INTERNATIONAL CIVIL AVIATION ORGANIZATION

A United Nations Specialized Agency

ICAO Environment Advisory Group Meeting (EAG/15)
January 20-21, 2016

Agenda Item 1

Appendix: Supplemental Material

for

Results of Technical Analyses by CAEP

Presented by ICAO CAEP

Content

Appendix A: **Analysis of Route-Based Approach**

Appendix B: **Comparison of Schemes**

Analysis of Route-Based Approach

Tasks:

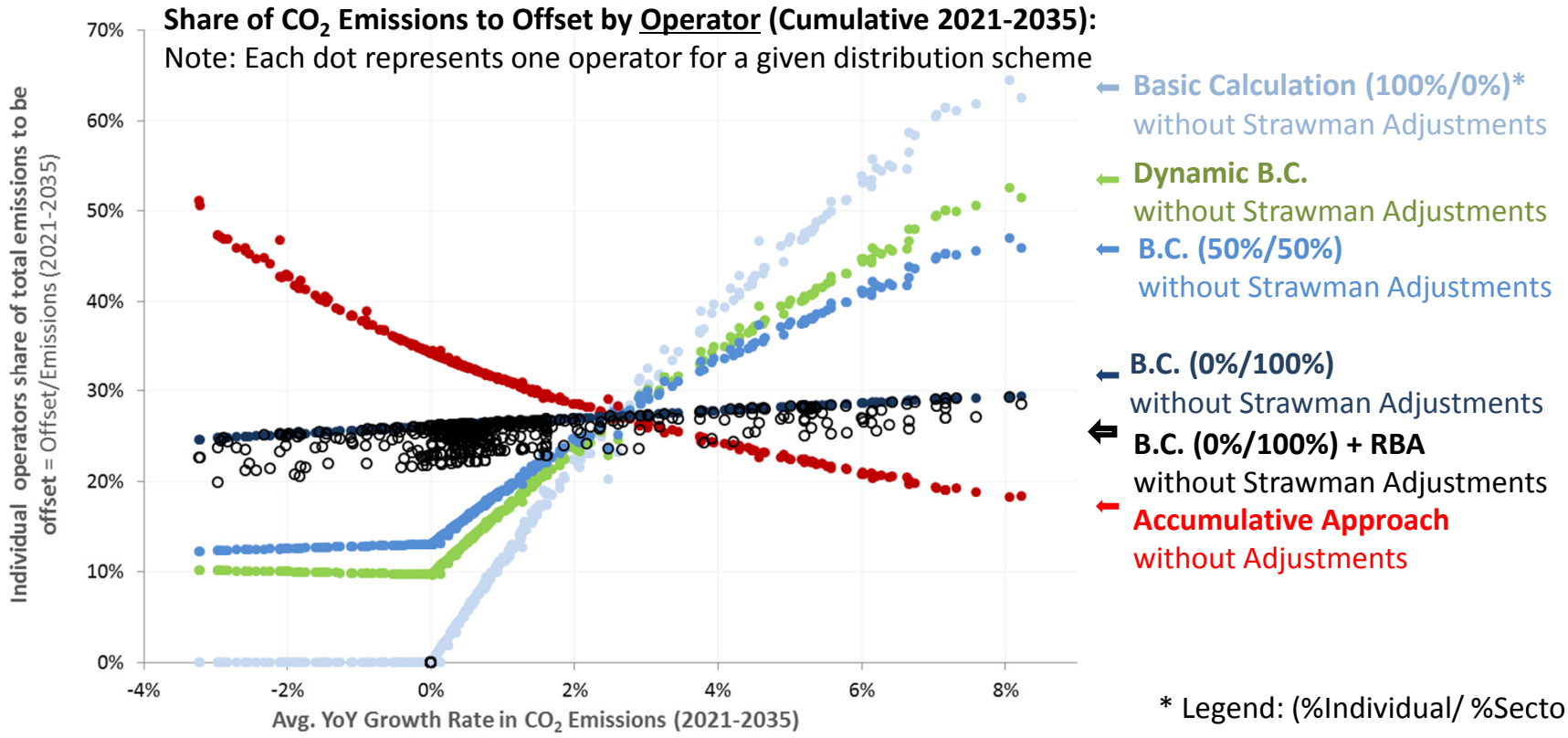
- Analyze alternative sequence of Lowest Emissions States, Operator Exemptions and Route Based Approach;
  - Separate LES Exemptions from the RBA/Phase In (i.e., Group D States) and apply the LES as an upstream step in the process for computing offset obligations (similar to Strawman implementation).
- Complete sensitivity of key results to changes to the threshold for the groups specified in WP/1 for each metric.
- Complete assessment of whether metrics and thresholds generate an incentive to reroute flights.

Alternative Sequence of Lowest Emissions States, Operator Exemptions and Route Based Approach

- The effects of sequences of LES, Operator Level Exemptions and Route Based Approach were discussed during the EAG/14 meeting.
- It was mentioned and proposed that the LES exemptions could be extracted from the RBA Phase In (i.e., Group D States).
- CAEP developed an alternative model and implementation of Route Based Approach with Phase In, where;
  - (1) LES are applied upstream (similar to Strawman),
  - (2) Operator level exemptions i.e., 10,000tCO_2 are then applied,
  - (3) Route Based Approach Phase In for Groups of States A, B and C –without group D- are applied downstream as an adjustment (similar to EAG/12 analyses)

Alternative Sequence of Lowest Emissions States, Operator Exemptions and Route Based Approach

- CAEP showed that an upstream application of LES and downstream application of RBA/Phase In was feasible.
- This approach results in an isolated effect of RBA/Phase In i.e., reductions in offset obligations solely due to RBA/Phase In.



* Legend: (%Individual/ %Sectoral)

Analysis of Route-Based Approach

Tasks:

- Analyze alternative sequence of Lowest Emissions States, Operator Exemptions and Route Based Approach;
  - Separate LES Exemptions from the RBA/Phase In (i.e., Group D States) and apply the LES as an upstream step in the process for computing offset obligations (similar to Strawman implementation).
- Complete sensitivity of key results to changes to the threshold for the groups specified in WP/1 for each metric.
- Complete assessment of whether metrics and thresholds generate an incentive to reroute flights.

Approach and Baseline Assumptions for Comparing Schemes with and without RBA

- To compare the schemes for distributing offsets with and without Route Based Approach, a baseline case was developed.
- Key assumptions include;
  - 100% Sectoral Basic Calculation – No phase in.
  - No Fast Grower Adjustments
  - No Early Mover Adjustments
  - Technical exemptions (same as Strawman V1.1)
  - Least Emitting States threshold set at 2.5%

Assumptions on Metrics and State Groupings

- EAG11-WP/1 proposed three metrics:
  - A combination of **CO_2** and **GNI/capita**
  - **CO_2** and **GDP**
  - **CO_2/(population/land area$^{1/2}$)** and **GDP/Population**
- …and dividing states into 4 groups (A,B,C and D) using thresholds specified in the working paper.
- Phase in profiles for routes based on the grouping of states were also specified
- Analysis for EAG/14 meeting focuses on understanding the effects of thresholds for defining groups of States A, B, C and D.

Assumptions on Changes to the Thresholds for the Groups Specified in WP/1 for Each Metric

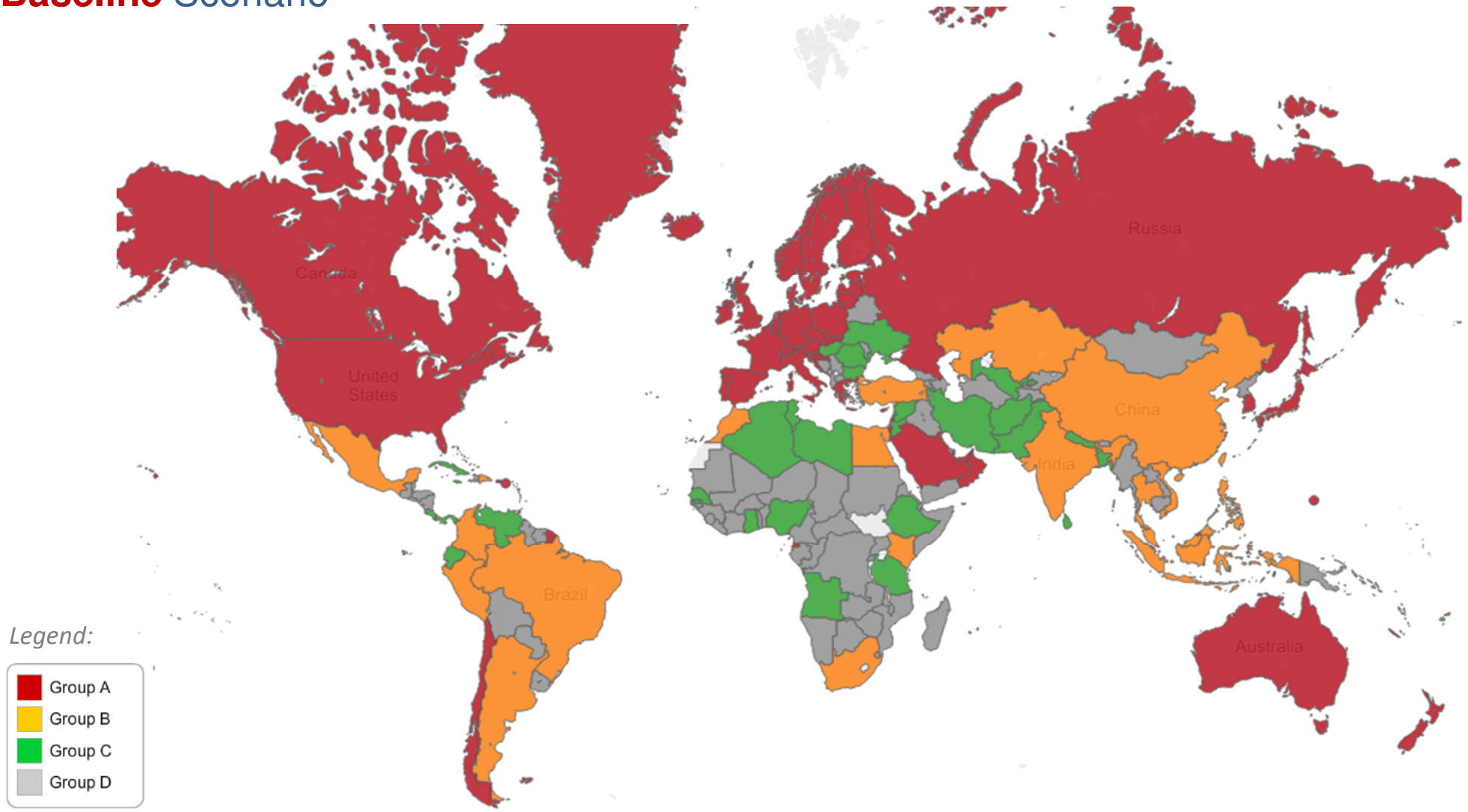
	Metric 1: CO_2 and GNI per Cap.			Metric 2.a: CO_2 and GDP			Metric 2.b: CO_2*$LA^{0.5}$/Pop. and GDP/Pop		
Scenario / Groups of States	**Less** Inclusive	**Baseline**	**More** Inclusive	**Less** Inclusive	**Baseline**	**More** Inclusive	**Less** Inclusive	**Baseline**	**More** Inclusive
Group A	World Bank Country and Lending Group			Cumulative Emissions greater than **35%**	Cumulative Emissions greater than **30%**	Cumulative Emissions greater than **25%**	Cumulative Emissions greater than **35%**	Cumulative Emissions greater than **30%**	Cumulative Emissions greater than **25%**
Group B	Not in Group A and above **12.5%**	Not in Group A and above **7.5%**	Not in Group A and above **2.5%**	Cumulative Emissions greater than **20%**	Cumulative Emissions greater than **15%**	Cumulative Emissions greater than **10%**	Cumulative Emissions greater than **20%**	Cumulative Emissions greater than **15%**	Cumulative Emissions greater than **10%**
Group C	between **12.5%** and **2.5%**	between **7.5%** and **2.5%**	**N/A**	Group C - States **not in group A, B or D**.					
Group D	Not in Group A and below **2.5%**			States **below the y =2.5%** Lowest Emissions States threshold					

Input: Metric #1 CO2 and GNI/Cap

ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive
ANTIGUA AND BARBUDA	A	A	A	UNITED ARAB EMIRATES	A	A	A	MALDIVES	C	C	B	MALI	D	D	D
AUSTRALIA	A	A	A	UNITED KINGDOM	A	A	A	SYRIAN ARAB REPUBLIC	C	C	B	MARSHALL ISLANDS	D	D	D
AUSTRIA	A	A	A	UNITED STATES	A	A	A	AFGHANISTAN	C	C	B	MAURITANIA	D	D	D
BAHAMAS	A	A	A	CHINA	B	B	B	NEPAL	C	C	B	MICRONESIA, FEDERATED STATES OF	D	D	D
BAHRAIN	A	A	A	INDIA	B	B	B	FIJI	C	C	B	MOLDOVA, REPUBLIC OF	D	D	D
BARBADOS	A	A	A	THAILAND	B	B	B	TANZANIA, UNITED REPUBLIC OF	C	C	B	MONGOLIA	D	D	D
BELGIUM	A	A	A	TURKEY	B	B	B	ALBANIA	D	D	D	MONTENEGRO	D	D	D
BRUNEI DARUSSALAM	A	A	A	MALAYSIA	B	B	B	ARMENIA	D	D	D	MOZAMBIQUE	D	D	D
CANADA	A	A	A	BRAZIL	B	B	B	AZERBAIJAN	D	D	D	NAMIBIA	D	D	D
CHILE	A	A	A	MEXICO	B	B	B	BELARUS	D	D	D	NICARAGUA	D	D	D
CROATIA	A	A	A	SOUTH AFRICA	B	B	B	BELIZE	D	D	D	NIGER	D	D	D
CYPRUS	A	A	A	EGYPT	B	B	B	BENIN	D	D	D	PALAU	D	D	D
CZECH REPUBLIC	A	A	A	INDONESIA	C	B	B	BHUTAN	D	D	D	PAPUA NEW GUINEA	D	D	D
DENMARK	A	A	A	ARGENTINA	C	B	B	BOLIVIA	D	D	D	PARAGUAY	D	D	D
EQUATORIAL GUINEA	A	A	A	PHILIPPINES	C	B	B	BOSNIA AND HERZEGOVINA	D	D	D	RWANDA	D	D	D
ESTONIA	A	A	A	KAZAKHSTAN	C	B	B	BOTSWANA	D	D	D	SAINT LUCIA	D	D	D
FINLAND	A	A	A	KENYA	C	B	B	BURKINA FASO	D	D	D	SAINT VINCENT AND THE GRENADINES	D	D	D
FRANCE	A	A	A	MOROCCO	C	B	B	BURUNDI	D	D	D	SAMOA	D	D	D
GERMANY	A	A	A	VIET NAM	C	B	B	CAMBODIA	D	D	D	SAO TOME AND PRINCIPE	D	D	D
GREECE	A	A	A	COLOMBIA	C	B	B	CAMEROON	D	D	D	SERBIA	D	D	D
ICELAND	A	A	A	PERU	C	B	B	CAPE VERDE	D	D	D	SEYCHELLES	D	D	D
IRELAND	A	A	A	DOMINICAN REPUBLIC	C	B	B	CENTRAL AFRICAN REPUBLIC	D	D	D	SIERRA LEONE	D	D	D
ISRAEL	A	A	A	PAKISTAN	C	C	B	CHAD	D	D	D	SOLOMON ISLANDS	D	D	D
ITALY	A	A	A	NIGERIA	C	C	B	COMOROS	D	D	D	SUDAN	D	D	D
JAPAN	A	A	A	BANGLADESH	C	C	B	CONGO, THE DEMOCRATIC REPUBLIC (	D	D	D	SURINAME	D	D	D
KOREA, REPUBLIC OF	A	A	A	UZBEKISTAN	C	C	B	`	D	D	D	SWAZILAND	D	D	D
KUWAIT	A	A	A	VENEZUELA	C	C	B	DJIBOUTI	D	D	D	TAJIKISTAN	D	D	D
LATVIA	A	A	A	PANAMA	C	C	B	EL SALVADOR	D	D	D	TOGO	D	D	D
LITHUANIA	A	A	A	CUBA	C	C	B	ERITREA	D	D	D	TONGA	D	D	D
LUXEMBOURG	A	A	A	UKRAINE	C	C	B	GABON	D	D	D	TURKMENISTAN	D	D	D
MALTA	A	A	A	JORDAN	C	C	B	GAMBIA	D	D	D	UGANDA	D	D	D
NETHERLANDS	A	A	A	SRI LANKA	C	C	B	GEORGIA	D	D	D	URUGUAY	D	D	D
NEW ZEALAND	A	A	A	ETHIOPIA	C	C	B	GRENADA	D	D	D	VANUATU	D	D	D
NORWAY	A	A	A	LEBANON	C	C	B	GUATEMALA	D	D	D	YEMEN	D	D	D
OMAN	A	A	A	TUNISIA	C	C	B	GUINEA	D	D	D	ZAMBIA	D	D	D
POLAND	A	A	A	ROMANIA	C	C	B	GUINEA-BISSAU	D	D	D	ZIMBABWE	D	D	D
PORTUGAL	A	A	A	IRAN, ISLAMIC REPUBLIC OF	C	C	B	GUYANA	D	D	D	CONGO	D	D	D
QATAR	A	A	A	SENEGAL	C	C	B	HAITI	D	D	D	COOK ISLANDS	D	D	D
RUSSIAN FEDERATION	A	A	A	LIBYAN ARAB JAMAHIRIYA	C	C	B	HONDURAS	D	D	D	DOMINICA	D	D	D
SAINT KITTS AND NEVIS	A	A	A	MAURITIUS	C	C	B	IRAQ	D	D	D	KOREA, DEMOCRATIC PEOPLE'S REPUB	D	D	D
SAUDI ARABIA	A	A	A	HUNGARY	C	C	B	KIRIBATI	D	D	D	MYANMAR	D	D	D
SINGAPORE	A	A	A	ANGOLA	C	C	B	KYRGYZSTAN	D	D	D	NAURU	D	D	D
SLOVAKIA	A	A	A	ECUADOR	C	C	B	LAO PEOPLE'S DEMOCRATIC REPUBLIC	D	D	D	SOMALIA	D	D	D
SLOVENIA	A	A	A	JAMAICA	C	C	B	LESOTHO	D	D	D	TIMOR-LESTE	D	D	D
SPAIN	A	A	A	ALGERIA	C	C	B	LIBERIA	D	D	D	TUVALU	D	D	D
SWEDEN	A	A	A	COSTA RICA	C	C	B	MACEDONIA, THE FORMER YUGOSLAV	D	D	D				
SWITZERLAND	A	A	A	BULGARIA	C	C	B	MADAGASCAR	D	D	D				
TRINIDAD AND TOBAGO	A	A	A	GHANA	C	C	B	MALAWI	D	D	D				

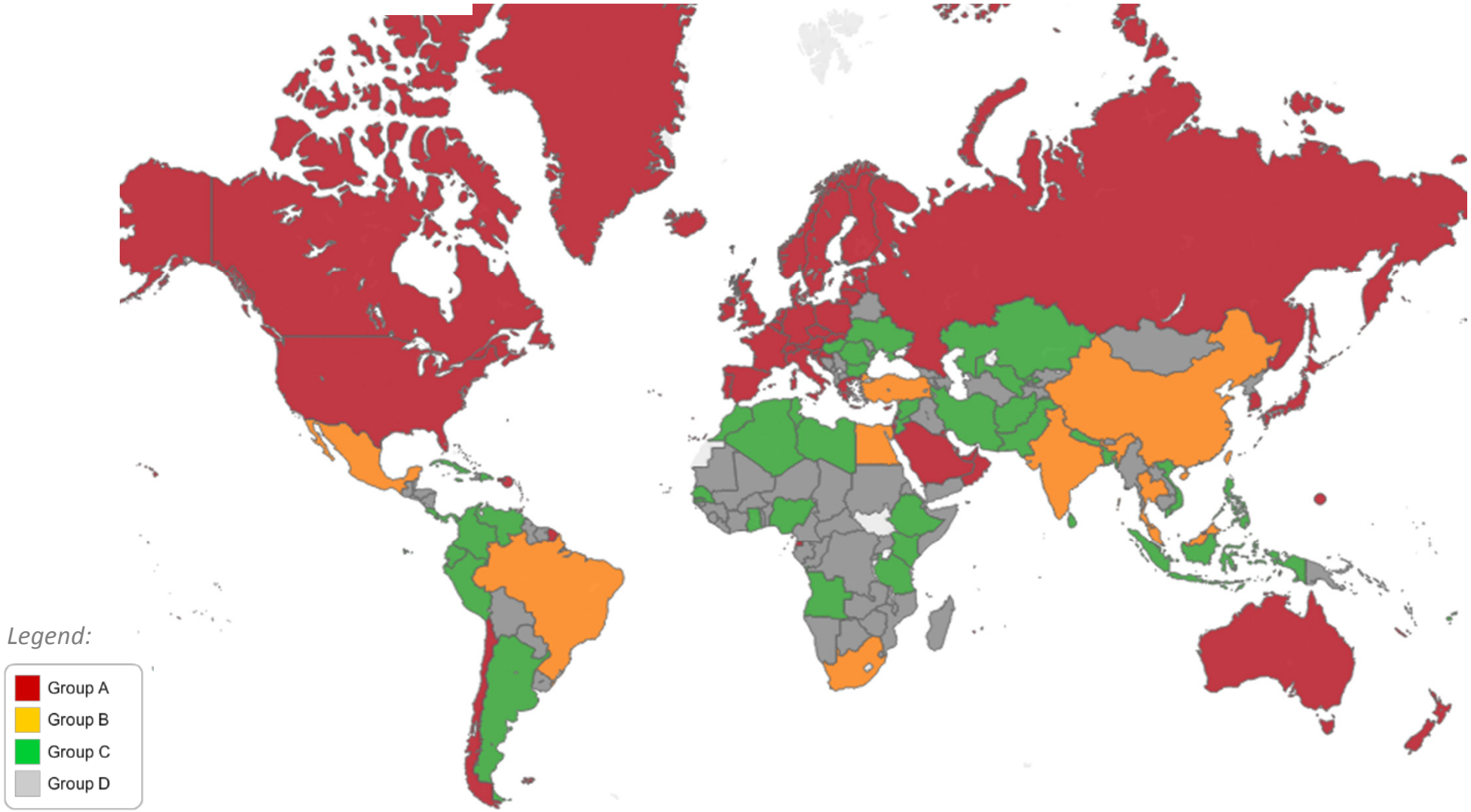
Input: Metric #1 CO2 and GNI/Cap

Baseline Scenario



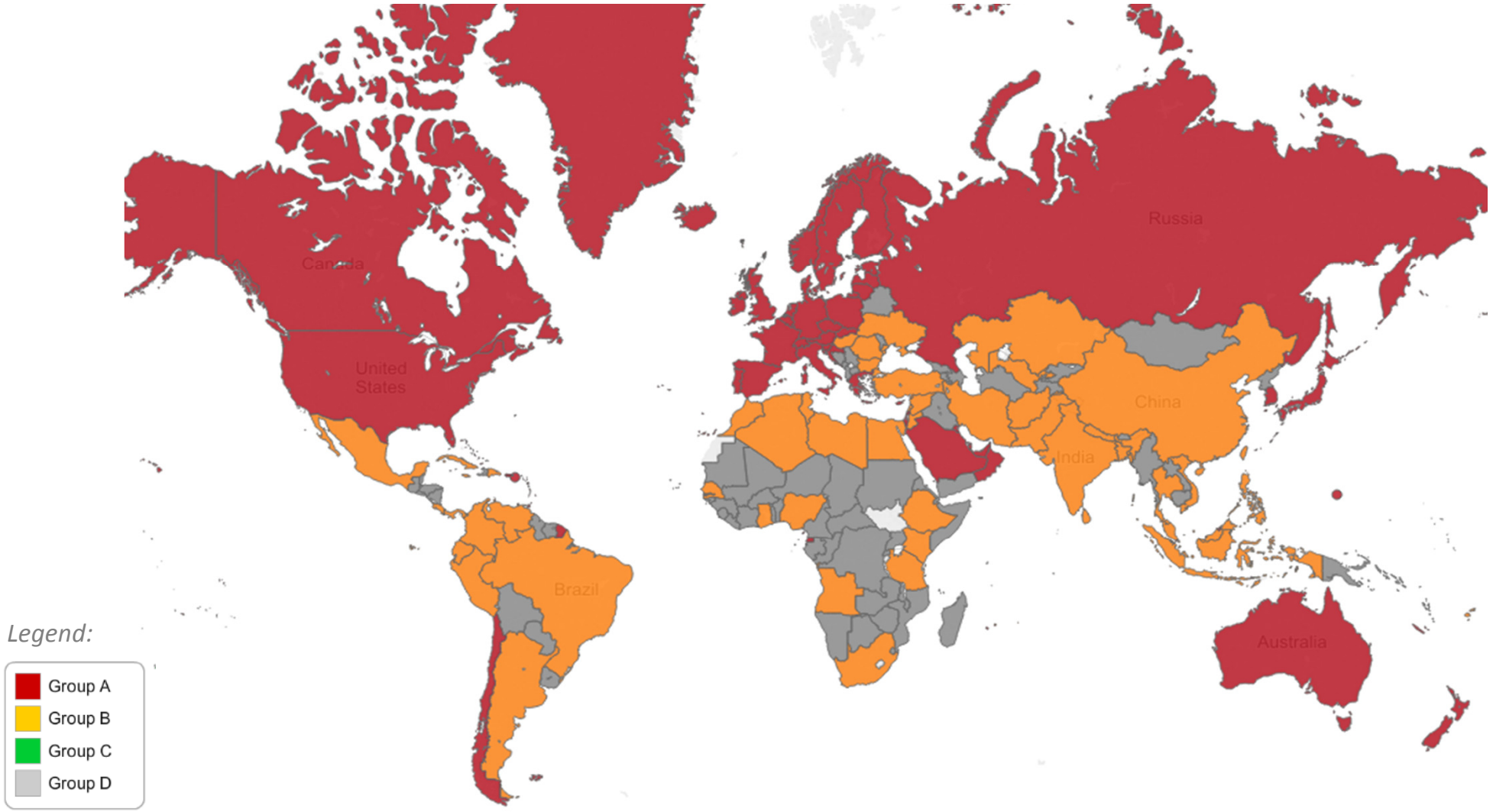
Input: Metric #1 CO2 and GNI/Cap

Less Inclusive Scenario



Input: Metric #1 CO2 and GNI/Cap

More Inclusive Scenario

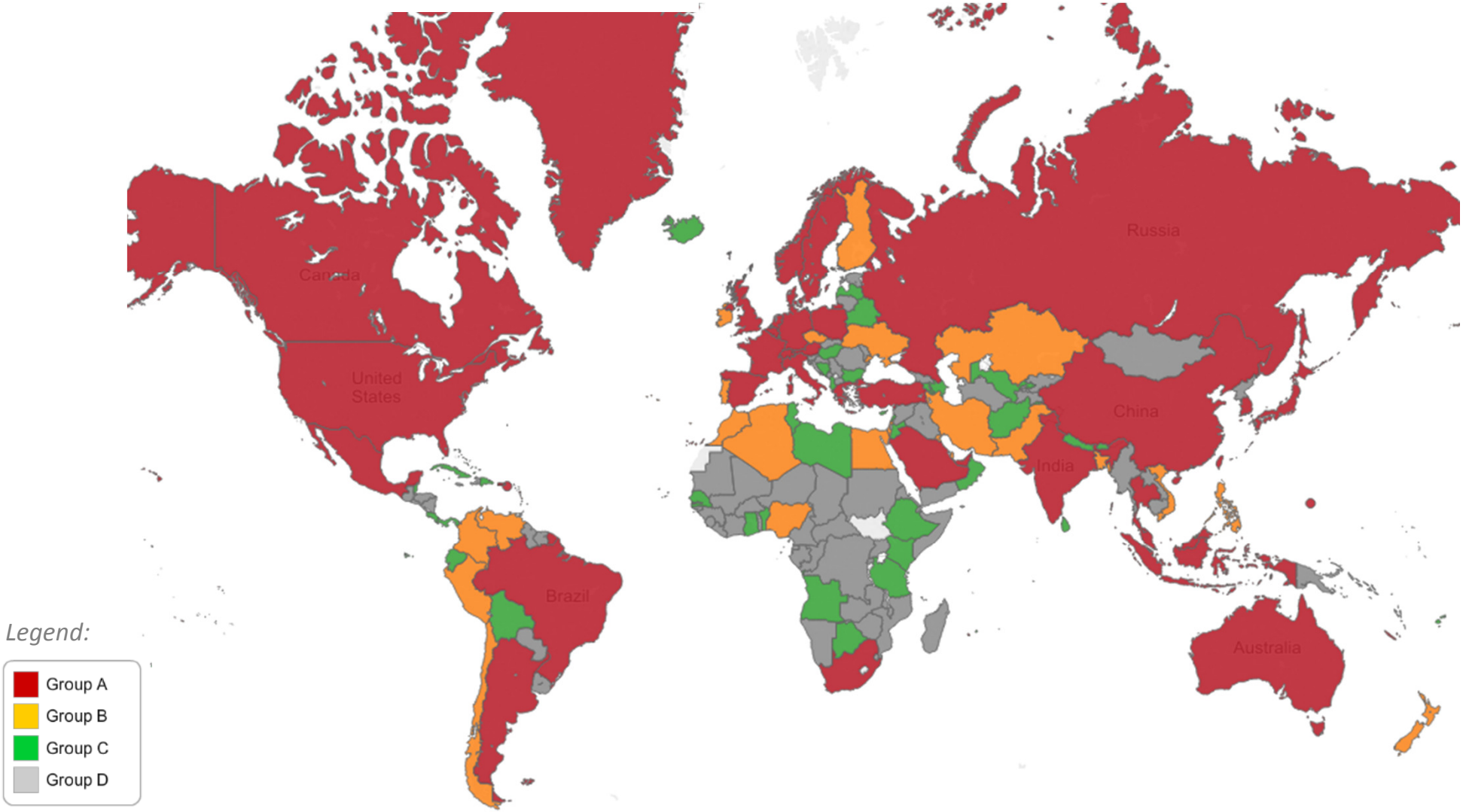


Input: Metric #2.a CO2 and GDP

ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive
UNITED STATES	A	A	A	PERU	C	B	B	BOLIVIA	C	C	C	MOZAMBIQUE	D	D	D
CHINA	A	A	A	KAZAKHSTAN	C	B	B	BOSNIA AND HERZEGOVINA	C	C	C	NAMIBIA	D	D	D
JAPAN	A	A	A	KUWAIT	C	B	B	BOTSWANA	C	C	C	NICARAGUA	D	D	D
GERMANY	A	A	A	VIET NAM	C	B	B	BRUNEI DARUSSALAM	C	C	C	NIGER	D	D	D
UNITED KINGDOM	A	A	A	MOROCCO	C	B	B	BURKINA FASO	D	D	D	PALAU	D	D	D
FRANCE	A	A	A	BANGLADESH	C	B	B	BURUNDI	D	D	D	PAPUA NEW GUINEA	D	D	D
ITALY	A	A	A	UKRAINE	C	B	B	CAMBODIA	D	D	D	PARAGUAY	D	D	D
SPAIN	A	A	A	ALGERIA	C	B	B	CAMEROON	D	D	D	RWANDA	D	D	D
CANADA	A	A	A	HUNGARY	C	C	B	CAPE VERDE	D	D	D	SAINT KITTS AND NEVIS	D	D	D
INDIA	A	A	A	DOMINICAN REPUBLIC	C	C	B	CENTRAL AFRICAN REPUBLIC	D	D	D	SAINT LUCIA	D	D	D
KOREA, REPUBLIC OF	A	A	A	CUBA	C	C	B	CHAD	D	D	D	SAINT VINCENT AND THE GRENAD	D	D	D
AUSTRALIA	A	A	A	LUXEMBOURG	C	C	B	COMOROS	D	D	D	SAMOA	D	D	D
BRAZIL	A	A	A	LIBYAN ARAB JAMAHIRIYA	C	C	B	CONGO, THE DEMOCRATIC REPUB	D	D	D	SAO TOME AND PRINCIPE	D	D	D
RUSSIAN FEDERATION	A	A	A	ANGOLA	C	C	B	COTE D'IVOIRE	D	D	D	SERBIA	D	D	D
NETHERLANDS	A	A	A	TUNISIA	C	C	B	CROATIA	D	D	D	SEYCHELLES	D	D	D
MEXICO	A	A	A	ECUADOR	C	C	C	DJIBOUTI	D	D	D	SIERRA LEONE	D	D	D
TURKEY	A	A	A	OMAN	C	C	C	EL SALVADOR	D	D	D	SLOVAKIA	D	D	D
UNITED ARAB EMIRATES	A	A	A	KENYA	C	C	C	EQUATORIAL GUINEA	D	D	D	SLOVENIA	D	D	D
SAUDI ARABIA	A	A	A	SRI LANKA	C	C	C	ERITREA	D	D	D	SOLOMON ISLANDS	D	D	D
SWITZERLAND	A	A	A	BAHRAIN	C	C	C	ESTONIA	D	D	D	SUDAN	D	D	D
BELGIUM	A	A	A	LEBANON	C	C	C	GABON	D	D	D	SURINAME	D	D	D
THAILAND	A	A	A	BULGARIA	C	C	C	GAMBIA	D	D	D	SWAZILAND	D	D	D
SOUTH AFRICA	A	A	A	UZBEKISTAN	C	C	C	GEORGIA	D	D	D	TAJIKISTAN	D	D	D
INDONESIA	A	A	A	PANAMA	C	C	C	GRENADA	D	D	D	TOGO	D	D	D
SINGAPORE	A	A	A	ETHIOPIA	C	C	C	GUATEMALA	D	D	D	TONGA	D	D	D
SWEDEN	A	A	A	COSTA RICA	C	C	C	GUINEA	D	D	D	TRINIDAD AND TOBAGO	D	D	D
ARGENTINA	A	A	A	CYPRUS	C	C	C	GUINEA-BISSAU	D	D	D	TURKMENISTAN	D	D	D
POLAND	A	A	A	JORDAN	C	C	C	GUYANA	D	D	D	UGANDA	D	D	D
MALAYSIA	B	A	A	TANZANIA, UNITED REPUBLIC OF	C	C	C	HAITI	D	D	D	URUGUAY	D	D	D
AUSTRIA	B	A	A	GHANA	C	C	C	HONDURAS	D	D	D	VANUATU	D	D	D
DENMARK	B	A	A	ICELAND	C	C	C	IRAQ	D	D	D	YEMEN	D	D	D
GREECE	B	A	A	SENEGAL	C	C	C	KIRIBATI	D	D	D	ZAMBIA	D	D	D
NORWAY	B	A	A	LATVIA	C	C	C	KYRGYZSTAN	D	D	D	ZIMBABWE	D	D	D
PORTUGAL	B	B	A	AFGHANISTAN	C	C	C	LAO PEOPLE'S DEMOCRATIC REPU	D	D	D	ROMANIA	D	D	D
IRELAND	B	B	A	MAURITIUS	C	C	C	LESOTHO	D	D	D	JAMAICA	D	D	D
ISRAEL	B	B	A	NEPAL	C	C	C	LIBERIA	D	D	D	SYRIAN ARAB REPUBLIC	D	D	D
EGYPT	B	B	A	BARBADOS	C	C	C	LITHUANIA	D	D	D	CONGO	D	D	D
FINLAND	B	B	A	FIJI	C	C	C	MACEDONIA, THE FORMER YUGO	D	D	D	MYANMAR	D	D	D
QATAR	B	B	B	MALDIVES	C	C	C	MADAGASCAR	D	D	D	COOK ISLANDS	D	D	D
PHILIPPINES	B	B	B	ALBANIA	C	C	C	MALAWI	D	D	D	SOMALIA	D	D	D
COLOMBIA	B	B	B	ANTIGUA AND BARBUDA	C	C	C	MALI	D	D	D	TIMOR-LESTE	D	D	D
IRAN, ISLAMIC REPUBLIC OF	B	B	B	ARMENIA	C	C	C	MALTA	D	D	D	KOREA, DEMOCRATIC PEOPLE'S RI	D	D	D
NEW ZEALAND	B	B	B	AZERBAIJAN	C	C	C	MARSHALL ISLANDS	D	D	D	DOMINICA	D	D	D
NIGERIA	B	B	B	BAHAMAS	C	C	C	MAURITANIA	D	D	D	NAURU	D	D	D
CHILE	B	B	B	BELARUS	C	C	C	MICRONESIA, FEDERATED STATES	D	D	D	TUVALU	D	D	D
VENEZUELA	B	B	B	BELIZE	C	C	C	MOLDOVA, REPUBLIC OF	D	D	D				
PAKISTAN	B	B	B	BENIN	C	C	C	MONGOLIA	D	D	D				
CZECH REPUBLIC	C	B	B	BHUTAN	C	C	C	MONTENEGRO	D	D	D				

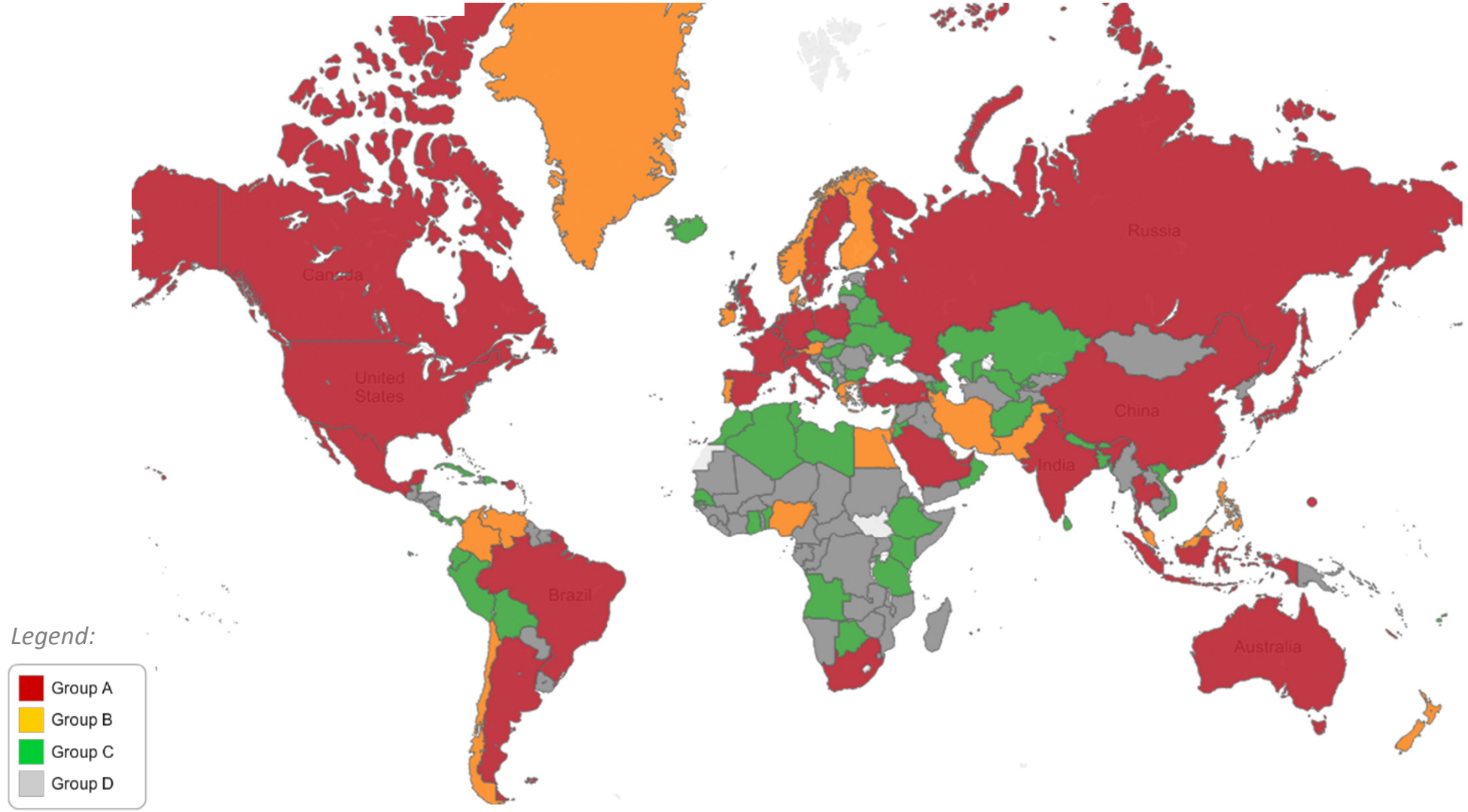
Input: Metric #2.a CO2 and GDP

Baseline Scenario



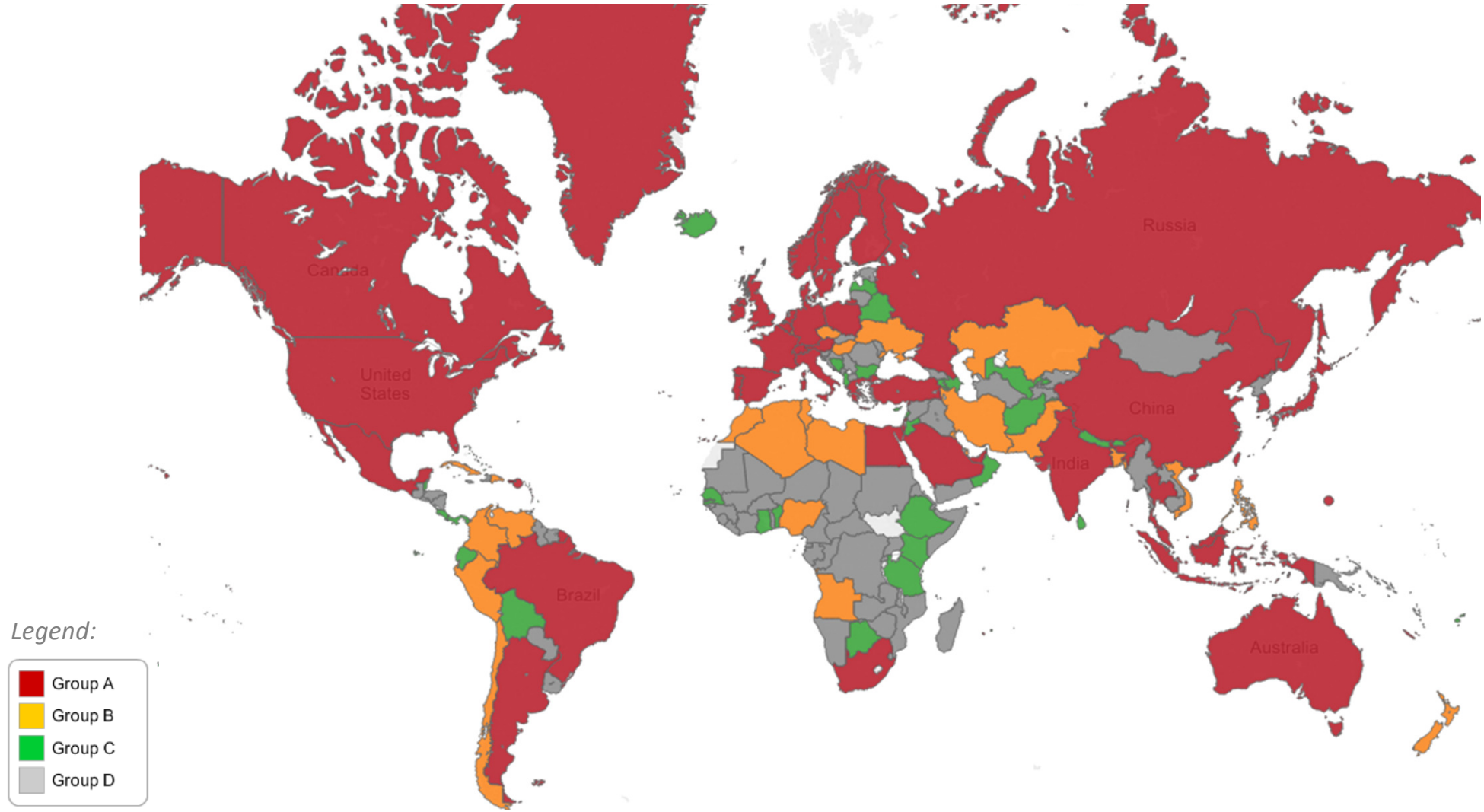
Input: Metric #2.a CO2 and GDP

Less Inclusive Scenario



Input: Metric #2.a CO2 and GDP

More Inclusive Scenario

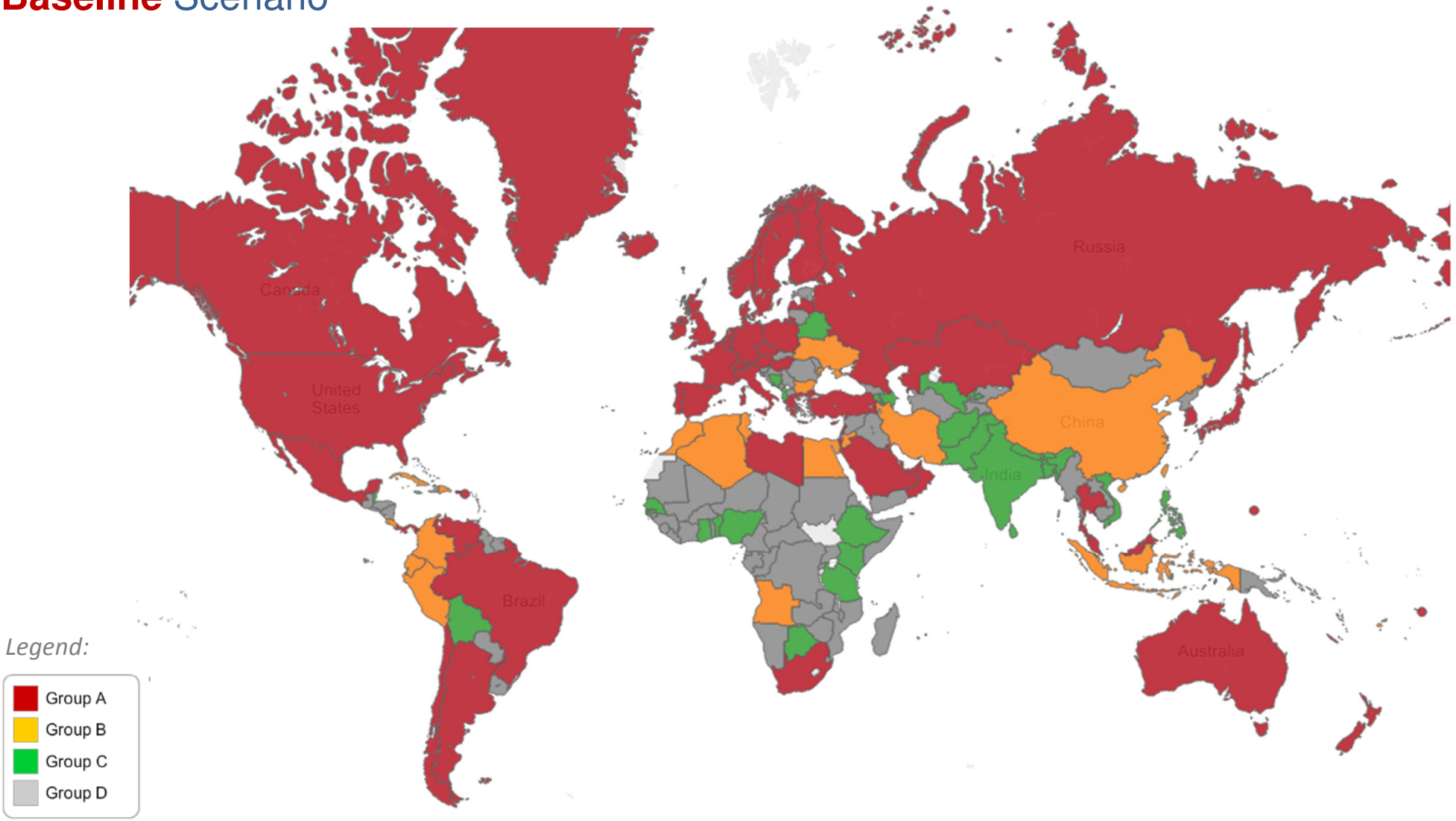


Input: Metric #2.b CO2/(Pop* LA$^{0.5}$) and GDP/Cap

ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive	ICAO Member State	Less Inclusive	Baseline	More Inclusive
AUSTRALIA	A	A	A	HUNGARY	A	A	A	BOLIVIA	C	C	C	MOZAMBIQUE	D	D	D
UNITED STATES	A	A	A	THAILAND	A	A	A	BOSNIA AND HERZEGOVINA	C	C	C	NAMIBIA	D	D	D
CANADA	A	A	A	VENEZUELA	A	A	A	BOTSWANA	C	C	C	NICARAGUA	D	D	D
ICELAND	A	A	A	LEBANON	A	A	A	BRUNEI DARUSSALAM	C	C	C	NIGER	D	D	D
QATAR	A	A	A	CHINA	B	B	A	BURKINA FASO	D	D	D	PALAU	D	D	D
LUXEMBOURG	A	A	A	PERU	B	B	B	BURUNDI	D	D	D	PAPUA NEW GUINEA	D	D	D
NORWAY	A	A	A	MAURITIUS	B	B	B	CAMBODIA	D	D	D	PARAGUAY	D	D	D
UNITED ARAB EMIRATES	A	A	A	COSTA RICA	B	B	B	CAMEROON	D	D	D	RWANDA	D	D	D
UNITED KINGDOM	A	A	A	FIJI	B	B	B	CAPE VERDE	D	D	D	SAINT KITTS AND NEVIS	D	D	D
SWITZERLAND	A	A	A	DOMINICAN REPUBLIC	B	B	B	CENTRAL AFRICAN REPUBLIC	D	D	D	SAINT LUCIA	D	D	D
SWEDEN	A	A	A	CUBA	B	B	B	CHAD	D	D	D	SAINT VINCENT AND THE GRENAD	D	D	D
NEW ZEALAND	A	A	A	COLOMBIA	B	B	B	COMOROS	D	D	D	SAMOA	D	D	D
GERMANY	A	A	A	MALDIVES	B	B	B	CONGO, THE DEMOCRATIC REPUB	D	D	D	SAO TOME AND PRINCIPE	D	D	D
FINLAND	A	A	A	TUNISIA	B	B	B	COTE D'IVOIRE	D	D	D	SERBIA	D	D	D
FRANCE	A	A	A	BULGARIA	B	B	B	CROATIA	D	D	D	SEYCHELLES	D	D	D
IRELAND	A	A	A	JORDAN	B	B	B	DJIBOUTI	D	D	D	SIERRA LEONE	D	D	D
NETHERLANDS	A	A	A	ANGOLA	B	B	B	EL SALVADOR	D	D	D	SLOVAKIA	D	D	D
DENMARK	A	A	A	ALGERIA	B	B	B	EQUATORIAL GUINEA	D	D	D	SLOVENIA	D	D	D
SPAIN	A	A	A	MOROCCO	C	B	B	ERITREA	D	D	D	SOLOMON ISLANDS	D	D	D
AUSTRIA	A	A	A	ECUADOR	C	B	B	ESTONIA	D	D	D	SUDAN	D	D	D
JAPAN	A	A	A	EGYPT	C	B	B	GABON	D	D	D	SURINAME	D	D	D
BELGIUM	A	A	A	IRAN, ISLAMIC REPUBLIC OF	C	B	B	GAMBIA	D	D	D	SWAZILAND	D	D	D
SAUDI ARABIA	A	A	A	UKRAINE	C	B	B	GEORGIA	D	D	D	TAJIKISTAN	D	D	D
ITALY	A	A	A	INDONESIA	C	B	B	GRENADA	D	D	D	TOGO	D	D	D
SINGAPORE	A	A	A	PHILIPPINES	C	C	B	GUATEMALA	D	D	D	TONGA	D	D	D
KUWAIT	A	A	A	SRI LANKA	C	C	B	GUINEA	D	D	D	TRINIDAD AND TOBAGO	D	D	D
GREECE	A	A	A	SENEGAL	C	C	B	GUINEA-BISSAU	D	D	D	TURKMENISTAN	D	D	D
OMAN	A	A	A	UZBEKISTAN	C	C	B	GUYANA	D	D	D	UGANDA	D	D	D
KOREA, REPUBLIC OF	A	A	A	INDIA	C	C	C	HAITI	D	D	D	URUGUAY	D	D	D
PORTUGAL	A	A	A	KENYA	C	C	C	HONDURAS	D	D	D	VANUATU	D	D	D
CYPRUS	A	A	A	VIET NAM	C	C	C	IRAQ	D	D	D	YEMEN	D	D	D
ISRAEL	A	A	A	NIGERIA	C	C	C	KIRIBATI	D	D	D	ZAMBIA	D	D	D
LIBYAN ARAB JAMAHIRIYA	A	A	A	GHANA	C	C	C	KYRGYZSTAN	D	D	D	ZIMBABWE	D	D	D
RUSSIAN FEDERATION	A	A	A	PAKISTAN	C	C	C	LAO PEOPLE'S DEMOCRATIC REPU	D	D	D	CONGO	D	D	D
BAHRAIN	A	A	A	AFGHANISTAN	C	C	C	LESOTHO	D	D	D	COOK ISLANDS	D	D	D
ARGENTINA	A	A	A	TANZANIA, UNITED REPUBLIC OF	C	C	C	LIBERIA	D	D	D	DOMINICA	D	D	D
MALAYSIA	A	A	A	NEPAL	C	C	C	LITHUANIA	D	D	D	JAMAICA	D	D	D
BARBADOS	A	A	A	ETHIOPIA	C	C	C	MACEDONIA, THE FORMER YUGO	D	D	D	KOREA, DEMOCRATIC PEOPLE'S RI	D	D	D
CHILE	A	A	A	BANGLADESH	C	C	C	MADAGASCAR	D	D	D	MYANMAR	D	D	D
TURKEY	A	A	A	ALBANIA	C	C	C	MALAWI	D	D	D	NAURU	D	D	D
KAZAKHSTAN	A	A	A	ANTIGUA AND BARBUDA	C	C	C	MALI	D	D	D	ROMANIA	D	D	D
CZECH REPUBLIC	A	A	A	ARMENIA	C	C	C	MALTA	D	D	D	SOMALIA	D	D	D
MEXICO	A	A	A	AZERBAIJAN	C	C	C	MARSHALL ISLANDS	D	D	D	SYRIAN ARAB REPUBLIC	D	D	D
SOUTH AFRICA	A	A	A	BAHAMAS	C	C	C	MAURITANIA	D	D	D	TIMOR-LESTE	D	D	D
BRAZIL	A	A	A	BELARUS	C	C	C	MICRONESIA, FEDERATED STATES	D	D	D	TUVALU	D	D	D
PANAMA	A	A	A	BELIZE	C	C	C	MOLDOVA, REPUBLIC OF	D	D	D				
POLAND	A	A	A	BENIN	C	C	C	MONGOLIA	D	D	D				
LATVIA	A	A	A	BHUTAN	C	C	C	MONTENEGRO	D	D	D				

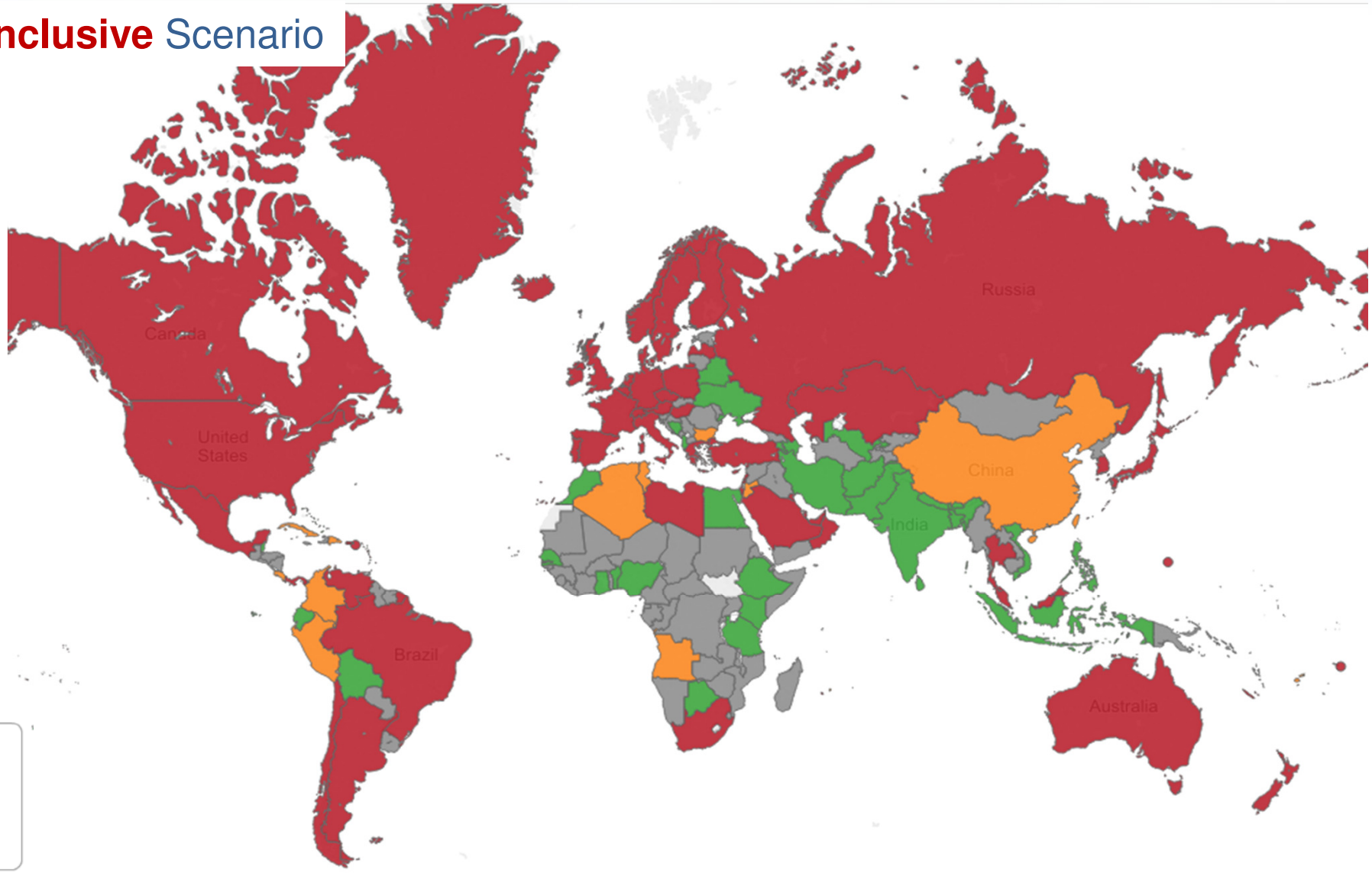
Input: Metric #2.b CO2/(Pop* LA$^{0.5}$) and GDP/Cap

Baseline Scenario



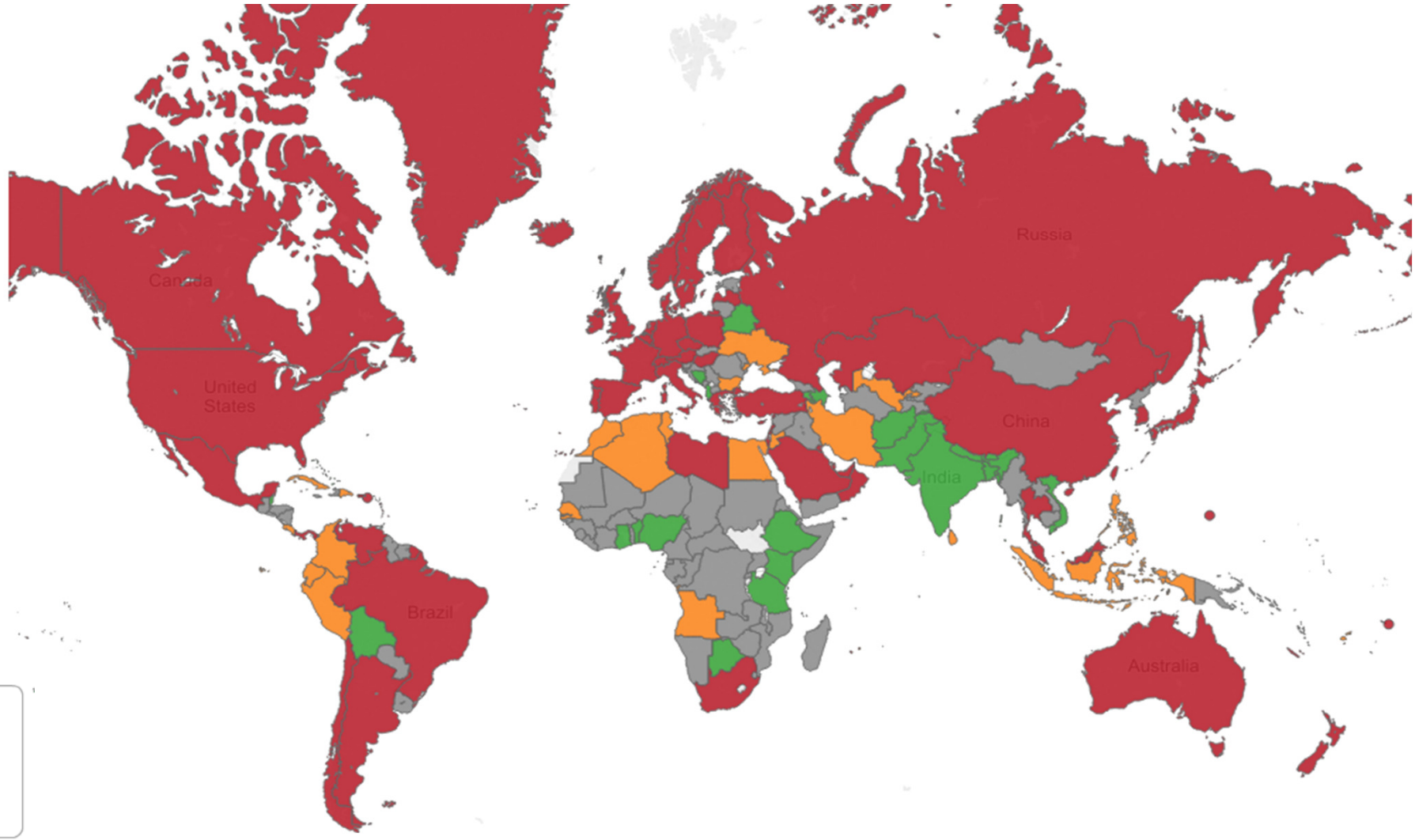
Input: Metric #2.b CO2/(Pop* LA$^{0.5}$) and GDP/Cap

Less Inclusive Scenario



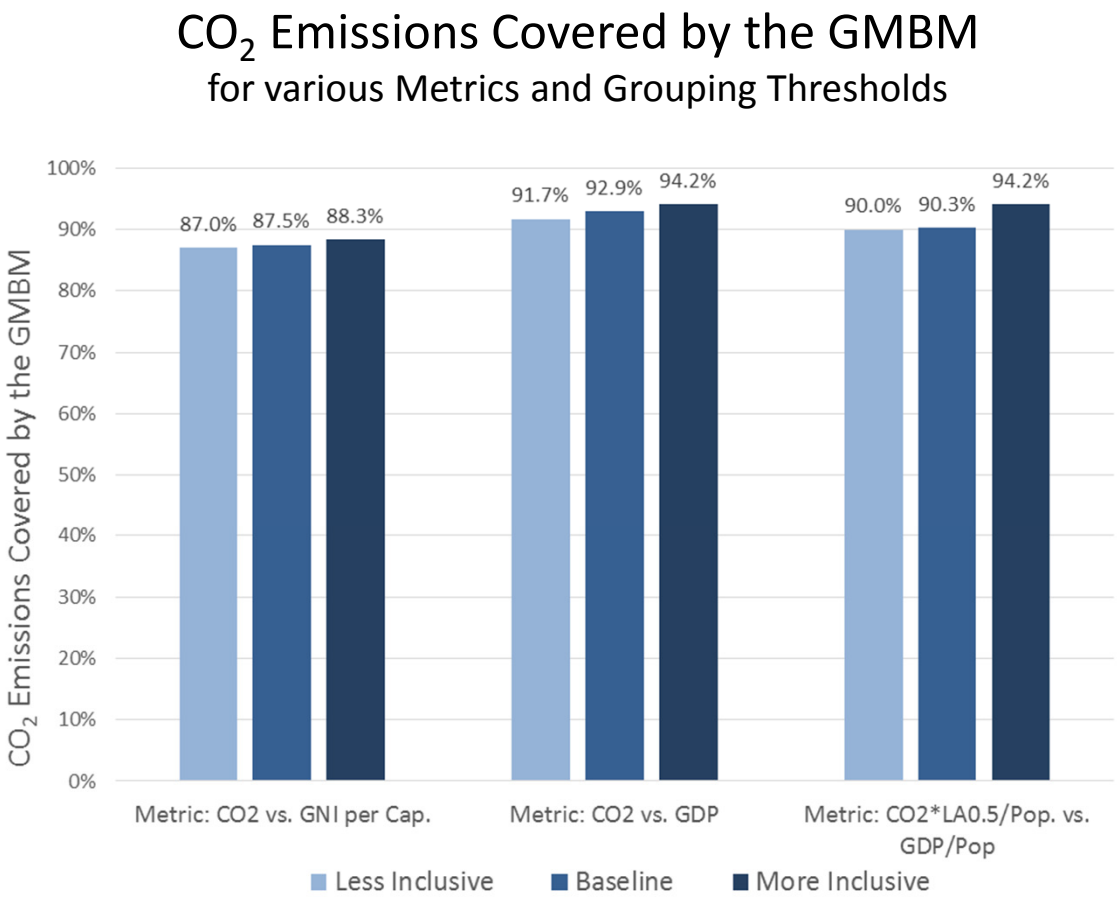
Input: Metric #2.b CO2/(Pop* LA$^{0.5}$) and GDP/Cap

More Inclusive Scenario



Sensitivity of Key Results to Changes to the Threshold for the Groups Specified in WP/1 for Each Metric.

- Changes in threshold values to determine groups of States generally has marginal influence on total CO_2 Emissions covered by the GMBM.
- Influence depends on metric (i.e., State rankings) and whether some large emitting States cross the thresholds.
- All operators (aggregated by their State of registration) experience a decrease/increase of offset obligations from the baseline case;
  - Metric 1: -4% to 5%
  - Metric 2a: -11% to 14%
  - Metric 2b: -5% to 9%



Content

Appendix A: **Analysis of Route-Based Approach**

Appendix B: **Comparison of Schemes**

Comparison of Schemes

Tasks:

- Continue to analyze potential market distortion across schemes for distributing offset obligations.

- Complete the assessment of complexity of the schemes
  (illustrate and assess complexity against other dimensions of complexity e.g., monitoring/data collection, reporting/data sharing, computational, mitigation of missing data/reports, cost from MRV).

- Summary of Comparison of Schemes

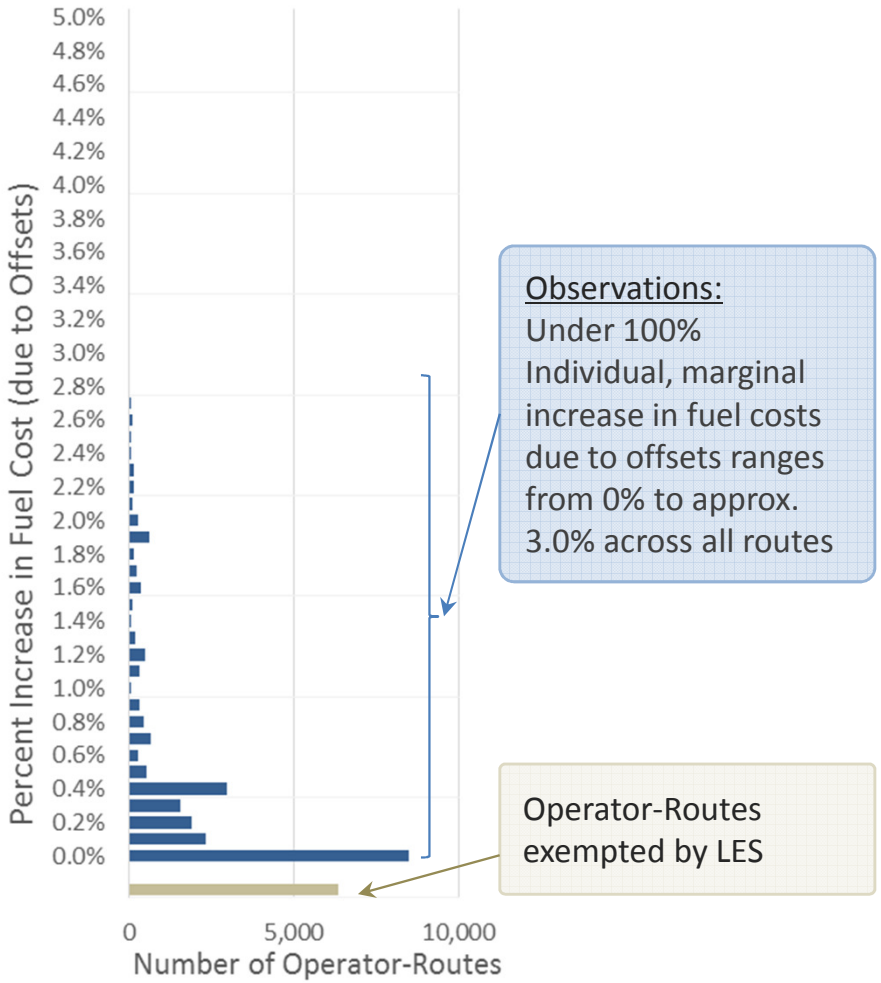
Background & Approach

- To assess potential difference in cost across schemes for distributing offset obligations, CAEP analyzed and compared the cost of offset obligations relative to fuel costs for 3225 State-to-state pair routes and for over 820 operators.
- Metric of cost of offset obligations relative to fuel costs was derived from assuming $/tCO$_2$ for offsets and $/gallon of Jet Fuel (consistent with prior CAEP modeling assumptions for GMBM).
- Tracked relative cost impacts across approx. 29,000 operator-routes.
- Note: Operator's offset obligations on specific route was allocated proportionally to operator's share of emissions on route vs. its total emissions in same year.

Illustration: Basic Calculation 100%/0% and 0%/100%

- Results across 29,000 operator-routes for two sample schemes

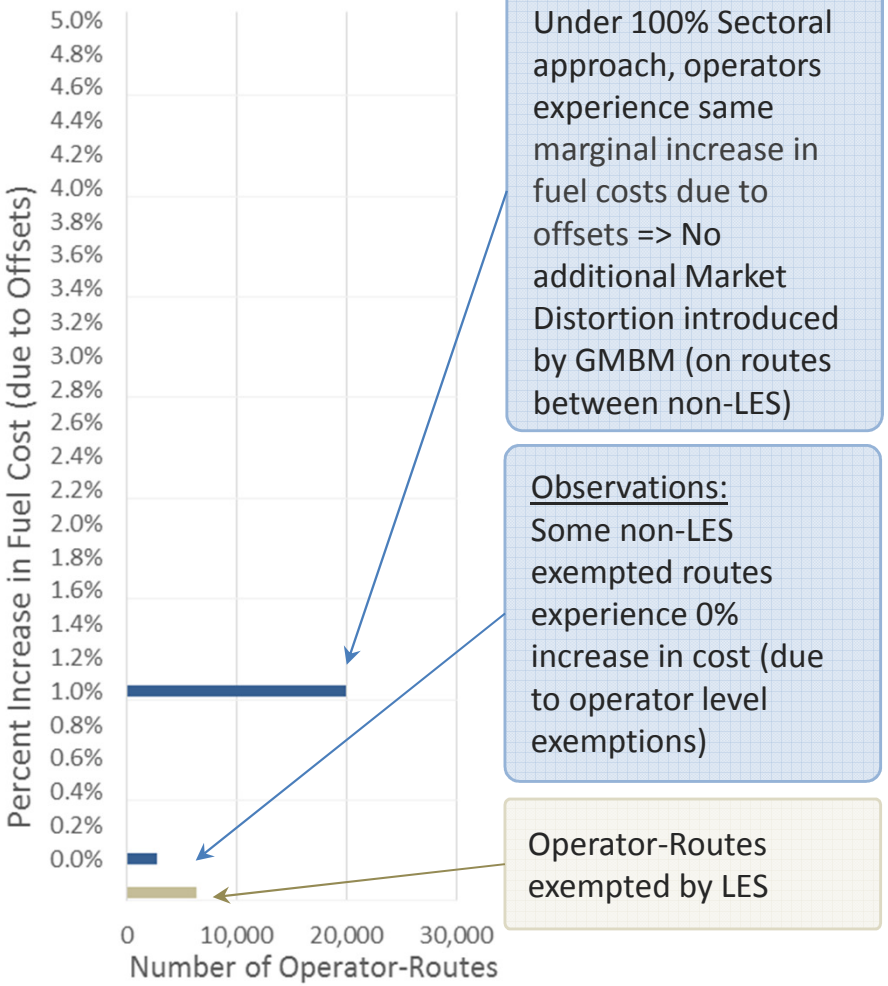
Basic Calculation
100% / 0% w/o Adjustments



Observations:
Under 100% Individual, marginal increase in fuel costs due to offsets ranges from 0% to approx. 3.0% across all routes

Operator-Routes exempted by LES

Basic Calculation
0% / 100% w/o Adjustments



Observations:
Under 100% Sectoral approach, operators experience same marginal increase in fuel costs due to offsets => No additional Market Distortion introduced by GMBM (on routes between non-LES)

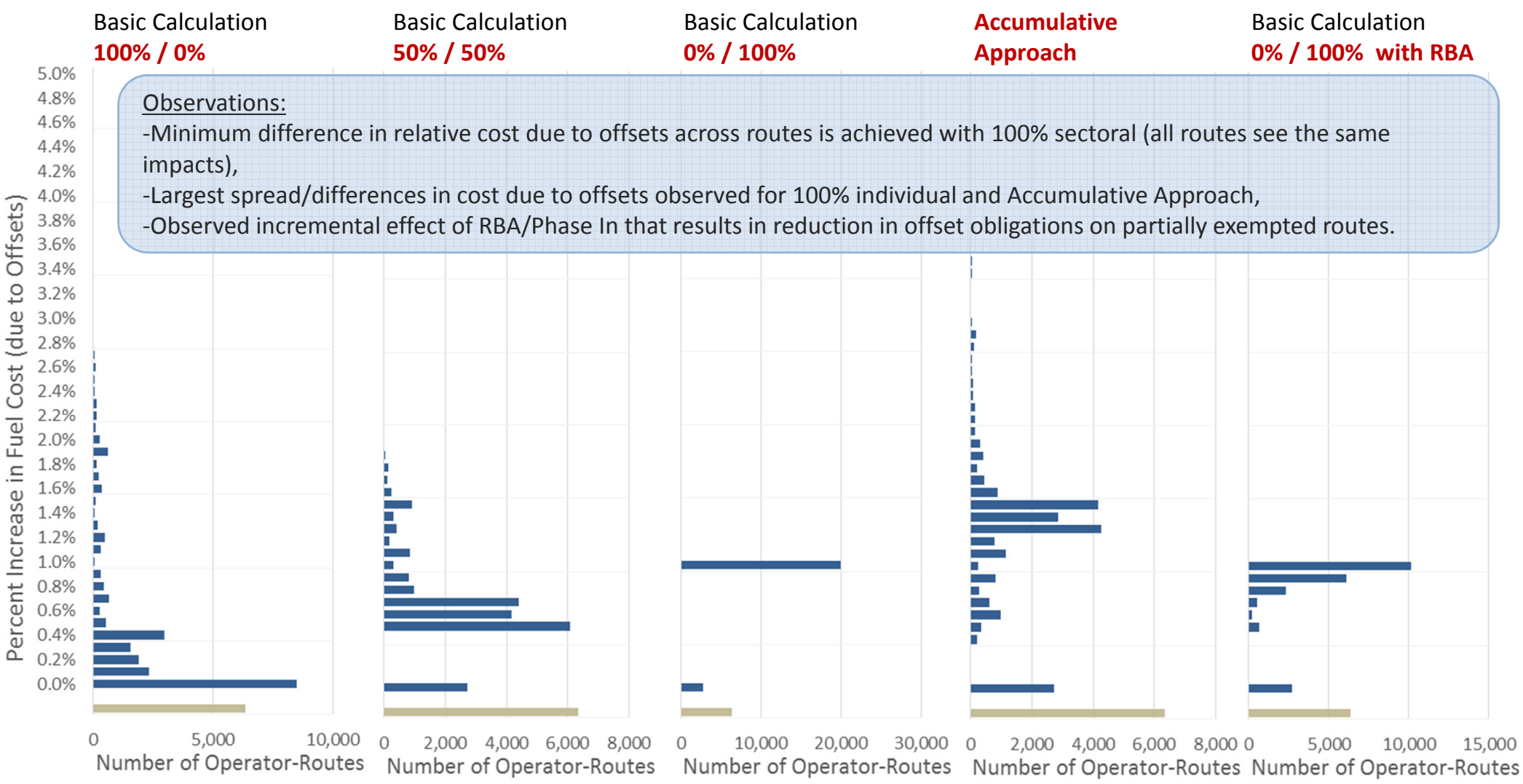
Observations:
Some non-LES exempted routes experience 0% increase in cost (due to operator level exemptions)

Operator-Routes exempted by LES

Assumptions for Illustration: Year 2025, Unit Cost of Fuel: 3.0 $/gallon, Unit Cost of Carbon: 15 $/tCO$_2$

Market Distortion across Schemes for Distributing Offset Obligations

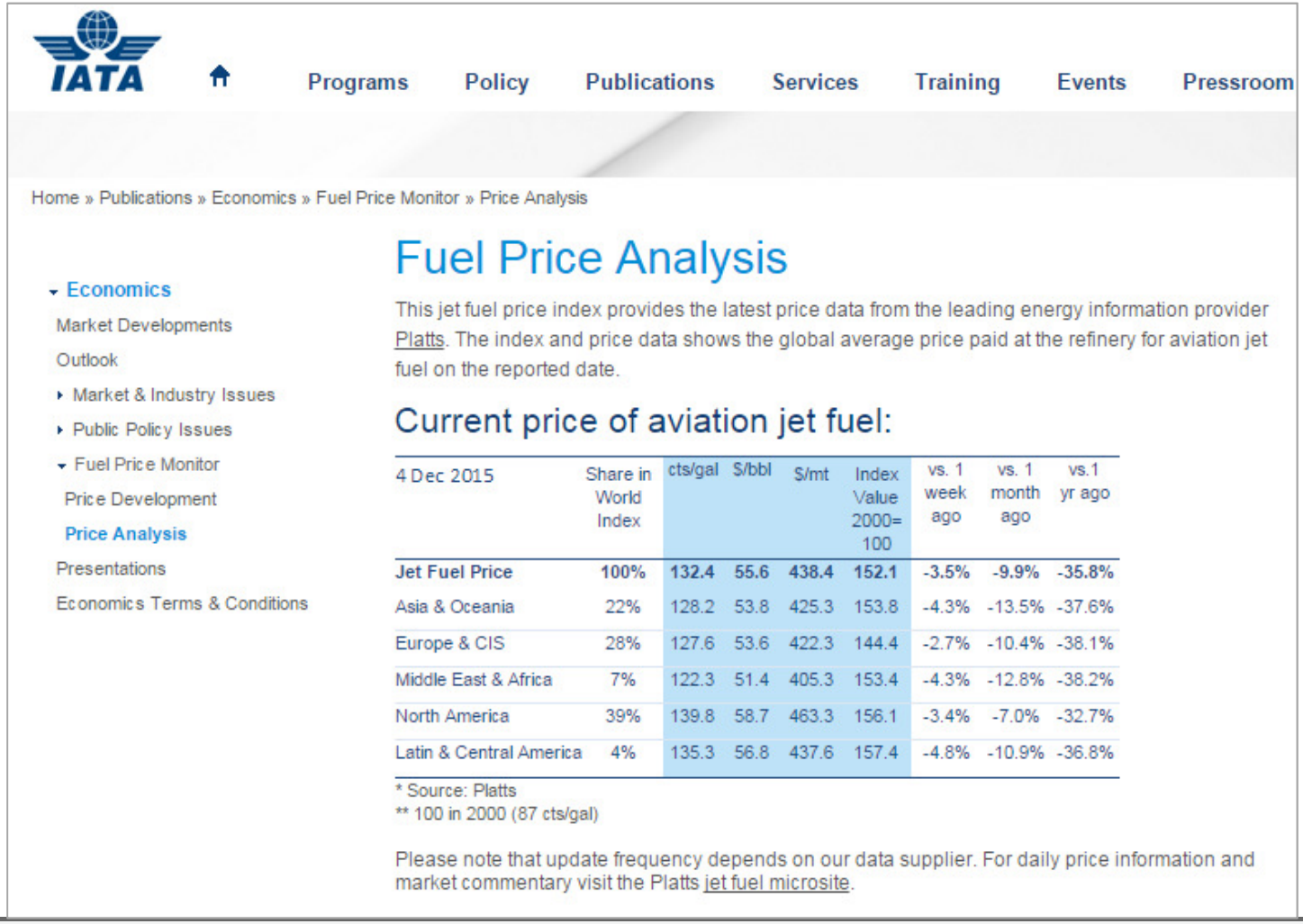
- Summary of cost of offset relative to fuel cost across approx. 29,000 operator-routes



Assumptions for Illustration: Year 2025, Unit Cost of Fuel: 3.0 $/gallon, Unit Cost of Carbon: 15 $/$tCO_2$, RBA/Phase In: Metric 2b and Attribution Profile 3bB, Assumes no FG and EM adjustments

Putting GMBM Related Market Distortion in the Context of Existing Difference in Fuel Costs

- Unit fuel costs varies across world regions.
- As of Dec 4 2015, unit fuel costs ranged from -8% to +6% around average global price.



IATA Programs Policy Publications Services Training Events Pressroom

Home » Publications » Economics » Fuel Price Monitor » Price Analysis

- Economics
  - Market Developments
  - Outlook
  - Market & Industry Issues
  - Public Policy Issues
  - Fuel Price Monitor
    - Price Development
    - Price Analysis
  - Presentations
  - Economics Terms & Conditions

Fuel Price Analysis

This jet fuel price index provides the latest price data from the leading energy information provider Platts. The index and price data shows the global average price paid at the refinery for aviation jet fuel on the reported date.

Current price of aviation jet fuel:

4 Dec 2015	Share in World Index	cts/gal	$/bbl	$/mt	Index Value 2000=100	vs. 1 week ago	vs. 1 month ago	vs.1 yr ago
Jet Fuel Price	**100%**	**132.4**	**55.6**	**438.4**	**152.1**	**-3.5%**	**-9.9%**	**-35.8%**
Asia & Oceania	22%	128.2	53.8	425.3	153.8	-4.3%	-13.5%	-37.6%
Europe & CIS	28%	127.6	53.6	422.3	144.4	-2.7%	-10.4%	-38.1%
Middle East & Africa	7%	122.3	51.4	405.3	153.4	-4.3%	-12.8%	-38.2%
North America	39%	139.8	58.7	463.3	156.1	-3.4%	-7.0%	-32.7%
Latin & Central America	4%	135.3	56.8	437.6	157.4	-4.8%	-10.9%	-36.8%

* Source: Platts
** 100 in 2000 (87 cts/gal)

Please note that update frequency depends on our data supplier. For daily price information and market commentary visit the Platts jet fuel microsite.

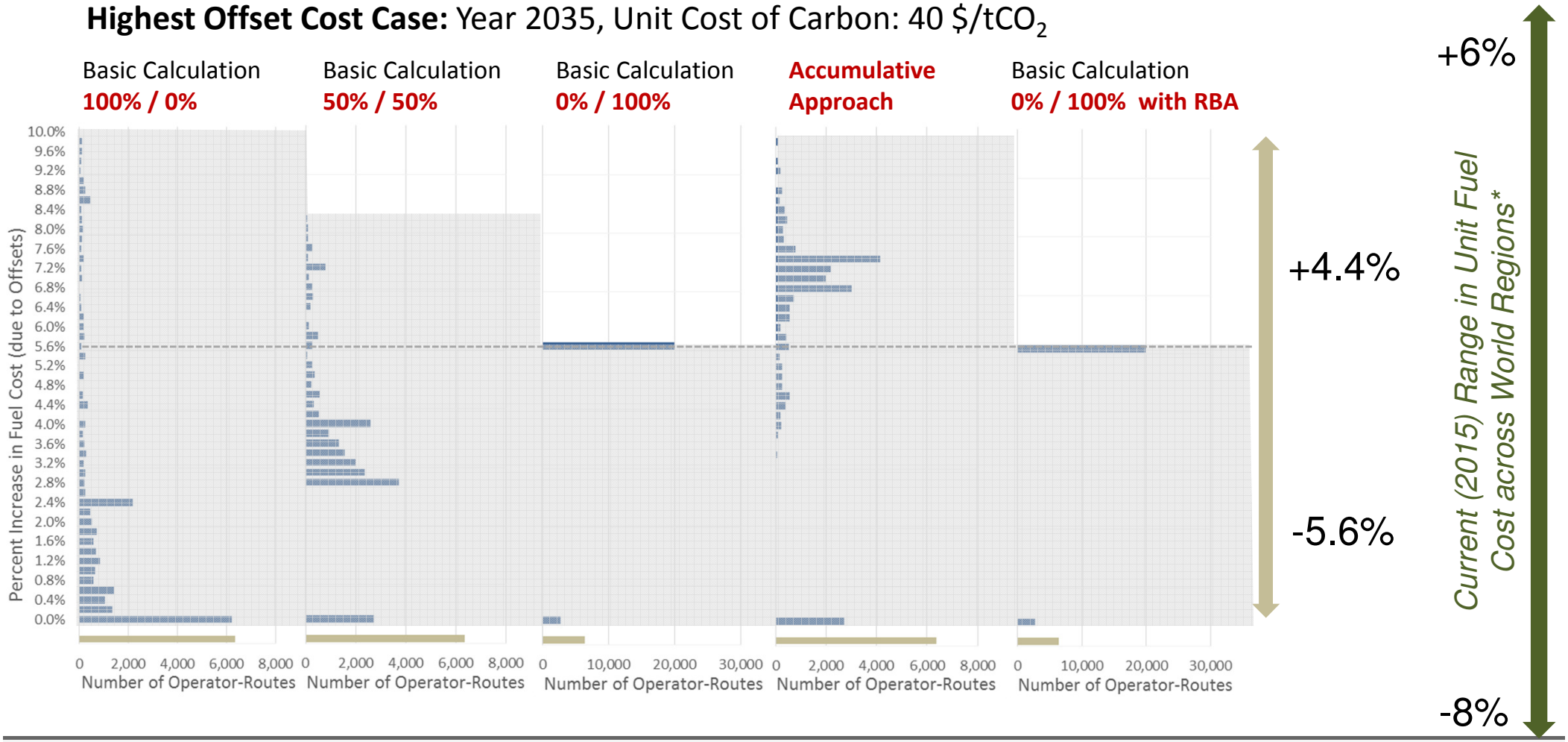
	cts/gal	Difference from Average
Average Jet Fuel Price	132.4	0%
Asia & Oceania	128.2	-3%
Europe & CIS	127.6	-4%
Middle East & Africa	122.3	**-8%**
North America	139.8	**6%**
Latin & Central America	135.3	2%

*** IATA, "**Fuel Price Analysis", Source: http://www.iata.org/publications/economics/fuel-monitor/Pages/price-analysis.aspx

Putting GMBM Related Market Distortion in the Context of Existing Differences in Fuel Costs

- Differences in relative fuel cost from offsets due to differentiation from the GMBM is within the current range in unit fuel costs across world regions.

Highest Offset Cost Case: Year 2035, Unit Cost of Carbon: 40 $/tCO$_2$

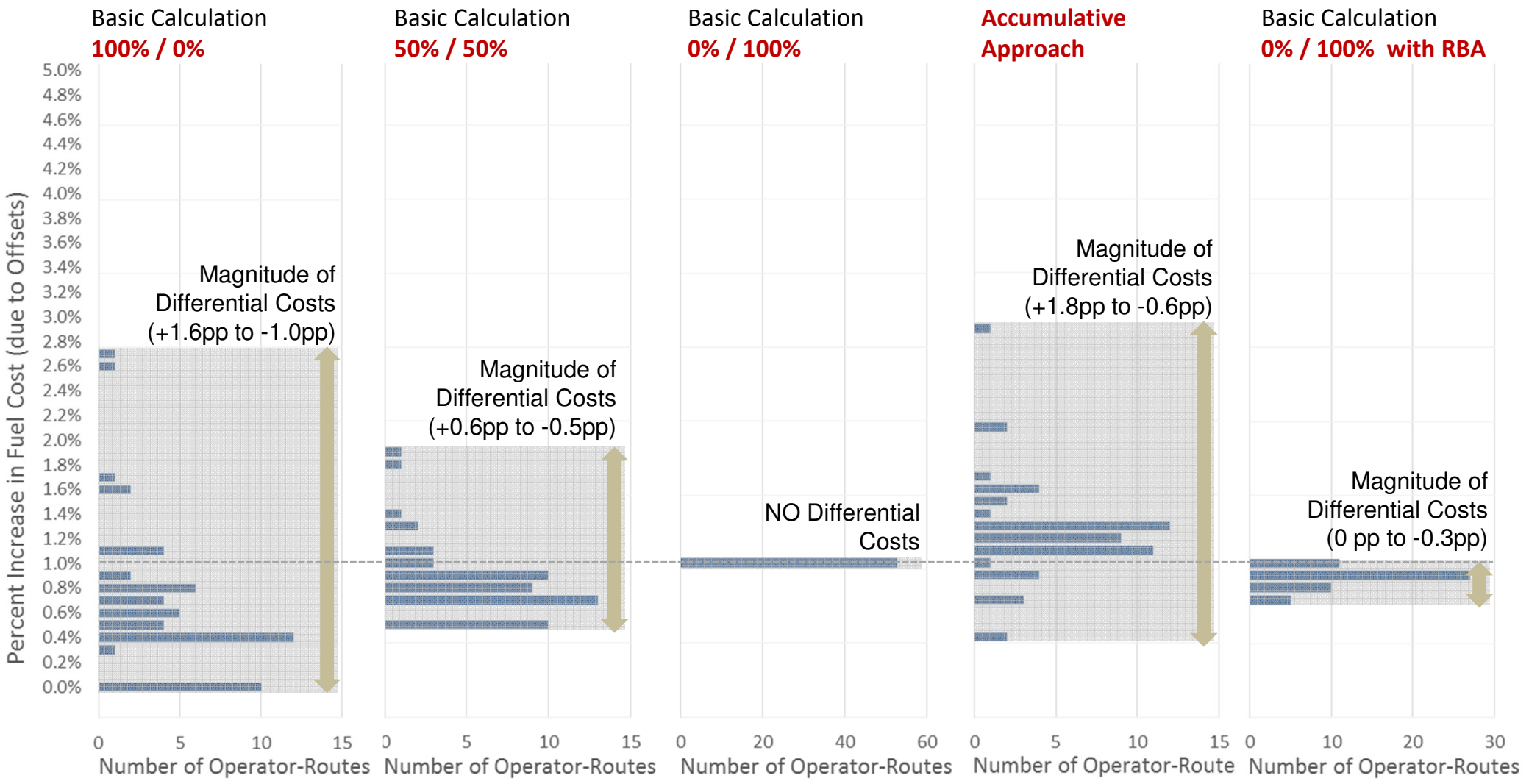


Additional Assumptions: Unit Cost of Fuel: 3.0 $/gallon, RBA/Phase In: Metric 2b and Attribution Profile 3bB, Assumes no FG and EM adjustments

State-Pair Route Specific Analysis:

Illustration with sample Long-Haul Route between Group A-B States

- Summary of cost of offset relative to fuel cost for sample State to State route (53 operators)

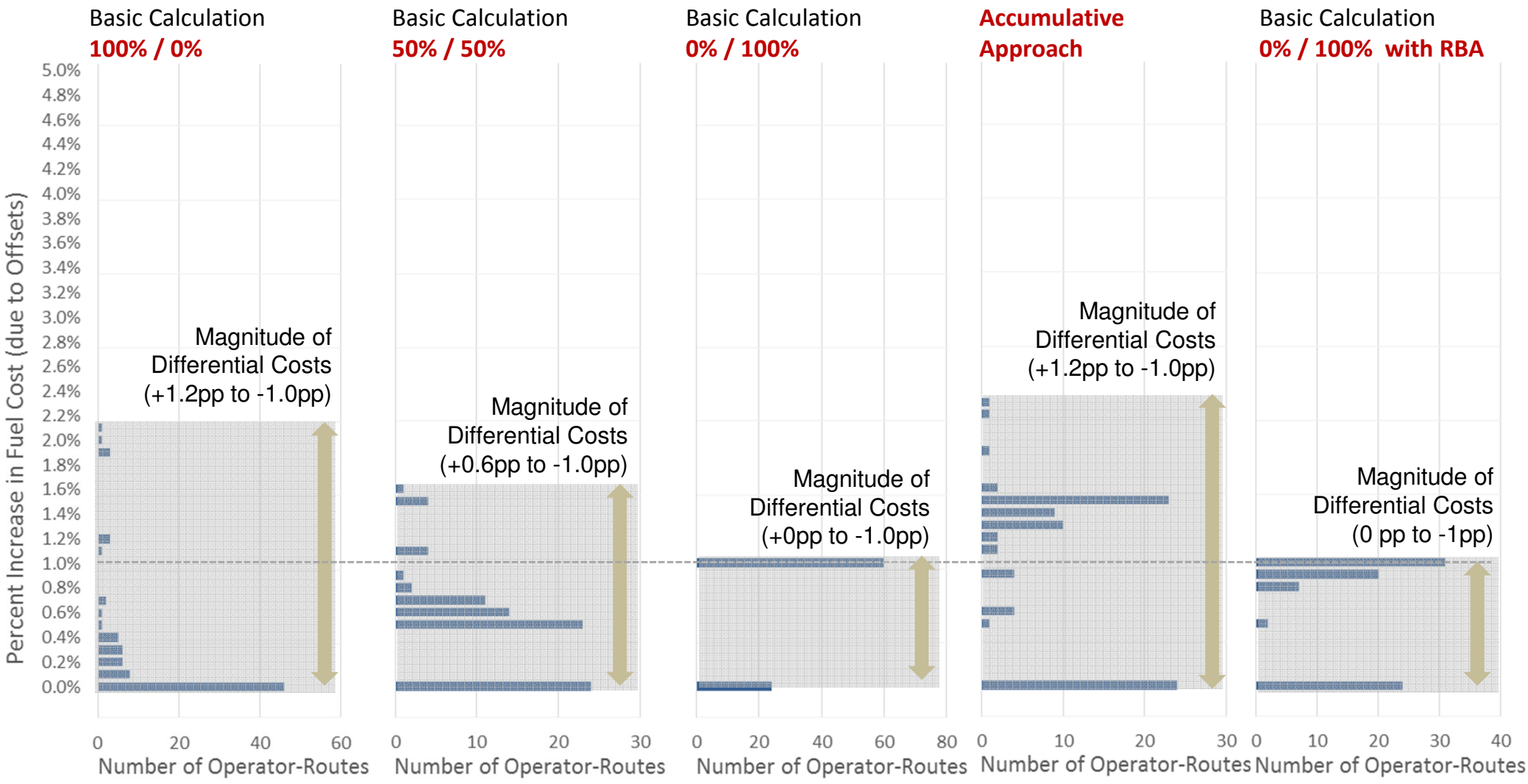


Assumptions for Illustration: Year 2025, Unit Cost of Fuel: 3.0 $/gallon, Unit Cost of Carbon: 15 $/t$CO_2$, RBA/Phase In: Metric 2b and Attribution Profile 3bB, Assumes no FG and EM adjustments

State-Pair Route Specific Analysis:

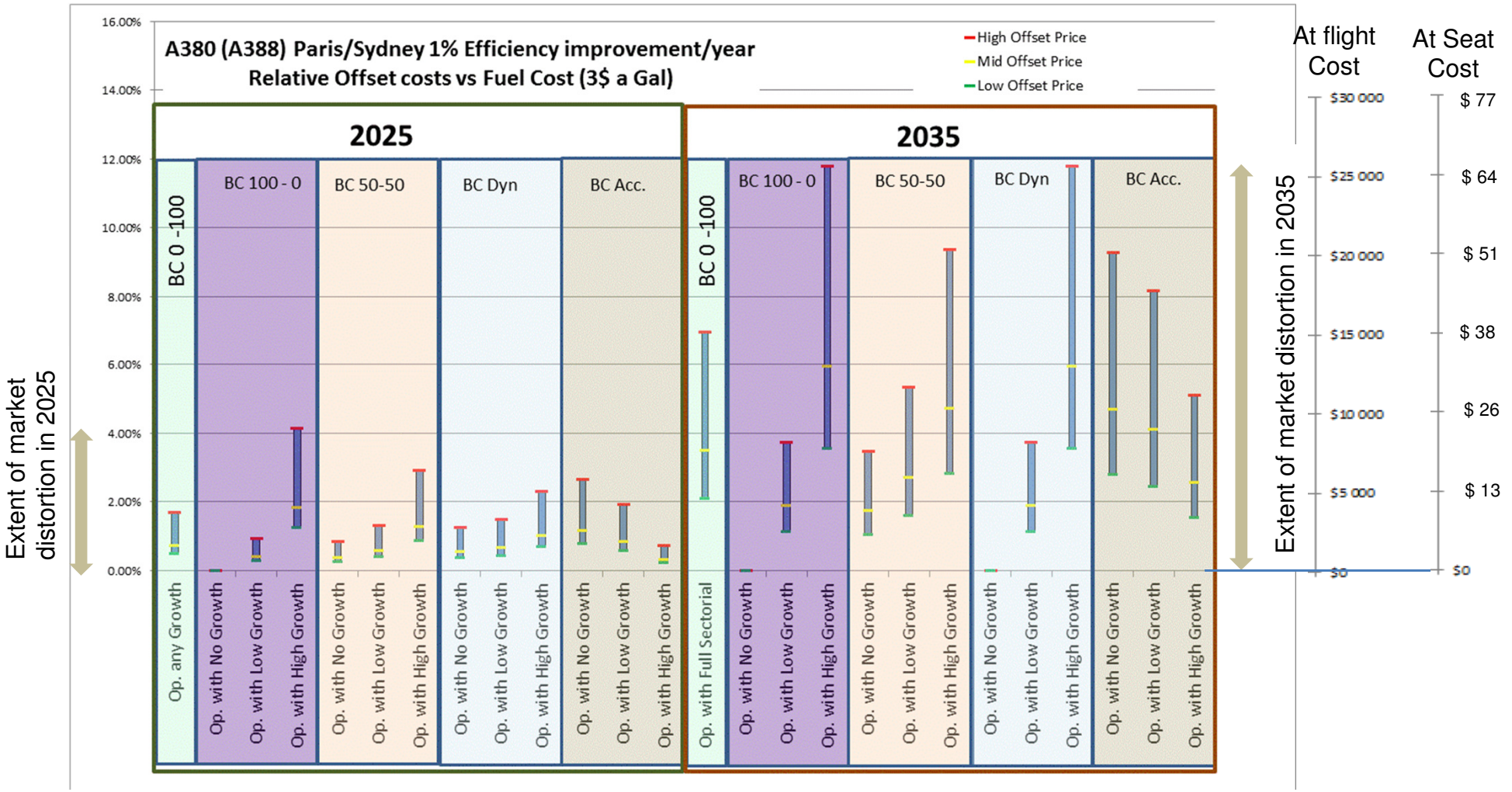
Illustration with sample Short-Haul Route between Group A-A States

- Summary of cost of offset relative to fuel cost for sample State to State route



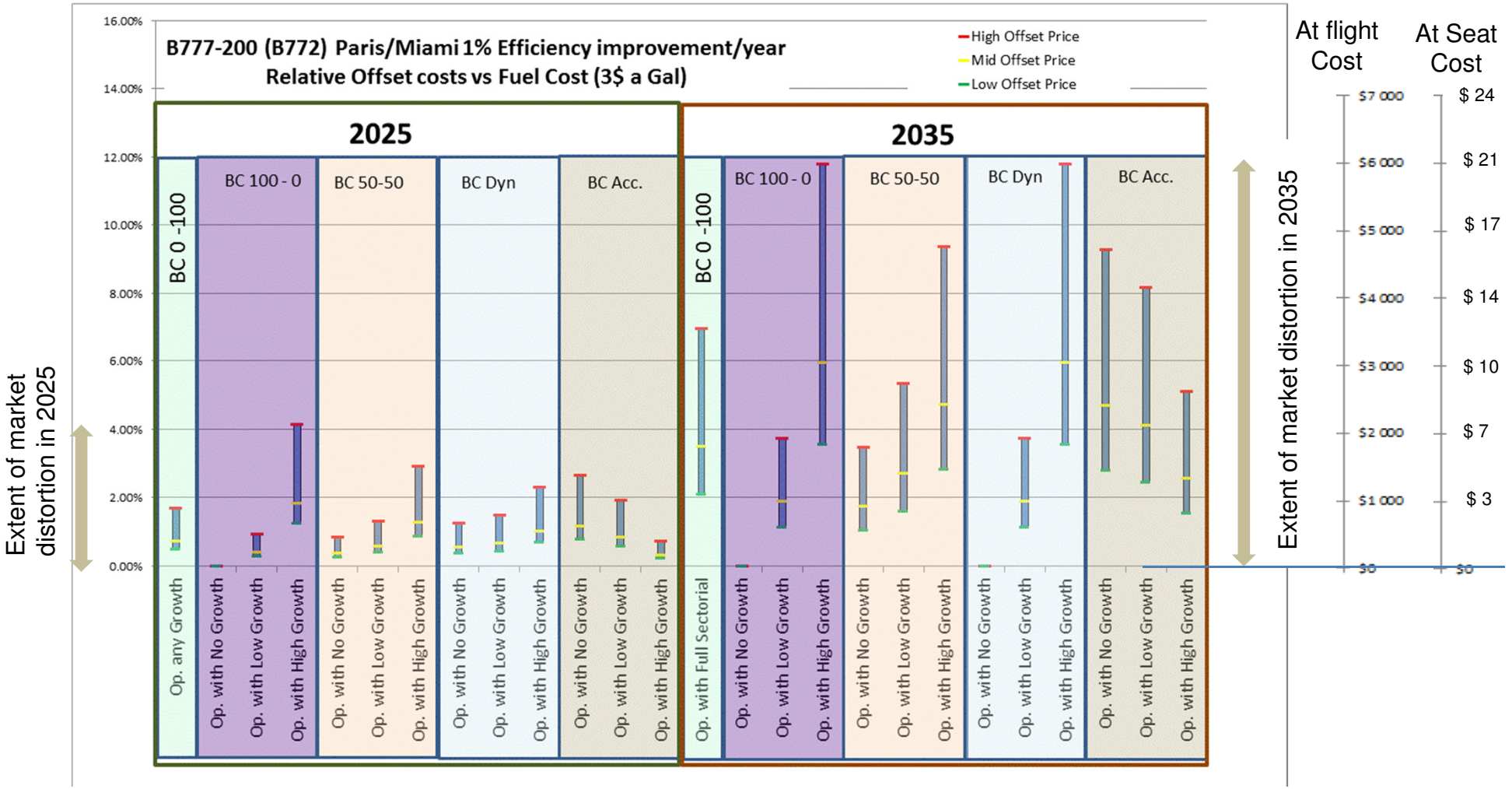
Assumptions for Illustration: Year 2025, Unit Cost of Fuel: 3.0 $/gallon, Unit Cost of Carbon: 15 $/tCO$_2$, RBA/Phase In: Metric 2b and Attribution Profile 3bB, Assumes no FG and EM adjustments

Applied to dedicated route
Example 1 Paris Sydney with a stop over



A full sectorial does provide equal offsetting obligation independently of the growth
A stop over in a LES would result in no offsetting obligation
Similarly a stop in a state with an RBA would see the offsetting obligation reduced proportionally to the phase In %

Applied to dedicated route
Example 2 Paris Miami



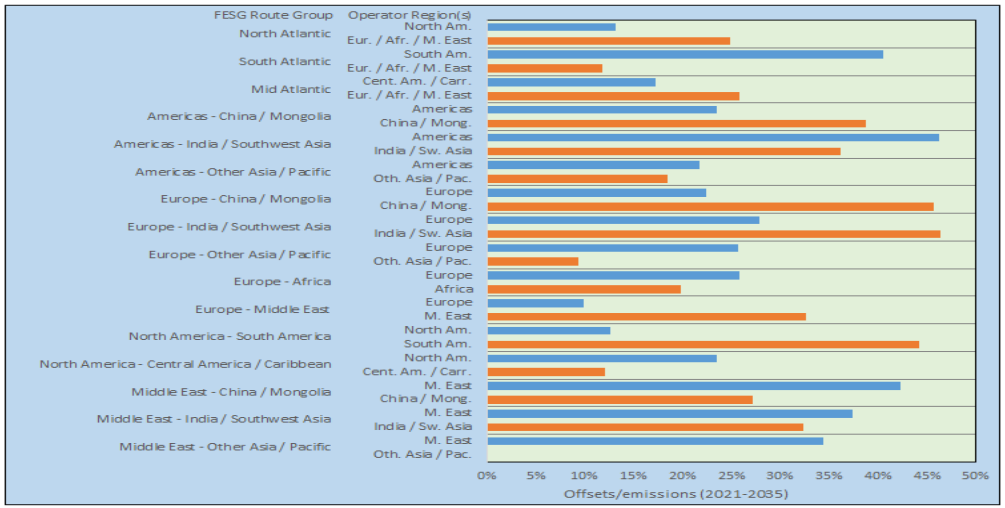
A full sectorial does provide equal offsetting obligation independently of the growth
A stop over in a LES would result in no offsetting obligation
Similarly a stop in a state with an RBA would see the offsetting obligation reduced proportionally to the phase In %

Take away from Example

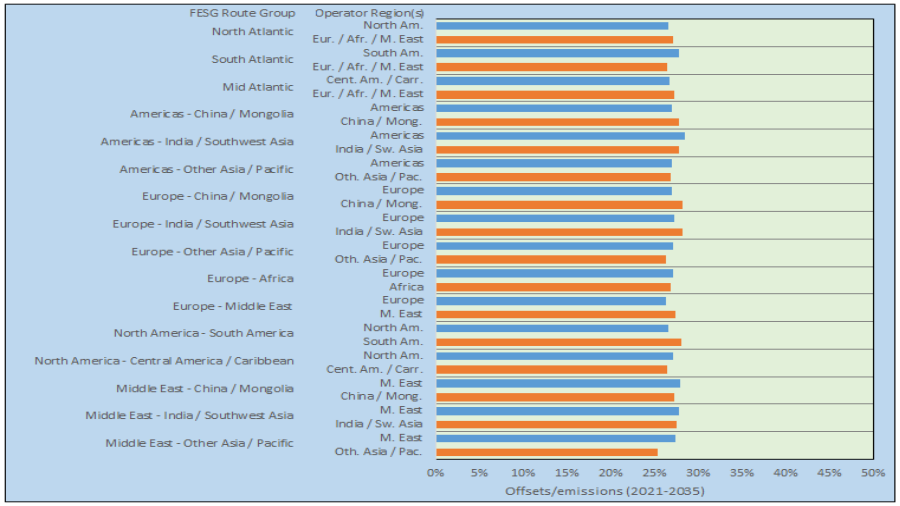
- Similar to “global” approach
  - the full sectorial is the approach which generate the smallest market distortion
  - The individual and accumulative creates the bigger distortion
- The extent of the distortion is limited and directly related to the price of the offset
- The impact of the market distortion is relative to distance between the market
- An RBA approach will not create distortion on a route (in an 100% sectorial) unless a stop over with a different offsetting obligation is used (this difference will be in direct relation to the phase in % or the differentiation introduced). Up to a 4.5% difference in 2035

Cumulative Offsets (2021-2035) as Share of Total Emissions for Operator Regions per FESG Route Group

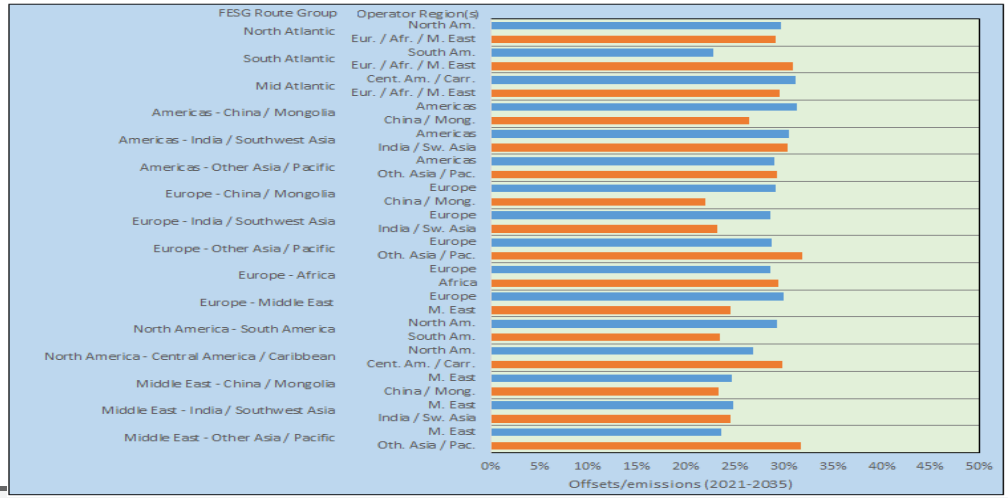
Individual approach



Sectoral approach



Accumulative approach



Conclusion: The sectoral approach has the least chance of distortions

Potential Market Distortion across Schemes: Route Level Distortions and New Entrants

- Market distortions could potentially arise at the route level in any given compliance year. The magnitude of the potential distortion varies across the different approaches.
- The offset obligations allocated to New Entrants in particular vary across the different approaches and could generate market distortions both at route level and at operator level.

Approaches / Risk of Market Distortion	Basic Calc. (100/0), (50/50), (0/100) or Dynamic w/o Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/LES	Accumulative Approach w/o Adjustments w/o LES	Basic Calc. (100/0), (50/50), (0/100) or Dynamic w/ RBA** (EAG/11-WP/1)	Basic Calc. (100/0), (50/50), (0/100) or Dynamic w/ RBA** (EAG/11-WP/1) w/ Redistribution	Alternative RBA 1: EAG/12 Concept 5	Alternative RBA 2: EAG/12 Concept 4
Route Level	(100/0): HIGH (50/50): MID (0/100): LOW Dynamic*: LOW-MID-HIGH	HIGH FG adjustments increase the risk		HIGH	(100/0): HIGH (50/50): MID (0/100): LOW Dynamic*: LOW-MID-HIGH		LOW	HIGH (0/100)
New Entrants	(100/0): HIGH (50/50): MID (0/100): LOW Dynamic*: LOW-MID-HIGH	HIGH FG adjustments increase the risk		HIGH	(100/0): HIGH (50/50): MID (0/100): LOW Dynamic*: LOW-MID-HIGH		LOW	HIGH (0/100)

* The risk of market distortion evolves in parallel to the individual share in the basic calculation

** RBA adjustments temporarily softens the potential distortion in the period 2021-2026 by reducing the coverage.

Possible Inequalities Induced by the GMBM

- Due to the fact that the GMBM applies only for international aviation and the flights to and from the LES can be exempted some inequalities can be introduced;
- Some example cases were compared:
  1. Flight Frankfurt-Sydney via Singapore with one via Ho Chi Minh City
  2. Fight San Francisco-Moscow via Frankfurt with one via New York
  3. A destination switch from Dusseldorf-Tenerife with Dusseldorf-Sal (Cape Verde) with a LCC
- Analysis shows that there are inequalities, but that the effects on the ticket prices are small (max ± 50 for a business and ± 10 US$ for an economy ticket);
- Based on analyses of sample markets, difference in cost increase between two markets is expected to be on the order of a few dollars, which may not result in incentives for switching destinations.

Comparison of Schemes

Tasks:

- Continue to analyze potential market distortion across schemes for distributing offset obligations.

- Complete the assessment of complexity of the schemes
  (illustrate and assess complexity against other dimensions of complexity e.g., monitoring/data collection, reporting/data sharing, computational, mitigation of missing data/reports, cost from MRV).

- Summary of Comparison of Schemes

Summary of Assessment of Relative Complexity across Schemes

Stakeholder	Approaches / Dimensions of Complexity Assessed	Basic Calc. (Ind.=100 %/ Sect.=0%) w/o Adjustments	Basic Calc. (0/100), (50/50), or Dynamic w/o Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/o FG and EM Adjustments w/ LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/LES	Accumulative Approach w/o Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ RBA (EAG/11-WP/1)	Basic Calc. (0/100), (50/50), or Dynamic w/ RBA (EAG/11-WP/1) w/ Redistribution	Alternative RBA 1: EAG/12 Concept 5	Alternative RBA 2: EAG/12 Concept 4
Operators (MRV)	Minimum Data To Be Reported by Operator to State and ICAO	N/A*	Operator level CO_2 emissions	Operator level CO_2 emissions and RTK	Operator level CO_2 emissions and Route level CO2 Emissions	Operator level CO_2 emissions and RTK Route level CO2 Emissions	Operator level CO_2 emissions and RTK Historical CO2 Emissions	Operator level CO_2 emissions and RTK Route level CO_2 Emissions	Operator level CO_2 emissions and RTK Route level CO_2 Emissions	Operator level CO_2 emissions and RTK Route Level/ Historical CO2 Emissions	Operator level CO_2 emissions and RTK Route level CO_2 Emissions
	Availability of data from MRV	Data could be available from MRV					Not available from MRV	Data could be available from MRV		Not available from MRV	Data could be available from MRV
	Complexity of data collection for the operator	Low		Mid			N/A	Mid		N/A	Low
ICAO/Third Party	Quantity of data needed for computations of offsets	0	1600 – 16,000	6500 - 64000	77000 - 300000	78000 - 320000	3200 - 32000	6500 - 64000	78000 - 320000	71000 - 260000	75000 - 290000
	Complexity of data gap filing process	N/A	Low	Mid	High	High	Mid	High	High	High	High
	Computations of Offsets	**No difference in computational complexity across schemes** *[CAEP analyses of EAG have shown feasibility of computations for all schemes]*									

* Note: Operator level CO_2 emissions needed to compute offset obligations but no information from other operators needed/shared to compute offset obligations

Assumptions for Quantification of Amount of Data to be Shared among Stakeholders

- Due to potential impacts on reporting requirements, exemptions, etc. a low and high estimate for the amount of data to be shared was assumed.

Assumptions by Type of Data

	Number of Data Points		Reference of Assumptions	
Type of Data	Low	High	Low	High
System level	1	1	n/a	n/a
State level	191	191	Number of ICAO Member States	
Operator level	1621	15,970	Number of operators above 10,000tCO_2 after other technical exemptions. *Ref. GMTF/7-WP/6*	Total potential number of operators after MTOM and flight purpose technical exemptions. *Ref. GMTF/7-WP/6*
Operator Specific State to State Route level	71,000	260,000	Assumed an average of 44 routes per operator (for operators with CO_2 emissions above 10,000tCO_2). *Reference: CAEP/ASG Common Operations Dataset OD dataset*	Assumed an average of 44 routes per operator (for operators with CO_2 emissions above 10,000tCO_2) and 13 routes per operator for operators below 10,000tCO_2 *Reference: CAEP/ASG Common Operations Dataset OD dataset*
Number of Routes (or Route Groups)	23	3225	Number of CAEP/FESG route groups	Number of State to State Routes. *Reference: CAEP/ASG Common Operations Dataset OD dataset*

Summary of Assessment of Type and Quantity of Data* to be Shared

Approaches / Type and Quantity of Data to be Shared		Basic Calc. (Ind.=100 %/ Sect.=0%) w/o Adjustments	Basic Calc. (0/100), (50/50), or Dynamic w/o Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/o FG and EM Adjustments w/ LES	Basic Calc. (0/100), (50/50), or Dynamic w/ FG and EM Adjustments w/LES	Accumulative Approach w/o Adjustments w/o LES	Basic Calc. (0/100), (50/50), or Dynamic w/ RBA (EAG/11-WP/1)	Basic Calc. (0/100), (50/50), or Dynamic w/ RBA (EAG/11-WP/1) w/ Redistribution	Alternative RBA 1: EAG/12 Concept 5	Alternative RBA 2: EAG/12 Concept 4
Type of Data	System level	*No need to share data*	√	√	√	√	√	√	√	√	√
	State level				√	√		√	√		
	Operator level		√	√	√	√	√	√	√	√	√
	Route level				√	√		√	√	√	√
	Historical data						√			√	
Quantity of Data*	Operator -> States -> ICAO/Third Party	0	1600 – 16,000	3200 - 32000	74000 - 275000	75000 - 290000	1600 - 16000	3200 - 32000	75000 - 290000	71000 - 260000	73000 - 270000
	ICAO/Third Party -> States -> Operator	0	1 – 1	3200 - 32000	1600 - 16000	3400 - 32000	1600 - 16000	3200 - 32000	3200 - 32000	23 - 3200	1600 - 16000
	Total	0	1600 – 16,000	6500 - 64000	76000 - 290000	78000 - 320000	3200 - 32000	6500 - 64000	78000 - 320000	71000 - 260000	75000 - 290000

** First order assessment of number of data records (i.e. group of one or more data elements). A range (optimistic – conservative) is provided to reflect potential uncertainty due to a number of factors such as exemptions, reporting requirements. See supporting material in Appendix.*

Comparison of Schemes

Tasks:

- Continue to analyze potential market distortion across schemes for distributing offset obligations.

- Complete the assessment of complexity of the schemes
  (illustrate and assess complexity against other dimensions of complexity e.g., monitoring/data collection, reporting/data sharing, computational, mitigation of missing data/reports, cost from MRV).

- Summary of Comparison of Schemes

Translation of EAG/10 Criteria into Measureable Indicators for Analysis

Criteria (from EAG/10)	**Metrics** used for Assessment	Type of Assessment
1.a) **Overall cost to operators** and…	**USD**	Quantitative
1.b)… **cost to representative individual operators**	**% Offset / CO_2 Emissions** (by operator)	Quantitative
2. **Factors and adjustments used to differentiate obligations**	**Enumeration of Factors and Adjustments**	Qualitative
3. The possible extent of ***market distortion***	**Cost differential attributed to the market-based measure**	Qualitative & Quantitative
4. **Data availability** to implement an approach	**Identification of source of data**	Qualitative & Quantitative
5. **Administrative simplicity**	**First order estimate of level of simplicity**	Qualitative
6. **Scope of coverage** (emissions coverage)	**% Offset / CO_2 Emissions** (at the global level)	Quantitative
7. **Predictability and stability**	**- Analysis of propagation of forecast uncertainty for each scheme** **- Descriptive analysis**	Qualitative & Quantitative
8. **Ability to manage new entrants, operators who exit the market, mergers**, etc.	**Description of process for managing new entrants, operators who exit the market and mergers.**	Qualitative

Summary of Comparison of Schemes (w/o RBA)

Criteria \ Approaches	Basic Calc. (Ind=100/Sect=0)	Basic Calc. (50/50)	Dynamic Basic Calc.	Basic Calc. (0/100)	Accumulative Approach
1.a) **Overall cost to operators** and… 1.b)… **cost to representative individual operators**	Cost from full CO_2 coverage reduced by (LES, and Tech. Exemptions)				
	See Appendix Slide 5 for summary of analytical results				
2. **Factors and adjustments used to differentiate obligations**	Basic Calculation (BC), Fast Grower (FG), Early Mover (EM), Least Emitting States (LES)				Approach itself reflects differentiation. Scheme could accommodate other adjustments if necessary
3. The possible extent of **market distortion**	High	Mid	Mid	Low	High
4. **Data availability** to implement an approach	Data from GMBM MRV System				Data not available from GMBM MRV (pre-2018)
5. **Administrative simplicity**	High (if no adjustments are used) else Mid	Mid (Low if LES is implemented)			
6. **Scope of coverage** (emissions coverage)	Full CO_2 coverage minus (LES and Tech. Exemptions)				Full – (LES and Tech Exemptions)
7. **Predictability and stability** for operators	*<u>Predictability:</u> Schemes with high individual share tend to result in higher uncertainty of future offsets obligations (given uncertainty in CO2 emissions). Conversely, schemes with higher sectoral share result in lower uncertainty*				
8. **Ability to manage new entrants, operators who exit the market, mergers,**	New entrants, exit and mergers manageable				Challenges associated with use of historical data. Other sources of data being explored.

** Legend for Basic Calculation: (%Individual/ %Sectoral)*

Summary of Comparison of Schemes based on Route Based Approach

Criteria \ Approaches	RBA (EAG/11-WP/1)	RBA (EAG/11-WP/1) with Redistribution	Alternative RBA 1: Concept 5	Alternative RBA 2
1.a) **Overall cost to operators** and…	Partial coverage	Cost from full CO_2 coverage	Cost from full CO2 coverage.	Cost from full CO2 coverage
1.b)… **cost to representative individual operators**	See slide 5	N/A	Deviation from 100% Sectoral without adjustments, depending on the level of differentiation across routes (see appendix)	Cost impact depends on the participation of each route category in operator's total routes
2. **Factors and adjustments used to differentiate obligations**	Basic Calculation (BC), Fast Grower (FG), Early Mover (EM), Least Emitting States (LES)		Look-back year	Basic Calculation (BC), Fast Grower (FG), Early Mover (EM)
3. The possible extent of **market distortion**	Reduced market distortion compared to operator based approach for distributing offset obligations (if associated with schemes with high sectoral shares)		No market distortion at route level: Same treatment across Operators at route level.	High due to 100% operator level distribution approach
4. **Data availability** to implement an approach	Data from GMBM MRV System (and other sources to define State metric as needed)		Look-back years: aggregated route level data from GMBM MRV System and 2010 from the COD 2010. Operator level data from GMBM MRV System.	Data from GMBM MRV System if CO2 used to define state groupings. IF RT used a data source would need to be found.
5. **Administrative simplicity**	Low (Similar to LES)			Low
6. **Scope of coverage** (emissions coverage)	Partial	Full CO_2 coverage minus (LES and Tech. Exemptions)	Full coverage (in some cases, it could be less than full coverage if, e.g., routes not in the look back year become active)	Partial
7. **Predictability and stability** for operators	Depends on operator level distribution approach	Less predictable than without redistribution		
8. **Ability to manage new entrants, operators who exit the market, mergers**, etc.	New entrants, exit and mergers manageable			