Economic impacts of regulating aviation’s full climate impact – insights from the AviClim research project

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Outline

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1. AviClim project: Possibilities for limiting aviation's full climate impact from an economic point of view:

AviClim research question: How to best limit aviation's full climate impact (CO_2, NO_x, H_2O, contrails, etc.) from an economic policy point of view? The regulating measure should lead to the lowest costs as compared to other measures and avoid competitive distortions between airlines.

For the first time, the AviClim project addressed the **full climate impact** of aviation **simultaneously** and investigated the associated economic and environmental effects. AviClim was conducted 2011 – 2015. An up-date was provided in 2019.

Within this **interdisciplinary** research project, three DLR Institutes were involved: Institute of Air Transport and Airport Research (co-ordinator), Institute of Propulsion Technology and Institute of Atmospheric Physics.

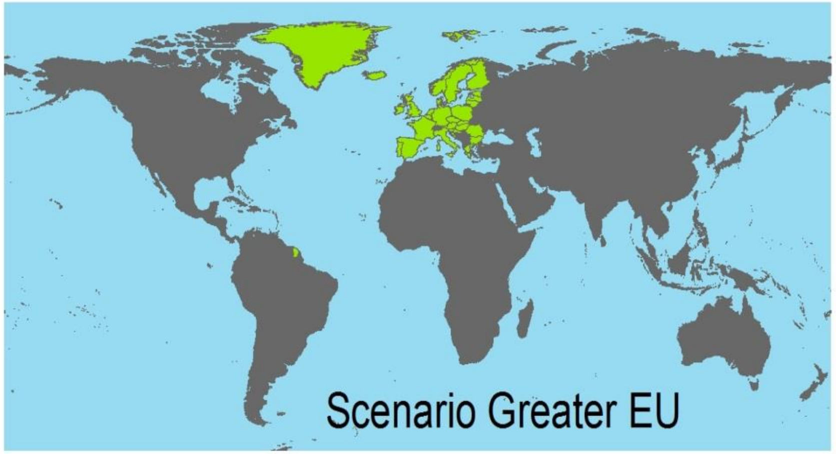
1. AviClim: regulating measures and scenarios investigated

Best options for **market-based and operational measures** for the reduction of all climate relevant species from aviation include:

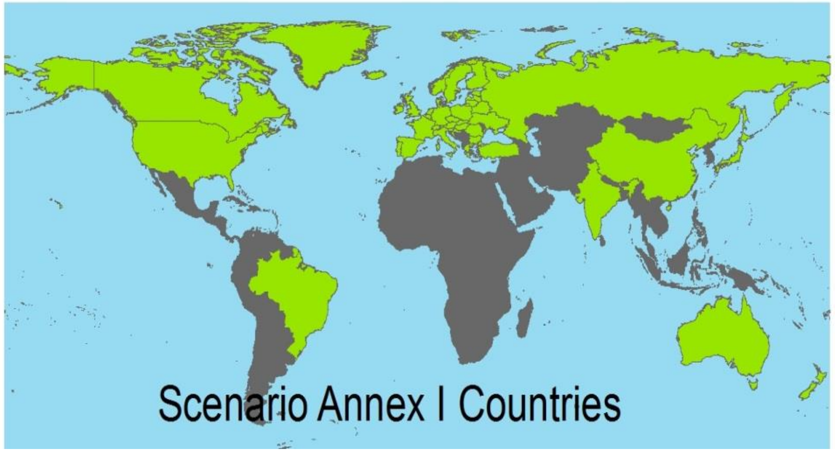
- **Climate tax** on all important climate relevant species from aviation;
- **Climate charge** on NO_x emissions plus CO_2 emissions trading scheme combined with **climate-optimal flight trajectories** for the minimization of contrails (applied on 50% of flights between 30 and 60°N on an altitude between 9 and 12 km);
- Open **emissions trading** scheme on CO_2, NO_x, H_2O and contrails.

These measures have been selected in respect to economic efficiency, environmental benefits and practicability. They have been combined with **4 scenarios** which differ concerning the level of international support for these climate protecting measures.

1. AviClim: geopolitical scenario overview



The blow-ups show the United Arab Emirates and Singapore, respectively.



1. AviClim: prices and metrics

Within AviClim, three **alternative price paths** have been assumed:

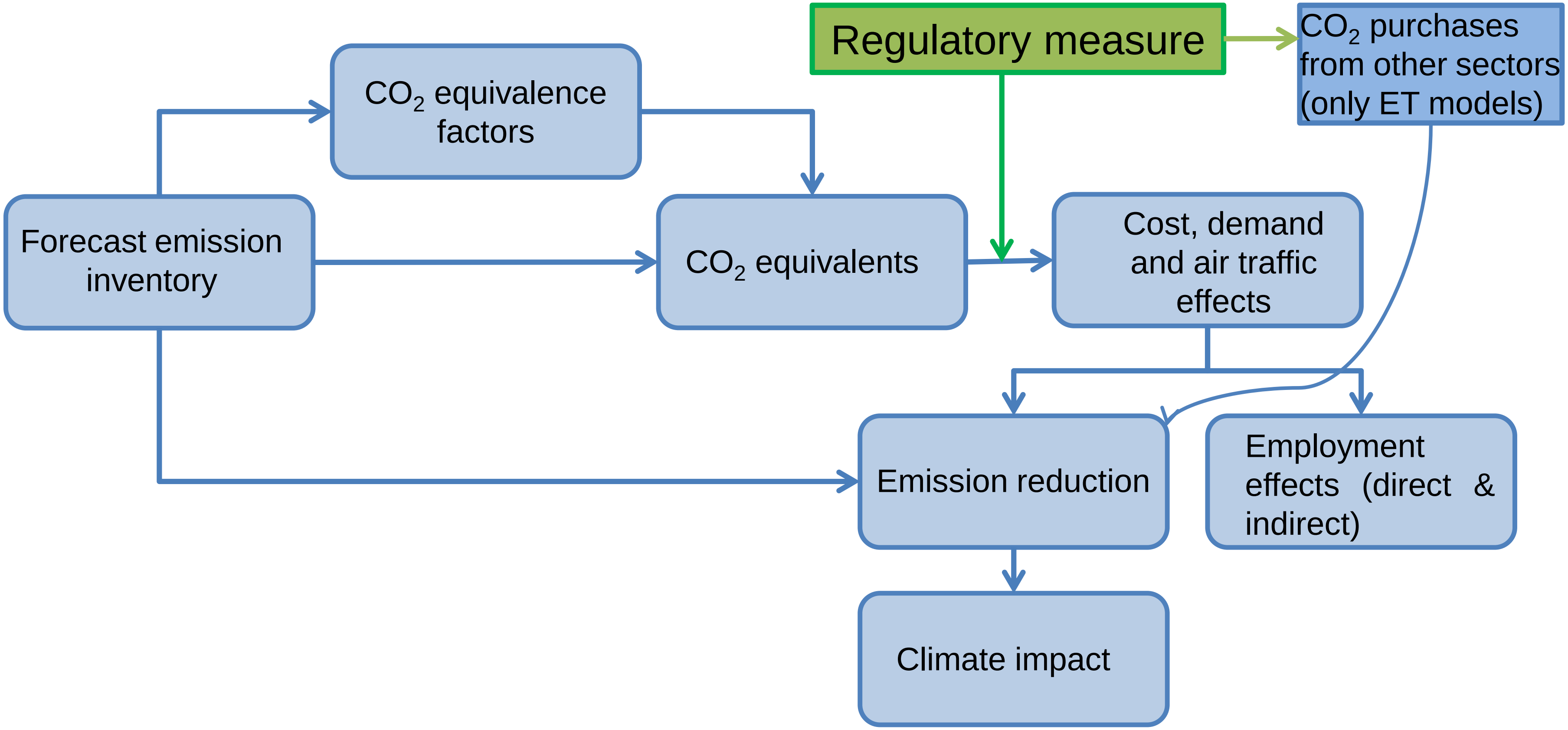
Price Path	2010	2020	2030
Low Price	10	20	30
High Price	10	40	80
Mixed Price	10	40/20	30/80

Prices in USD per ton of CO_2 equivalent.

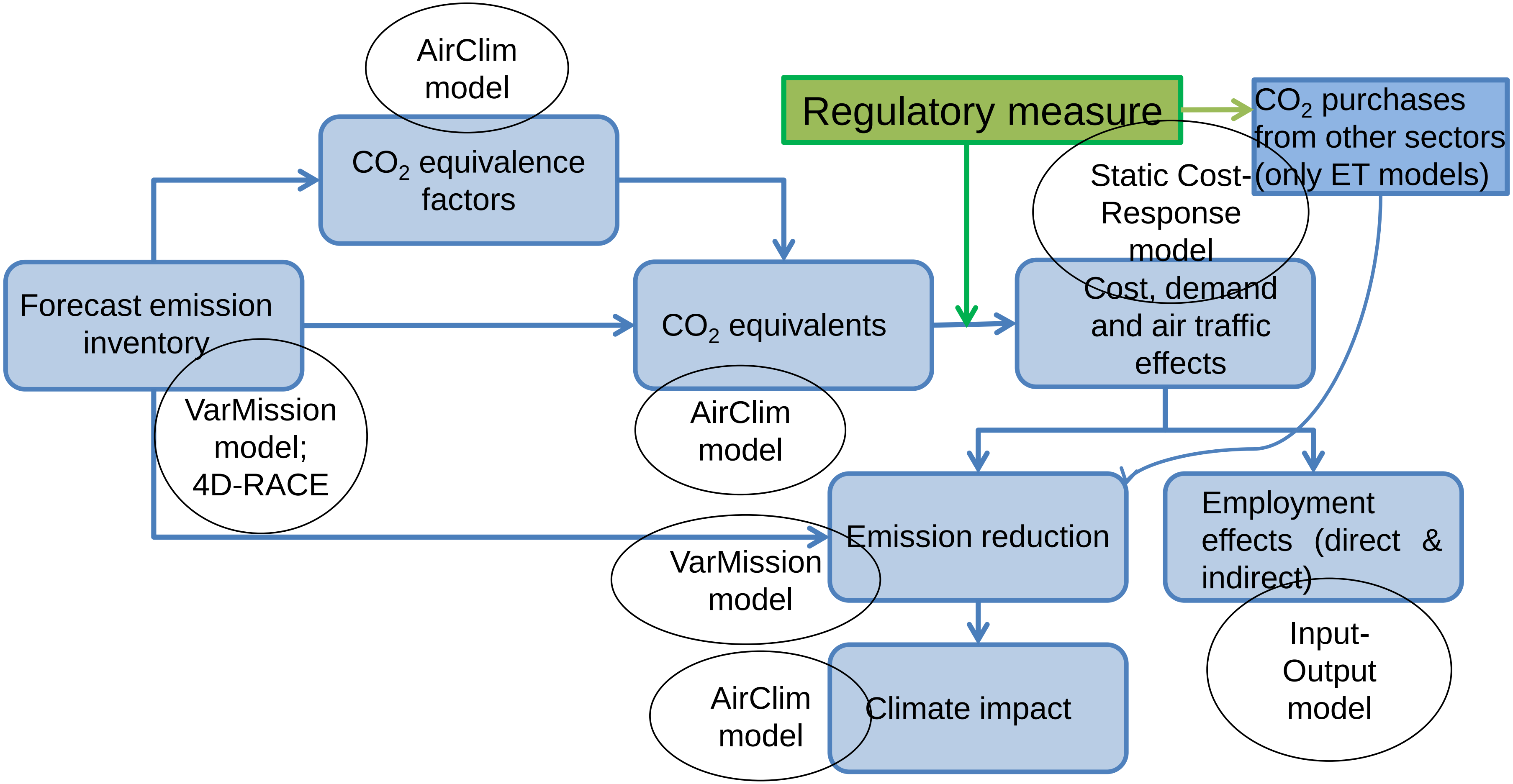
Two **alternative metrics** for the translation of the climate impact of non CO_2 species into CO_2 equivalent have been investigated:

Average Temperatur Response (atr) 20 and Average Temperatur Response (atr) 50. ATR is the mean temperature change over a time horizon of 20 and 50 years.

1. AviClim modelling approach (1)

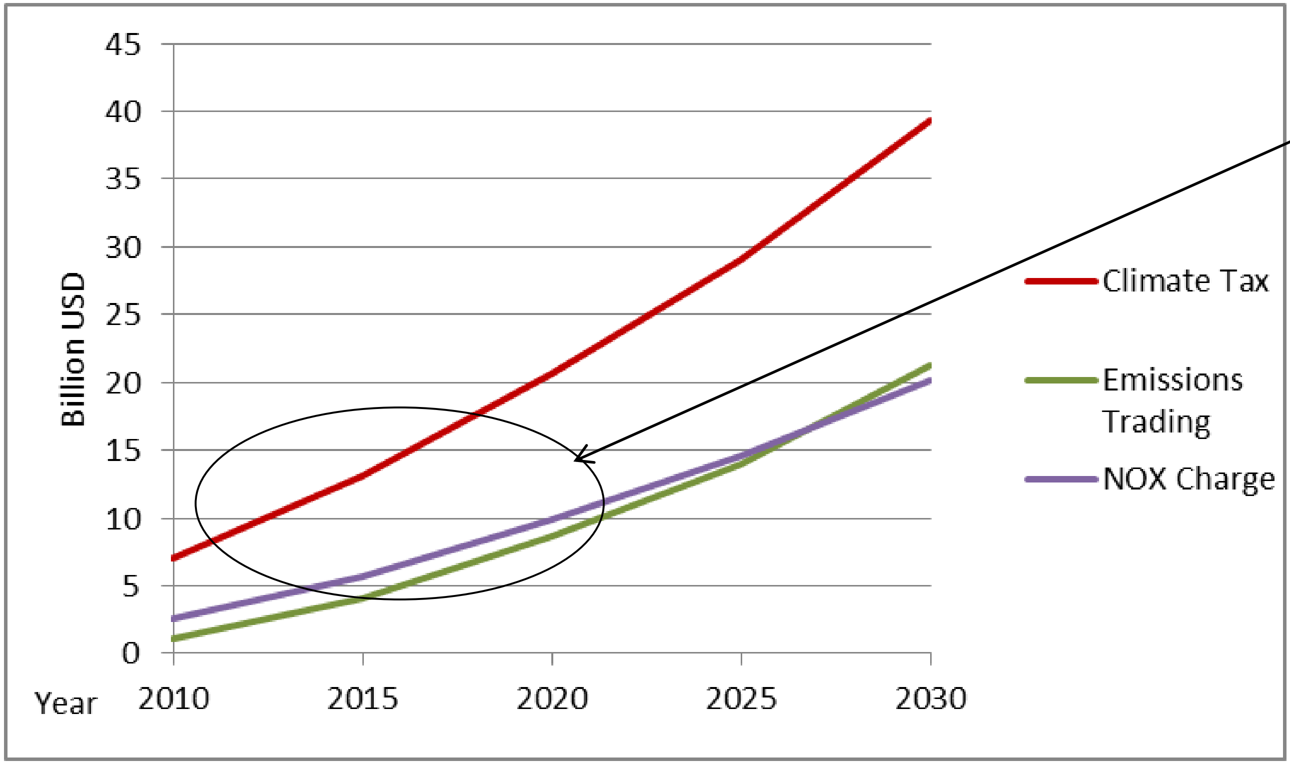


1. AviClim modelling approach (2)



2. AviClim main results (1): costs

Scenario „Greater EU“, atr 50, Low Price Scenario

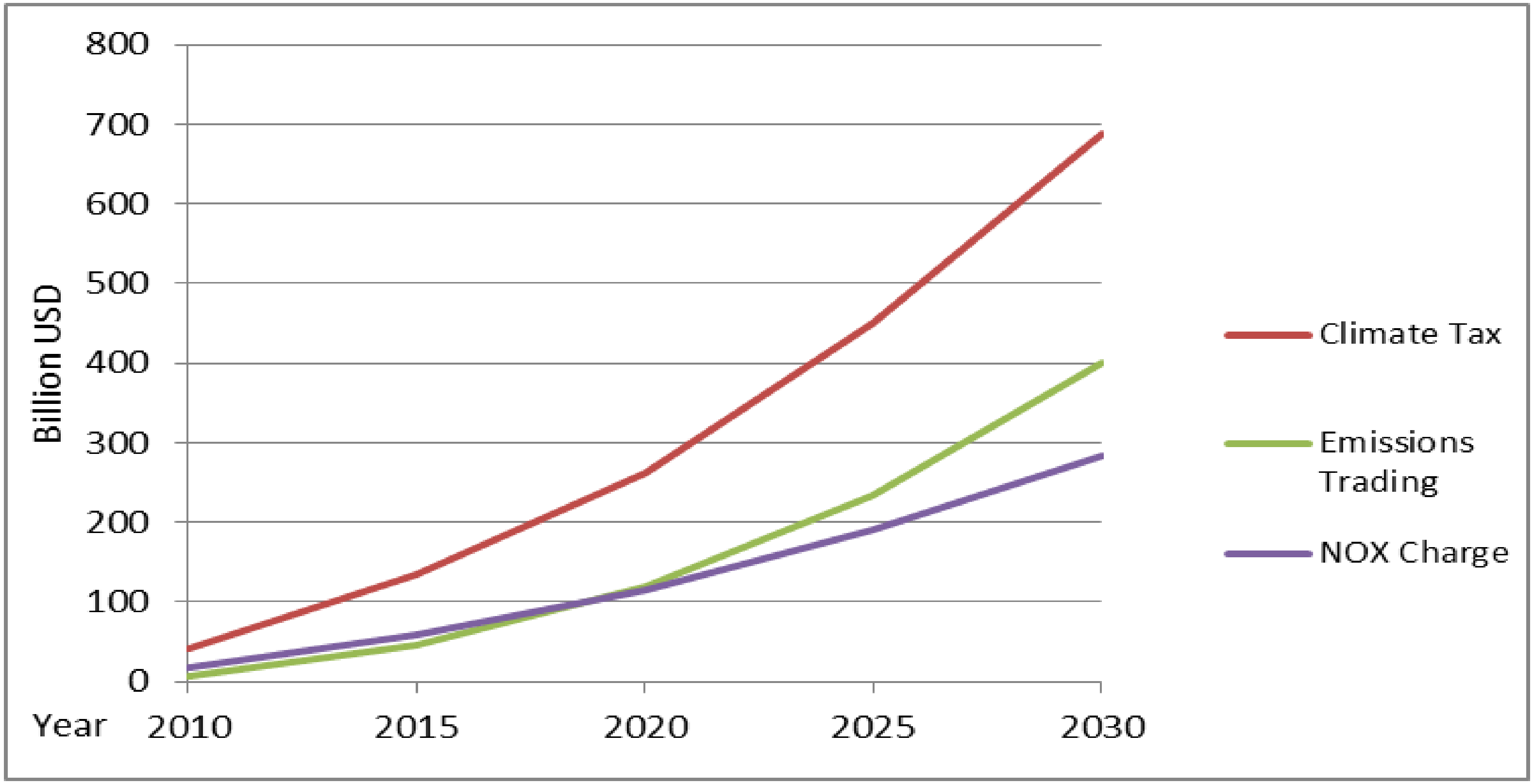


specific assumptions ET models: 85% of 2010 emissions allocated for free

NO_X Charge includes CO_2 trading and operational measures.

2. AviClim main results (2): costs

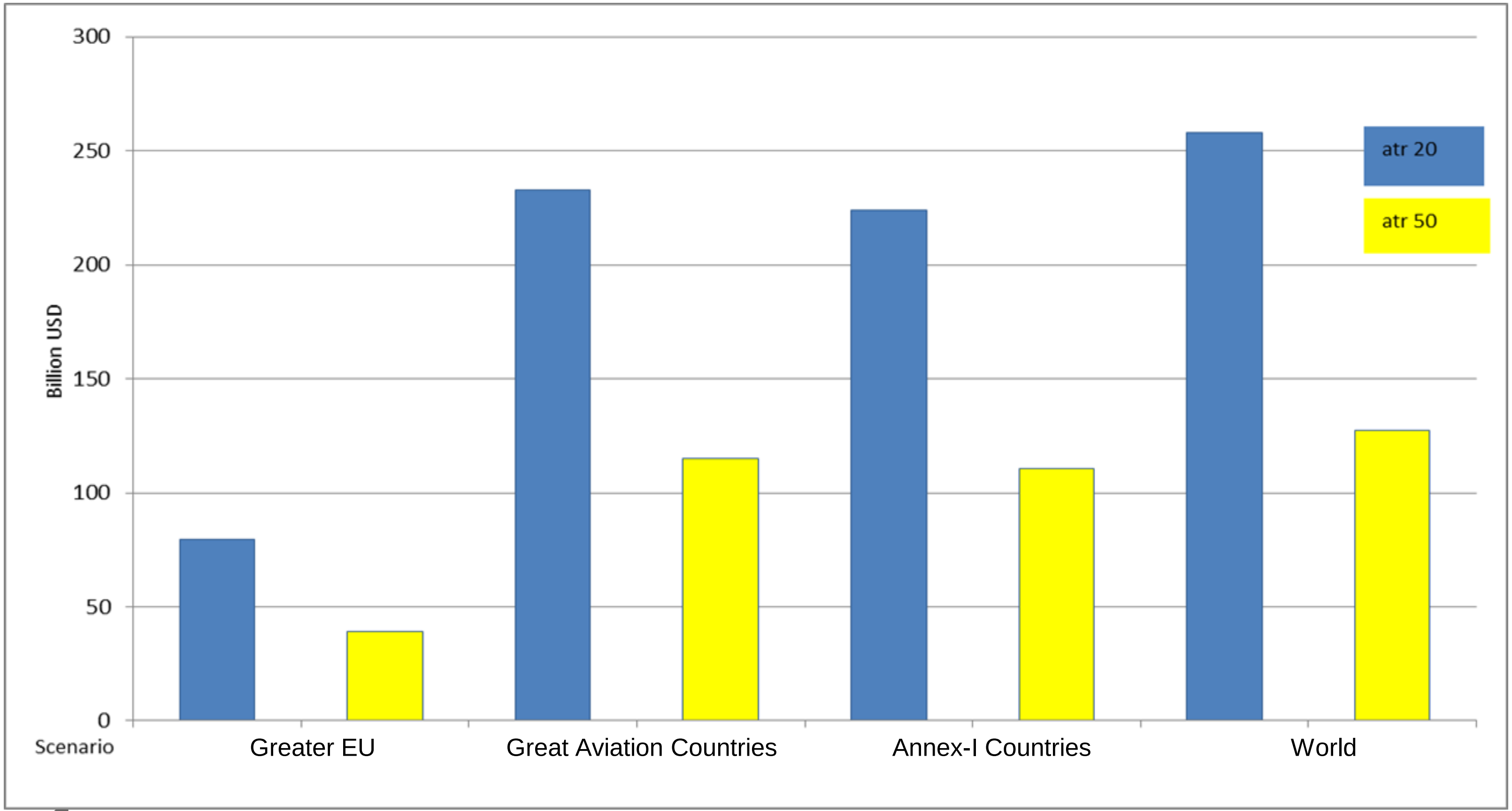
Scenario „World“, atr 20, High Price Scenario



NO_X-Charge includes CO_2 trading and operational measures.

2. AviClim main results (3): influence of climate metrics on costs

Climate Tax, 2030, different geographical scenarios, Low Price Scenario



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2. AviClim main results (4): demand for kerosene

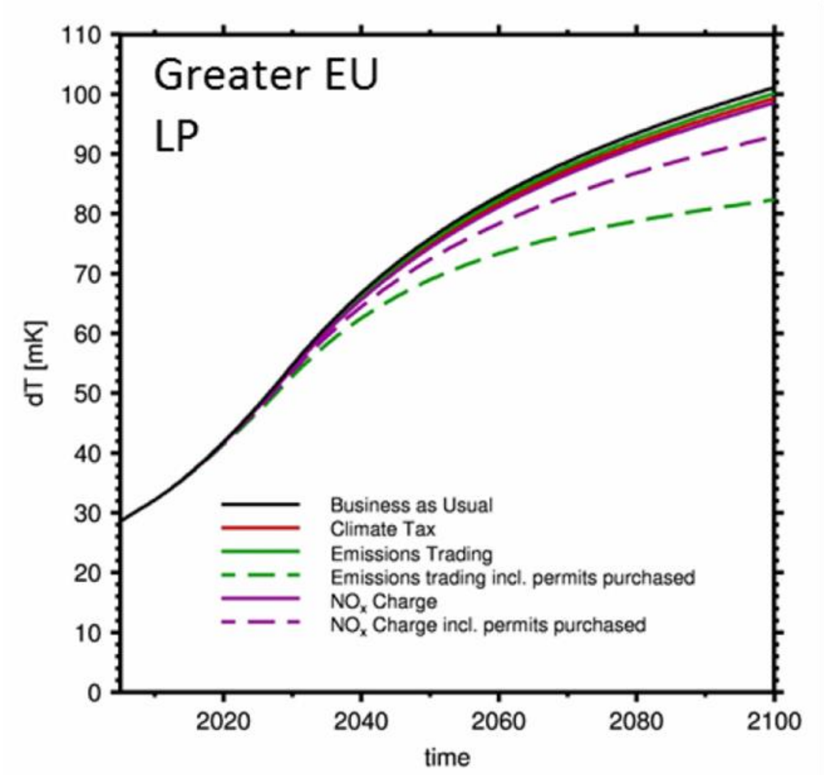
Change in demand for kerosene in per cent compared to business as usual scenario, price elasticity of demand: -0.8, atr 50, in the year 2030

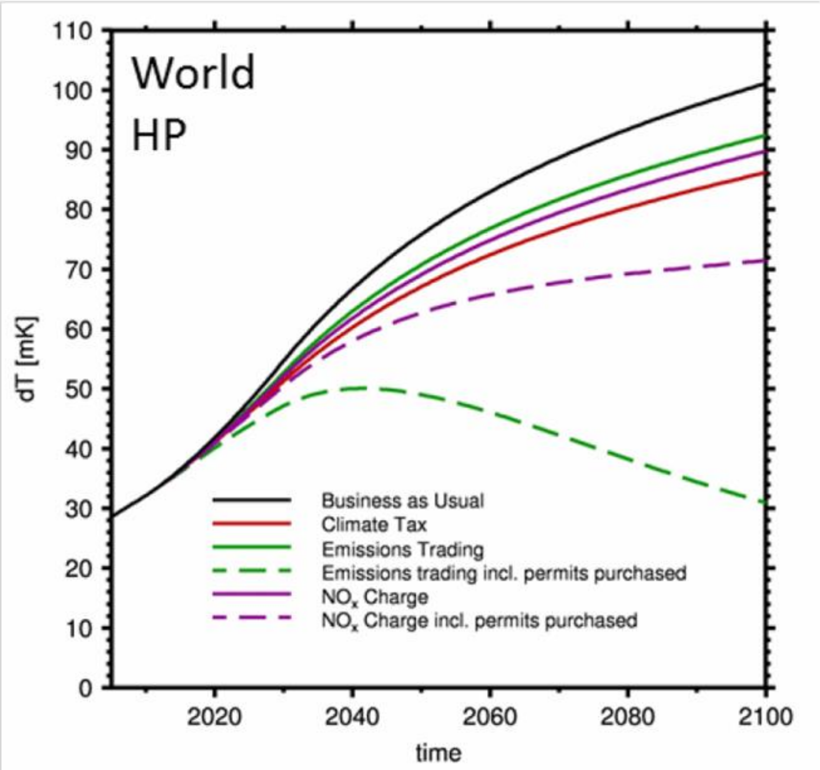
Low Price Scenario	**„Greater EU“**	**„Great Aviation Countries“**	**„World“**
Climate Tax	-1.8%	-5.9%	-6.7%
Emissions Trading	-0.9%	-3.4%	-3.9%
NO_x charge	-0.6%	-1.9%	-2.2%
High Price Scenario	**„Greater EU“**	**„Great Aviation Countries“**	**„World“**
Climate Tax	-5.1%	-15.8%	-17.8%
Emissions Trading	-2.7%	-9.2%	-10.4%
NO_x charge	-2.4%	-6.5%	-7.4%

NO_X-Charge includes CO_2 trading and operational measures.

2. AviClim main results (5): temperature development

Scenario „Greater EU“, Low Price Scenario, and Scenario „World“, High Price Scenario, demand elasticity – 0.8 (case 2), metric atr 50, compared to a Business-as-usual temperature development





NO_X Charge includes CO_2 trading and operational measures.

3. AviClim: summary

AviClim modelling results indicate that under the assumptions explained above, a **global emissions trading scheme** for the political regulation of both CO_2 and non-CO_2 emissions from aviation would be the best solution from an economic and environmental point of view. The second-best solution would be the combination of both marked-based and operational measures.

Under a **global emissions trading scheme, costs and impacts on competition** could be kept at a moderate level. At the same time, **environmental benefits** are significant. The possibility to purchase emission permits from other sectors (so-called "open emissions trading scheme") is important for the positive outcome.

AviClim results will be important for the **political negotiations** on EU, UNFCCC and ICAO (International Civil Aviation Organization) level.

4. AviClim update: research question

How to include aviation‘s full climate impact in the EU Emissions Trading Scheme?

AviClim update has been conducted in 2019. Published:

Scheelhaase, Janina (2019) “How to regulate aviation's full climate impact as intended by the EU council from 2020 onwards”, in: *Journal of Air Transport Management* 75, pp. 68-74

4. AviClim update: How does an ETS work in principle?

- Within an Emissions Trading Scheme, so-called emissions **permits** are traded. These enable the owner of the permit to emit a specific amount of CO_2. Without permit, it is forbidden (and strongly sanctioned) to emit CO_2.

- The **total amount** of CO_2 permits is **fixed** within an Emissions Trading Scheme. Therefore, the CO_2 emissions of all trading entities are capped (so-called **emissions cap**).

- Emissions permits are **freely traded** on the ETS market(s). This way, permits will be sold by companies with relatively low abatement costs for CO_2 and bought by companies with relatively high abatement cost.

- At the end of the day, an Emission Trading Scheme allows for a **cost-efficient reduction of CO_2** in the economy.

4. AviClim update – EU ETS for aviation (basic facts)

- **Legal framework**: EU Directives 2008/101/EC and 2009/29/EC.

- **Affected operations:**
  - **Flights departing and arriving in the EU, Iceland and Norway (EEA)** from 2012 onwards ("original = Full Scope")
  - **Intra-EEA flights only** ("Stop-the-Clock" regulation for the period 2013-2016, still in operation as of December 2019) ("Reduced Scope")
  - **General exclusions:** Aircraft below 5.7 t Maximum Take-Off Mass (MTOM), VFR, government & military flights, and certain flights to remote regions, etc.

- **Emissions cap:**
  - 2012: **97%** of so-called historical emissions (2004-2006 average)
  - from 2013: **95%** of so-called historical emissions.

5. Possibilities for including non-CO_2 species in the EU ETS (1)

The costs for complying with the EU ETS have been modelled by weighing the climate relevant emissions under the cap with the specific metric for CO_2, NO_X, H_2O, contrails, respectively. The metric atr_{50} translates the climate impact of all species into equivalent CO_2. This metric varies with the flight position p and the species.

$$\text{Climate relevant species under the EU ETS} = \sum_{p \in Flight} CO_{2_{(p)}} + NO_{x(p)} * atr_{50}{}_{(p)}^{(NO_x)} + H_2O_{(p)} * atr_{50}{}_{(p)}^{(H_2O)} + dist_{(\delta)} * atr_{50}{}_{(p)}^{(Cont)}$$

Where: $NO_{X\ (p)}$ is the amount of NO_X emitted on the different flight altitudes, degrees of longitudes and latitudes (identical with flight position p) at different points in time. H_2O is the amount of H_2O emitted on flight position p. Contrails and CO_2 are differentiated by flight position p, too, the latter only to take the thrust-setting of the engines into account.

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5. Possibilities for including non-CO_2 species in the EU ETS (2)

The formula can be applied to all flights and airlines under the EU ETS on a **flight-by-flight-basis**.

Airlines can to do this **in retrospect** (after the flight has been conducted) since the actual flight route taken and the local atmospheric conditions at that time and flight position are known by the airline which conducted the flight as well as by the Air Navigation Service Provider (Eurocontrol, e. g.).

The **summation** of all individual flights' amount of CO_2 equivalent equates to the total amount of climate relevant species (in million tons) under the trading scheme.

6. Costs and competitive impacts of an EU ETS regulating aviation’s full climate impact (1)

Calculation of cost per airline under the EU ETS:

CO_2 equivalent emittet – permits allocated for free = number of permits needed

number of permits needed * price per permit = cost for complying with EU ETS

However, an estimation of the costs on individual companies’ level would be associated with too many uncertainties. This is because airline’s management strategies and market developments play a predominant role in this respect, which are difficult to foresee for external parties.

Therefore we estimate the cost impact on selected flights. It should be noted that these estimations are based on a number of simplifying assumptions, for instance on the EU ETS cap.

6. Costs and competitive impacts of an EU ETS regulating aviation’s full climate impact (2)

Table 1. Climate relevant emissions of selected flights in the year 2020

Departure	Destination	Aircraft	Seats	Distance (miles)	CO_2 + Non-CO_2 (tons)	CO_2 (tons)
AMS	CDG	B737	132	248	9.8	6.5
CGN	TXL	B738	189	289	12.0	7.3
BCN	DUS	A319	144	726	46.5	11.5
DUB	FMM	B738	189	814	62.6	17.0
MUC	PMI	A320	144	756	54.3	14.5
DUS	DXB	A332	278	3114	427.3	105.3
MUC	MIA	A333	221	5008	590.5	177.9
CDG	LAX	B772	280	5670	1088.8	243.7
PRG	JFK	A332	225	4082	543.7	128.6

Source: DLR modelling results, based on Scheelhaase et al. (2014).

6. Costs and competitive impacts of an EU ETS regulating aviation's full climate impact (3)

Table 2. Cost for complying with the EU ETS per flight segment in the year 2020

Departure	Destination	Airline	Rate of free allocation	Price per permit (€/t CO_2equivalent)	Cost for emission permits per flight segment in €	
					CO_2 + Non-CO_2 regime	CO_2 regime
AMS	CDG	KL	0.56	8	34.50	22.60
CGN	TXL	4U	0.62	8	36.45	22.29
BCN	DUS	4U	0.62	8	141.74	34.88
DUB	FMM	FR	0.62	8	190.82	51.89
MUC	PMI	LH	0.56	8	190.30	50.64
DUS	DXB	EK	0.52	8	1628.31	401.24
MUC	MIA	LH	0.56	8	2068.43	623.08
CDG	LAX	AF	0.56	8	3813.84	853.63
PRG	JFK	DL	0.52	8	2071.96	490.27

Source: DLR modelling results, based on Scheelhaase et al. (2014).

6. Costs and competitive impacts of an EU ETS regulating aviation's full climate impact (4)

Table 3. Cost for complying with the EU ETS per passenger in the year 2020

Departure	Destination	Airline	Seats	Load factor	Cost per passenger per flight segment in €	
					CO_2 + Non-CO_2 regime	CO_2 regime
AMS	CDG	KL	132	0.81	0.32	0.21
CGN	TXL	4U	189	0.76	0.25	0.15
BCN	DUS	4U	144	0.76	1.29	0.32
DUB	FMM	FR	189	0.97	1.04	0.28
MUC	PMI	LH	144	0.79	1.66	0.44
DUS	DXB	EK	278	0.75	7.80	1.92
MUC	MIA	LH	221	0.79	11.79	3.55
CDG	LAX	AF	280	0.86	15.80	3.54
PRG	JFK	DL	225	0.86	10.76	2.55

Source: DLR modelling results, based on Scheelhaase et al. (2014). Belly freight has not been taken into account. Load factor data taken from the airlines' websites.

7. Conclusions (1)

How to **regulate aviation's full climate impact** (CO_2, H_2O, NO_x, contrails etc.) in the EU? A likely approach is the inclusion of all climate relevant species from aviation in the European Emissions Trading Scheme. We analyzed the cost effects of this approach on the level of individual flights.

According to DLR modelling results, the **cost effects** of the EU-ETS addressing both CO_2 and non-CO_2 emissions will be **much larger** than under the current scheme. The cost effects also depend on the **length** and **altitude of the flight**. Especially the **flight time operated on cruise level** is an important factor for the climate effect of each flight.

This will have consequences for the **competitive environment** of the aircraft operators under the trading scheme:

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7. Conclusions (2)

1. Only optimizing fuel efficiency will **no longer be rewarded**. Instead it becomes more important to minimize both CO_2 and NO_x emissions.

2. Airlines concentrating on **long-haul operations** will be facing a competitive disadvantage compared to aircraft operators mainly offering short- and medium-haul flights.

3. It will be important to include **all flights** to and from Europe to avoid competitive distortions between the airlines.

For environmental reasons, aviation’s full climate impact and not just CO_2 should be **regulated soon**. We developed a **practicable method** for this approach.

Thank you for audience!