Reducing the environmental impact of aviation by using Sustainable Development Indicators

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Abstract

The aim of this paper is to research the possibility for a sustainable development in air transport. The research measures the environmental, economic and social costs and benefits air transport generates.

I. General Introduction

In the recent years a lot of studies showed that instead of the traditional approach to pollution, e.g. “development *or* environment” it is more appropriate to research how to further improve our economy without increasing the environmental impact: “development *and* environment”. This new concept is called **sustainable development**, "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (1)

With the use of **Sustainable Development Indicators** (SDIs) the progress towards sustainability can be measured and – after necessary follow up actions – enhanced. In order to get a complete picture environmental, economic and social indicators have to be applied. As the transport industry is the most polluting one it is a primary target of sustainability studies (e.g. Sustainable Transport Performance Indicators). However most of the studies concentrate on road and/or the differences between road and rail transport in terms of pollution.

Aviation is not the primary target in environmental research, besides the most common domain is noise reduction despite the fact that emission has a much more negative impact on the environment than noise. The reasons for neglecting aviation are: until recently the share of aviation in emission in comparison to total transport numbers was relatively low and it is much easier to use more environment friendly engines, technologies in road, rail and maritime transport than in air transport.

However the time has come to study **sustainability in aviation** as well, because:

1, Air traffic is maintaining a much heavier growth rate than other transport modes
2, If aviation is lagging behind in terms of environmental measures compared to other transport modes the share of the air transport industry of total transport related emissions may grow above the growth rate in terms of passengers and freight.
3, In the recent years serious discussion has been started for the need to design a green (or at least greener) aircraft and at the same time the issue of alternative fuel in aviation is raised frequently.

Therefore the aim of this paper is to research the possibility for a sustainable development in air transport. The research will measure the environmental, economic and social costs and benefits air transport generates.

II. The methodology for setting up Sustainable Aviation Indicators

2.1. Sustainability in Transportation and in Aviation

In order to get better results whenever possible only indicators directly related to aviation – let's call them Sustainable Aviation Indicators (SAI) - should be used, the second option is the usage of Sustainable Transport Performance Indicators (STPI) and only the third is to work general Sustainable Development Indicators.

The first step is to define what sustainability means in transportation and within that in aviation.

"The goal of sustainable transportation is to ensure that environmental, social, and economic considerations are factored into decisions affecting transportation activity" (2) From a systematic point-of-view the sustainable transportation system (STS) is "one in which fuel consumption, vehicle emissions, safety, congestion, and social and economic access are of such levels that they can be sustained into the indefinite future without causing great or irreparable harm to future generations of people throughout the world" (3)

In terms of aviation, we can state **the air transport system is sustainable if all the environmental, social and economic needs are met without compromising the ability of future generations to meet their own needs.**

On the other hand these statements have to be handled carefully because the measured transport mode is only a contributor to the environmental problems. It is even impossible in most cases to distinguish the environmental effect of transportation in general from other causing factors of pollution (industry, home consumption, etc.). It is more the case for only one transport mode. As a result there are two different approaches we can use for aviation:

1, The air transport system is sustainable if all the environmental, social and economic needs are met *in the ratio of its share among all the transport modes and pollution related activities in general* without compromising the ability of future generations to meet their own needs.

Share is obviously not a well definable number as it is a combination of share in pollution, share in contribution to GDP, share to social needs (e.g. mobility).

2, **The air transport system is sustainable if all the environmental, social and economic needs are met *without compromising the ability of future generations to have access to air transport.***

In this comparison approach it is assumed (at least hoped) that sustainability will be a criteria in most spheres of life and it will have a negative effect on those areas of life which are lagging behind in this process. With other words if in the future sustainability will be the basis of other transport modes, it may happen that the "unsustainability" of aviation will decrease the ability of future generations to have access to air transport.

The relation of economic, community and ecological development is show in the graph below (Fig1):

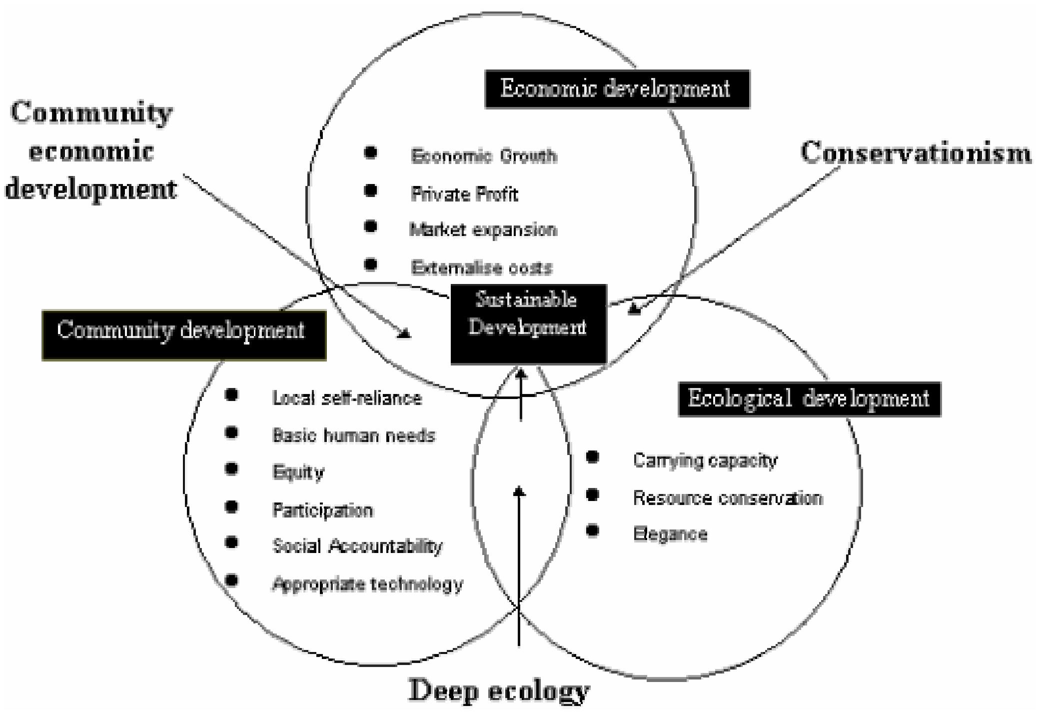

Fig1 - The overlapping zones of interest within the weak interpretation of sustainable development represented by 'ecological modernisation' (Pinfield 1997)

2.2. How to choose Sustainable Development Indicators?

When choosing the right SDIs for aviation the selection criteria of Anderson will be applied:

1. Ease of availability

The indicator itself, or the information from which it is calculated, should already be available, or can be made available easily and cheaply.

2. Ease of understanding

The indicator should be relatively easy to understand.

3. Measurability

To be relevant, the indicator must relate to a measurable entity rather than a concept.

4. Significance

The indicator should measure something believed to be important, or should reflect or represent something of significance.

5. Speed of availability

There should be little delay between the element being measured and the availability of the data on this.

6. Pattern of incidence

The indicator should be able to utilise spatial and social information so that a picture of relative incidence rather than simply aggregate impacts is available.

7. Comparability

Ideally, international comparisons should be possible through the use of appropriate indicators, but those chosen should not be selected purely to simplify international comparisons at the expense of other objectives.

III. Sustainable Aviation Indicators

The chosen indicators have to fulfill the requirement described in chapter I: both in terms of the sustainability definition and in terms of the Anderson criteria.

3.1. Environmental Indicators

All the sustainability is a balanced approach taking into account economic, social and environmental needs in this study priority will be given to environmental indicators.

The following sub-categories apply to aviation:

- Emissions
  - pollution of the air due to fuel burnt by aircraft
  - pollution of the air due to fuel burnt by vehicles moving airside
  - pollution of the air due to fuel burnt by vehicles moving landside (e.g. the mainly passengers reaching the airport)

- Noise
  - noise of the aircraft when flying, especially during take-off and landing
  - noise of airside ground operations (incl. aircraft and vehicles
  - noise of landside movements (incl. fast trains connecting the airport with the general rail system)

- Resource Use
  - Land Use: primary reason is building, expanding new airports and its facilities (terminals, runways, taxiways, etc.)
  - Aircraft manufacturing
  - Producing all the aviation related equipment (vehicles, communication equipment, general office facilities, etc.)

- Waste
  - waste generation at airports (water, general waste, etc.)

If the impact of aviation on environment is measured accurately, obvious all the factors mentioned above should be taken into account. However **in this study only emissions will be considered**. The reason is the following:

If we want to get short term benefits when fighting against for a sustainable work in case of each industry, transport mode the focus should be on the negative impact that threatens the environment most by that industry, transport mode.

In aviation nowadays there is a lot of ongoing work to decrease noise generated by aircraft. These initiatives are useful, but unfortunately move the focus from what really matters: emissions. Aircraft noise can harm only a portion of the world's population and they have means to fight against it locally through their public representatives (civil organizations, municipalities, government, etc.)

Resource use is not a special aviation related problem and hence the solution should be find in areas which are higher contributor to the given impact. Land use it is the responsibility of the building, construction industry, manufacturing is the responsibility of the manufacturing industry in general. (Solutions for environmental friendly production, recycling should come from automotive industry and the solutions used there can be applied in aeronautics as well.)

Waste at airports is again do not differ from "normal" public wasting of a city, so solutions should be invented elsewhere.

Although its share is growing among the other transport modes, one can say that aviation is only a small contributor to emissions, so following the logic above, the solution should be found elsewhere (e.g. focus should be made on road transport). It is inevitable that the environmental impact of road transport should be decreased to make our world sustainable. However aviation has a lot of specialties why the “green” technology innovations in road transport cannot be applied here. The reason is that passengers got used to a scheduled based, quick and nowadays cheaper and cheaper air transportation. However according to our present knowledge it would be much greater challenge to change the main sources of aeronautical pollution (jet engines) to something revolutionary less polluting than in the case of other transport modes. Fast new trains are usually electrically powered and although most of the electricity comes from polluting power plants, there are already existing clear alternatives to substitute them, e.g. wind turbines. Similarly electrical cars do exist and although it is hard to imagine an all – electrical road transport, it is even much easier than something similar in air transport. This **specialty of aviation in terms of aircraft powering justifies the distinguished analysis in terms of sustainability**.

Pollution at airports because of the vehicles (passenger related vehicle movement landside and handling related vehicle movement airside) is sometimes even bigger than the pollution due to aircraft movements. However the solution of this fact has to be a part of initiatives aiming to decrease the impact of road transport. As a consequence **this paper is focusing solely on the pollution of the air as a result of aircraft operations**.

The two most relevant environmental indicators are the following:

- **NOX emission**
- **CO2 emission**

3.2. Economic Indicators

There are a lot of possible economic indicators that can be used in a sustainability analysis (prices, taxes) but in this study we will use only the two most relevant indicators:

- **Contribution to GDP**
- **Share in employment**

3.3. Social Indicators

The following is a short list of social indicators that can apply to aviation:

- Safety
- Health
- Accessibility

Maintaining a very high safety level is the primary driving force in aviation. Initiatives aiming to make aviation more sustainable must not compromise this criteria. Besides, there is no conflict among environmental protection and safety. As a result safety will not be used in this study.

The overall health level of the population is a very important issue. Pollution of the environment has a direct negative impact of the health of our civilization (and of all the living beings which is not considered here).

In terms of aviation accessibility can be translated to mobility as the industry is a major contributor to the mobility of people: linking continents together, an essential mean for the world economy and a significant part of the leisure industry.

In consequence this study will use the following two social indicators:

- **Cost of health care of population**
- **Contribution to the mobility of the population**

IV. The Value of Sustainable Aviation Indicators

After defining the six indicators to be used, value should be rendered to them. As the numbers are used for comparison, it is not important to have nominal values in all cases, ratios can fit the purpose as well.

There is no need to justify that the aviation is not sustainable as it is, unfortunately there is no such industry in the world at the moment. This study is made with the hope that this said fact will be changed in the future, therefore the values chosen for SAIs should reflect a possible value at a certain date.

There are several studies available on the future of Air Traffic Management (Vision 2020, ACARE SRA-1, SRA-2, EUROCONTROL strategies, etc.). This study is mainly based on the:

- ACARE Strategic Research Agenda (2)
- And the CONSAVE 2050 project

The CONSAVE 2050 project (4), forecasts the situation of aviation for 2020 2050 following four different scenarios. Although 2050 is a more realistic date to achieve sustainability in aviation to ease the comparability and to have more accurate forecasts of trend values forecasted for 2020 will be used. A short introduction of the CONSAVE scenarios:

1.1 Unlimited Skies (ULS): This scenario assumes a very high air transport demand highlighting the challenges ahead for the global aviation industry.

1.2 Regulatory Push & Pull (RPP): The (hypothetical) ”unconstrained” demand of this scenario is the same as in Unlimited Skies above. However, a number of constraints as well as regulatory actions addressing those are likely to dampen the effect on global transport volume.

2 Fractured World (FW): This fractured world scenario assumes an absolute decline in international flights and the second lowest GDP-air transport elasticity of all scenarios considered. The available scenario literature provides no equivalent example, making this scenario quantification highly interesting but also challenging.

3 Down to Earth (DtE): This scenario of significant lifestyle changes (high environmental consciousness) postulates an entire decoupling of air transport from GDP growth.

4.1 Values to Environmental Indicators

The “Ultra Green Air Transport System” is one of the five scenarios the **SRA2** explains. When trying to achieve a sustainable aviation it is not a question that this is the most relevant scenario for this study. The goals are the following for the decrease of emission by aircraft:

- **NOX emission: - 80%**
- **CO2 emission: - 50%**

There are domains – airports, ATM system – where the environmental impact can be decreased but it is evident that the main results can be achieved at the source: the aircraft. The ACARE scenario aims a 50% reduction of fuel burn by aerodynamic improvements, weight reduction, fuel-efficient engines and systems.

The European Cleans Sky project initiative plans to demonstrate the possibility of a more environmental friendly aircraft and there are similar initiatives in the US to make the aircraft more fuel – efficient. So although the goals seem to be too ambitious they may be reached by 2020. The question is **will the ambitious goals be enough?**

The two main concerns are the following:

- Growth rate of aviation
- Usage rate of less polluting aircraft

Growth rate in this case it is only a sub-indicator to the environmental SAIs, but it is a very important one. Aviation growth is very rapid and as it is mentioned in chapter one it is maintaining a much faster growth rate than other transport modes.

The highly cost-efficient scenario forecasts that air traffic will be 3,5 times higher than it was in 2000.

Till 2020 the Unlimited Skies scenario of CONSAVE seems to be the more realistic, meaning a 100% growth rate in terms of passengers. It is a question whether there is a 1:1 one relation to passenger growth and aircraft movements (this later one has a direct link to emissions) but it is very likely that till 2020 the different concepts – maintaining hub-operations with larger aircraft to be cost-effective and meet the increasing need of passengers to travel directly to destinations – will balance each other.

In terms of the scenarios even the CONSAVE project forecasts the implementation of regulatory environmental measures only after 2020. The higher cost of a greener aircraft can have an impact on ticket prices and hence the growth rate of aviation, but this is not considered till 2020. The reason is until there are no related regulatory measures, aircraft manufacturers will not be able to sell an aircraft which is more costly to due environment friendliness. The aircraft can be more expensive but the main driving factor for an airline to choose that aircraft is the higher efficiency rate: e.g. **what really matters is the less operating cost due to less fuel burnt and not the less pollution due to less fuel burnt**.
So any higher cost of an aircraft due to be able to consume less fuel is first of all a cost associated with higher efficiency and cannot be taken into consideration at an environmental indiciator.

As indicated in the chart below we estimate that the **air traffic will double till 2020** on the basis of 2000 numbers. This is shown in the chart below as well.(Fig2)

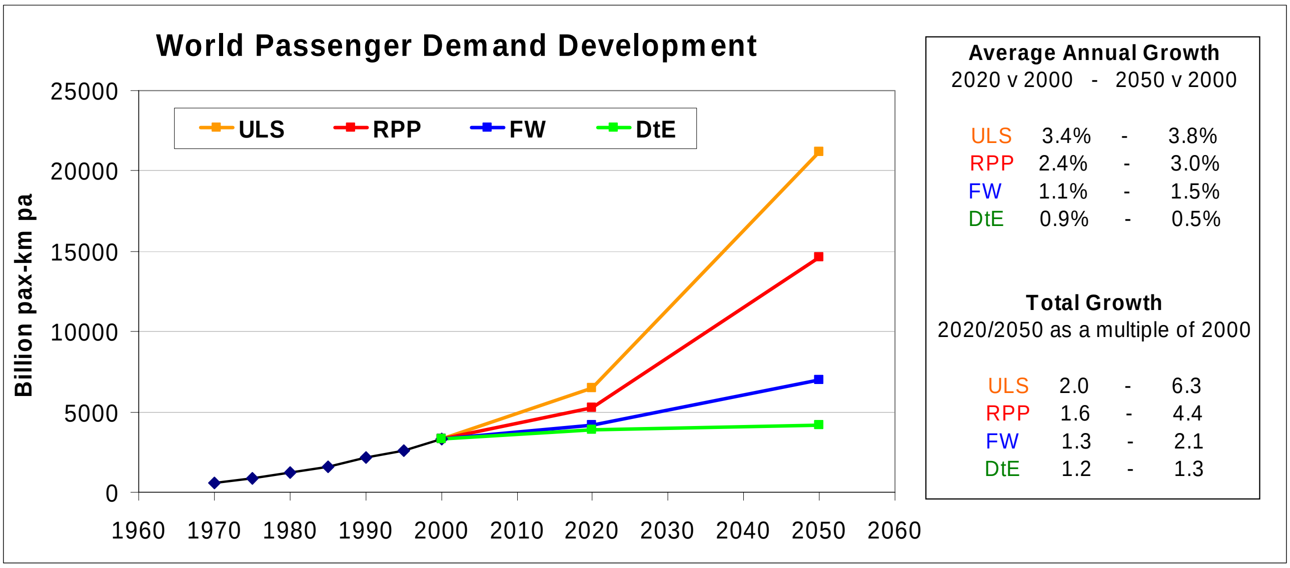

Fig2 – World Passenger Demand Development – CONSAVE 50

The other issue is what will be the usage rate of a less polluting aircraft meeting the ACARE goals by 2020?

Aircraft development is long process and although nowadays the most efficient airlines do operate a very young fleet the older aircraft are still used somewhere. So even if most of the aircraft types manufactured in 2015 will meet the ACARE SRA 2 criteria by 2017 (which is very optimistic scenario) in terms of the global aircraft fleet it is not likely that the results will be better than the followings (Fig 3):

CO2: - 20% - e.g. 80% of 2000 pollution
NOX: - 30% - e.g. 70% of 2000 pollution

If traffic doubles the overall environmental indicators can look like (own estimations):

CO2: 160% of 2000, e.g. + 60%
NOX: 140% of 2000, e.g. + 40%

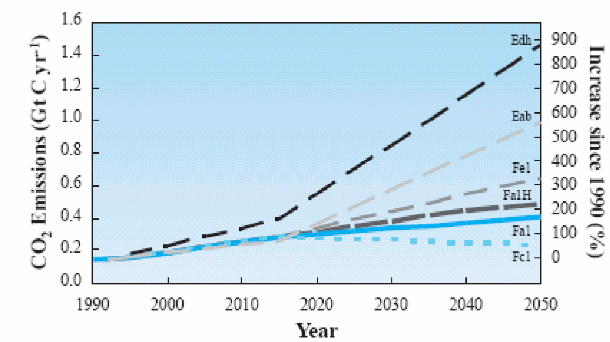

Fig3 - Scenarios for CO2 emission linked to aviation - Intergovernmental Panel on Climate Change

In terms of **changes in the share of the total pollution** it is the following according to the ULS scenario of CONSAVE – as indicated in the chart below (Fig4):

CO2: +24%
NOX: +8%

CO2 emissions: Share of civil aviation	2000	2020	2050
ULS	1.82%	2.27%	3.11%
RPP – kerosene	1.82%	1.99%	3.68%
RPP – cryoplane	1.82%	1.99%	0.17%
FW	1.82%	1.48%	1.64%
DtE	1.82%	1.86%	2.23%

NOx emissions: Share Of civil aviation	2000	2020	2050
ULS	2.12%	2.31%	2.50%
RPP – kerosene	2.12%	1.90%	2.45%
RPP – cryoplane	2.12%	1.90%	0.42%
FW	2.12%	1.53%	1.60%
DtE	2.12%	1.31%	0.85%

Fig 4: CONSAVE 2050 Presentation

4.2. Values to Economic Indicators

The contribution of total aeronautics sector (including ATM) to the GDP of Europe is 2,6% (2000 figures, ACARE SRA2). Besides indirect effect of aviation to GDP is around 8-10% although it is very hard to estimate as if there would be no airline operations from one day to another it will make a dramatic impact on the world economy.

ACARE forecasts the following growth in terms of contribution to European GDP for 2020:

3,3% from 2,6%, meaning a 27% increase.

Indirect contribution would grow with basically the same rate to 11-13% from 8-10%. In some parts of the world the growth rate is expected to be higher, but even a UK study shows that passenger traffic has increase by 280% at UK airports from 1975 till 1998 while at the same time the overall GDP growth was 60%. (5)

On the basis of this it can be estimated that the growth in **contribution to the world GDP of aviation will be approximately**

+ 35 % by 2020
(on the basis 2000 figures)

The world GDP was 41,290 billion USD in 2004 and it is expected to be 2/3 higher by 2020 meaning 60,000 billion USD. (6) Taking 3,3% of this means that **the share of aviation in GDP will be 2,000 billion USD in 2020**. (It should be a bit less as the contribution of aviation to the total GDP of the world is less than its contribution to Europe's.) This number is backed by a current number of 1,400 billion USD – (7)

The doubling of air traffic can mean the doubling of related jobs, although the relation is not expected to be purely linear. But even the ACARE SRA forecasts 4 million jobs in comparison to 2 million jobs in the given period. Current global estimation is 28 million jobs. (7) On the basis of the forecasted period of traffic this can mean:

100% increase in aviation related employment.

4.3 Values to social indicators

A US study highlights that "about 25% of health problems are already environmental in origin" (8)

Average health care spending is difficult to estimate on a world wide basis but it is **around 500 USD per person**. (9) World population is expected to be 8 billion in 2020 (10) so the total health expenditure will be about 4,000 billion USD of the world. Even if the ratio of health problems due to environmental pollution will be the same (it is unfortunately not likely) then the cost of health care due to environmental problems will 1,000 billion USD yearly for the world.

Mobility is a very important contributor our recent civilisation. Personal interactions of people living far from each other are essential to make the world economy working. Although digital communication can decrease the need for travel with a certain rate, currently it is impossible to imagine a situation when air travel plays only a minor role in the world. Even the Fractured World and Down-to-Earth scenarios of CONSAVE 2050 forecasts a 100% increase in demand, although not by 2020 but only by 2050. Very complex social – economic research is necessary to give a quantitative number to this SAI and it is obviously beyond the scope of this study. So this remains as a qualitative factor for the time being.

V. Comparison

Further studies are needed to set up a complex model to take into account all the relevant SAIs. This chapter only highlights some comparative relations of SAIs to each other.

5.1. Environmental Indicators versus Social Costs

According to the ULS scenario of CONSAVE the share of aviation of emission in 2020 will be the following:

CO2 - 2,27%
NOX – 2,31%

So taking 2,3% of the total spending it can be forecasted that the **yearly spending for health care for compensating the harm aviation makes is 237 billion USD in 2020**. In terms of growth it is approximately **+15%** compared to 2000.

To ease the calculation for time being we assume a linear relation to the growth of pollution and the negative effect it generated in terms of health, however it is a rather exponential relation, but calculating the ratio is beyond the scope of this study.

5.2. Economic Indicators versus Social Costs

The share of aviation caused health care spending is less than the share of aviation in terms of contributing to the GDP: 237 billion USD compared to 2000 USD billion.

5.3. Environmental versus Economic Indicators

This paper cannot consider every aspects of environmental costs pollution generates. What is the cost of pollution? – This question is nearly impossible to be answered. The methodology would be to sum everything that should be done to make the environment again close to the status where there was no significant industry, e.g. to the status of the times of 1800. Then the share of aviation in terms of pollution gives a share to the costs associated to “green” our environment. This question is not till pollution is increasing, **when there is a decrease in pollution, then it is time to consider how the effects of the past pollution can be resolved and how much it would be**.

Conclusion

This paper tried to justify why it is necessary to research sustainability of aviation. The methodology followed is the usage of Sustainable Development Indicators, in this case setting up Sustainable Aviation Indicators and rendering values to them. The study was closed by a comparative analysis.

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