KPI – Economic Indicator
Effect on EU/Rest of the World Steel Trade

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SSSA is involved in the **Subproject 9 Scenarios, Sustainability, Dissemination & Training**, in particularly in the **Work Package 4**. This KPI, developed at SSSA, measures the most important effects in the EU/Rest of the World Steel Trade due to the implementation of a new technology: a quantitative approach has been used in order to evaluate the **EU raw material dependence** from the rest of the world and an approach both qualitative and quantitative has been used in order to calculate the variations in the **EU Competitiveness**. An important consideration in the development of KPIs is the selection of the appropriate measurement categories. The selection is based, first of all, on the quantification of the European dependence through the weight of the non-EU supplier countries and through the weight of the most important raw materials in the production process, then on the measurement of the European competitiveness. Due to its particular features, the steelmaking sector has been taken into consideration in order to provide a template calculation. The article describes the methodology and the algorithms applied in the steel sector. Finally, some results that have been obtained in an exemplar case are described and discussed.

Introduction

Key Performance Indicators (KPIs) are metrics used to help an organization to define and to measure progress toward organizational goals.

KPIs are frequently used to measure activities such as the benefits of leadership development, engagement, service, and satisfaction. KPIs are typically tied to an organization strategy (as exemplified through techniques such as the Balanced Scorecard).

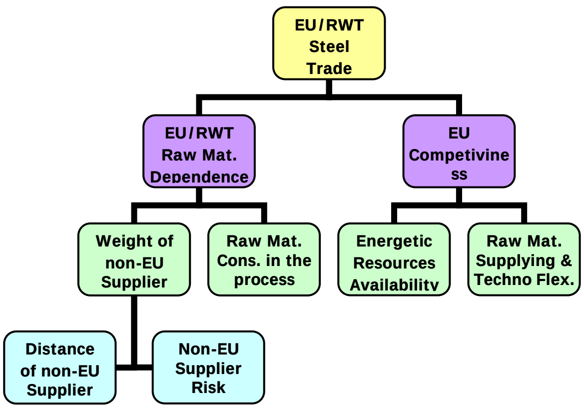
The present paper presents a KPI which is useful to evaluate and compare the effects on the EU/non-EU trade of different industrial technologies. Obviously, the new technology does not necessarily replace an older one, as sometimes both can jointly operate.

The starting point stems mainly from understanding how the market evolves in those European production areas characterized by shortages of raw materials to determine a possible increase of dependence on non-EU countries and a consequent loss of competitiveness for Europe. So, it is important to understand if it is more convenient to continue the production in Europe or transfer part or the entire production in other countries outside Europe. In the medium term, a shift of some phases of the process from Europe to regions that can offer secure raw materials supplies and reasonably priced energy could be, in particular, a result of the dependence on raw materials imports, high energy prices and enhanced environmental protection measures.

However, especially when dealing with industrial cycles with considerable environmental impact, such as chemical and metallurgical industry, the shift of some production phases to countries with lower environmental standards and lower energy prices does not contribute to improve the sustainable development across the world it merely worsens the European position.

This paper describes the KPI methodology, focused on qualitative and quantitative methods. An important consideration in the development of KPIs is the selection of the appropriate measurement categories. The selection is based, first of all, on the quantification of the European dependence through the weight of the non-EU supplier countries and through the weight of the most important raw materials in the production process, then on the measurement of the European competitiveness through a quantitative and a qualitative measurement. Due to its particular features, the steelmaking sector has been taken into consideration in order to provide a template calculation.

The paper is organized as follows: the first part is devoted to the explanation of the methodology, while the second is dedicated to the results applied to a case study, which is the steel sector and, in particular, to the blast furnace technology. The follow tree chart schematizes the explained work in the next pages:



The Raw Materials Dependence

When a new technology has to be implemented, the EU imports of raw materials from the rest of the world can increase or decrease with respect to the Business as Usual (BAU).

In a region like EU the weight of raw materials imports is determinant for the heavy manufacturing industry and the quantity is obviously an immediate indicator of the situation. But in an industrial sector which uses various raw materials from more than one non-EU supplier with difference in the local price, it is very useful to know a numerical indication of the whole dependence and the influence of each raw material on it.

An index that measures the raw materials dependence through these following variables has been extrapolated, which takes into account:

► importance of the raw material in the production process. this variable is linked to the cost of the raw material that is necessary to produce 1 ton of Hot Rolled Coil (HRC). The cost has been calculated as the product between the price and the raw material quantity necessary to produce a 1 ton of the final product;

► weight of the non-EU supplier Country. The view has been to calculate this value by combining these following parameters:

- quantity $Q(s)_c$ of the raw material s imported from the country c;

- risk (geopolitical and industrial) factor r_c of the country c;

- distance d_c between the country c and EU.

Because the price of raw material s can vary among different countries, a country specific annual average price $P(s)_c$ has been taken into consideration for each raw material s.

Moreover the quantity $Q(s)_c$ of the imported raw material s can be calculated as the product of the quantity (kg) required to produce a ton of final product (average of the range by Best Available Techniques Reference Document on the Production of Iron and Steel) and the percentage of the importation from the country c.

According to the above criteria, a specific index to calculate the dependence by each imported raw material has been developed **(1)**:

$$D_{(s)} = \left(\frac{\sum_c P_{(s,c)} \cdot Q_{(s,c)} \cdot r_c \cdot d_c}{\sum_i P_{(s,c)} \cdot Q_{(s,c)}} \right) \cdot i_{(s)\,EU}$$

In a time benchmarking a factor **Δer** should be introduced in sum of the numerator and subtraction of the denominator in the ratio which is the difference between the exchange rate €/$ in the basis year and in the year under investigation, because it is reasonable to suppose that a strong value of the Euro money reduces the grade of the dependence from non-EU countries.

If a raw material is completely self produced inside the geographical area of the European Union, the index D(s) is fixed zero, because the dependence does not exist.

The global dependence index D, which is the start line of the analysis, has been obtained averaging each raw material index **(2)**:

$$D_{BAU} = \overline{D}_{(s)_{BAU}}$$

At this point, the various index D(s) for the new technologies of production can be calculated, as follows **(3)**:

$$D_{(s)_{...}} = D(s)_{BAU} \cdot F(s)$$

where **(3a)**:

$$F(s) \overset{\Delta}{=} \frac{\sum_c Q(s,c)_{...}}{\sum_c Q(s,c)_{BAU}} \quad \text{if} \quad D(s)_{BAU} > 0$$

or **(3b)**

$$F(s) \overset{\Delta}{=} \frac{\sum_c Q(s,c)_{BAU}}{\sum_c Q(s,c)_{...}} \quad \text{if} \quad D(s)_{BAU} < 0$$

In this way, the dependence has been measured by using the differences in the raw material consumption between the examined technology and the BAU. The increase or decrease in the consumption of a raw material is proportionally divided up to the non-EU countries.

If a raw material is not used in the BAU, the dependence index of that raw material has been calculated by using the formula **(1)**: this is the case of the dependence of SP11 or SP12 from the natural gas, where the reference situation could be calculated in the first route using data, for example, from a current process of Direct Reduction.

The global dependence index D for each new technology can be estimated, by averaging **(4)** the single index D(s):

$$D_{...} = \overline{D}_{(s)...}$$

By means of equation (1), the dependence index $D(s)_{BAU}$ of steelmaking in each country of EU15 in 2000 and EU25 in 2006 has been calculated, by selecting six significant imported raw materials (fines and concentrates of iron ore, pellet, lump, coking coal, PCI coal and coke) which are used to produce 1 ton of HRC:

Route		BAU (EU15)	
Raw Materials	*Total*	*Import*	***D (s)***
Fines/Concs	*1021,6*	*732,5*	***5,54***
Pellet	*429,3*	*364,9*	***5,27***
Lump	*384,9*	*384,9*	***7,45***
Coke	*390,5*	*78,5*	***1,19***
Coking Coal	*405,6*	*308,2*	***3,00***
Pci Coal	*365,6*	*247,9*	***3,20***

$$D_{BAU} = 4{,}22$$

Route		BAU (EU25)	
Raw Materials	*Total*	*Import*	***D (s)***
Fines/Concs	*1124,5*	*862,5*	***5,54***
Pellet	*429,3*	*264,9*	***0,13***
Lump	*384,9*	*384,9*	***6,42***
Coke	*390,5*	*45,7*	***1,37***
Coking Coal	*448,2*	*340,6*	***2,57***
Pci Coal	*365,6*	*247,9*	***3,22***

$$D_{BAU} = 3{,}23$$

It is important to remark that the index has very limited variations in a time benchmarking when the industrial sector under investigation has a reference market of raw materials where the total import share from non-EU countries is very wide and a single supplier has a 40-70% share of the non-EU import. This is the case of the iron and steel industry in EU.

EU Competitiveness Measure

In the coming years, competitiveness will be the most serious challenge of the European metals industry with respect to the rest of the world. In particular, the increasing prices of energy and raw materials, ambitious environmental requirements, the needs to improve sectorial skills and the managing of structural change are the most important issues.

Two areas have been investigated: *"Energetic Resources Availability"* and *"Raw Materials Supplying and Technology Flexibility".* For both areas, three categories have been taken into consideration (*Energetic Resources Availability, Raw Materials and Process Flexibility, Complexity and Safety of the Technology*). In the Energetic Resources Availability area, there is the Electricity Consumption subcategory which has been measured trough a quantitative evaluation. The other subcategories belonging to the remaining areas have been measured through a qualitative assessment.

VALUATION METHOD	AREAS OF MEMBERSHIP	CATEGORIES	SUB-CATEGORIES
QUANTITATIVE	A) Energetic Resources Availability	1. Energetic Resources Availability	Electricity Consumption
QUALITATIVE	A) Energetic Resources Availability	1. Energetic Resources Availability.	Energetic Efficiency
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	2. Raw Materials and Process Flexibility	Raw Materials Flexibility
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	2. Raw Materials and Process Flexibility	Flexibility Location Requirements
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	2. Raw Materials and Process Flexibility	Manufacturing Flexibility
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	3. Complexity and Safety Technology	Production Planning Complexity
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	3. Complexity and Safety Technology.	Technology Complexity
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	3. Complexity and Safety Technology	Sophistication Production Process
QUALITATIVE	B) Raw Materials Supplying and Technology Flexibility	3. Complexity and Safety Technology	Technology Safety

Figure 1. Categories and subcategories under assessment

A tool has been created in order to resume all the scores obtained for each subcategories and give a final score for each Ulcos technology. Just to click on one of the grey cells and another work sheet will open where the score has to be inserted and where the parameters to be taken into consideration for the evaluation, are reminded.

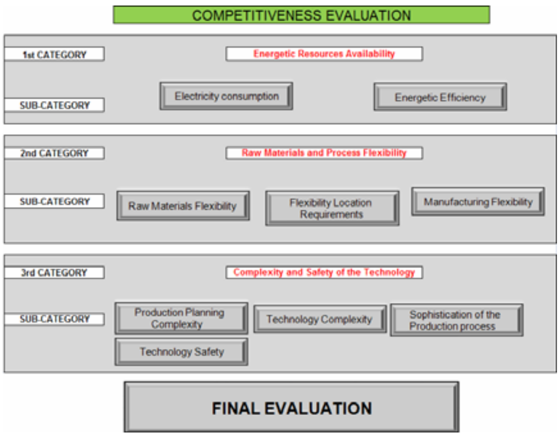


Figure 2. Competitiveness: introduction mask

It is necessary to click on "**Final Evaluation**" and a re-capitulary work sheet, averaging the scores, will be able to assign the **final scores** (**3,22** for the **BAU**) for each ULCOS routes.

FINAL EVALUATION	VALUES				
SUBCATEGORIES	BAU	SP10	SP11	SP12	SP13
Electricity Consumption	5	-	-	-	-
Energetic Efficiency	3	-	-	-	-
Raw Materials Flexibility	3	-	-	-	-
Flexibility of the Location Requirements	3	-	-	-	-
Manufacturing Flexibility	3	-	-	-	-
Production Planning Complexity	3	-	-	-	-
Technology Complexity	3	-	-	-	-
Sophistication of the Production Process	3	-	-	-	-
Technology Safety	3	-	-	-	-
ASSIGNED SCORES	3,22	-	-	-	-

Figure 3. Competitiveness table calculation

Quantitative Method: Electricity Consumption Subcategory

The aim of evaluating the Electricity Consumption subcategory is to find not only the process which consumes less energy, but also the best country to implement a process from the energetic point of view. Actually the implementation of a process in a country which is heavily energy dependent from non-EU countries could really be not convenient not only for the country itself, but also for the European competitiveness, which is the sum of the competitiveness of each European country.

According to the considerations above, a formula has been extrapolated considering these following index:

$$I_{Elec.Cons} = I_{(proc.cons)} \times I_{i(elec.price)} \times Ip_i$$

where:

$$I_{(proc.cons)} = \frac{El.C_{NT}}{El.C_{BAU}}$$

$EL.C_{NT}$= electricity consumption of a new technology

$EL.C_{BAU}$= electricity consumption of BAU

$$I_{i(el.price)} = \frac{El.P_i}{N}$$

i= European Country

$El.P_i$= yearly average electricity prices of *i* European Country

N= weighted average of non EU Countries electricity prices

Ip_i= percentage of imported electricity of *i* European country from non-EU countries

The two first index have the following meanings:

$I_{(proc.cons)}$ takes into consideration the ratio between the electricity consumption of the new technology and the electricity consumption of the actual technology (BAU).

$I_{i(el.price)}$ is given by:

- for EU, the ratio between the yearly average European price of electricity and the weighted average of the non-EU countries electricity prices;
- for each European country, the yearly average of each European country and the weighted average of the non-EU countries electricity prices.

Only those non-EU Countries, which export electricity in EU, have been taken into consideration. The data used for the calculation of the index related to the countries ($I_{(el.price)}$) were taken from the Statistical Yearbook, published in the 2006, from UCTE, Union for the Co-ordination of Transmission of Electricity. France, Germany, Spain, Sweden, Czech Republic, Slovenia, Slovakia and Poland have been considered as net electricity exporters. Denmark and Ireland have not been taken into consideration as they stopped the steel production. The Non-EU Countries, which export electricity in EU-25 during 2005, are Albania, FYROM, Russia, Bulgaria, Norway, Switzerland, Romania, Ukraine West, Croatia, Serbia & Montenegro. All the calculations have been carried out considering data related to the 2005 year. The amount of purchased electricity until the production of a ton of HRC is around 0,03 MWh/t HRC (23% of the total amount).

The results obtained are:

ROUTE BAU			
	$I_{Elec.Cons}$	$\log(I_{Elec.Cons}+1)$	Assigned Scores
Sweden	0,52	0,18	5
Poland	0,62	0,21	5
France	0,65	0,22	5
Uk	0,66	0,22	5
Czech Republic	0,67	0,22	5
Slovenia	0,68	0,23	5
Slovakia	0,79	0,25	5
Portugal	0,80	0,25	5
Spain	0,81	0,26	5
Belgium	0,87	0,27	5
EU-25	0,91	0,28	5
Finland	0,93	0,29	5
Austria	0,93	0,29	5
Netherlands	1,01	0,30	5
Germany	1,01	0,30	5
Hungary	1,10	0,32	5
Greece	1,41	0,38	4
Italy	1,85	0,45	4

Figure 4. Electricity Consumption Index and the assigned scores for each European Country

The figures of the $I_{Elec.Cons.}$ have been transformed in data more easily comparable to each other, by using the logarithm. In order to avoid negative figures, 1 has been added to the results. Moreover, 5 equal intervals have been created and for each interval, a score from 5 (the “Best Score”) to 1 (the “Worst Score”), along with the intermediate values, has been assigned.

Through the above formula, the European countries with an high rate of electricity dependence from non EU countries, as well as an high price of electricity (such as Greece and Italy) are associated to low scores, while the European countries which are not dependent from non EU countries and with a low price of electricity (such as France, Sweden and UK) obtained the highest scores.

Qualitative Method

The qualitative evaluation has been carried out through a structured questionnaire with closed response questions comparing the current competitive situation determined by the actual technology BAU with the new Ulcos technologies. A five point Likert-type scale format ranging from "Much better than..." (5) to "Very worse than..." (1) with a middle anchor point of (3) "Same as the actual technology", should be used. High values of the resulting KPI will be associated to a new Ulcos technology, that is able to improve the competitive standing with respect to the BAU and to adapt itself to the market needs. Following a little explanation of each subcategories will be given. The score to be assigned to each subcategory of the Ulcos technologies should consider the following factors:

Energetic Efficiency

- % of the recovered energy;
- % of the energy internally produced;
- % of the energy losses.

Raw material Flexibility

- the possibility of the technology to change raw materials input;
- the possibility of the technology to modify the resources mix used in the production process.

Flexibility of the Location Requirements

- the possibility to easily find a location for the production process;
- the importance for the new technology of being close to some special field.

Manufacturing Flexibility

- *Delivery Flexibility* ("Is it possible to modify in the new technology the production/delivery scheduling in order to meet unexpected requirements customers?");
- *Volume Flexibility* ("Is the new technology capable to operate at various batch sizes and/or at different production output levels economically and effectively?");
- *Machine Flexibility* ("is the equipments of the new technology able to perform many types of operations in an economic and effective way?)

The judgement to allocate to "*Manufacturing Flexibility*" will be obtained averaging the values of the above three issues.

Production Planning Complexity

- can the production planning be scheduled at any moments?;
- are the process features able to well highlight in advance bottlenecks or losses of time, in order to avoid delays and/or interruptions in production?

Technology Complexity

- the complexity of the implementation of the technology (the time necessary to realize the technology);
- the complexity to implement the plant design and the plant layout necessary for the optimization of the performances of the production activities.

Sophistication of the Production Process

- the equipment of the production process is really delicate and can easily break;
- the level of the robustness and reliability of the production process is suitable.

Technology Safety

- the time planned to the maintenance;
- the time planned to the staff training;
- the machines are equipped with all the safety devices respecting all the regulations.

KPI Final Measurement

At this point, two evaluations have been obtained:

	BAU	SP10	SP11	SP12	SP13
Raw Material Dependence	***3,23***	-	-	-	-
Competitiveness Measure	***3,22***	-	-	-	-
Final Evaluation	**0,99**	-	-	-	-

Figure 5. Final Results

those are the EU raw material dependence measure and the EU competitiveness measure.

These two measures have been jointed according to this relationship **(5)**:

$$\text{KPI} = \frac{\text{EU Competitiveness}}{\text{EU Raw Material Dependence}}$$

The technology to be preferred is the technology which increases the competitiveness with respect to the Business as Usual and reduces the raw material dependence with respect to the Business as Usual.

The technology which obtains the highest score with respect to the BAU will be the preferred one.

Conclusions

Through this study, a quantification has been attempted of the most important effects that may result in the market between the EU and the rest of the world when a new technology has to be implemented in an industrial sector.

The results were obtained by using data related to the steel sector, but the above formulas can be used also in many fields of applications.

In particular, this analysis has a great relevance when a technology has to be chosen in comparison with the actual technology and other technologies.

Moreover, this study can also be focused on a single country (to find out which technology is best to deploy) or it can also be made a comparison between Europe and another continent (to see how the dependence can vary from one continent to another using the same technology).

Acknowledgements

The present work is part of the ULCOS program, which operates with direct financing from its 48 partners, especially of its core members (ArcelorMittal, Corus, TKS, Riva, Voestalpine, LKAB, Saarstahl, Dillinger Hütte, SSAB, Ruukki and Statoil), and has received grants from the European Commission under the 6th Framework RTD program and the RFCS program [1]. The sole responsibility of the issues treated in the present paper lies with the authors; the Commission is not responsible for any use that may be made of the information contained therein.

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