the percentage distribution of the cumulative BaU emissions across route groups per operator region. For all three operator regions, the highest share of their emissions take place on route group B. Especially for Asian operators a high share of their emissions stem from this route group (84%). The figure also shows that African operators hardly operate on route group A (only 1% of their emissions). African operators also have the highest share of emissions relating to route group D (22%), which are the exempted routes to/from the Lowest Emission States.

Figure 3: Cumulative BaU emissions of international aviation (2021-2035) per route group and operator region in megatons



Source: Authors' own calculations

Figure 4: Percentage distribution of cumulative BaU emissions of international aviation (2021-2035) across route groups per operator region

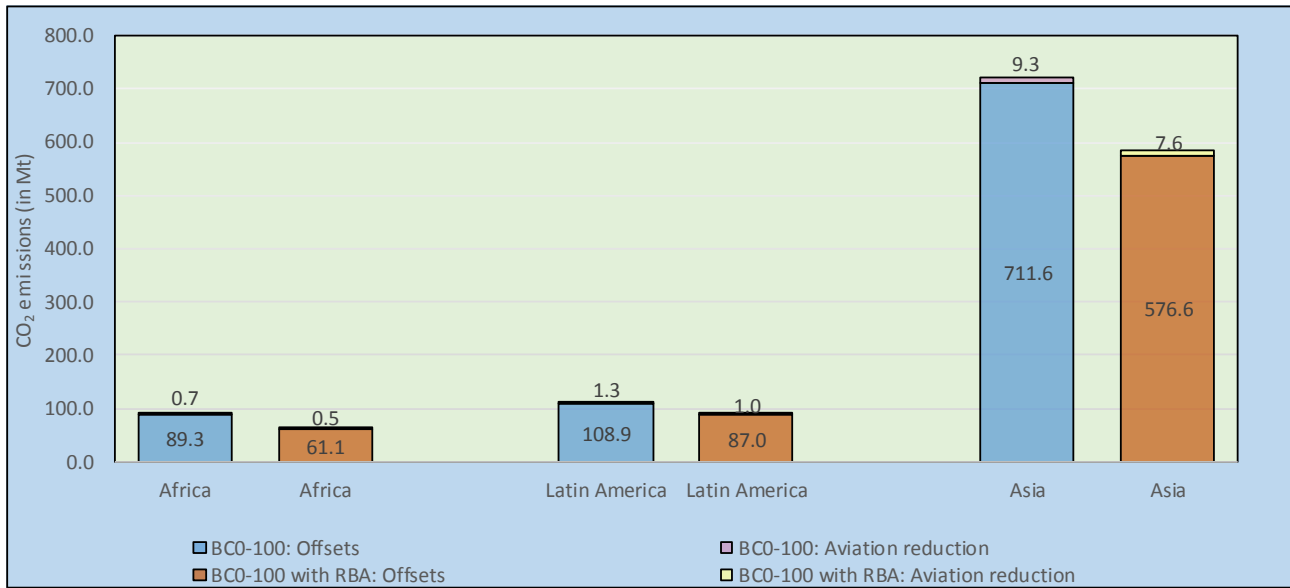


Source: Authors' own calculations

Figure 5 presents the cumulative offsets and reduction within the aviation sector per operator region for BC0-100 with and without the RBD. As also shown by the results in Table 2 the reduction within the aviation sector - related to the pass-through of the offset costs and the resulting reduction in demand - is generally small. For all three operator regions the number of offsets to be bought is lower if a RBD were introduced. For African operators the cumulative offsets are reduced from 89.3 Mt to 61.1 Mt (reduction of 32%). For operators from Latin America / Caribbean and Asia, this reduction is 20% and 19% respectively. The relative reduction for Africa is highest because:

- a relatively high proportion of emissions of African operators is related to route group C (for which only 50% of the emission growth is required to be offset); and
- a relatively low proportion of emissions of African operators is related to route group A (for which an additional obligation applies in order to compensate for the reduction of the offset obligation of route groups B and C).

Figure 5: Cumulative offsets and reduction within aviation sector in megatons (2021-2035) per operator region for BC0-100 (100% sectoral rate) with and without RBD

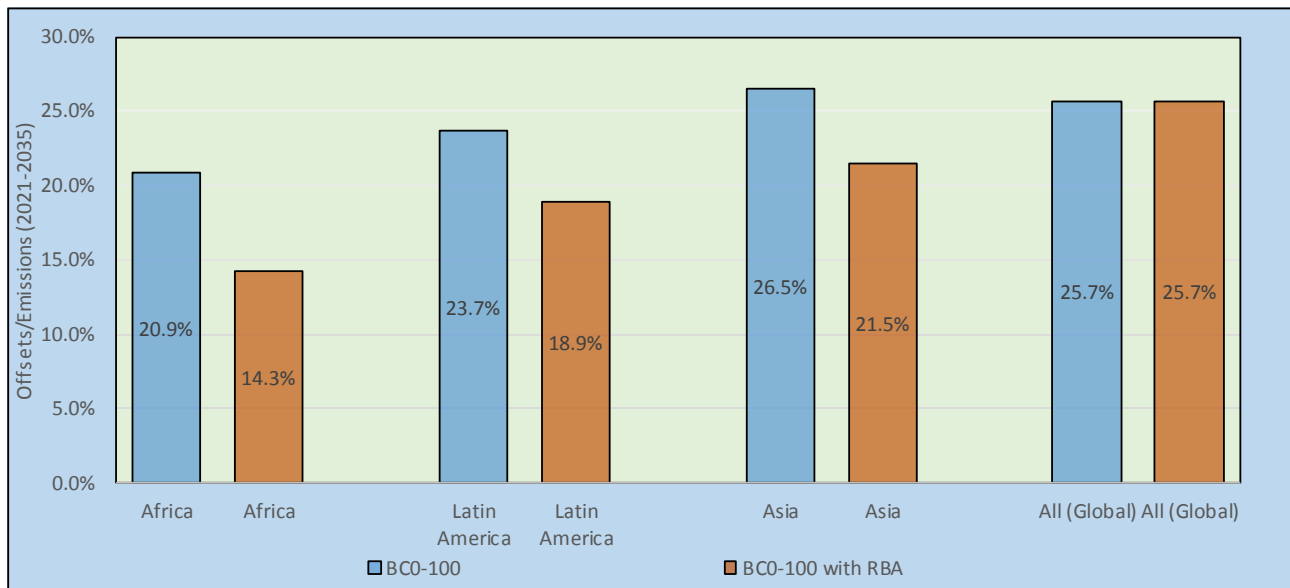


Source: Authors' own calculations

For all three operator regions considered in this paper, the option with a RBD implicates a reduction in the number of cumulative offsets on the one hand (Figure 5). On the other hand, Table 2 shows that the total number of cumulative offsets is the same for both GMBM options (3,188 Mt). Hence, the operators from other world regions will have to offset more emissions in the case of a RBD. Especially operators from the EU and North America operate largely on route group A, and will have a larger offset obligation in the case of a RBD.

Figure 6 shows the cumulative offsets as a share of total BaU emissions per operator region for both GMBM options. The shares are also shown for all global operators. The two options show the same share of the total BaU emissions over the period of 2021-2035 to be offset for all global operators (25.7%).

Figure 6: Cumulative offsets (2021-2035) as a share of total BaU emissions per operator region for BC0-100 (100% sectoral rate) with and without RBD



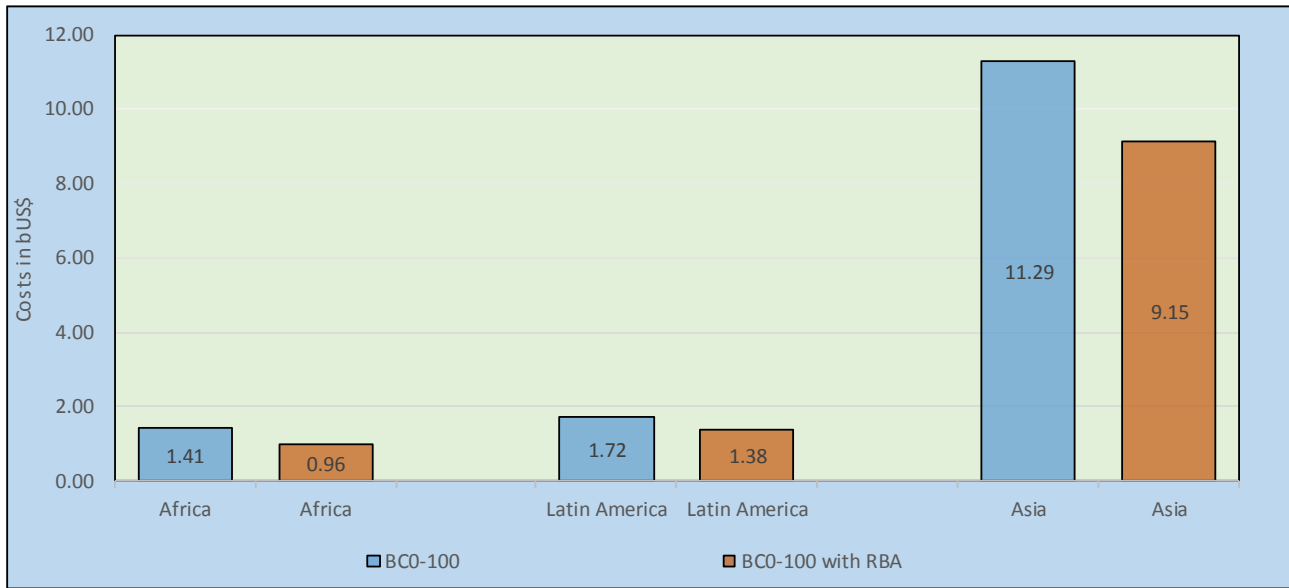
Source: Authors' own calculations

In the case of BC0-100 (no RBD) African operators need to offset 20.9% of their BaU emissions, which is lower than the global average of 25.7%. The lower obligation for African operators is related to the relatively large part of their operations taking place on the routes to and from the Lowest Emission States (i.e. route group D). As described above, in both GMBM options these routes are exempted from offset obligations (Table 1). The introduction of a RBD further reduces the share of emissions of African operators to be offset to 14.3%. The share of emissions to be offset for the other two operator regions is also reduced if a RBD is introduced.

We have also examined the cost of purchasing offsets per operator region. The results are presented in Figure 7. The results in Table 2 illustrate that for both GMBM options the total costs (across all routes and hence across all operators) amount to US\$ 50.4 billion for the period of 2021-2035. The distribution of the absolute costs for buying offsets across operator regions is different for the two GMBM options. For the three operator regions considered in this paper, the costs are reduced if a RBD is introduced. From the numbers in Figure 7, it follows that the reduction in costs amounts to:

- Africa US\$ 0.45 billion
- Latin America / Caribbean US\$ 0.35 billion
- Asia US\$ 2.14 billion.

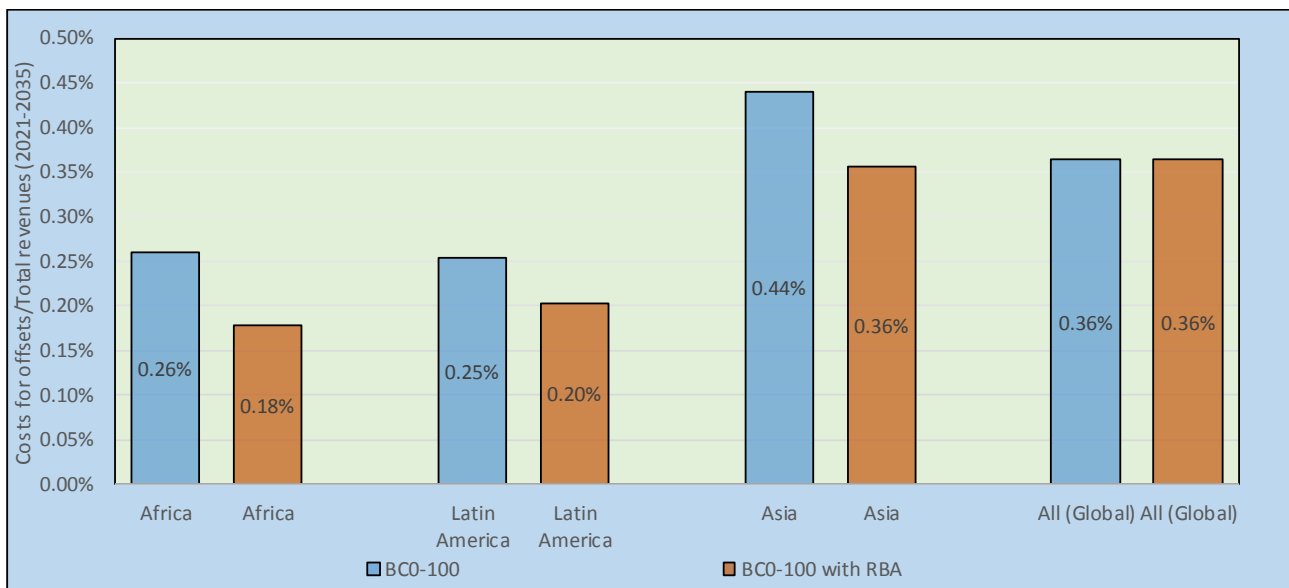
Figure 7: Costs to buy offsets (2021-2035) in US\$ billion per operator region for BC0-100 (100% sectoral rate) with and without RBD



Source: Authors' own calculations

Figure 8 expresses the costs to buy offsets as a percentage of total revenues. Since for all three operator regions the absolute costs for buying offsets are reduced if RBD is introduced, the costs as a percentage of total revenues are also reduced. For operators from other regions (in particular the EU and North America) the costs will increase in the case of RBD. Across all operators, the costs for buying offsets are 0.36% of total operating revenues in both GMBM options.

Figure 8: Costs to buy offsets (2021-2035) as percentage of total revenues per operator region for BC0-100 (100% sectoral rate) with and without RBD



Source: Authors' own calculations

Finally, Table 3 below presents the reduction of demand in terms of Revenue Tonne Km (RTK) on international flights per operator region for the period of 2021-2035. Generally, since the cost impacts are limited in relative terms, the impacts on demand are also limited (less than 0.5 %). For all three operator regions the demand impacts are even more limited if a RBD is introduced. This is because the offset costs – which are assumed to be passed through, causing higher fares – are also more limited in the case of the GMBM option with RBD.

Table 3: Reduction of RTK on international flights in 2021-2035 period per operator region for GMBM options (% reduction relative to BaU scenario)

Operator region	GMBM options	
	BC0-100	BC0-100 with RBD
Africa	0.18 %	0.12 %
Latin America	0.25 %	0.20 %
Asia	0.33 %	0.26 %
All (global)	0.34 %	0.34 %

Source: Authors' own calculations

5. Costs per offset generated

In a final step, costs induced by the GMBM should be compared with the amount of offsets which can be generated in the three developing country regions. This analysis draws on the Clean Development Mechanism (CDM) project pipelines provided and regularly updated by UNEP DTU (2015) and IGES (2015). Both databases are compiled from data provided in the project design document (PDD) of each CDM project. This data is complemented by information from other sources and the authors' own calculations and estimates based on UNEP DTU and IGES. The additional data provided in each of the databases is slightly different: IGES, for example, includes an estimate of the projected yearly Certified Emissions Reductions (CER) issuance per project ranging from 2000 to 2047, while UNEP DTU compares projected and actual issuance to calculate an issuance success rate, which was used to adjust the future CER supply potential. Therefore, both databases can be merged to one comprehensive database by referring to the unique number of each CDM project.

In addition to registered projects, the databases also include projects which are withdrawn, rejected or under validation. However, only registered projects are taken into account in this analysis. In order to provide a conservative estimate, the yearly supply potential estimated by IGES was adjusted according to the project-type specific issuance success rate. For project types for which it was not possible to determine an issuance success rate for statistical reasons, the overall average was applied. On average, actual issuance and thus the adjusted CER supply are about 15% lower than estimated in the PDDs. This estimate was used to determine the shares of the developing country regions in the additional offset supply induced through the GMBM, which was assumed to be equal to the aggregated offset demand over the period of 2021 to 2035 (Table 2).

Table 4 provides an overview of the results of this analysis. The aggregated costs induced by the GMBM for the developing country regions amount in total to US\$ 14.4 billion or US\$ 11.5 billion, depending on whether the GMBM is with or without RBD. In other words, costs of developing

country regions with RBD were on average 20 % lower than without RBD; in Africa they were even almost one third lower (-32 %).

Table 4: GMBM-induced costs, offset supply and threshold price aggregated from 2021 to 2035 per developing country region

	GMBM induced cost		Offset supply	Threshold price	
	w/o RBD	with RBD		w/o RBD	with RBD
	US\$ bn		Gt CER	US\$/t	
All countries	50.40	50.40			
Developing country regions (DCR)	14.42	11.49	3.11	4.64	3.69
Africa	1.41	0.96	0.08	17.63	12.00
Asia	11.29	9.15	2.63	4.29	3.48
Latin America / Caribbean	1.72	1.38	0.40	4.30	3.45
DCR w/o ZAF, CHN, BRA, CHI, MEX			3.11	4.64	3.69
Africa			0.33	4.27	2.91
Asia			2.00	5.65	4.58
Latin America / Caribbean			0.78	2.21	1.77

Source: Authors' own calculations based on AERO-MS, UNEP DTU (2015), IGES (2015)

The total additional offset supply from these regions aggregates to 3.11 Gt CERs. It is slightly lower than the aggregated demand because a small share of offsets will be generated in other regions. However, the potential supply is dominated by the largest suppliers, which are either in emerging economies or even members of OECD, namely South Africa (26 %), China (86 %) and Brazil (37 %), Chile (12 %) and Mexico (14 %). If these countries were excluded because their offset potential was deemed as part of their commitment under the Paris Agreement, the individual shares of the developing country regions in the potential offset supply would change considerably.

If the region-specific induced costs are divided by the potential offset supply, a price threshold can be calculated beyond which the regional revenues from offset projects were on average higher than the GMBM-induced costs, provided that all projected CERs were generated and sold as offsets. These threshold prices range from 4.64 US\$/t to 3.69 US\$/t on average, depending on whether the GMBM offset obligations are with RBD or not. These threshold prices indicate the GMBM-induced costs per CER. If the average revenues from selling the offsets are higher on average than these threshold prices, the respective region would net-profit from introducing the GMBM.

6. Supply-demand ratio

To examine whether a region would net-benefit from the introduction of a GMBM, the regional supply potential can be compared with the regional offset demand. Table 5 provides an overview of the respective supply-demand ratio per region.

Table 5: Offset demand, offset supply aggregated from 2021 to 2035 and the supply-demand ratio per developing country region

	Offset demand		Offset supply	Supply-demand ratio	
	w/o RBD	with RBD		w/o RBD	with RBD
	Gt		Gt CER	Gt/Gt	
All countries	3.19	3.19			
Developing country regions (DCR)	0.91	0.73	3.11	3.42	4.26
Africa	0.09	0.06	0.08	0.89	1.33
Asia	0.71	0.58	2.63	3.70	4.53
Latin America / Caribbean	0.11	0.09	0.40	3.64	4.44
DCR w/o ZAF, CHN, BRA, CHI, MEX			3.11	3.42	4.26
Africa			0.33	3.67	5.50
Asia			2.00	2.82	3.45
Latin America / Caribbean			0.78	7.09	8.67

Source: Authors' own calculations based on AERO-MS, UNEP DTU (2015), IGES (2015)

On average, the three developing country regions can generate 3.4 times more offset units than would be required to cover the offset demand from the respective region. If RBD were introduced, the ratio would even increase to 4.3. And even in Africa, the region with the smallest supply-demand ratios, one third more offsets could potentially be generated than would be required for covering the region's demand if RBD were introduced. If the emerging economies and OECD members were excluded, the ratios of Africa and Latin America / Caribbean increase, while Asia's ratio decreases but would still be significantly larger than its regional demand.

Usually the costs of generating an offset unit are on average lower than the offset price because otherwise there would be no incentives to invest in such mitigation projects. However, even if the cost of generating offsets equalled the offset price, the regions could net-benefit from introducing the GMBM because revenues from selling offset units would exceed the costs of purchasing offset units for the GMBM.

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