HOW IMPORTANT ARE ENVIRONMENTAL FACTORS IN THE CASE FOR HIGH SPEED RAIL? A COMPARISON OF THE UNITED KINGDOM AND SPAIN

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ABSTRACT

High Speed Rail (HSR) offers the potential to provide enhanced regional connectivity within Europe whilst countering the increase in short-haul flights. The reduced emissions of HSR compared with short-haul air trips is an important part of the argument for an expanded network yet such an assessment is only partial in its consideration of the full range of environmental impacts. There are substantial financial and natural resource costs of constructing HSR and, to better understand the degree to which the environment is indeed important in the decision-making process this paper reviews the processes for assessing the benefits of HSR and reviews and their practical impacts, using four case studies.

The paper begins by setting the policy context for High Speed Rail with some introductory statistics on the current state and proposed expansion of the European network. Next, the paper reviews and contrasts appraisal practice in the UK, Spain and at a pan-European level to consider the key stages and components of ex-ante project appraisal. The paper then reviews four case studies (two each from the UK and Spain) to explore the economic case for HSR and within this the importance of environmental benefits in the final decision. The degree to which the environmental impacts of HSR have influenced route selection is also identified.

The paper concludes that the economic case for the reviewed HSR schemes is typically not strong relative to other potential investments in transport. The environmental benefits form only a small proportion of the net benefits and, given the high capital cost of the schemes, if the argument to invest in HSR is largely environmental then there are many other investments which would deliver bigger environmental savings with much better returns on investment. The treatment of environmental impacts within the appraisal process is clearly

identified and, whilst the guidance in Spain requires some further development, there are clear examples of the extent to which Environmental Impact Assessment has influenced route alignment and route choice. On the basis of these case studies it appears that HSR has the most to offer in journey time benefits to travellers. As a pro-environmental policy it has significant limitations.

Keywords: High Speed Rail, Appraisal methods, Environmental factors, Decision-Making.

1. HIGH SPEED RAIL IN EUROPE

It is twenty-nine years since France opened the first European High Speed Rail - from Paris to Lyon- and the HSR network within Europe has since been expanded to almost 10,000 km. Germany with its line *NBS Hannover-Würzburg*, Italy with the *Direttissima Rome-Firenze*, and Spain with the *AVE Madrid-Sevilla* followed France by building their own lines separately.

In 1989 the Community of European Railways published a document in which the idea of a European network appeared for the first time, 'Proposal for a European high-speed network'. The idea was based on linking the High-speed rail national plans, with the following objectives, which are the same as those that led France, Germany, Italy and Spain to plan their first HSR lines:

> - to overcome limited capacity on critical links of the rail network,(…France)
>
> - to increase speeds on particularly slow sections of the trunk network(…Germany and Italy)
>
> - to improve the accessibility of more remote regions(…Spain) (Vickerman, 1996:22)

The first conclusion and recommendation of the document was the definition of a 'master plan' to expand this network over the period to 2010. The essential lines of the network would be 9,000 km of new lines, 15,000 km of upgraded lines and 1,200 km of link lines. Fourteen corridors were defined and considered priority projects as shown in Figure 1. (COM, 1991).

Between 1990 and 1998, the network was expanded from 1,000 km of opened lines in 1990 to almost 2,800 km in 1998 as shown in Figure 2.

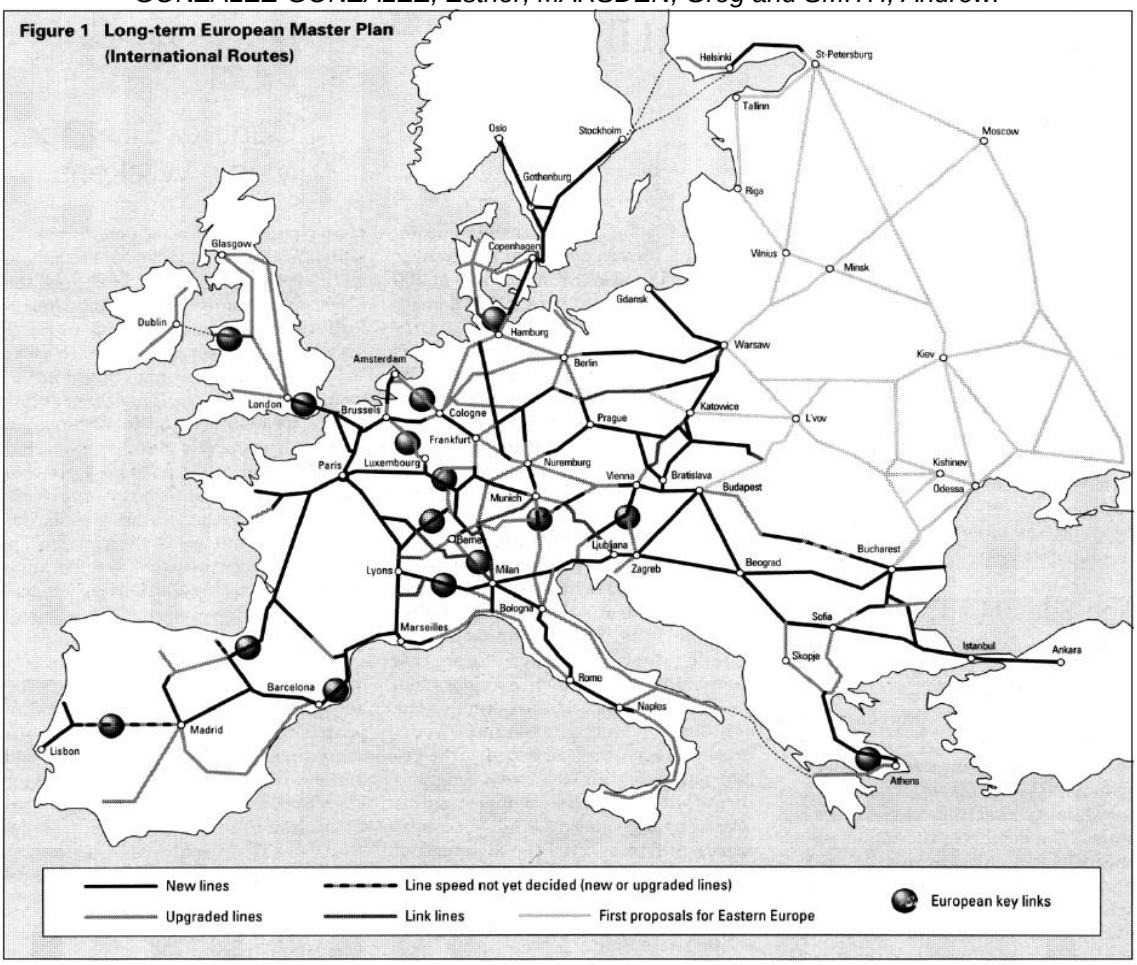

Figure 1 – European Communities Plan 1991 for European HS network to 2010. Source: Ellwanger and Wilckens, 1994:18.

			length in km (new lines)
1981	France	TGV South-East (1st part)	301 km
	Italy	Direttissima (1st part)	150 km
1983	France	TGV South-East (2nd part)	116 km
1984	Italy	Direttissima (2nd part)	74 km
1988	Germany	NBS Würzburg-Hannover (1st part)	90 km
1989	France	TGV Atlantic (1st part)	176 km
1990	France	TGV Atlantic (2nd part)	106 km
1991	Germany	NBS Würzburg-Hannover (2nd part)	237 km
	Germany	NBS Mannheim-Stuttgart	100 km
1992	Spain	Madrid-Seville	471 km
	Italy	Direttissima (3rd part)	24 km
	France	TGV Rhône-Alpes (1st part)	38 km
1993	France	TGV North (without Lille-Belgium frontier)	320 km
1994	France/GB	Channel Tunnel	50 km
	France	North/South-East Connection	70 km
	France	TGV Rhône-Alpes (2nd part)	83 km
1996	France	Atlantic Connection	32 km
1997	France / Belgium	Lille-Brussels	84 km
	Germany	(Hannover)-Wolfsburg-Berlin	158 km
	Germany	Wolfsburg-Braunschweig-(Göttingen)	12 km
	Germany	(Hamburg)-Uelzen-Stendal-(Berlin)	15 km
1998	Belgium	Brussels-(Aachen)	89 km

Figure 2 – European HS network development 1981-1998. Source: Ellwanger and Wilckens, 1994:20.

Other conclusion of the proposal was the need of undertaking complementary studies, such as the overall environmental impact of the network in comparison with other transport modes

> The working party recognised the need to undertake an overall environmental impact study of the European high-speed rail network to add to existing data on the comparative environmental damage caused by the high-speed trains, conventional trains, road traffic, and air traffic, and to define the measures to be taken to minimise such damage. (COM, 1991:12)

In 2001 the Gothenburg European Council concluded that the European transport policies should be environmentally sustainable by encouraging the use of more environmentally-friendly modes of transport. The White Paper of the Commission of the European Communities, *'European transport policy for 2010: time to decide'* affirm that it should be done through the development of multi-modal corridors and high speed trains.

> The Common Transport Policy should tackle rising levels of congestion and pollution and encourage use of more environmentally-friendly modes of transport. (COM, 2001:6)
>
> To this end, they must redirect Community action to allow the development of multimodal corridors giving priority to freight and a high-speed network for passengers. (COM, 2001b:51)

The result of the White Paper was a policy in which 30 priority projects were defined, 20 regarding railways and hence high speed rails. In 2008 the network reached 9,693 km and it is planned to expand to 23,200km in 2020 and 32,000 km in 2030. (DG Tren, 2009:1). The future network is shown in Figure 3. The stated capacity and regional connectivity goals remain important but there appears to have been a shift in language to HSR being justified or justifiable on environmental grounds.

For the Spanish case, it agrees with the National Infrastructure Plan, PEIT 2005-2020, in which is planed a HSR network of 10,000 km by 2020. For UK there are also benefits to modal shift to high-speed rails.

> The Plan is infused with our concern for sustainable development and by great sensitivity to environmental concerns and criteria. It is no coincidence that the modes of transport most enhanced by the PEIT, such as rail, are precisely those which contribute most to transport sustainability. (PEIT, 2005:3)

> It is clear that modal shift from other modes of transport to high-speed rail will provide additional benefits to the overall result. (Network Rail, 2009:29)

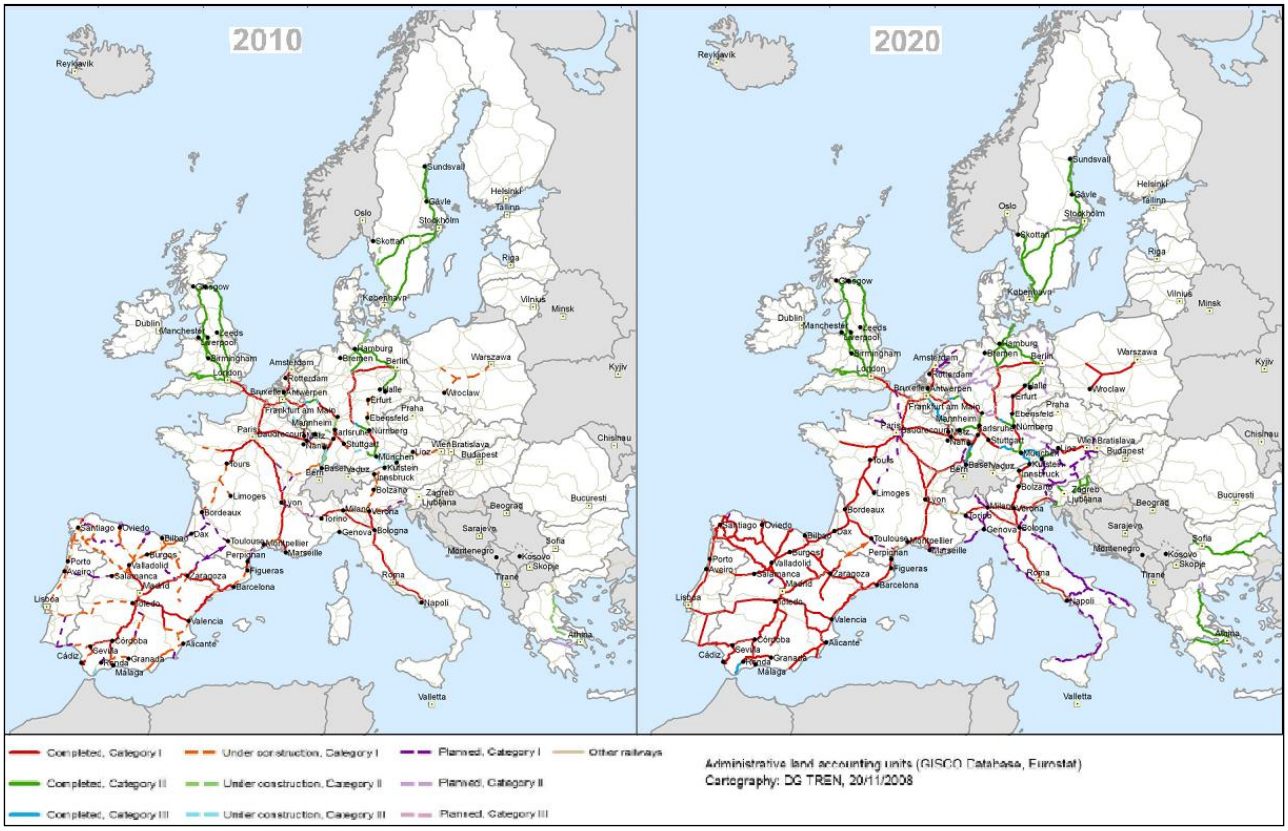

Figure 3 – European HS network development Plan 2010 and 2020. Source: Personal compilation from DG Tren, 2009:80 and 82.

Construction of a European HS network led to several studies or projects which compared the different appraisal methodologies of the countries in order to harmonise them (HEATCO, 2005) or learn from other countries to improve the national guidelines (Mackie and Kelly, 2007; Davies, 2004; de Rus et al, 2009)

Moreover, the huge quantity of funds and efforts that the construction of the European HS network would need has led several authors to question if it is really worthwhile to build this amount of new lines (de Rus and Nash, 2007; Preston, 2009). CBA appraisal methodologies and ex-ante and ex-post analyses of some lines have been reviewed (de Rus and Inglada, 1997).

Whilst the environmental benefits of HSR have been presented, their importance to the decision-making process and the value for money of achieving environmental savings in this way has not been presented. This is particularly important given the significant natural resource costs which fixed rail infrastructure generate relative to air travel. To further consider the claims about the role of HSR in reduced environmental impacts, this paper reports on research that has examined the assessment of HSR projects and for a subset of projects the key environmental outcomes. The study was established as a comparative methodology between the UK and Spain. These countries were selected because both have

stretches of high speed line and are either actively undertaking or currently planning for expansions to the network. Whilst both countries should exhibit a degree of comparability due to the gradual harmonisation of appraisal processes within Europe there are likely to remain considerable local divergences in practice. The paper begins by exploring the appraisal process adopted in each country with a more detailed coverage of environmental impacts. Next, the four case studies are presented along with key appraisal summary information from each of the studies to show how the guidelines have been applied in practice. It is worth noting that, although significant public works, the full details of the appraisals has not been available to the research team. Weaknesses in the dataset are acknowledged where appropriate. The findings are then drawn together in a discussion of the extent to which the environment is important to the case for High Speed Rail and the extent to which it influences route selection and route alignment.

2. APPRAISAL METHODOLOGIES IN UK AND SPAIN

2.1. UK procedures

The *Guidance on Rail Appraisal*, developed by the Department for Transport within the Transport Appraisal Guidance (TAG), is the current official rail appraisal document used in UK. The guidance maintains the key elements of its predecessor, the SRA (Strategic Rail Authority) Appraisal Criteria, but is more consistent with the appraisal methodologies used for other modes.

A detailed fifteen-step process describes the appraisal methodology set out in the most recent guideline.

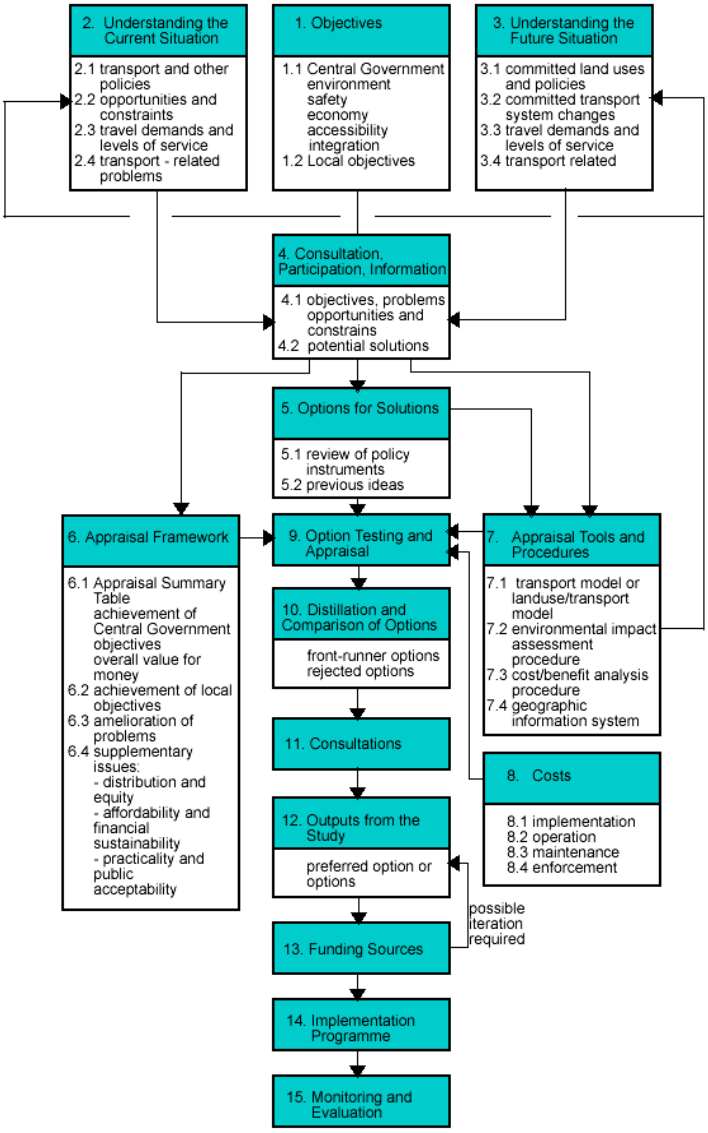

Figure 4 – UK Appraisal: Steps of the process. Source: DfT, 2004a.

The first stages are concerned with the analysis of the objectives, the current situation and the future potential problems of the transport sector and network, as well as demand forecasting which could justify the construction of a new line. Participation and consultations of authorities, providers, users and general public is a very important step to define the problems, objectives and the possible solutions. Selection of the options is very important part of the process as well as the appraisal itself.

The process for comparing the benefits of potential interventions forms one third of the whole process. The proposed lines, described in technical, environmental, social and economic terms, are evaluated to achieve the five Government objectives: *environment, economy, accessibility, safety and integration* (DfT, 2007:9). The appraisal tools used are: Environmental Impact Assessment (EIA), Cost-Benefit Analysis (CBA) and Geographic Information Systems (GIS).

The UK process combines the CBA with information from other categories including integration and accessibility to provide a comparison table for the decision-maker for each option. The final stages of the process refer to the implementation and monitoring of the chosen project.

The environment features in the decision-making process in several ways:

1. As a part of the Central Government objectives.

2. As a part of the Project screening definition of physical constraints, such as sensitive areas, are made.

3. Environmental Bodies, Policies or Rules are involved in the consultation and participation stage.

4. Environmental issues are considered in the appraisal framework. Parts of EIA feature in the appraisal. Furthermore CBA evaluate some impacts as part of the benefits.

Table I – UK appraisal: Environmental impacts

Monetised impacts (within CBA): related to traffic levels impacts	Qualitative measured impacts: regarding 'Land take'
Noise Local air quality Greenhouse gases	Landscape Townscape Biodiversity Heritage of historic resources Water environment

Source: own work from DfT, 2004b.

5. Monitoring has legal requirements regarding the environment impacts.

2.2. Spanish procedures

The Department of Transport, Tourism and Communications[1] of Spain, published in 1987 the only official appraisal manual of railways, *Manual of Investment evaluation of Iberian-gauge railways* (*Manual de evaluación de inversiones en ferrocarril de vía ancha*). It was updated in 1991, and is still used today.

This appraisal focuses on a particular kind of railway among the three different infrastructures Spain has[2], the Iberian-gauge railways. However, despite the changes the introduction of the new railways, the appraisal had not been modified. HSR appraisal of new lines uses the existing manual modifying some of the characteristics, such as prices, time savings and demands forecasts, based on the experience of other lines as well as European

[1] It is called Department of Public Works and Transport at present.

[2] Spain has Narrow gauge railways for local trips, Iberian-gauge railways for interregional trips (the most extensive network), and UIC gauge railways for HSR.

guidelines. An assessment of the harmonisation of European appraisal practices concluded that:

> At the moment appraisal methods in Spain are based on former most conventional manuals. Most of these manuals are planned to be revised and updated. However in recent years appraisal is progressively being based on European guidelines. (HEATCO, 2005)

Six steps form the appraisal process of the Investment manual.

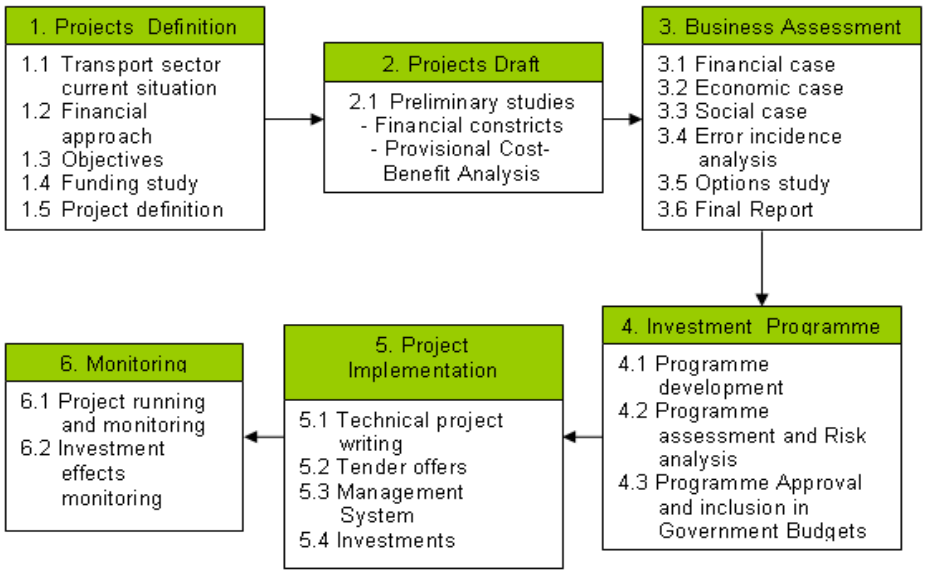

Figure 5. Spain Appraisal: Steps of process. Source: own work based on MTTC, 1987.

Although comprising fewer steps, the appraisal process in Spain is in many ways similar to the UK. However, there are significant differences in the application of the appraisal comparison between the two countries. The CBA in Spain presents financial, economic and social assessments and the selection of the preferred option is made using a Multicritera Analysis (MCA) where the result indicators compiled in a vector are weighted. In the UK the decision-maker makes these trade-offs at the time of decision. Comparison of the methods in the two countries is discussed further in section 2.3 below. For more information on the use of CBA, MCA and other appraisal methodologies see HEATCO project; Davies, 2004; Odgaar et al, 2005; Bristow and Nellthorp, 2000; Grant-Muller et al., 2001.

Environmental factors are considered during all the process:

1. The first signal is that environment is one of the objectives of the PEIT 2005-2020, the Spanish transport programme which refers to the expansion of the HSRs. The objectives are:

   > system efficiency, social and territorial cohesion, sustainability (regarding environmental commitments) and the economic development and competitiveness (MF, 2005:37).

2. The next consideration is that EIA is legally required for each option within the project definition and preliminary studies. Definition of environmental sensitive areas is made in similar way to the UK procedure.

3. Economic assessment considers environmental factors in its third point, the social assessment.

4. As happened in UK, a compulsory study carry out by the Department of Environment is needed to go ahead with the project, the DIA ('Declaración de Impacto Ambiental', Environmental Impact Statement). This study estimates the global environmental impacts of the project.

5. Finally, monitoring phase includes an environmental effects monitoring.

The environmental characteristics measured in the appraisal are four: Noise, Air Pollution, Barrier effect and Visual intrusion. The main objective of the methodology is obtaining one indicator for each impact. Some of them, Noise and Air pollution can be translated directly into monetary values whereas the other two have a value which has a quantitative and a qualitative part. It is worth noting that the methods for calculating Noise and Air pollution (Local and GHG for UK) are different between the UK and Spain although our assessment suggests that the differences are not fundamental to the appraisal process.

2.3. European guidelines

As the HSR network in Spain has received substantial European funds we expect that some of the appraisal work has been consistent with the European Guidelines. We analysed the relevant appraisals for our study, the *Railway Project Appraisal Guidelines* (RAILPAG) and the *Guide to Cost Benefit Analysis of Investment Projects*. However, the RAILPAG document is outdated, last version on 2005[3], whereas the CBA guide is updated in 2008, taking into account the RAILPAG recommendations and procedures.

The Commission Appraisal process follows a structure in which the CBA is the main part. The whole process consists of three phases: the Admissibility of the projects, the Methodology check, based on the CBA and the risk assessment, and the Commission decision. If this decision is positive, it means the project is desirable, the amount of funds is calculated along with further assessments (EC and EIB, 2005).

A mention of the environmental impacts appears in the CBA although the guideline relies on each State Member the decision to choose the proper methodology to calculate them. When the country has no local values available the EU guideline recommends the use of HEATCO project[4] and a handbook within the IMPACT[5] study. However it refers to the typical environmental impacts:

[3] And RAILPAG is based on the previous CBA Guide as well.

[4] 'HEATCO project', based on developing Harmonised European Approaches for Transport Costing and Project Assessment: http://heatco.ier.uni-stuttgart.de/. (EC-DG, 2008:79).

> air quality, climate change, water quality, soil and groundwater quality, biodiversity and landscape degradation, technological and natural risks. (EU-DG, 2008:222)

2.4. Comparison of the methods

CBA

Environmental impacts are considered within the Economic assessment in UK and in EU, although UK adds many of the indicators of the EIA in the CBA. They are include in two places within the methodology in UK, since the monetised impacts enter in the CBA result (Analysis of Monetised Cost-Benefit table – AMCB) whereas the non-market impacts are taken into account in the Appraisal Summary Table (AST) with a qualitative consideration. Spain evaluates the Environmental impacts within the social assessment in quantitative and qualitative values which form indicators compiled in a vector. At the end of the appraisal every proposal obtains one single vector which contains indicators of each assessment in economic, quantitative or qualitative values.

Finally, the decision criteria are different, not only regarding the indicators used in it but the applied criteria itself. UK and Europe consider the result of the business case as the evaluation of the indicators, the NPV and the BCR. The decision is taking considering if they are positive or negative and then they are used to establish a classification or ranking among the projects. In contrast, Spain groups the result indicators – financial, economic and social NPV, BCR and IRR plus indicators of time savings, comfort, safety, environmental impacts, rent balance, employment, energy consumption and others – into a vector. A MCA or a mathematical approach (optimising 3 objective functions: in financial, economic and social terms) is used to determine the ranking.

Environmental impacts evaluation

The kind of effects and the ways in which they are measured are different. Noise and air pollution are quantitative calculated in both countries. In the case of noise, UK refers to the change in noise levels for number of people affected as well as in the Spanish case, but the way in which the noise is calculated is different. On the other hand, the effect on air pollution is treated very different between the two appraisals. UK has two effects, Local air quality and Greenhouse Gases (GHG) effects whereas Spain only has the Air pollution effect. The UK air quality assessment includes changes in NO_x and PM_{10} concentrations in exposed properties; the UK GHG assessment is based on changes in equivalent tonnes of carbon

[5] Handbook with estimates of external costs in the transport sector, February 2008. http://ec.europa.eu/transport/costs/handbook/index_en.htm (EC-DG, 2008:79).

concentrations and an application of shadow prices; whilst the Spanish guideline – very outdated – refers of changes in carbon monoxide concentrations on people affected.

The rest of the impacts taken into account in the appraisal are evaluated in qualitative terms. For the UK case an Environmental Capital Approach based on a seven point scale is used for landscape, townscape, heritage, biodiversity and water environment effects (see Table 1 above). Spain, in its part, evaluates the barrier and visual intrusion effects as a mix of qualitative (four point scale and esthetical value respectively) and quantitative (number of people affected for both of them and obstruction index for the second effect) measures. Severance, land use, geology and flora and fauna are considered in the study to submit for the DIA. These analyses are very important for the route ranking and selection process. Both countries study each option under environmental terms taking into account the qualitative values of the potential impacts.

3. CASE STUDIES

3.1. Definition of the case studies

In order to better understand the influence of the divergent appraisal processes explained above, in terms of how they are used in practice, we considered the study of four cases, two in each country. This analysis allows us to record the application of the procedures and techniques utilized and how they have changed through these years.

Table II – Case studies

Country	Line	Year of starting Appraisal	Date of completion
UK	*Channel Tunnel Rail Link* (CTRL)	1987	2007
UK	*High Speed 2* (HS2)	2001	-
Spain	*AVE Madrid-Zaragoza-Barcelona-French border*	1987	2008
Spain	*AVE Madrid-Segovia-Valladolid*	1994	2007

Source: own work.

Choosing the UK cases was an easy task since the *Channel Tunnel Rail Link* (CTRL) is the only HSR built in UK and *High Speed 2* (HS2) is the second HSR planned in the country.

CTRL is the line which connects London with the Channel Tunnel and hence UK with the rest of Europe. It is a 109 km track line with three intermediate stops, Stratford, Ebbsfleet and Ashford, which allows the use of domestic and commuter trips. The route, the most expensive line in the world, was constructed in two separate phases. The first section, between the Channel tunnel and Ebbsfleet, is a 70 km track line and was opened on 2001. The second section, to London, is 39 km track and was opened in 2007.

HS2 – the North-South line – plans to connect the main cities in Great Britain: London, Birmingham, Liverpool, Manchester, Leeds, Newcastle, Edinburgh and Glasgow. This

connection forms an infrastructure of 8 sections for a potential HSR network, from which 16 HSL options are suggested (see figure 6 below).

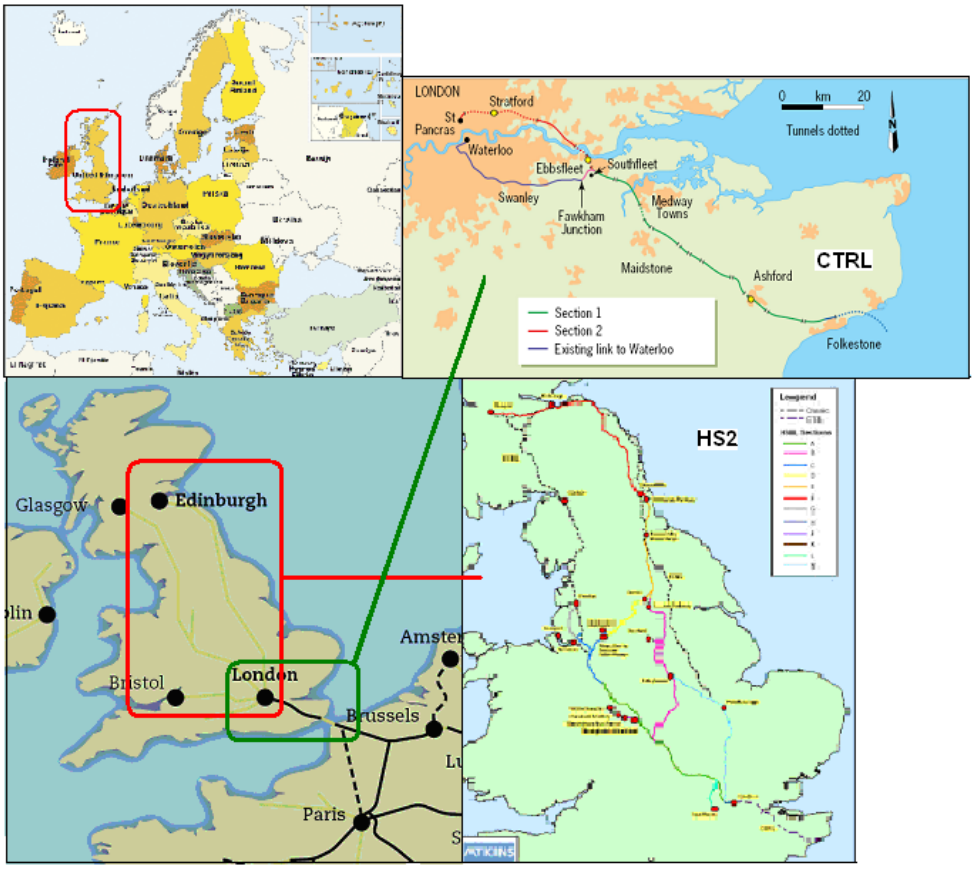

Figure 6 – UK case studies: CTRL and HS2. Source: personal compilation from: Grengauge21, 2009:12; Allett and Mitchell, 2003:14 and ATKINS, 2002:VII.

On the other hand, the Spanish line *AVE Madrid-Zaragoza-Barcelona-French border* (AVE Madrid-Barcelona) was chosen because of its importance in providing the link to the European network, as the CTRL. Furthermore this line goes through the most important cities of Spain.

Among the HSR in use, it is the longest line in the world even without the last section, 621km between Madrid-Barcelona and 804 in total (ADIF, 2009). The line connects the capital cities of six provinces, Madrid, Guadalajara, Zaragoza, Lleida, Tarragona and Barcelona. The route is divided into four sections: Madrid-Zaragoza-Lleida opened in 2003, Lleida-Tarragona opened in 2006, Tarragona-Barcelona opened in 2008 and the final section from Barcelona to Figueras which is under construction at present. The three first sections are used only for passenger transport whereas the last section is planned to be also used for freight transport.

The second Spanish line is the *AVE Madrid-Segovia-Valladolid* (AVE Madrid-Valladolid) which is the following relevant line after the Madrid-Barcelona, in terms of length and cost, besides being a part of the second international connexion. This line provides the union between Madrid and the North-Northwest part of Spain, being the first part of four future lines to: A Coruña, Oviedo, Santander and Vitoria. The last one connects with the 'Basque Y' and

hence with Europe, forming part of the so-called Atlantic Branch of the South-west European high-speed rail link.

The line has a length of around 180 km and two intermediate stations, Segovia and Olmedo, sited 68 km and 133 km from Madrid respectively. The construction of the line started in 2001 and finished at the end of 2007.

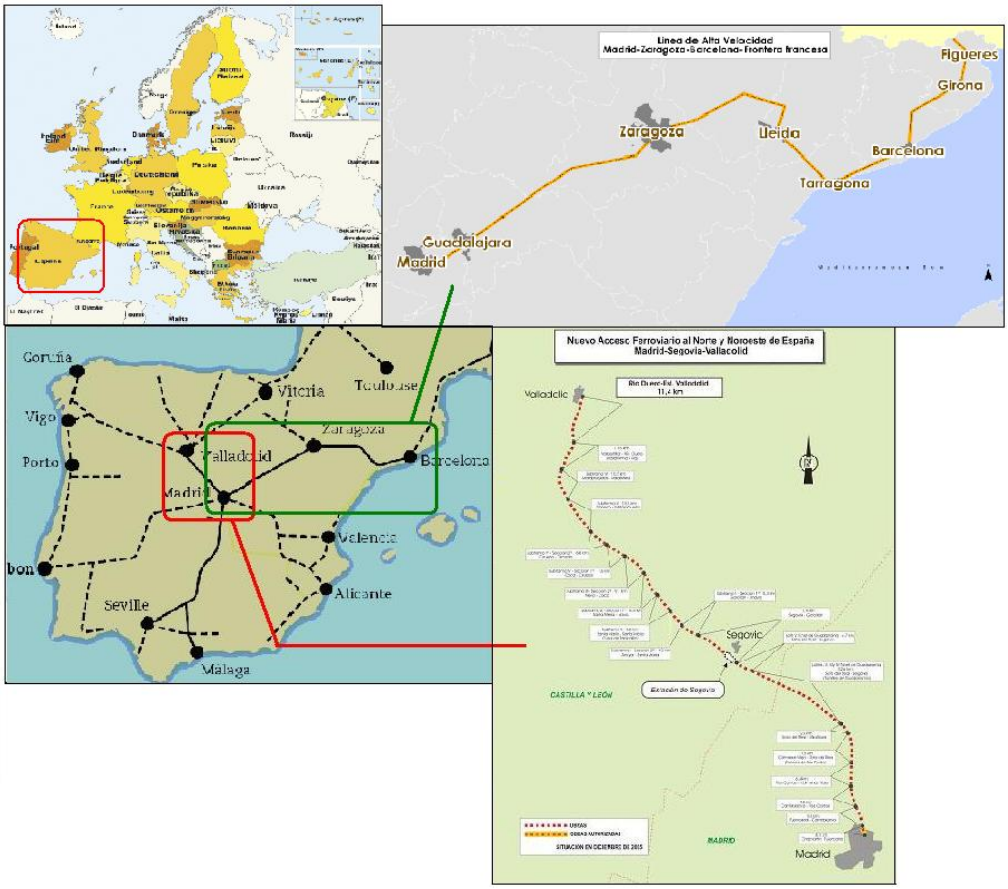

Figure 7 – Spanish case studies: AVE Madrid-Zaragoza-Barcelona and AVE Madrid-Segovia-Valladolid. Source: personal compilation from: Grengauge21, 2009:12; MF, 2005:95 and Gobierno de España, 2009.

3.2. Case studies analysis

CTRL

CTRL was studied in great detail since there was no specific guideline in UK to analyse high-speed rail, thus it served to define a set of proper standards and procedures. Once the need of a new line was determined, a public consultation had to decide between several proposals studied in terms of transport benefits, socioeconomic factors and environmental impacts. Environment was the most important concern of the appraisal. Environmental standards – from a review of major infrastructures in UK and Europe – served to identify the unacceptable sub-routes and make a rank of the options. Two sections were studied, Section1 between the Channel Tunnel and Ebbsfleet and Section2 to London.

Although environmental decisions in the first section (especially at three main points – Ashford, Boxley and Medway – were difficult and analysed in great detail; in the end the route through this area (sometimes referred to as the Garden of England) was deemed environmentally acceptable. Section 2 decision of tunnelling was easier because it was considered as the only environmental possible solution whilst the choices of the route and the station to arrive in London were more difficult. In the first place it was suggested a southern route to King Cross Station, however environmental concerns again caused the route to change for the easterly one to St. Pancras Station due to the potential impacts in southeast London. The tunnelling solution made CTRL the most expensive HS line in the world.

HS2

HS2 appraisal relied on the SRA guidance and hence on the CTRL process. Environmentally sensitive sites related to the national designations of AONB (Area of Outstanding Natural Beauty), National Parks and SSSIs (Sites of Special Scientific Interest) were identified, such as the Chilterns AONB and Peak District National Park. All the options were defined trying to reduce the number of sensitive areas affected and avoid or minimise the potential environmental impacts.

In this case the options were studied against the five objective of the Government, in which the Appraisal Summary Table (AST) collected all the objectives, their sub-objectives with their impact description, measure and assessment. The environmental objective collected the qualitative and quantitative measures of the sub-objective impacts, such as the net reduction in tonnes of NO_x and PM_{10} and the score impact on key landscape designations (ATKINS, 2003b:G7). The economic measure of the environment has not yet been considered since the HS2 study is, as yet at a strategic level.

AVE Madrid-Barcelona

The length of the line implied crossing a complex and diverse environment which was assessed in depth. The line was divided into four sections, Madrid-Zaragoza-Lleida, Lleida-Tarragona, Tarragona-Barcelona and Barcelona-Figueras.

The environment statement was made section by section. The first section was evaluated very rapidly. Later a special agreement with the SEO/BirdLife association was made to define the overall impact in sensitive areas and monitoring the impacts once the line was opened. In this case, fifteen sensitive areas were defined by the agreement. On the other hand, within the section between Tarragona and Barcelona, the entrance on Barcelona was solved by tunnelling. There were several troubles with structural stability of relevant buildings which delayed its construction.

AVE Madrid-Valladolid

To make easier the study of the line it was divided into two sections, Madrid-Segovia and Madrid-Valladolid. The environment through which section 1 had to pass was very significant, the Guadarrama range and its south part. The range is an area of high environmental value with several protected countryside areas according the national designations of Special Bird Protection Areas and Sites of Community Importance and its south part is heavily developed. To solve the potential impacts in these areas the condition of tunneling solution for each proposal was defined. The result of the assessment was the construction of the fourth longest tunnel in Europe and the fifth in the world, 28.4km. The connection with the Segovia city was the creation of a new station in its peripheral area. Section 2 main problem was the entrance in Valladolid city which after an environmental ranking of the options was solved by tunneling.

Appraisal CBA

CBA is an important part of the appraisals, especially in UK cases. Costs and benefits are similarly structured for each case study, as we can see in the following table. Costs are related to infrastructure or capital costs, maintenance and operation, whereas benefits relate to revenues, users and non-users benefits and reduction costs as environment savings. Some environmental impacts appeared as benefits since they are considered impact reductions from transfers, of passengers or freight, from other modes of transport, basically from road.

In the case of CTRL freight transfers from road and for classic rail was considered as environmental benefits. For the case of roads it was assigned to lorry kilometres according to the type of road from which the freight was expected to transfer[6] (NAO, 2001:35). The value of the savings in the table was a result of the relief of rail congestion, mainly between CTRL and Ashford, estimated of £90 million by the Department[7] (NAO, 2001:81).

Given that HS2 is evaluated at strategic level, environmental impacts was not monetised but the guidelines and hence the environmental appraisal and its AST has evolved obtaining quantitative measures of more impacts than CTRL. For example the environmental appraisal of the study estimated that emissions of all pollutants decrease with HSL in 2016 by up to 0.4% due to the reduction in vehicle kilometres and specifically the better option would decrease oxides of nitrogen by 324 tonnes and PM_{10} emissions by 13 tonnes, which corresponds to 0.2% and 0.1%, respectively, of total UK emissions from road transport predicted for 2016 (ATKINS, 2003: 3-11).

Finally, the study of the AVE Madrid-Barcelona presented along with the CBA four sensitivity analyses in which the environmental savings are 4.3% of the total benefits for all of them.

[6] The 1993 Union Railways Ltd report also estimated expected freight transfer, but the Department could not locate the detailed calculations (NAO, 2001:35).
[7] Again the NAO report had no seen the detail calculations.

However, CBA has a clear priority as indicated in the project approval guidance. This states that BCR (Benefit Cost Ratio) forms the starting point for assessing value for money and that

> understanding and estimating the implications of non-monetised impacts for value for money is by its nature very difficult. The impacts need to be significant relative to costs to change the value for money indicated by BCRs alone (DfT, 2006, p4)[8].

Table III – Case studies CBA

Line	Costs aspects	Benefit aspects	Environmental benefits	Environment /overall benefits	NPV/BCR
CTRL	- Government grants - Access charge - Eurostar revenue and repayment - Additional costs underground and Thameslink	-International users -Domestic users -Regeneration - Environment - Road decongestion	Freight transfers: emissions reduction	90 £ million 3.9% of total benefits	NPV: 220£million BCR: 1.1
HS2*	- Capital costs - HSL Operating - Reduction Classic operating	- Revenues - Users - Non-users	Not monetized: only considered Appraisal Summary Table	-	NPV_{max}: 9* billion £ NPV_{min}: -2.7* billion BCR_{max}: 1.34* BCR_{min}:0.59*
AVE Madrid-Barcelona	- Infrastructure - Maintenance - Operation	- Benefits - Reduction of costs in other modes and environment	Reduction impacts in other modes: local, global and noise pollution	595.3 € million 4.4% of total benefits	NPV:1.251€ million BCR: 1.78
AVE Madrid-Valladolid**	- Infrastructure - Rolling stock - Maintenance - Operation	- Users - Operators - Environment - Accidents	Transfers: Reduction in emissions	**	**

*Option 8 has the maximum values, Option 15 the minimum. Average of the 16 options: NPV: 2.7 billion £ and BCR: 1.13.
** Note: Ave Madrid-Valladolid CBA is considered from a study regarding complete line Madrid-Valladolid-La Coruña. The CBA related to the part Valladolid-La Coruña. We assume the first part of the line would analyze similar aspects.
Source: personal compilation from NAO, 2001:36; ATKINS, 2003:5-2 and 5-4; Coto, Inglada and Rey, 2007: 921; and Álvarez, Caride and González, 2003:20-21.

[8] The guidance suggests that projects demonstrating a Benefit to Cost ratio in excess of 2 constitutes high value for money and most if not all of these projects will be funded.

Comparison between the two countries

HS2 has evolved significantly from CTRL experience, since the updated guidelines learnt from this experience, whereas for the Spanish cases, both lines are more modern than the official guideline so their processes are similar to each other.

The definition of the environment and therefore the important sites and the potential impacts was a first determining stage in both countries – a previous EIA –. The options were defined trying to avoid these sites and minimising the potential impacts. As well as national and international relevant sites designations in UK cases, Spanish cases made agreements with the SEO/BirdLife association to study several sensitive areas for birds.

Impacts in urban areas were considered in both cases by using tunnelling solutions along with following the existing routes. The costs of tunnelling solutions are very substantial and environmental constraints can, from this perspective, be seen to have had a significant impact on construction and value for money. The Spanish lines planned peripheral stations for intermediate cities, such as Segovia.

CBA analysed several environmental impacts, such as reductions in local and global pollution which were the impacts which could monetised and were relevant for the scale of the study. The other non-monetised impacts were considered in the decision-making with its qualitative measured, such as the use of the AST for the HS2. The contribution of environmental savings to the overall social benefits of the schemes was small, of the order of 2-4%, dependent on the scheme in both the UK and Spanish case studies.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Main conclusions

Environmental analyses were made in each project appraisal, the definition of the route options appear to have been significantly influenced by the presence of environmental sensitive areas or large resident populations with efforts made to minimize these impacts. There was a strong process based assessment of environmental implications involving both public and official consultations.

Environmental evaluation is taking an increasing role in the economic assessment process over time as witnessed by the changes from the first stages of the CTRL to the current approach to HS2 for example. More environmental aspects are taken into account and are more influential in all the phases of the process.

The debate about the environmental benefits of HSR largely seems to focus on air-rail substitution – since CO_2 emissions reduction, such as for return travel Paris-London are estimated 168g/passenger-km by air versus 11 g/passenger-km by HS Eurostar (DG-Tren, 2009:97). Nonetheless, in the case studies considered in this paper, environmental impacts play only a minor role in the overall scheme benefits with the main impacts being traveller

time benefits (4% versus 74%). The argument for promoting HSR on environmental grounds seems weak. At best the benefits to the environment are small (and almost certainly achievable elsewhere in transport or the economy through other cheaper measures - such as reducing demand for travel, encouraging the use of more efficient vehicles, fiscal measures (Gross et al, 2009) – and at worst they create significant local environmental disturbance. These may be more important at a strategic level where they to be considered cumulatively as part of a full Strategic Environmental Assessment. The mitigation costs of the construction have formed a significant proportion of the total costs (e.g. ADIF states that more than 12% of the overall cost of the AVE Madrid-Valladolid is used by mitigation measures and the tunnelling of CTRL contributed substantially to making it the most expensive HSR line in the world). Mitigation has been an important feature but nonetheless this creates an irreversible change in habitats.

Strengths of the appraisal processes

- The environment is formally considered as part of the appraisal frameworks with clear indicators.
- Environmental impact assessment is required for each country to go ahead with the project. In several steps of the process the environment is essential and can be seen to have influenced route design.

Weaknesses of the appraisal processes

- There is no clear statement of the overall environmental assessment based on monetised and non-monetised elements.
- It is not possible to determine the real weight which the environment is given in the decision-making process due to the piecemeal way in which the impacts are assembled and compared.
- Spain's local guideline related to rail infrastructures is out dated and the application of a mixture of EU and Spanish procedures is not fully transparent.
- Spain has no official publications of the High Speed Rail lines appraisals made which makes a full external analysis of impacts challenging.

Strategic decisions about the size and scale of the HSR network appear to predate the assessments of environmental impact. At a strategic level the environmental benefits relative to air travel are part of the justification for HSR yet these are very small compared to journey time savings and connectivity benefits. The landscape and biodiversity environmental damage of HSR feature strongly in the assessment process, sometimes at great expense, but are largely treated as natural capital which is substitutable by the enhancements to social capital that HSR brings.

4.2. Recommendations

- Promote greater transparency regarding the reasons for supporting HSR. If its environmental benefits are the main point to support them, HSR should be compared with quite different ways of achieving the same gains.

- Promoting updating and harmonisation of HSR rail guidance across Europe.

- Ex-post evaluations are necessary in order to progress the appraisal for the following lines and inform the new decisions.

- Promote more transparency for the Spanish lines appraisals in order to make easier ex-post analysis.

- Quantification of several environmental issues should be improved, following the current European research studies such as the COST 350 project which study indicators as land take (ha/km), fragmentation of habitats (areas probability), consumption of non-renewable materials and recycling of waste in consumption (tons of materials and % recycling), soil pollution (g/kg dry mass), etc. (Goger et al, 2006). Furthermore, environmental concerns must be more present in the rest of the appraisal phases such as one part of the decision criteria not only under economic terms.

- The decision-criteria should be more detailed indicating how important is each aspect to be considered, in terms of describing the weights to apply and why are they chosen.

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