



ICAO

ENVIRONMENT

NO COUNTRY LEFT BEHIND



Capacity Building for CO₂ mitigation from international aviation - Fourth Seminar
Mombasa, Kenya
12-14 December, 2018

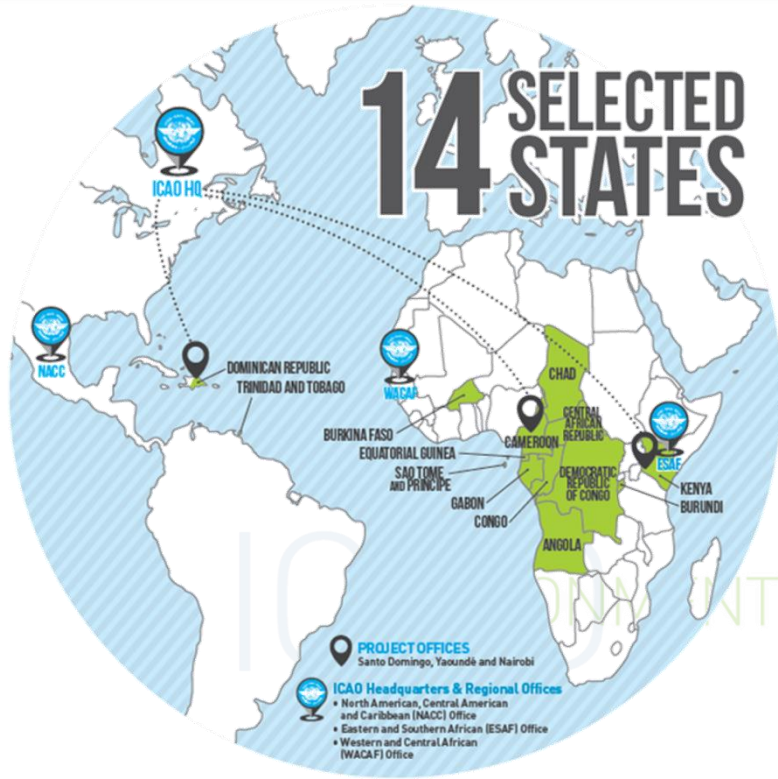
Marginal Abatement Cost (MAC) Curve Tool Introduction and Live Demo

By Neil Dickson, Chief, Environmental Standards Section, ICAO





**CAPACITY
BUILDING
FOR CO₂
MITIGATION
FROM INTERNATIONAL
AVIATION**

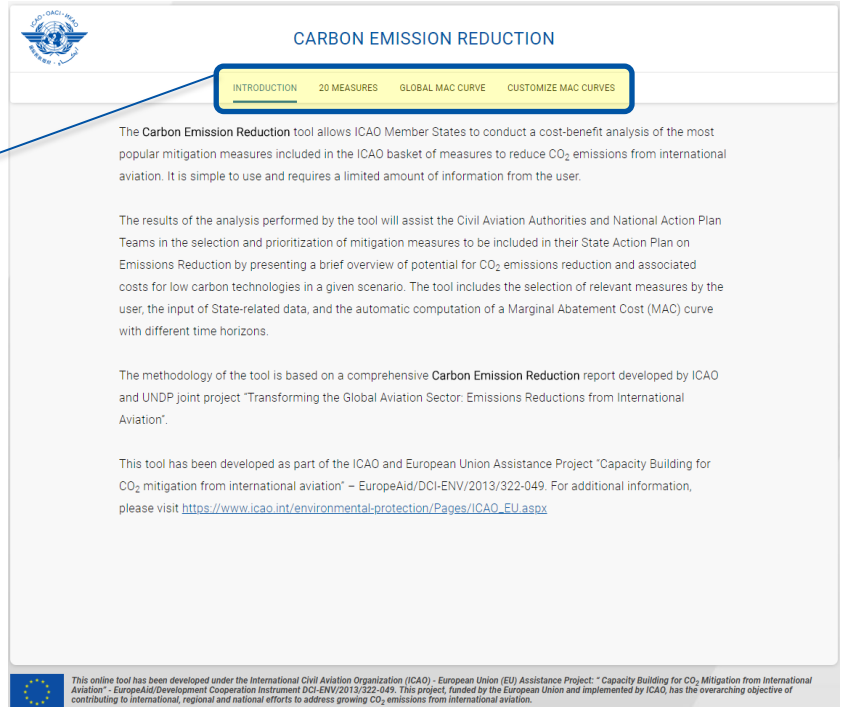




Introduction

4 Tabs to navigate through the tool:

- Introduction
- 20 Measures
- Global MAC curve
- Customize MAC curves



CARBON EMISSION REDUCTION


INTRODUCTION 20 MEASURES GLOBAL MAC CURVE CUSTOMIZE MAC CURVES

The **Carbon Emission Reduction** tool allows ICAO Member States to conduct a cost-benefit analysis of the most popular mitigation measures included in the ICAO basket of measures to reduce CO₂ emissions from international aviation. It is simple to use and requires a limited amount of information from the user.

The results of the analysis performed by the tool will assist the Civil Aviation Authorities and National Action Plan Teams in the selection and prioritization of mitigation measures to be included in their State Action Plan on Emissions Reduction by presenting a brief overview of potential for CO₂ emissions reduction and associated costs for low carbon technologies in a given scenario. The tool includes the selection of relevant measures by the user, the input of State-related data, and the automatic computation of a Marginal Abatement Cost (MAC) curve with different time horizons.

The methodology of the tool is based on a comprehensive **Carbon Emission Reduction** report developed by ICAO and UNDP joint project 'Transforming the Global Aviation Sector: Emissions Reductions from International Aviation'.

This tool has been developed as part of the ICAO and European Union Assistance Project 'Capacity Building for CO₂ mitigation from international aviation' – EuropeAid/DCI-ENV/2013/322-049. For additional information, please visit https://www.icao.int/environmental-protection/Pages/ICAO_EU.aspx

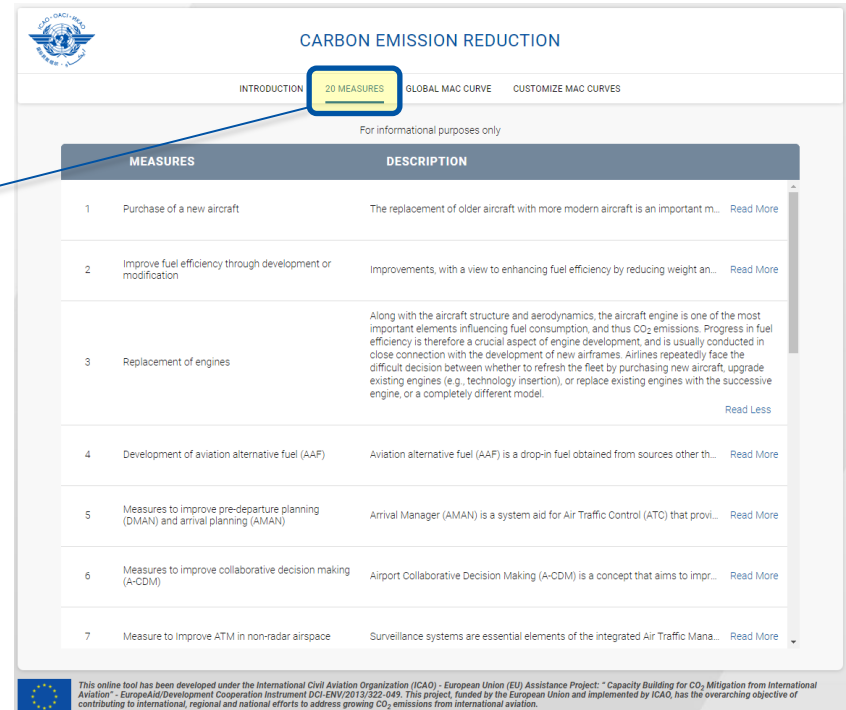
 This online tool has been developed under the International Civil Aviation Organization (ICAO) - European Union (EU) Assistance Project: "Capacity Building for CO₂ Mitigation from International Aviation" - EuropeAid/Development Cooperation Instrument DCI-ENV/2013/322-049. This project, funded by the European Union and implemented by ICAO, has the overarching objective of contributing to international, regional and national efforts to address growing CO₂ emissions from international aviation.



20 Measures

Tab: 20 Measures

This tab provides a description for the 20 measures available in this tool



The screenshot shows a web interface for 'CARBON EMISSION REDUCTION'. The '20 MEASURES' tab is selected and highlighted. Below the navigation tabs, there is a table with two columns: 'MEASURES' and 'DESCRIPTION'. The table lists seven measures, each with a number, a brief description, and a 'Read More' link. A blue line points from the '20 Measures' tab to the table.

MEASURES	DESCRIPTION
1 Purchase of a new aircraft	The replacement of older aircraft with more modern aircraft is an important m... Read More
2 Improve fuel efficiency through development or modification	Improvements, with a view to enhancing fuel efficiency by reducing weight an... Read More
3 Replacement of engines	Along with the aircraft structure and aerodynamics, the aircraft engine is one of the most important elements influencing fuel consumption, and thus CO ₂ emissions. Progress in fuel efficiency is therefore a crucial aspect of engine development, and is usually conducted in close connection with the development of new airframes. Airlines repeatedly face the difficult decision between whether to refresh the fleet by purchasing new aircraft, upgrade existing engines (e.g., technology insertion), or replace existing engines with the successive engine, or a completely different model. Read Less
4 Development of aviation alternative fuel (AAF)	Aviation alternative fuel (AAF) is a drop-in fuel obtained from sources other th... Read More
5 Measures to improve pre-departure planning (DMAN) and arrival planning (AMAN)	Arrival Manager (AMAN) is a system aid for Air Traffic Control (ATC) that provi... Read More
6 Measures to improve collaborative decision making (A-CDM)	Airport Collaborative Decision Making (A-CDM) is a concept that aims to impr... Read More
7 Measure to improve ATM in non-radar airspace	Surveillance systems are essential elements of the integrated Air Traffic Mana... Read More

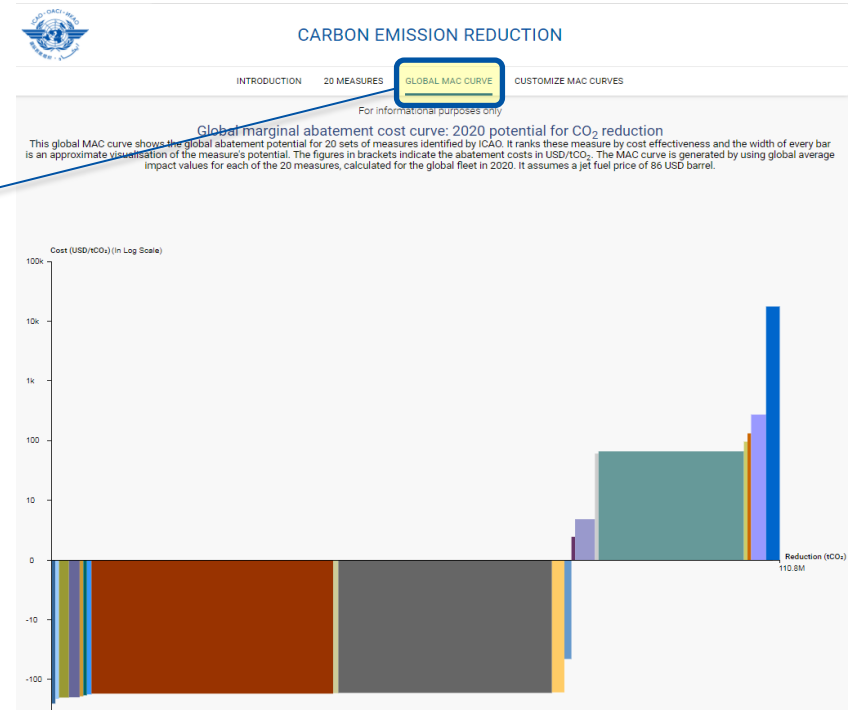
This online tool has been developed under the International Civil Aviation Organization (ICAO) - European Union (EU) Assistance Project: "Capacity Building for CO₂ Mitigation from International Aviation" - European Development Cooperation Instrument DCI-ENV/2012/322-049. This project, funded by the European Union and implemented by ICAO, has the overarching objective of contributing to international, regional and national efforts to address growing CO₂ emissions from international aviation.



Global MAC curve

Tab: Global MAC curve

This tab highlights the Global MAC curve (i.e. the MAC curve based on the 192 ICAO Members States)

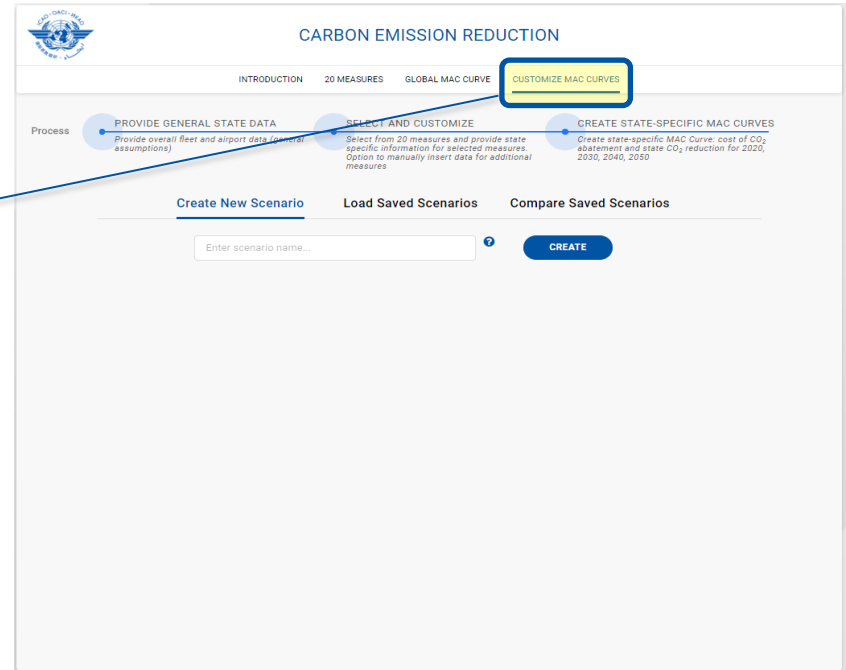




Customize MAC curves

Tab: Customize MAC curves

This tab allows the users to customize the MAC curve at the local level (i.e. based on



CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE **CUSTOMIZE MAC CURVES**

Process

- PROVIDE GENERAL STATE DATA
Provide overall fleet and airport data (general assumptions)
- SELECT AND CUSTOMIZE**
Select from 20 measures and provide state specific information for selected measures. Option to manually insert data for additional measures
- CREATE STATE-SPECIFIC MAC CURVES
Create state-specific MAC Curve: cost of CO₂ abatement and state CO₂ reduction for 2020, 2030, 2040, 2050

Create New Scenario Load Saved Scenarios Compare Saved Scenarios

Enter scenario name... **CREATE**



Customize MAC curves

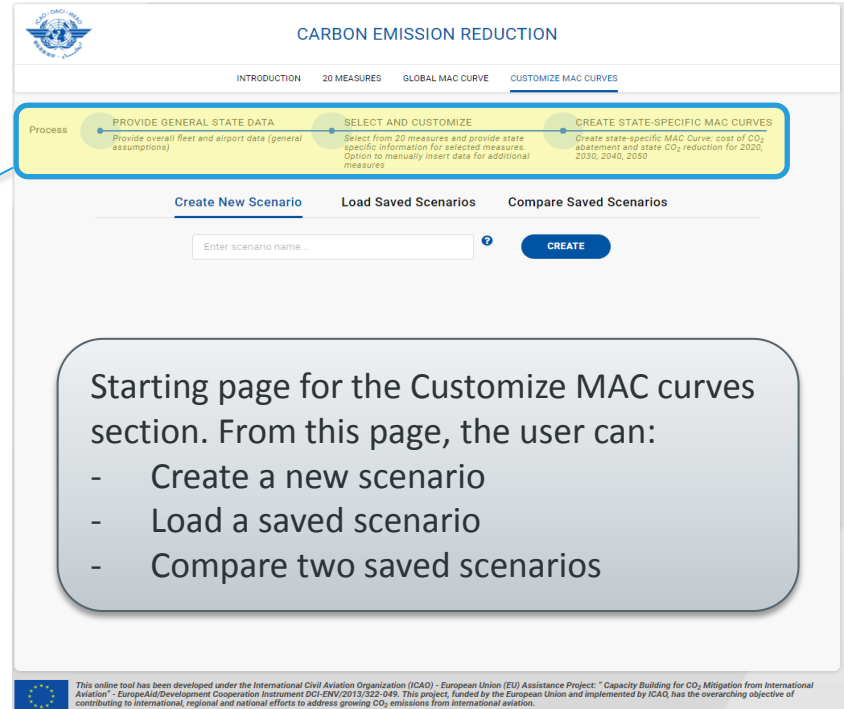
Tab: Customize MAC curves

The process is the following:

Step 1: Provide General State Data

Step 2: Select and customize measures

Step 3: Generate MAC curve



CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE **CUSTOMIZE MAC CURVES**

Process

- PROVIDE GENERAL STATE DATA**
Provide overall fleet and airport data (general assumptions)
- SELECT AND CUSTOMIZE**
Select from 20 measures and provide state specific information for selected measures. Option to manually insert data for additional measures
- CREATE STATE-SPECIFIC MAC CURVES**
Create state-specific MAC Curve: cost of CO₂ abatement and state CO₂ reduction for 2020, 2030, 2040, 2050

Create New Scenario Load Saved Scenarios Compare Saved Scenarios

Enter scenario name... **CREATE**

Starting page for the Customize MAC curves section. From this page, the user can:

- Create a new scenario
- Load a saved scenario
- Compare two saved scenarios

This online tool has been developed under the International Civil Aviation Organization (ICAO) - European Union (EU) Assistance Project: "Capacity Building for CO₂ Mitigation from International Aviation" - European Development Cooperation Instrument (DCI-ENV/2013/322-349). This project, funded by the European Union and implemented by ICAO, has the overarching objective of contributing to international, regional and national efforts to address growing CO₂ emissions from international aviation.



Customize MAC curves

CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE CUSTOMIZE MAC CURVES

PROVIDE GENERAL STATE DATA SELECT AND CUSTOMIZE CREATE STATE-SPECIFIC MAC CURVES

Warning: In case a field is left blank, the application will proceed with zero as value for that cell for further calculation

Fleet Airports Download Aircraft Category Map

Types of Aircraft	2020		2030		2040		2050	
	Number of aircraft	Average age	Number of aircraft	Average age	Number of aircraft	Average age	Number of aircraft	Average age
Turbo Prop	378	12.68	378	12.68	378	12.68	378	12.68
Narrow Body	757	9.26	757	9.26	757	9.26	757	9.26
Wide Body (2 engines)	120	5.88	120	5.88	120	5.88	120	5.88
Wide Body (4 engines)	19	20	19	20	19	20	19	20

BACK RESET SAVE AS DRAFT & EXIT NEXT

Information on fleet profile

Information on airports profile

CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE CUSTOMIZE MAC CURVES

PROVIDE GENERAL STATE DATA SELECT AND CUSTOMIZE CREATE STATE-SPECIFIC MAC CURVES

Warning: In case a field is left blank, the application will proceed with zero as value for that cell for further calculation

Fleet Airports

Airport Size (Annual Arrivals)	2020	2030	2040	2050	Peak Operation (%)	Average Taxi-Time (mins/operation)
	Number of Airports	Number of Airports	Number of Airports	Number of Airports		
Small (<25k arrivals)	246	246	246	246	35	16
Medium (25k-100k arrivals)	271	271	271	271	35	21
Large (>100k arrivals)	29	29	29	29	35	26

BACK RESET SAVE AS DRAFT & EXIT NEXT



Customize MAC curves

Click on the title of the measure in order to customize the measure

Select or unselect measures

CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE CUSTOMIZE MAC CURVES

PROVIDE GENERAL STATE DATA SELECT AND CUSTOMIZE CREATE STATE-SPECIFIC MAC CURVES

Warning: In case a field is left blank, the application will proceed with zero as value for that cell for further calculation.

To include a measure into your scenario, click on the checkbox (left of the measure). Then click on the text of the measure label to pull up the list of variables for which you need to enter your own values. Warning: If you leave a field empty the system will automatically assume its value is zero.

MEASURES

- 1 Purchase new aircraft
- 2 Improve fuel efficiency through modifications
- 3 Replacement of engines
- 4 Development of biofuels
- 5 Measures to improve pre-departure planning (DMAN) and arrival planning (AMAN)
- 6 Measures to improve collaborative decision making (A-CDM)
- 7 Measures to improve ATM in non-RADAR airspace
- 8 Measures to increase fuel efficiency of departure and approach procedures
- 9 Measures to introduce COO and CDO
- 10 Measures to improve aircraft guidance on apron
- 11 Measures to improve taxiing
- 12 Minimizing weight
- 13 Minimizing flaps
- 14 Minimizing reverse use
- 15 Reduced speed
- 16 Engine wash and zonal dryers

ADD/EDIT CUSTOM MEASURES

2020 2030 2040 2050

Development of biofuels

- Share of alternative fuels

ALL 0.5 %

BACK RESET SAVE AS DRAFT & EXIT NEXT

On the right side of the tool, users can customize measures for each decade from 2020 to 2050.

Default values are based on global figures





Customize MAC curves

CARBON EMISSION REDUCTION

INTRODUCTION 20 MEASURES GLOBAL MAC CURVE **CUSTOMIZE MAC CURVES**

PROVIDE GENERAL STATE DATA **SELECT AND CUSTOMIZE** CREATE STATE-SPECIFIC MAC CURVES

Warning: In case a field is left blank, the application will proceed with zero as value for that cell for further calculations.

ADD/EDIT CUSTOM MEASURES

To include a measure into your scenario, click on the checkbox left of the measure. Then click on the text of the measure label to pull up the list of variables for which you need to enter your own values. Warning: if you leave a field empty, the system will automatically assume its value is zero.

MEASURES

- 1 Purchase new aircraft
- 2 Improve fuel efficiency through modifications
- 3 Replacement of engines
- 4 Development of biofuels
- 5 Measures to improve pre-departure planning (DMAN) and arrival planning (AMAN)
- 6 Measures to improve collaborative decision making (A-CDM)
- 7 Measures to improve ATM in non-RADAR airspace
- 8 Measures to increase fuel efficiency of departure and approach procedures
- 9 Measures to introduce COO and CDO
- 10 Measures to improve aircraft guidance on apron
- 11 Measures to improve taxiing
- 12 Minimizing weight
- 13 Minimizing flaps
- 14 Minimizing reverser use
- 15 Reduced speed
- 16 Engine wash and zonal dryers

2020 2030 2040 2050

Development of biofuels

- Share of alternative fuels

ALL 0.5

BACK RESET SAVE AS DRAFT & EXIT NEXT

Upload Measures

Upload from file... **BROWSE** [Download Template](#)

Warning: New measures uploaded via Excel will over-write previously entered custom measures for this scenario

Add/Edit Measures Inline Cost of CO2 reduction: In USD / tonne | Reduction in CO2: Tonnes

Custom Measure Name	2020		2030		2040		2050		
	Cost	Reduction	Cost	Reduction	Cost	Reduction	Cost	Reduction	
Measure 1	100	10	200	20	300	30	400	40	-
Measure 2	150	15	250	25	350	35	450	45	-
	0	0	0	0	0	0	0	0	-

+ Add Another Measure

CANCEL **SAVE**

Users can add Custom Measures:

- Upload measures
- Add/Edit measures directly from the interface



Customize MAC curves

The tool returns results for each measure selected for the years 2020, 2030, 2040 and 2050 in the following format:

- **Cost** (USD/tonne of CO₂ abated)
- **Reduction** (in thousand of tonnes of CO₂)

CARBON EMISSION REDUCTION

INTRODUCTION | 20 MEASURES | GLOBAL MAC CURVE | **CUSTOMIZE MAC CURVES**

PROVIDE GENERAL STATE DATA | **SELECT AND CUSTOMIZE** | CREATE STATE-SPECIFIC MAC CURVES

EXPORT SCENARIO TO EXCEL

Generating the customised MAC curve might take time. During this time do not refresh the browser window

Cost of CO₂ reduction: In USD / tonne | Reduction in CO₂: In thousand tonnes

Measure Name	2020		2030		2040		2050	
	Cost	Reduction	Cost	Reduction	Cost	Reduction	Cost	Reduction
Airport infrastructure (runways, ta...	65.96	356.26	113.97	409.06	140.62	374.61	148.37	360.05
Development of biofuels	241.93	87.72	200.49	834.36	175.37	2505.44	175.37	5447.43
Improve fuel efficiency through mo...	-46.07	117.19	-62.13	73.83	-64.45	19.72	-97.27	0.87
Installation of fixed electrical grou...	-254.10	26.08	-254.10	83.30	-254.10	101.63	-254.10	106.06
Measures to improve collaborative...	-226.74	73.21	-275.38	131.79	-306.25	185.90	-321.16	228.88
Measures to increase fuel efficienc...	-165.69	964.29	-162.57	1550.62	-160.43	1556.44	-160.00	1551.28
Measures to introduce CCO and C...	-165.88	892.35	-165.88	1784.70	-165.88	1784.70	-165.88	1784.70
Minimizing weight	-45.51	124.52	-38.63	281.12	-31.42	397.64	-24.87	604.84
Use cleaner alternative sources of ...	131.76	1.13	131.76	5.02	131.76	9.41	131.76	19.95

BACK | SAVE AS DRAFT & EXIT | NEXT

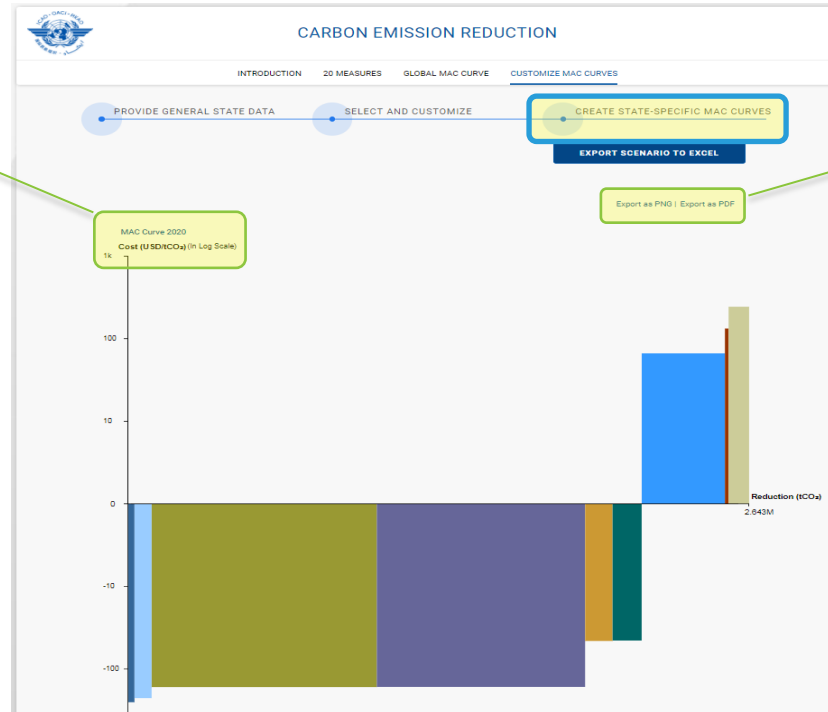
Users can export scenario (i.e. results) into an Excel spreadsheet



Customize MAC curves

The tool shows a MAC curve for each decade (2020, 2030, 2040 and 2050).

This screenshot shows the 2020 MAC curve.



Users can export MAC curves in the two following formats:

- PDF
- PNG

All MAC curves exported include a legend



For more information on this project, please visit ICAO's website:

https://www.icao.int/environmental-protection/Pages/ICAO_UNDP.aspx



ICAO

ENVIRONMENT

NO COUNTRY LEFT BEHIND



ICAO

North American
Central American
and Caribbean
(NACC) Office
Mexico City

South American
(SAM) Office
Lima

ICAO
Headquarters
Montréal

Western and
Central African
(WACAF) Office
Dakar

European and
North Atlantic
(EUR/NAT) Office
Paris

Middle East
(MID) Office
Cairo

Eastern and
Southern African
(ESAF) Office
Nairobi

Asia and Pacific
(APAC) Sub-office
Beijing

Asia and Pacific
(APAC) Office
Bangkok



THANK YOU