Developing a Strategic Framework for an Airline dealing with the EU Emission Trading Scheme

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The European Commission has decided that the aviation sector will be included in the EU Emission Trading Scheme (ETS) in 2012. This has significant impacts on the business and the strategy of airlines. All of a sudden, airlines must possess emission rights in order to be able to operate their aircraft. Given the uncertainty over how exactly the EU ETS is going to be implemented in the next few years and the unexpected fluctuations in prices of fuel and the CO2 emission rights, airlines are faced with a multifaceted challenge: how to best incorporate EU ETS in the business strategy of an airline? In order to support airlines with this complex process, in this research project a strategy model with different regulatory scenarios is developed, with which the exposure of an airline to EU ETS can be calculated. The model has been piloted in an airline to determine how future airline strategy should be adopted based on the regulatory environment. It is clear from the analysis of the different scenarios, that every regulatory scenario has its own optimal strategy, ranging from increasing fuel efficiency to using alternative types of fuel.

Nomenclature

$A_{i,free,t}$	=	free allowances received in year *t* by airline *i*
$DOC_{i,ETS,t}$	=	the direct operating costs induced by the EU ETS for airline *i* in year *t*
e	=	efficiency factor of airline (kg CO_2 / RTK)
$E_{i,ETS,t}$	=	mass of CO_2 emissions in the year *t* of airline *i* under the scope of EU ETS
$E_{i,total,t}$	=	mass of CO_2 emissions in the year *t* of airline *i*
$E_{sector,2004\text{-}06}$	=	mass of CO_2 emissions in years 2004 to 2006 of air transport sector under the scope of EU ETS
$ETSP_m$	=	market price for emissions
n	=	number of airlines falling under the scope of EU
$P_{EUA,t}$	=	average price paid for an EUA in year *t*
$Traffic_{i,ETS,t}$	=	traffic in year *t* of airline *i* under the scope of EU ETS
$Traffic_{i,total,t}$	=	traffic in year *t* of airline *i*
$y_{i,a,t}$	=	adapted yield
$y_{i,ETS,t}$	=	yield increase (€/RTK) when emission rights are passed through to the passenger in year *t*
$y_{i,t}$	=	yield of airline *i* in year *t* without passing through emission costs
$y_{i,total,t}$	=	total yield in year *t* of airline *i* (incl. yield increase due to pass through of emission costs)
α	=	pass through rate of emission costs
β	=	ratio of purchased to necessary allowances; no free allowances
γ_t	=	emission exposure

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ε_m	=	price elasticity for either cargo (*m*=*c*) or passengers (*m*=*p*)
η_t	=	cap factor, currently set at 97%
φ_t	=	traffic exposure
ω_t	=	free allowances factor; currently set to 82%

I. Introduction

VIRTUALLY all scientists agree that greenhouse gases have contributed to the global warming of the earth and the rising of sea level. Since 1990, CO_2 emissions from the air transport sector, which are directly related to the amount of fuel consumed, have increased by 87% and now account for approximately 3.5% of the anthropogenic contribution to climate change according to an impact assessment[1]. Consequently, reductions thanks to new technology and efficiency have not been sufficient to compensate for the rapid growth of global air traffic (50% over the last decade)[2]. Due to this universal consensus the Kyoto Protocol has been introduced in 1997 to combat the unrestricted generation of greenhouse gases.

In 2005 the EU established the EU Emission Trading Scheme (EU ETS) to meet the Kyoto requirements. Energy intensive industries subject to EU ETS had to reduce their emissions of greenhouse gases. The three year period from 2005 to 2007 was the first trading period in which selected industries were obliged to surrender emission rights for the greenhouse gases they produced. These emission rights can be bought or sold, thereby creating a market for emission rights. The EU amended the EU ETS Directive to include the air transport industry in its scope, meaning that airlines will have to buy emission rights for the amount of greenhouse gases emitted.

The introduction of EU ETS has significant impact on the airlines. Suddenly additional forces are thrust upon the airline; airlines have to comply with the EU ETS Directive if they want to be able to keep operating. To be compliant with the directive, the airline must be in possession of the emission rights. The airline can acquire these rights in three ways: part of the air transport sector allowances will be allocated freely based on historical (2010) tonne-kilometre (RTK) benchmarking. The rest of the air transport allowances will be distributed through an auction. Furthermore, all allowances can be traded on the market at any time. Apart from the amendment of the EU ETS Directive to include aviation, the directive is in the process to be improved and extended which might have implications for the air transport sector. It might be treated as a standard industry sector, with more stringent targets.

All in all, this is a complex framework that influences operational as well as financial aspects of the airline. So it has been suggested to treat EU ETS as a strategic business issue, rather than merely a matter of environmental compliance[3]. Therefore, the main research question is defined as: *"What is the best strategic option to incorporate EU ETS in the business model of an airline?"*

II. Technical Approach

A strategy model is built, which supports decision makers of an airline in developing the strategy that helps them lowering the EU ETS burden. Using the developed model gives a detailed insight in the strategy possibilities of the airline in the future. The future is caught in scenarios, which helps to further increase knowledge.

The strategy model is developed in which the relation between scenario variables, decision variables and performance measures is discussed. In this model, scenario variables on which the airline has no influence describe the environment in which the airline operates. Decision variables describe the strategy of the airline regarding EU ETS. The combination of scenario variables and decision variables will result in a figure for different key performance indicators (KPI). These KPI's determine the value or performance of a strategy.

Several alternative strategies are looked at and evaluated. Strategies are created using a bottom up approach. In the bottom up approach some basic actions are selected that change performance of the airline under the burden of EU ETS for the better. Choices are made in the face of uncertainty, and the outcome of the performance of an action will thus be affected by random factors that are outside the control of the decision makers of the airline. The random evolution of these factors is captured in scenarios. The scenarios are backed up by scenario variables thus giving a more quantitative basis to the scenario development.

The analysis of consequences for the airline is performed. External factors are analyzed. These factors are used as an input for scenario analysis. Factors include political factors as well as economic factors like the price of the right to emit CO_2. Subsequently, strategies for each scenario are designed.

During the construction of this model, apart from literature, many variables influencing the airline were analyzed during a brainstorm session. They were drawn schematically in an impact-uncertainty diagram. The ordering of variables in a two dimensional matrix to value them on manageability and impact, made it easy to make a distinction between decision variables and scenario variables. On the one hand, high impact factors that are manageable (through strategy) are defined as decision variables. On the other hand, high impact variables being uncertain are defined as scenario variables. The low impact variables will not be included or used for the impact analysis on airline, since they only make the model more complex. If a factor was ranked with a minimum of 4 and at least one 5 for manageability and impact, the factor was given the status of decision variable

III. Analysis of EU Emission Trading Scheme

This section aims to give some background information on the objectives of the Kyoto Protocol, the way the current EU Emissions Trading Scheme works, the proposals for subjecting aviation to an EU ETS scheme, and the political uncertainties as to how this will exactly happen.

A. Background: Kyoto Protocol

In the mid 1980s significant public concern was raised by an increasing amount of scientific studies reporting human interference with the climate system. As a result the UN World Meteorological Organisation (WMO) and the UN Environmental Programme (UNEP) established the International Panel on Climate Change (IPCC) in 1988. In 1990, the First Assessment Report was issued by IPCC confirming that climate change is a threat to the earth. This report was a major incentive for a global treaty to address climate issues. This resulted in the United Nations Framework Convention on Climate Change (UNFCCC), which is an international environmental treaty emanating from the United Conference on Environment and Development (UNCED), known as the ‘Earth Summit’ held in Rio de Janeiro in 1992. The treaty is aimed at ‘stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human originated interference with the climate system’. UNFCCC offers principles that serve as guidelines for dealing with these climate issues. These principles led to the attachment of the Kyoto protocol. The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change[4,5].

The Kyoto Protocol is a ‘cap and trade’ system: The protocol imposes national caps on the greenhouse gas emissions of developed states. The average cap per state is decreased so that it reduces overall CO_2 emissions by 5.2% below the 1990 baseline in the period 2008-2012. In practice, states define caps for industrial entities. Several industries fall under the scope of the Kyoto Protocol: energy intensive industries, industrial processes, agriculture and waste industries[6]. Air transport sector emissions are not subjected to the Kyoto Protocol, since it was argued that the ICAO would come with its own emission reduction system. This has not happened and the transport sector in general might therefore be included in the successor of the Kyoto Protocol. There is no clarity yet on the successor of the Kyoto Protocol after 2012. However, in February 2007, different states agreed in principle on the outline of a succeeding treaty to the Kyoto Protocol. Whether the airline sector becomes part of this succeeding international agreement remains an uncertainty.

B. Current EU Emission Trading Scheme

In January 2005 the EU ETS commenced operation as the largest international, multi-sector greenhouse gas emission trading scheme world-wide. The EU ETS is an independent framework that enables the EU member states to adhere to their obligations under the Kyoto Protocol. The scheme is based on Directive 2003/87/EC, which entered into force on 25 October 2003[7]. In January 2005 the first phase (2005-2007) commenced. During this period several specific industries were covered by the scheme: power generation and energy intensive industries (iron & steel, glass, cement, pottery and bricks). The second trading period is 2008 to 2012. The European Commission proposed to add the air transport industry to the existing EU ETS and the resulting Directive has been published 13 January 2009[8]. The argumentation of the EU is that not including the air transport sector in the EU ETS undermines any efforts made by other industrial sectors to fulfill Europe’s Kyoto commitment to reduce emissions of greenhouse gases. A major revision and the final results will probably be implemented in the third trading period (2013 to 2020).

Like Kyoto, the EU ETS is a ‘cap and trade’ system. An emission cap is defined, for each individual installation in a National Allocation Plan (NAP), which is submitted by each EU member state and approved by the European Commission. Installations exceeding their quotas are allowed to buy unused credits from companies that are better at cutting their emissions. The goal of a ‘cap and trade’ system is to seek reductions in emissions through the push for more advanced technologies or planning. Separate installations are able to buy or sell emission rights. In addition to carbon trading a ‘Linking Directive’ allows operators to use a certain amount of Kyoto certificates from flexible mechanism projects for compliance purposes. Furthermore, an EUA (EU tradable unit) is backed by an AAU (Kyoto tradable unit), which both are allowance units for the emission of one ton of CO_2.

C. EU ETS and Aviation

The EU amended the EU ETS Directive to include the air transport industry in its scope, meaning that airlines have to have emission rights for the amount of greenhouse gases emitted. The airline will be able to acquire emission rights in three ways (at least in the beginning of the EU ETS): Part of the air transport sector allowances will be allocated freely based on historical (2010) tonne-kilometre (RTK) benchmarking. The rest of the air transport sector allowances will be distributed through an auction. Furthermore, all allowances can be traded on the market at any time. It is a complex framework that influences operational as well as financial aspects of the airline.

The EU Directive[7] and the proposal to amend Directive 2003/87/EC[9] are important to the air transport sector. Firstly, the EU has set the goal to include the air transport sector in the scheme and secondly the EU wants to revise the existing EU ETS Directive. For both goals the Directive is/ will be amended. They are referred to as Track I and Track II henceforth. Track I is a proposal that amends the current emission directive so that the air transport sector will be included in the directive, but will be treated completely as a separate group from 2012. The second proposal, Track II, is an amendment of the standard directive based on a revision and experiences of the first trading phase of the EU ETS (2005-2007). One of the subjects, which are part of the revision, is the inclusion of the air transport sector in the directive in 2013. In this case the air transport sector is treated as a standard industry sector. This results in two high probability scenarios. The first scenario comes forward from the amendment of EU ETS to include aviation activities and represents the current agreement[7]. The second proposal is a revision of the existing directive[9], in which the air transport sector industry is treated as one of the three generalized industry groups.

Track 1: Air Transport Sector treated as Separate Industry Group
The defining elements of the first scenario are discussed below in more detail:

Table 1. Elements of EU Directive

Design parameter	Final proposal
Implementation date	2012 is first commitment year
Region	All airlines operating in the EU will be subjected to the EU ETS. Flights departing from the EU or arriving in the EU will fall under the scope of EU ETS. It is not just EU based airlines that are subjected to the scheme, but also airlines from outside the EU.
Baseline	Average CO_2 emissions 2004 – 2006 per year by airlines for all stretches that fall under the scope of the proposal. The baseline is determined on the basis of data from Eurocontrol. Exact details are not clear yet. However, CE Delft states that Eurocontrol research papers have estimated the CO_2 emissions around 217.7 Mt for the year 2005[12].
Cap	The ‘cap’ represents the total number of emission rights that will be allocated yearly to the air transport sector industry. The cap equals a percentage of the baseline. 2012: 97% 2013 and subsequent years: 95% Subject to revision of Directive
Auction	15%
Trade system	Most likely a semi-open trading environment: Air transport sector may buy from other sectors, but other sectors cannot use air transport sector emission rights for compliance, due to the fact that air transport is not included in the Kyoto Protocol.
Benchmarking	The free allocation is determined on the basis of traffic: Revenue Tonne Kilometers (RTKs) In 2011 each airline has to submit its RTK figure of 2010 under the scope of the EU ETS to the European Commission.
Greenhouse gases	CO_2
Reserve allowances	Limited to 1 million allowances for fast growing airlines – new entrants

Track II: Air Transport Sector Treated as Standard Industry

Article 30 of the EU ETS Directive states the possibility of a total revision of the Directive. The EU ETS has proved to be effective according to European Commission[11]. The latest official data show that the 15 EU member states which originally signed up to Kyoto had achieved a 2% CO_2 cut in 2005 compared to 1990 levels. This report is recently backed up by Ellerman and Joskow[12]. Furthermore, projections of the EEA report[13] imply that, based on existing policies alone, this figure should rise to 7.4% by 2010 – just short of the Kyoto target (8% for EU15). However, in March 2007, EU leaders agreed that, by 2020, they would cut overall greenhouse gas emissions by 20% compared to 1990 levels. The Commission says this will require a “much steeper reduction path” for industrial emissions, which is the aim of its EU ETS reform proposal (Track II) for the post-2012 period, presented on 23 January 2008[14]. The main elements of the new system, which would enter into force in 2013 and run until 2020, are:

- scope of the scheme to be enlarged, in terms of:
    - industries; future industries might include the air transport sector, the petrochemical sector, the ammonia and the aluminum sector
    - greenhouse gases; other gases than CO_2 might be included
- share of free allowances will drop sharply; from 90% now to on average 40% in 2013[14]. Industries are subdivided into three 'boxes':
    - box I (e.g. power sector): 100% auctioning in 2013
    - box II (e.g.): auctioning increases from 20% in 2013 to 100% in 2020.
    - box III (industries with high changes of 'carbon leakage' to third countries): continue to get most allowances for free.

As yet the European Commission has selected the airline sector to be treated under the box II regiment. But within the European Parliament the leading environmental committee wants the airline industry to be treated under the box I regiment. So there is considerable uncertainty about future treatment of the airline industry and thus about the impact the EU ETS might have on airlines.

IV. The ETS Strategy Model

To manage this uncertainty an ETS Strategy Model has been developed, which supports decision makers of an airline in developing the strategy that enables lowering the EU ETS burden. In this section, the building blocks of the model are described. Using the developed model gives detailed insight in the strategy possibilities of the airline in the future. Several alternative strategies are looked at and evaluated. Strategies are created using a bottom up approach. In the bottom up approach some basic actions have to be selected that change performance of the airline under the burden of EU ETS for the better. Choices are made in the face of uncertainty, and the outcome of the performance of an action will thus be affected by random factors that are outside the control of the decision makers of the airline. The external environment, which the airline cannot affect, is captured by scenario variables. The decisions of airline are defined by decision variables. The strategy model, shown in Fig.1, is based on the fundament that each combination of a scenario and decision (or action) results in a pay – off of KPI value.

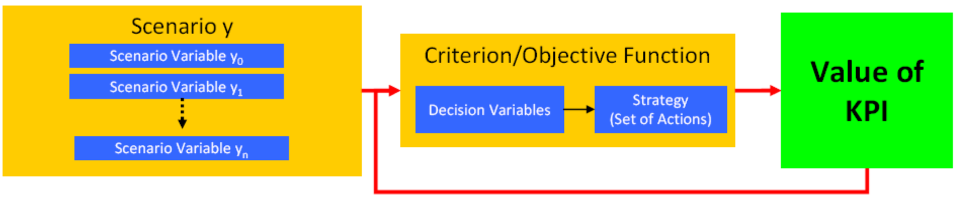

Figure 1. Schematic diagram of the EU ETS Strategy Model

So the airline decision makers need to choose an alternative action or a set of actions. This is being put in a (randomly selected) scenario. An objective or criterion should be defined. The criterion is used to find an optimal action for the decision maker by the link between the decision variable and KPI measures. A decision is optimal when the KPI is highest. Each combination of an action and scenario results in a KPI value.

A. Scenarios

As we have seen in paragraph III there is still a considerable amount of uncertainty of how exactly EU ETS will be implemented for the aviation sector. Therefore, several political scenarios have been developed, which are summarized in Table 2 below.

Table 2. Different scenarios

Scenario I	Characterized by low political pressure on CO_2 emissions of the air transport sector combined with a low EUA price and favorable demand elasticity figures.
Scenario II	The global fuel efficiency in Scenario II is higher than expected, which is chosen to be on the conservative end of the benchmark. Therefore the airline will obtain fewer free allowances than in Scenario I. Until 2015 no major changes in the aviation EU ETS directive will take place. From 2016 the percentage free EUAs that are allotted to the aviation sector will diminish at a rate of 14% in favor of auctioning. Favorable elasticity is observed.

Scenario III	Scenario III is characterized with and increasing auction percentage from 20% (2013) to 100% (2020). Unfavorable elasticity is observed.
Scenario IV	In scenario IV the European Parliament has effectively used its power to realize that the air transport sector becomes a standard Box I industry from the start of trading phase III (2013 to 2020). This significantly influences the profitability of airlines. Unfavorable elasticity is observed.

In these scenarios EUA prices, percentage of free allowances and different elasticities are observed.

B. Scenario variables

The external environment, which the airline cannot affect, is captured by scenario variables. These variables were further grouped in a PESTE analysis (see Fig. 2). The PESTE analysis is an analysis of the external macro environment in which the airline operates[15], and clusters external factors into different groups: Political, Economic, Social, Technological, and Environmental factors. The brainstorm session defined several scenarios by the main scenario variables determining the future of the airline. These factors are beyond the control or influence of the airline, but are, nevertheless, important when doing strategy planning.

Political	Economic	Social	Technological	Environment
Separate Aviation Directive remains to exist	EUA Price	Ageing population	Global Fuel Efficiency	Climate Change
Aviation Sector treated as any other industry (Box I or II)	CER Price	Changing family structures	New efficient aircraft	Local air and noise problems
Cap	Jet Fuel Price	Gore-effect	Emergence of new (bio) fuels	Indicators of increasing degradation
EU ETS CO2/RTK benchmark	EUA to CER Price Spread	Changing consumer values		
Auction System	Gas to Coal Price Spread	Demographic trends		
NOx rules	Ratio prices Jet Fuel to EUA			
Global emission rules	Pass Through Rate Competitors			
US will not pay Emission rights	Pass Through Opportunity Costs by Competitors			
Possible UN report on alarming change of environment	Other airlines avoid EU (ETS)			

Figure 2. The PESTE Analysis

Not all scenario variables are quantifiable, but they are correlated to other scenario variables. For instance, the variable whether the aviation industry falls under a separate or standard EU ETS treatment is translated in the scenario variables defining the cap and auction percentage.

C. Decision variables

The main determining variables of the airline operation in relation to EU ETS on which the airline has a direct influence are called the decision variables. By changing these decision variables the operation in relation to EU ETS is changed resulting in a better or worse performance. Indeed, the goal is to assess whether a strategy is performing well or not. Therefore, several performance measures are derived to be able to assess the appropriateness of a strategy subject to a scenario.

V. Results

Assumptions for all scenarios

Global fuel efficiency will grow 2% per annum. In other words, the mass of CO2 emissions per RTK will decrease with 2% per annum (IATA, 2004). The price elastic ties are as follows -1.6 for cargo and -1.0 for long haul leisure. The new US administration will have a positive standpoint on emission trading schemes in general. Therefore, the US will not act against the EU ETS.

The value of a strategy (in KPI terms) is dependent on the combination of the scenario variables and the decision variables. Firstly, in this section the decision variables are described. Related to the decision variables an analysis of the historical and current operation of the airline is performed using a large database with operational data of from January 2004 to July 2008. Secondly, several real actions that enable the airline to control the value of decision variables will be described. The decision variables must be changed to be able to control value when having a vision. A number of actions that affect decision variables are described.

Decision variables are the variables in the decision model, which the airline can effectively control. The strategy of the airline could define certain targets for the decision variables based on a certain view on the future development of the market. The goal is to set decision variable targets that maximise the value: A value maximising strategy based on a view.

A. **Decision variables**

In relation to EU ETS five important decision variables have been identified: CO_2 emissions of the airline, exposure to EU ETS, fuel efficiency, pass through rate, and green strategy and marketing. They are discussed in more detail below. The five decision variables are selected on the basis of the variables found during the brainstorm session.

CO_2 Emission

The EU ETS for the air transport will attach value to CO_2 emissions. Subsequently, an insight in the current and forecasted CO_2 emissions is important. In the strategy model the CO_2 emissions are defined as decision variables, for they are direct in the influence of the airline. For instance the decision ‘to not fly at all’ turns the emissions form the operation immediately to zero.

Exposure to EU ETS

In this paper two definitions of exposure are used. In the first definition ‘exposure’ represents the percentage of the mass of the CO_2 emissions under the scope of EU ETS to the mass of the CO_2 emissions of the total operation of an airline. In the second definition the ‘exposure’ represents the percentage of the traffic (RTK) under the scope of EU ETS to the traffic of the total operation of an airline. The equations (1) and (2) show the distinct relations clearly:

$$E_{i,ETS,t} = E_{i,total,t} \cdot \gamma_t \tag{1}$$

$$Traffic_{i,ETS,t} = Traffic_{i,total,t} \cdot \varphi_t \tag{2}$$

The exposure, φ_t is important in 2010 when an airline must hand over its traffic figure under the scope of EU ETS. The exposure, γ_t is important for the emission costs: The more emissions are produced under the EU ETS scope, the more EUAs must be obtained. By not landing or departing from the EU at all, the exposure would be set to zero. Of course, this is not a realistic measure, but it emphasizes the extent of control. Changing exposure does affect the costs of EU ETS directly. An airline has full control over this variable what makes it a decision variable.

Fuel efficiency of the airline

Since the fuel consumption is linearly related to the CO_2 emissions, fuel efficiency is defined by the ratio of the mass of the CO_2 emissions divided by the traffic expressed in revenue ton kilometers (RTK). The fuel efficiency could be changed by two factors: The increase in fuel efficiency of the aircraft and the change in average load factor (traffic divided by output: RTK/ATK). The fuel efficiency variable is important because of fuel consumption, but also for the determination of necessary EUAs in relation to the free EUAs.

Fuel efficiency is measured by the fuel consumption per RTK. The RTK is defined as the ton kilometers, which is dependent on mass and distance of transport. If an airline transports cargo it will generally be loaded with a higher mass than passenger flights. Subsequently, a cargo flight will generate on average more RTKs when distance is equal to a passenger flight. So an airline with a lot of cargo business pushes the fuel efficiency up, at least in its definition of fuel consumption per RTK.

The global fuel efficiency is a scenario variable and therefore described in the four scenarios. The European Commission will determine the total traffic (RTK) in 2010 and Eurocontrol will define the mass of the CO_2 emissions in 2004 to 2006. Based on these two figures benchmark fuel efficiency is defined. This figure is the benchmark on which the free EUAs are distributed. In the scenarios we assume a fuel efficiency benchmark derived from an ICAO document[x]. This paper assumes the global fuel efficiency computed by the ICAO to be a good guideline. The airline could set a fuel efficiency target. It could be independent or derived from other targets like traffic or output and the CO_2 emission target.

Pass Through Rate

In the airline market, fuel is passed through to the passenger or client. Based on the existence of a fuel surcharge policy, it would not be far fetched to also pass through emission costs (with or without opportunity costs). The cost of using an allowance is the opportunity cost of not selling it on the allowance market. It can be concluded, therefore, that the production of passenger kilometers or ton kilometers is always accompanied by sacrifice of the opportunity to sell the allowances on the market. The competition passes the value of both the free allowances and bought emission rights through to the client. This is a possible development, which could also occur in air transport sector. Nevertheless, Ernst and Young emphasize the difference in liberalization between the power and the air transport industry[3]. They report that the impact analysis of performed for the European Commission by CE Delft[16] are using simplistic models to demonstrate that increasing prices would seriously impact demand for travel.

Passing through emission costs is a decision variable. An airline can, depending on market conditions, decide to pass through, not to pass through or to pass through a partition. Part of the EUAs will be allocated for free to the airline and will not increase costs for the airline. Any additional necessary EUAs will be bought on the market or auction. The free EUAs will have opportunity costs and therefore it makes in economical terms sense to pass these (opportunity) costs through to the customer.

According to Brouwer et al.[17] around 75% of passengers are willing to pay on average €25 per ton CO_2. The EUA trades lower than this price and consequently, the market potential based on this paper is substantial. Of course, clear communication of the reason of the costs to the passenger is of vital importance. In this paper it is assumed that both cargo clients and passengers behave similarly. Until the suggested price per ton, the price elasticity is weakened. The global air transport sector yield will decline 1% per year a ‘business as usual’ scenario. This development is attributable to the (fuel) efficiency increase of the global fleet. A target could be set for the passing through of costs. This target could be independent or dependent on market conditions or dependent on a green policy as described below.

Green Policy

A green policy has multiple purposes. The image of being green adds up to the credibility and attractiveness of a company. It will push therefore traffic and would make a (full or partly) surcharge of emission costs possible. A green policy with a strong internal basis will save cost as a spin off. Saving costs and pushing revenues are two ingredients.

‘Green Policy’ is defined as a qualitative variable. A well performing green policy will save emissions, energy, consumption of goods and will therefore save costs. When the green policy is also marketed effectively it will strengthen the image of the airline relative to its peers. All these influential facts make striving for a serious green policy all the more worthwhile and have certainly a large impact on many aspects of the business.

Green policy is strongly interlinked with the effectiveness of passing through any EUA costs. Passengers are likely to accept costs of emissions to be paid when it is for the good cause. If an airline has a serious green policy being marketed well, this enables the costs to be passed through with a lesser decreasing traffic. In this case, revenues would not be affected largely by the EUA cost burden[17]. It is difficult if not impossible to quantify the extent to which green policy is executed.

B. EU ETS Strategy

The goal is to find the optimal combination of scenario variables and decision variables that leads to the optimum KPIs. The decision variables are affected by real actions and a set of actions is defined as a strategy. Therefore, the aim is to select the set of actions or strategy that results in favorable KPIs. The actions originate from a large set up brain storm session in 2006 within the airline. Every department that was able to contribute to reducing fuel costs were involved. Various actions have been fully or partly executed. However, after research many of have not yet been executed for various reasons (costs, complexity, etc). Others, can be further executed, for they were only partly established.

- Operational opportunities:
  - reducing weight,
  - efficient flight planning,
  - fuel efficiency actions
- Strategic opportunities:
  - network design,
  - revenue management

C. Performance of the airline

The financial performance relates to the cost side of the equation. If the costs incurred by the EU ETS are too high for an economic sound operation the other side of the equation needs to be adapted: Revenues should be increased by increasing the yield. This action has its influence on the commercial attractiveness of the product of the airline. To overcome decreasing traffic figures a commercial strategy is necessary.

An increased yield is an ingredient for less traffic. However, when the 'total product' is more attractive to customers, traffic figures will not decrease as much. Customer's perception is important. The elements discussed above ultimately bottle down in the operating performance. The operating performance of the airline is the result of a complex series of interactions between output decisions (ASK or ATK produced), the cost arising from those decisions (unit costs per ASK or ATK), the volume of the output that is actually sold, traffic (RPK or RTK), and the yield (revenue per RPK, RTK) earned from the sold output. The operating profit is a function of traffic, yield, output and unit costs, which are the four key operating performance measures (see Eqs. (1) and (2)).

$$Revenue = Traffic \text{ x } Yield \tag{3}$$

$$Variable\ DOC = Output \text{ x } Unit\ Costs \tag{4}$$

Traffic is defined with RPK or RTK and is equal to the sold output. Yield is defined as revenue earned per RPK or RTK. Output is defined as the available seat kilometer (ASK) or the available ton kilometer (ATK). Unit cost is the total operating costs divided by the output (cost per ASK or cost per ATK). The total operating performance is either a profit or a loss.

The performance of the airline is captured with several KPIs (operating performance measures). Of course compliance is most important and can be seen as a non-operating performance measure. Furthermore, the burden of EU ETS must be managed actively. Financial, commercial and integrity aspects are the fundamentals and the three aspects are interlinked and is a value chain.

Emission Costs: Variable DOC

The clearest influence of the EU ETS is certainly the additional costs the scheme passes to the air transport sector. Each emitted kg CO_2 the airline has to back up with emission rights. Therefore, the costs of emission rights are classified as variable DOC (Direct Operating Costs) like fuel and airport charges. The variable DOC can be influenced in two ways: Change the unit costs or do not produce output. The emergence of the cost of emissions will increase unit costs for flights under the scope of EU ETS. Output changes influence the variable Direct Operating Costs directly. By not flying, no emission rights have to be bought. In the emission context, the Direct Operating Costs are dependent on the free allowances $A_{i,free}$., the emissions E_i, and the EUA price. See Eq. (5) for the relation.

$$DOC_{i,ETS,t} = \left(E_{i,ETS,t} - A_{i,free,t}\right) \cdot P_{EUA,t} \tag{5}$$

In 2010 the number of free allowances is determined. Equation (6) shows the way it is determined. The only factor in which an airline has influence is the traffic in 2010: The more traffic the airline has, the more free allowances the airline will obtain. The other elements are scenario variables, outside the control of the airline.

$$A_{i,free,t} = \frac{E_{sector,2004-06}}{Traffic_{sector,2010}} \omega_t \eta_t \cdot Traffic_{i,ETS,2010} \tag{6}$$

Looking at Eqs. (1), (2), (5) and (6) and performing some manipulations it is possible to obtain Eq. (7):

$$DOC_{i,ETS,t} = \left(E_{i,total,t} \cdot \gamma_t - \frac{E_{sector,2004-06}}{Traffic_{sector,2010}} \omega_t \eta_t \cdot Traffic_{i,total,2010} \cdot \phi_{2010} \right) \cdot P_{EUA,t} \tag{7}$$

This equation shows clearly the dependence of the EU ETS costs ($DOC_{i,\mathrm{ETS},t}$) of the airline in the year t is on several decision variables, scenario variables and one (other) KPI ($Traffic_{i,total,2010}$). The emissions are dependent on fuel efficiency.

Unit Costs and Output

The abatement cost curve is a tool that provides insight in the cost efficient CO_2 reduction potential. This tool is useful in particular for the reduction of costs. By decreasing CO_2 emissions, the number of necessary EUAs lowers. Also, lowering the emission exposure (γ_t) is very effective, since then a smaller part of the emitted CO_2 have to be backed by EUAs. Then, in 2010 the free allowances are determined. The two decision variables that significantly influence the DOC for the future are the traffic exposure (φ_{2010}) and the $Traffic_{i,total,2010}$. A change of exposure (γ_t) of 1% means a change of cost of approximately € 700.000 when a EUA costs € 30. If an airline would produce the total available output (ATKs) within the scope of EU ETS in 2010, this would push up the free EUAs that that airline will obtain in future years, if traffic (RTKs) under the EU ETS scope will become higher.

A Marginal Abatement Curve (MAC) offers an evaluation of the level of emissions cut which a collection of actions could deliver. A MAC shows the quantity of reduction an action accomplishes (the abatement potential) and the related costs per ton of CO_2 reduction.

In Fig. 3 each measure is represented by a single dot on the MAC. The length of the line to the left of the dot represents the amount of abatement potential available from the action [ton CO_2]. The (horizontal) length of the MAC shows the total CO_2 savings available from the set of measures. The height of the dot corresponds to the unit cost of the action (the cost per ton of CO_2 reduced). Actions are ordered according to their unit cost. More cost effective measures are on the left hand side. If the action is below the x axis, the net present value (NPV) is positive and CO_2 emission. If more on the right, an action is less cost effective and if above the x-axis it costs more money than it brings in. The area under the line represents the total cost of the (set of) action(s). In the example (Fig. 3) the MAC is made for 10 actions of which the appraisal was possible in a realistic way. It covers a range of actions in the category of fuel efficiency improvements. It shows possibilities to abate and shows the full potential of several actions. Furthermore, it demonstrates the order in which reduction projects should be executed: First the most cost effective actions working towards less cost effective measures.

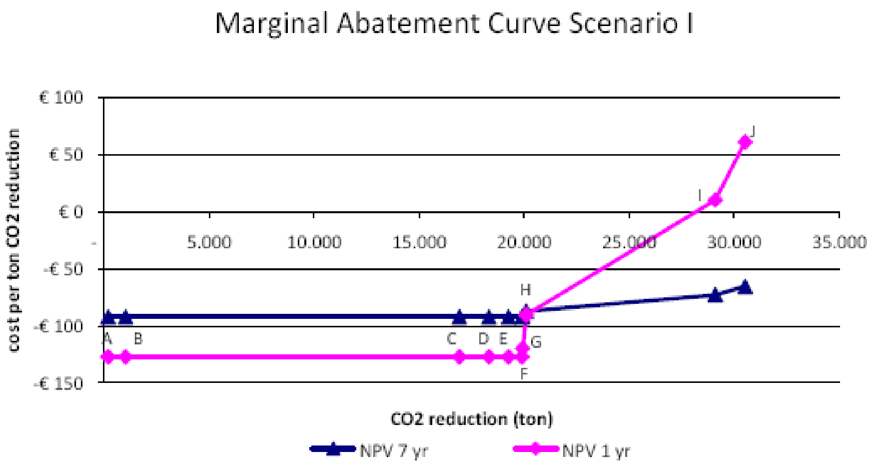

Figure 3. An example of a Marginal Abatement Curve. The cost per ton CO_2 reduction for a set of actions.

The creation of a MAC goes as follows. First compute the NPV based on the expected future cash flows (here cost reductions) and the investment. Then, divide the value by the annual CO_2 abatement expectation. The resulting figure represents the costs of the action per ton CO_2 reduction per year for a specific action (the marginal abatement costs). Repeat this for several reduction actions and rank them according their cost efficiency (value per ton CO_2 reduction). The ranked actions are put in a chart with on the horizontal axis the total abatement potential and on the vertical axis the computed marginal abatement costs. Then, lowering $E_{i,ETS,t}$ will lead to less EUAs apart from the related decrease in fuel consumption. In a Marginal Abatement Curve CO_2 reduction actions are summarised. The fuel reduction projects (A to J) refer to actions that were considered during the pilot. Several actions described in the section are selected and the Net Present Value (NPV) of the action is estimated and its annual CO_2 reduction potential is computed. For each scenario the NPV will differ, for they are heavily based on the jet fuel price development and the EUA price development in every scenario.

Total Revenues

The other side of the equation is the revenue. Revenues must absorb the costs of the EU ETS and are dependent on two major factors: Traffic and yield (See Eq. (8)).

$$R_{t,ETS,i} = Traffic_{i,ETS,t} \cdot y_{t,i} \tag{8}$$

Traffic is influenced by different factors of which the fare price is an important one. If the price increases, demand decreases according related to the demand curve or more practical the price elasticity. Another form of fuel efficiency is defined as the fuel consumed per unit of traffic (kg CO_2/RTK). This definition of fuel efficiency is affected by increasing the load factor as well. The latter definition is related to the revenue side of performance, since the denominator refers to paid ton kilometers.

The yield could change by passing through emission right costs to the customer. Cost could be either real cost that arose from buying extra emission rights next to the free EUA received or the opportunity costs from selling the free allowances on the market.

In the model some basic assumptions on price elasticity are used (see Eqs. (9) and (10)).

$$y_{i,total,t} = y_{i,t} + y_{i,ETS,t} \tag{9}$$

$$y_{i,ETS,t} = \alpha \cdot \beta \cdot P_{EUA,i} \cdot e \tag{10}$$

Equation (11) calculates the adapted yield, including when costs are passed through to the passenger.

$$y_{i,a,t} = y_{i,t} + (1+\varepsilon_m)\alpha \cdot \beta \cdot P_{EUA,t} \cdot e + \varepsilon_m \frac{(\alpha \cdot \beta \cdot P_{EUA,t} \cdot e)^2}{y_{i,t}} \tag{11}$$

This way revenue can be calculated, when the prices include passed through costs (see Eq. (12)).

$$R_{i,a,t} = Traffic_{i,ETS,t} \cdot y_{i,a,t} \tag{12}$$

D. Applied strategy model

[**PM**]

There are several political scenarios possible for the airline: From mild to very stringent. Furthermore, the price of emission rights is a risk source and different scenarios are possible as well. From the scenario analysis it is concluded that EU ETS could, on the one hand, be a challenge to the airline to cope with in the worse scenarios (III and IV). The main reasons are the high costs that are incurred. In these scenarios, more strategic actions (action list) help much in cutting emission costs. Nevertheless, these more strategic actions are dependent on the total business model of the airline and therefore cannot be implemented solely on the basis of reducing emission costs. On the other hand, it can be concluded that Scenario I and II leave space for the airline to keep its business as usual, but it should operate more efficiently.

Emissions reducing actions is among the measures performed for all alternative strategies. The MAC proves that reducing emissions with the actions in the chart are economically efficient even in Scenario I, which does not generate costs in the first years. The MAC was also produced for the other scenarios, but the conclusions were exactly the same as in Scenario I; the incentive was even greater for the higher costs of emission rights (higher NPV).

In Alternative Strategy III the emission exposure is reduced by changing the network design of the airline. Reduction of exposure is often referred to as 'carbon leakage'. Emissions are not necessarily reduced and this decision variable is not a sustainable option. However, it is one of the strongest decision variables: Less EUAs have to be submitted if emissions under the scope of EU ETS are reduced. Nevertheless, changing exposure demands quite a strategy change. It has severe influence on other aspects of the business of the airline. These reasons make a thorough deliberation necessary.

VI. Conclusions and Recommendations

The model has been piloted in an airline to determine how future airline strategy should be adopted based on the regulatory environment. It is clear from the analysis of the different scenarios, that every regulatory scenario has its own optimal strategy, ranging from increasing fuel efficiency to using alternative types of fuel.

EU ETS is a factor which airlines that fly in and into the European Union should take seriously. Although the current price fluctuates around the €13 for an EUA, the prices could become much higher. In a best case scenario money could potentially be earned. Also, revenues could be increased by passing through the emission costs to the customers.

Passing through costs is possible, since the elasticity is low in the first two scenarios. There are many decisions (variables) that influence the impact of EU ETS in different ways.

The research question "What is the best strategic option to incorporate the EU ETS in the business model?" is answered. To summarise: Every scenario has its own optimal strategy, nevertheless several common denominators exist. First of all, the emission trading is independent of scenarios. This function has to be performed to be compliant with EU ETS.

A. Future work

The MAC in this paper has only 10 actions included. It is strongly recommended to enlarge the scope of actions in a MAC for the airline. This should be done periodically, so that a current view is obtained on the reduction opportunities.

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