ECOEFFECT

MILJÖBEDÖMNING AV BEBYGGELSE

Naturresursförbrukning

Byggd Miljö

KTH Gävle

Miguel-Angel Romero

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KUNGL TEKNISKA HÖGSKOLAN

VETENSKAP OCH KONST

EcoeffectEnvironmental impact assessment of

Natural resource consumption

Index

1 Introduction

1.1 Intention

The EcoEffect method is focused in calculating the potential environmental impacts caused by building related activities and, in this case, those specifically related with the consumption of natural resources.

The EcoEffect approach intends to assess how the today's natural resource consumption **modifies the ability** of the current and coming generations to **fulfil their needs** by means of using natural resources.

With natural resource consumption is meant the use of pure raw materials like pure iron, crude oil, wood, etc.; i.e. the resource consumption is computed as consumption of pure raw materials instead of refined materials.

1.2 Natural Resources and Reserves

Natural resources are defined here as the materials or conditions occurring in nature and capable of economic exploitation.

Within natural resources, two main groups can be established depending on the capacity of regeneration:

- **Renewable resources**: resources that can be regenerated.
- **Non-renewable resources**: resources that can not be regenerated or regenerated only within a time horizon beyond current interest.

A further distinction, depending on the type of consumption, could be also established. Fossil fuels are burned and disappear entirely as resources, while metals are only transformed and spread in the earth crust with some possibility of future recovery.

- **Reversible consumption**: the consumption does not imply that the resources disappear entirely as resources.
- **Irreversible consumption**: the resources disappear entirely as resources when they are consumed.

Therefore, within the non-renewable resources, we consider two different sub-groups regarding the possibility of future recovery:

- **Non-recoverable:** resources with ”irreversible” consumption”
- **Recoverable:** resources with ”reversible” consumption

When it comes to the definition of natural resource reserves there are different considerations to be made. The size of the resource reserves is not an absolute value, but depends to a high degree on the amount of prospecting that had been done, the availability to be extracted, the market prize, the strategic significance, etc. The most general definition of reserves is referred to the physical/geological abundance of one resource on the earth’s crust, but this is still open to several interpretations that results in very different concepts of resource and/or reserves: proven reserves, probable reserves, paramarginal reserve, total resource, etc.

Almost all the mineral resources are physically inexhaustible but the cost for exploiting them may be infinitely high. Some authors have defined resources not accessible when they are *no longer economically attractive to continue production*. Within this reasoning the limit of resource accessibility is always economic and not geologic.

Here we will use the term **reserves** defined for USGS[1] and considered as *the currently known, technically and economically, accessible stock of a resource*. We identify the ” reserves” as the ”known or computed reserves” considered in UMIP[2].

1.3 Weighting aspects

The **resource consumption assessment** analyses the contribution of the current raw materials use to reduce the availability of natural resources for coming generations. This contribution varies, among others, in function of the rate of exploitation, the amount of the reserves and the capacity of renovation/renewal of the natural resource, but it depends, also, on several other factors related with the specific natural resource we are considering.

[1] ”Minerals Commodity Summaries 1998” US Geological Survey, January 1998.
[2] Environmental Assessment of Products. Wenzel H, Hauschild M, Rasmussen E. 1997.

These aspects have to be taken into account when determining the environmental impact of the consumption of natural resources. For this purpose a set of qualitative and quantitative weighting aspects are established and weighted.

1.4 Analytic Hierarchy Process (AHP)

In order to carry out a weighting procedure for natural resource consumption, the, so called, **Analytic Hierarchy Process**[3] (AHP) is applied.

By using this process, we will be able to derive weights and priorities by combining quantitative and qualitative information, using numerical data and motivated judgements.

Within this methodology we need to establish the following steps:

1. State the objective
2. Select the criteria and,
3. List the alternatives.

1. OBJECTIVE	**Environmental Impact Assessment of Resource Consumption**
2. CRITERIA	**Weighting Aspects**
3. ALTERNATIVES	**Natural Resource Categories**

2 Environmental Impact of Natural Resource Consumption

Therefore, as it has been mentioned, the objective of the EcoEffect method is to assess the environmental impact of natural resource consumption for the ability of the future generations to performance their functions as they are performed today.

The EcoEffect method expresses the environmental impact of resource consumption in terms of the contribution to the depletion of a certain resource and the significance of this depletion in a long-term perspective. The more the society depends on a certain resource the more significance the depletion of this resource has.

[3] Analytic Hierarchy Process. Saaty T. L. Expert Choice Inc. TASC. Pittsburgh, USA

The resource consumption impact, then, is understood as the potential environmental effect of a future resource scarcity caused by the today's use of natural resources.

The assessment of the resource consumption impact is, then, obtained in terms of the amount of resources used and in function of a certain **Resource Factor** (RF). This Resource Factor reflects the environmental effect that the reduction of resource availability will imply for the coming generations.

Finally, the environmental impact potential of natural resource consumption is derived by the following expression:

Resource Consumption Impact = Resource Consumption (Kg) x Resource Factor (RF)

3 Natural Resource Consumption Weighting

Until here, we have described how the **potential resource consumption impact will be expressed by means of the materials use and the Resource Factor (RF)**. It is obvious that within the **RF,** all the aspects that make some influence, in terms of future resource availability, should be included and weighted. Nevertheless, which aspects are significant and how they are weighted is not so obvious and it remains as an important issue where consensus has not been yet reached. Different models and researches have emerged with a different range of criteria and weights.

The UMIP[2] method expresses the resource consumption impact in function of the so called **Supply Horizon,** considering the amount of resource consumed and the years of remaining for the considered natural resource at the current rate of exploitation. But, others[4] and we still consider that there are other important aspects more than the supply horizon, which should be taken into account. Other systems have proposed some different aspects and weights (EQ[5], BEES[6], and EPS[7]).

[2] Environmental Assessment of Products. Wenzel H, Hauschild M, Rasmussen E. 1997.
[4] Resource depletion in Life-Cycle Assessment. Hertwich, E.G. Letter to the Editor, submitted to *Environmental Toxicology and Chemistry*
[5] LCA based Tool Eco-Quantum. Kortman, J.G.M.
[6] BEES 1.0 Building for Environmental and Economic Sustainability. Technical Manual and User Guide. B. Lippiatt. April, 1998. US Department of Commerce.
[7] The EPS Enviro-Accounting Method. Steen, B.;Ryding S.O. IVL Göteborg, 1992.

Considering the above, the EcoEffect method has developed a concept which describe the potential impacts in a conceptual basis[8] and applicable for every kind of effect category.

Based on that, a general set of weightings has been defined and structured in the following weighting categories: **extent, seriousness, recovery potential, and uncertainty**[8].

By this, the EcoEffect resource factor intends to consider, as far as possible, all the aspects that have some relevance within the sustainability perspective. These weighting categories have been specifically enunciated for the natural resource consumption.

The weighting aspects included in the EcoEffect Resource Factor (RF), results as follows:

EcoEffect Natural Resource Weighting Aspects

ASPECTS	GENERAL	RESOURCE FACTOR	INDICATOR /PARAMETER
Extent	Current State	**Supply Horizon**	years of remaining
	Rate of change	**Exploitation Rate of Change**	exploitation change rate (10 years)
Seriousness	Extent	**Yearly Resource Value**	yearly exploitation x resource market value
	Rate of change *(Not applied)*	**Accessibility Rate of Change**	primary embodied energy change rate (10 years)
Recovery Potential	Renewability	**Regeneration time**	years
	Reversibility	**Recovering Energy Rate**	recovering energy / primary embodied energy

For embodied energy not enough and consistent data has been found over the last 10 years. Therefore, the seriousness rate of change expressed by the accessibility rate of change has not been considered at this stage.

3.1 Extent

[8] EcoEffect Miljövärdering av Bebyggelse. Huvudrapport. Glaumann, M. KTH, Byggd Miljö, Gävle. Jan 1999

3.1.1 Natural Resource Consumption Current Extent

The current extent of the resource consumption is expressed in terms of the **Supply Horizon**, as it is described in the UMIP methodology[2].

The Supply horizon **(Sh)** provides a measure of the **resource's scarcity** and it is defined as the *number of years for which current consumption of the resource can continue before current reserves are exhausted*. It reflects how scarce the resource is relative to its consumption.

Then, the extent of the resource consumption, expressed by the supply horizon, is calculated as follows:

$$\textbf{Resource Consumption Current Extent} = \text{Supply Horizon } \textbf{(Sh)} = \frac{\text{current reserves magnitude}}{\text{yearly exploitation. - yearly growth}}$$

For non-renewable resources this supply horizon is always finite. For renewable materials the supply horizon will be infinite for that resources which are not consumed faster than their rate of regeneration.

3.1.2 Natural Resource Consumption Extent Change

The change in the resource consumption extent during a certain period of time is assessed here by means of the yearly decrease or increase of the reserves magnitude during that period, as it was defined for the Development Indicator within the Impact Potential Factor[9].

The yearly change of the resource consumption is expressed on the basis of the total amount of the reserves base for the reference year, and calculated as follows:

[2] Environmental Assessment of Products. Wenzel H, Hauschild M, Rasmussen E. 1997.
[9] External environmental impact of buildings. Glaumann M, Trinius W. Building and environment. Second International conference, June 9-12 1997, Paris. Proceedings Vol. 1. CSTB Paris

$$\textbf{Resource Consumption Extent Change} = \frac{\text{reference reserves magnitude - current reserves magnitude}}{\text{reference reserves magnitude x years of exploitation}}$$

3.2 Seriousness

3.2.1 Resource Consumption Current Significance

The level of significance or usefulness that a certain resource has for people and ecosystems functions has been set as the indicator to judge the seriousness of current pure raw material consumption.

The significance is defined as the *contribution of one pure raw material to make possible for people and ecosystems to perform their natural essential functions*[10]. This means that the consumption of one resource has **more significance** when it is more useful and, therefore, **more difficult to replace** by another material.

Some natural resources are more usable because they have more possible applications than others do; e.g. crude oil has more uses than other fossil fuels such coal or gas, which means also that a potential scarcity has different significance. Also, some materials are essential to certain applications, which means that they are more difficult to be replaced than others are. These resources are less substitutable and the consumption of them has more sever impact than for others.

This usefulness is expressed in terms of the resource consumption market value and calculated as follows:

$$\textbf{Resource Consumption Current Significance} = \text{yearly resource exploitation x resource market value}$$

[10] Agripedia Glossary. Porter L.T. College of Agriculture. University of Kentucky.

3.3 Recovery Potential

3.3.1 Natural Resource Consumption Reversibility

The consumption of some natural resources leads to irreversible damage when the utilisation implies that the material disappears entirely as resource, e.g. fossil fuels. On the other hand, the consumption of one resource is considered reversible if the material is only transformed in the manufacturing process and incorporated into a new product in a different state, e.g. metals, minerals, etc.

The reversibility of a resource not only depends on the raw material but also on the type of product for what it would be used. For instance, oil could not be recovered if it is burned as a fuel but it is relatively easy to recycle when it has been manufactured as plastic. Nevertheless, plastic can not be recovered as oil to be used as a liquid or gaseous fuel.

Therefore, the reversibility of a resource is assessed here in the basis of the **recovering energy** defined as the *magnitude of the energy consumption required for a later recovery of one resource that can be used as the primary raw material again.*

With primary raw material is meant that the material could be used for the same purposes as it could be used the pure raw material extracted from nature.

Then, the **Recovering Energy Rate** is established as the indicator of the natural resource consumption reversibility, by means of the comparison between the recovering energy and the primary embodied energy. The primary embodied energy is defined as the *energy required to extract natural resources from nature from which the secondary materials, substances and energy in a product/component derive*. It results as follows:

$$\textbf{Recovering Energy Rate} = \frac{\text{recovering energy}}{\text{primary embodied energy}}$$

If one resource is not to be recovered, like fossil fuels, then the recovering energy required for that material will be considered infinite and therefore the recovering energy rate will be also infinite.

As a reference for the comparison we will define for each material, the ***"reference recovering energy"*** as the lowest recovering energy values (*best practice* principle) calculated for pure raw materials in a specific database (these data should be provided by consistent research studies).

For renewable materials we will consider as recovering energy the energy required to grow up a certain resource, defined as the magnitude of the energy required to growth the same amount of new natural resource **(growth energy)**.

As a reference for the comparison we will define for each material, the ***"reference primary embodied energy"*** as the lowest energy values (*best practice* principle) calculated for pure raw materials in a specific database (these data should be provided by consistent research studies).

There are other aspects that make also some influence in the assessment of the reversibility of one material but the significance of these aspects is difficult to quantify and they have not included in the assessment, so far. Among them we found the followings:

- Potential number of pure raw material recovering cycles
- Amount of Pure raw Material substituted by the recovered material
- Pure raw material degradation by recovering cycle.

3.3.2 Natural Resource Renewability

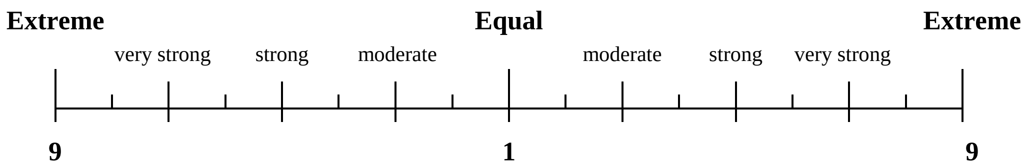
Here, the renewability of a natural resource is assessed in the basis of the time required to regenerate the resource from nature. For the wieghting procedure, those resources that can not be regenerated or regenerated only within a time horizon beyond current interest (non-renewable resources) will be considered with an extremelly large time of regeneration.

3.5 Weighting aspects comparison

The former considered weighting aspects have not the same importance when talking about natural resource consumption in terms of sustainability. Therefore, the relative importance of one aspect over another should be established. To estimate if a weighting aspect is more important than other, we should define additional criteria, which will be the basis to compare all the weighting aspects between them. For that purpose, we consider that the long-term perspective is the most important meaning of sustainability and we chose this as the base for weighting.

The weighting procedure is performed by an Analytic Hierarchy Process[3] and obtained by using pairwise comparisons. This has been carried out through a questionnaire delivered for an expert panel judgement.

The relative importance of one criterion (or aspect) over another is expressed by using the following pairwise comparisons scale described in the AHP[3] methodology:



As a result of the **AHP** application (see annex), the following weightings have been obtained.

3.5.1 General weighting aspects for Resource Consumption

Resource Consumption

		A	B	C		Weights
Ref	**Aspects**	**Extent**	**Seriousness**	**Recovery Potential**		
A	**Extent**	1	3	3		0,584
B	**Seriousness**		1	1/3	=	0,135
C	**Recovery Potential**			1		0,281

(See Annex)

3.5.2 Secondary Weighting Aspects

3.5.2.1 Resource Consumption Extent

Resource Consumption Extent

		A-1	A-2				Extent Weight		Weights
Ref	**Aspects**	**Supply Horizon**	**Rate of Change**						
A-1	**Supply Horizon**	1	4	=	0,8	x	0,584	=	0,467
A-2	**Exploitation Change**		1		0,2				0,117

(See Annex)

[3] Analytic Hierarchy Process. Saaty T. L. Expert Choice Inc. TASC. Pittsburgh, USA

3.5.2.2 Resource Consumption Seriousness

Resource Consumption Seriousness

Ref	Aspects	B-1 Market Value	B-2 Accessibility Change				Extent Weight		Weights
B-1	Market Value	1	-	=	1	x	0,135	=	0,135
B-2	Accessibility Change		-		-				-

(See Annex)

3.5.2.3 Resource Consumption Recovery Potential

Resource Consumption Recovery Potential

Ref	Aspects	C-1 Recovering energy	C-2 Regeneration Time				Extent Weight		Weights
C-1	Recovering energy	1	1/5	=	0,166	x	0,281	=	0,047
C-2	Regeneration Time		1		0,833				0,234

(See Annex)

3.5.3 Resource Consumption Weighting Aspects

Resource Consumption Weighting Aspects						
Aspects	**Supply Horizon**	**Exploitation Change Rate**	**Market Value**	**Accessibility Change**	**Recovering Energy Rate**	**Regeneration time**
Weights	**0,467**	**0,117**	**0,135**	**-**	**0,047**	**0,234**

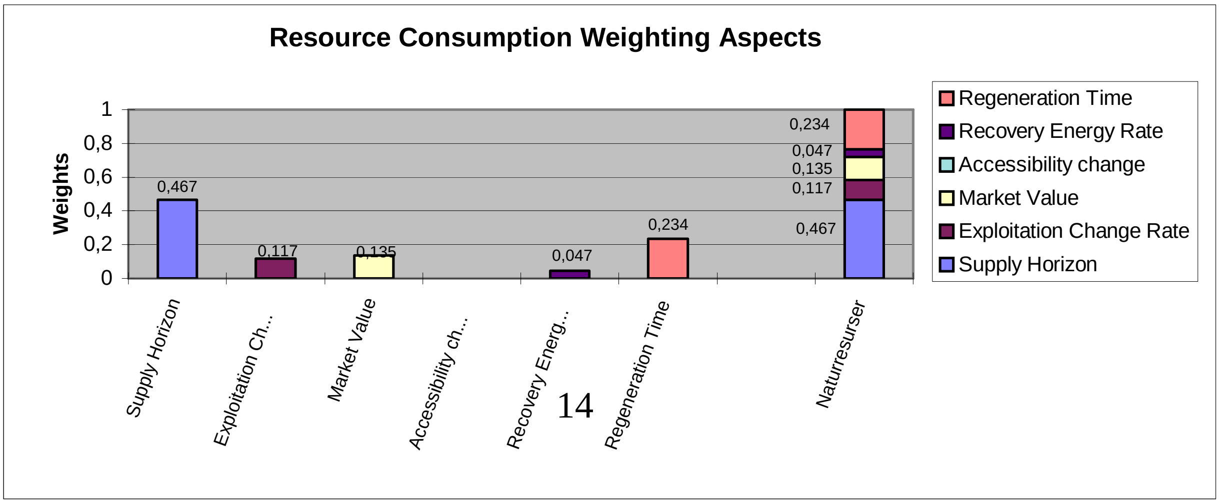


Fig. 1 Resource Consumption Aspects and Weights

4 Natural Resource Consumption

4.1 Categories

The Natural Resources are classified in the following groups called, for our purposes, **resource categories**. The basis for this classification are the guiding lists provided by SETAC[11] and UMIP[2], but other natural resources found in specific minerals and building database have been added [1, 2, 55, 6, 7, 11].

NATURAL RESOURCE CONSUMPTION CATEGORIES

METALS		FUELS		MINERALS		FLORA		NATURAL VALUES	CULTURAL VALUES
Copper	o	**Oil**	o	**Sand**	o	**Wood**	o		
Aluminium	o	Bio-fuels	o	Arsenic	x	Bamboo	-	Animals (species)	Human Settleme
Antimony	x	Bio-gas	x	Asbestos	-	Cellulose	-	Ground water	
Barite	-	Black-Liquor	x	Cement	o	Cork	x	Land	
Bauxite	x	Brown coal	x	Clay	o	Straw	x	Plants (species)	
Beryllium	x	Coal	o	Diamond	-	**Wood (Swede**	o	Rivers	
Bismuth	x	Natural Gas	o	Diatomite	-			Tidal Water	
Boron	-	Peat	x	Feldspar	x				
Bromine	-	Pellets	x	Fluorspar	-				
Cadmium	o	Sun	x	Gemstones	-				
Cerium	x	Uranium	x	Granite	x				
Cesium	-	Urban Waste	x	Graphite	x				
Chromium	o	Water	x	Gravel	x				

[1] "Minerals Commodity Summaries 1998" US Geological Survey, January 1998.
[2] "Environmental Assessment of Products". Wenzel H, Hauschild M, Rasmussen E. 1997.
[5] LCA based Tool Eco-Quantum. Kortman, J.G.M.
[6] BEES 1.0 Building for Environmental and Economic Sustainability. Technical Manual and User Guide. B. Lippiatt. April, 1998. US Department of Commerce.
[7] The EPS Enviro-Accounting Method. Steen, B.;Ryding S.O. IVL Göteborg, 1992. The EPS Enviro-Accounting Method. Steen, B.;Ryding S.O. IVL Göteborg, 1992.
[11] SETAC's working group on the impact assessment phase of the LCA, Udo de Haes, September 1996.

Cobalt	o
Columbium	-
Gallium	-
Garnet	-
Germanium	-
Gold	x
Hafnium	-
Helium	-
Ilmenite	x
Indium	-
Iodine	-
Iron	o
Kyanite	-
Lanthanum	x
Lead	o
Lithium	x
Manganese	x
Mercury	o
Molybdenum	x
Nickel	x
Palladium	-
Platinum	x
Rhenium	x
Rubidium	-
Rutile	-
Scandium	-
Selenium	x
Silver	o
Strontium	-
Tantalum	x
Tellurium	-
Thallium	x
Thorium	x
Tin	-
Titanium	x
Tungsten	-
Vanadium	x
Yttrium	-
Zinc	o

Wind	x
Wood-fuels	o

Gypsum	x
Kaolin	x
Limestone	x
Magnesium	-
Marble	x
Mica	x
Nitrogen	-
Perlite	x
Phosphate roc	o
Potash	x
Pumice	-
Quartz	-
Salt (NaCl)	x
Silicon	x
Soda Ash	-
Sodium Sulfat	-
Stone	-
Sulfur	-
Talc	-
Vermiculite	x
Zirconium	x

”o” Calculated in EcoEffect (at this stage)
”x” Considered in EcoEffect, but not calculated (Data not available)
”-” Not considered in EcoEffect

4.2 Category reference and reference category

In order to have a meaningful comparison within each natural resource category, one specific natural resource has been chosen as **category reference,** in the same way as the. GWP is expressed in CO2 equivalencies[9]. Then, the Resource Factor (RF) will be expressed in terms of this category reference equivalency.

[9] External environmental impact of buildings. Glaumann M, Trinius W. Building and environment. Second International conference, June 9-12 1997, Paris. Proceedings Vol. 1. CSTB Paris

Also, a category reference equivalency between the resource category references is obtained by the same procedure.

For that purpose, we establish **Metals** as the reference category and **Copper**, **Crude Oil**, **Sand** and **Wood** as category references (for the other categories more discussion should be carried out).

Reference category
METALS

Category References					
METALS	**FUELS**	**MINERALS**	**FLORA**	**NATURAL VALUES**	**CULTURAL VALUES**
Copper	**Crude Oil**	**Sand**	**Wood**		

4.3 Category equivalencies

As Metals has been chosen as reference category and, **Copper** as the category reference for metals, all the category references will be expressed in **Copper Equivalencies (CE)**.

Natural Resource Category equivalencies				
Categories	Category Reference	**rf**	Category Equivalency (*)	**Resource Factor RF**
Metals	**Copper**	**1**	**1**	**1**
Fuels	Oil	**1**	**0,73**	**0,73**
Minerals	Sand	**1**	**0,6**	**0,6**
Flora	Wood	**1**	**0,38**	**0,38**
Natural Values				
Cultural Values				

(*) As metals are the Reference Category the Category Equivalency = 1

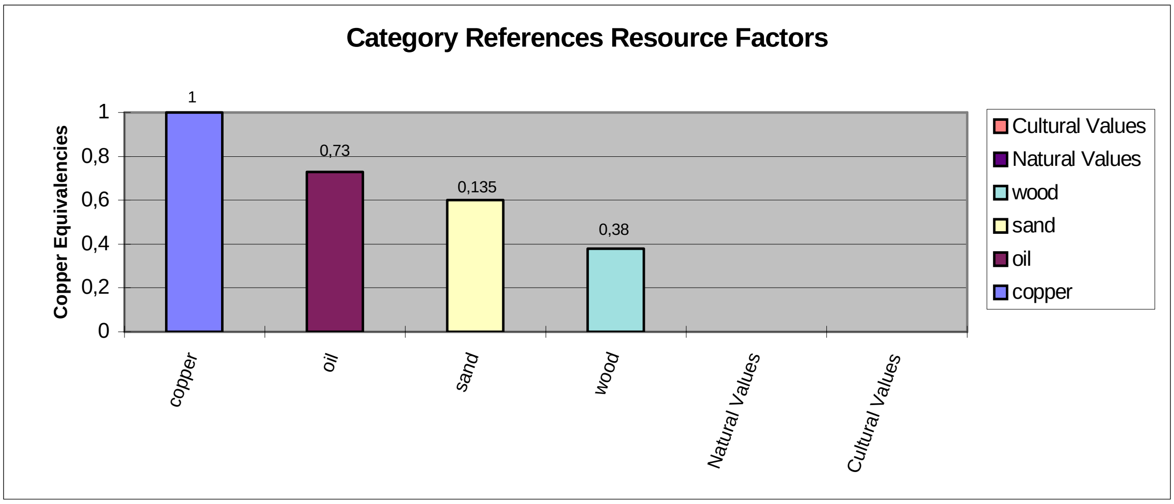


Fig. 2 Resource Factor for the Category References expressed in Copper Equivalencies

Within the respective Resource Category, each Resource Factor (RF) has been expressed, both in Category Equivalencies and in Copper Equivalencies (**CE**).

In order to better illustrate the methodology procedure, we show, here, the whole process for calculating the **iron and aluminium** Copper Equivalencies.

For the other Categories, the same procedure has been carried out. The detailed processes are described in the annex document.

4.3.1 Metals

METALS DEPLETION CATEGORY			
Category Reference	**rf**	Category Equivalency (*)	**Resource Factor RF**
Copper	**1**	1	**1**
aluminium	**0,59**	1	**0,59**
cadmium		1	
chromium	**0,33**	1	**0,33**
cobalt		1	
iron	**0,68**	1	**0,68**
lead	**1**	1	**1**
nickel	**0,67**	1	**0,67**
silver		1	
tin		1	
zinc	**1,04**	1	**1,04**

(*) As metals are the Reference Category the Category Equivalency = 1

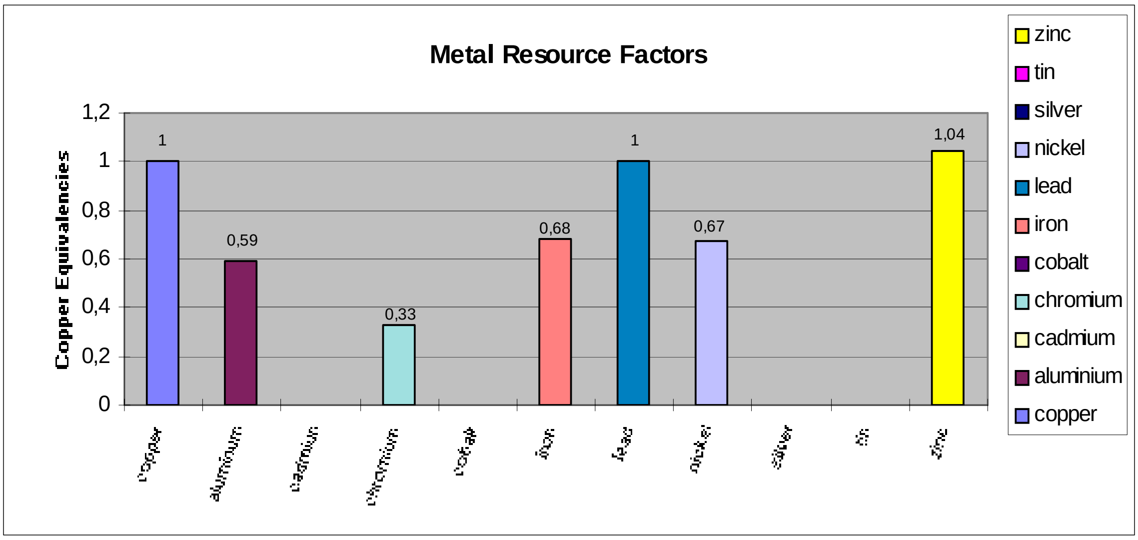


Fig. 3 Resource Factor for Metals expressed in Copper Equivalencies

4.3.1.1 Weighting of copper, aluminium and iron.

1 Which resource has the shortest *supply horizon*? How much shorter is it?

Eq= Equally, m = moderate, M = Much, V = Very much, E = Extremely SHORTER

	E		V		M		m		Eq		m		M		V		E	
copper				**X**														aluminium
28																		**196**
copper						**X**												iron
28																		**117**

2 Which resource is the fastest exploited? How much faster is it?
Ref: Exploitation change over the last 10 years

Eq= Equally, m = moderate, M = Much, V = Very much, E = Extremely FASTER

	E		V		M		m		Eq		m		M		V		E	
copper										**X**								aluminium
3,6																		**5**
copper								**X**										iron
3,6																		**0,9**

3 For which resource has the yearly extraction the largest market value? How much larger?

Eq= Equally, m = moderate, M = Much, V = Very much, E = Extremely LARGER

	E		V		M		m		Eq		m		M		V		E	
copper											**X**							aluminium
16																		**25,6**
copper																**X**		iron
16																		**412**

5 Which natural resource needs more time to regenerate? How much more time?
ref: years

Eq= Equally, m = moderate, M = Much, V = Very much, E = Extremely more TIME

	E		V		M		m		Eq		m		M		V		E	
copper									**X**									aluminium
EL																		**EL**
copper									**X**									iron
EL																		**EL**

6 Which resource needs more energy to regenerate? How much more?
ref: recovering energy/embodied energy

Eq= Equally, m = moderate, M = Much, V = Very much, E = Extremely much MORE

	E		V		M		m		Eq		m		M		V		E	
copper						**X**												aluminium
14																		**4,6**
copper											**X**							iron
14																		**25**

(See Annex)

4.3.2 Fuels

FUELS CATEGORY			
Category Reference	**rf**	Category Equivalency (*)	**Resource Factor RF**
Oil	**1**	**0,73**	**0,73**
coal	**0,49**	0,73	**0,35**
natural gas	**0,71**	0,73	**0,52**
peat	**0,35**	0,73	**0,25**
uranium	**0,4**	0,73	**0,3**
wood-fuels	**0,23**	0,73	**0,17**

(See Annex)

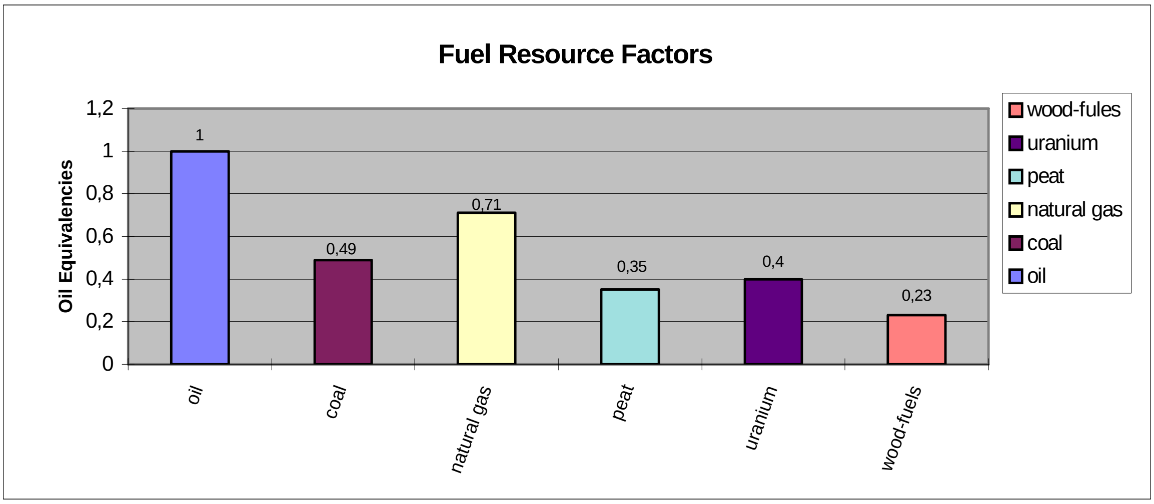


Fig. 4 Resource Factor for Fuels expressed in Copper Equivalencies

4.3.3 Minerals

MINERALS CATEGORY			
Category Reference	**rf**	Category Equivalency (*)	**Resource Factor RF**
Sand	**1**	**0,6**	**0,6**
cement	**0,77**	0,6	**0,46**
clay	**0,58**	0,6	**0,35**
granite		0,6	
gravel	**1**	0,6	**0,6**
gypsum	**0,72**	0,6	**0,43**
marble		0,6	
phosphate	**1,60**	0,6	**0,95**

(See Annex)

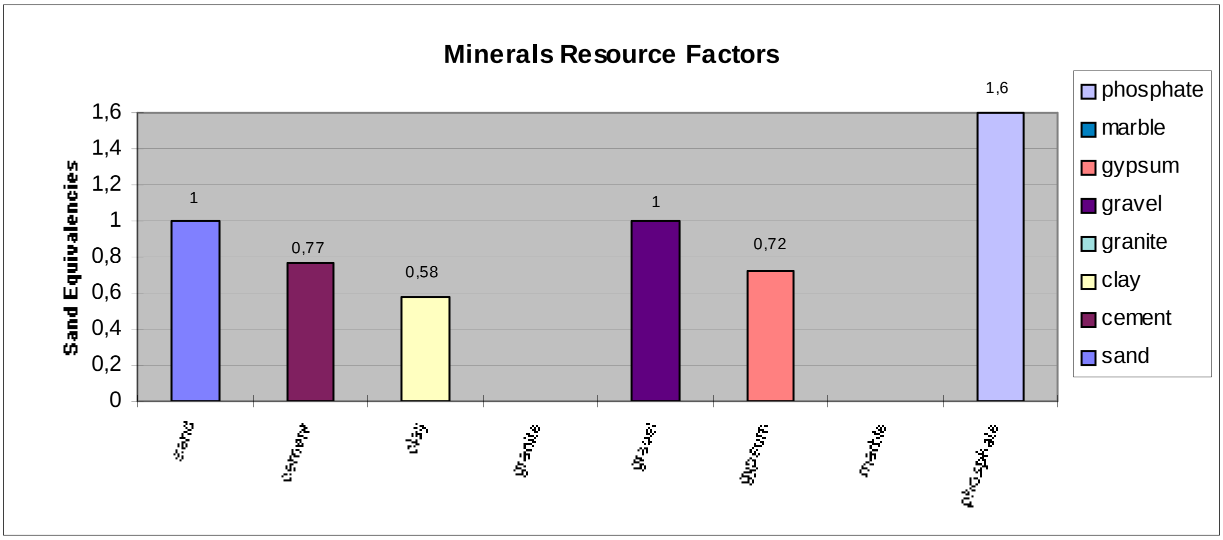


Fig. 5 Resource Factor for Minerals expressed in Copper Equivalencies

4.3.4 Flora

FLORA CATEGORY			
Category Reference	**rf**	Category Equivalency	**Resource Factor RF**
Wood (World)	**1**	**0,38**	**0,38**
Cork		0,38	
Straw		0,38	
Wood (Sweden)	**0,6**	0,38	**0,23**

(See Annex)

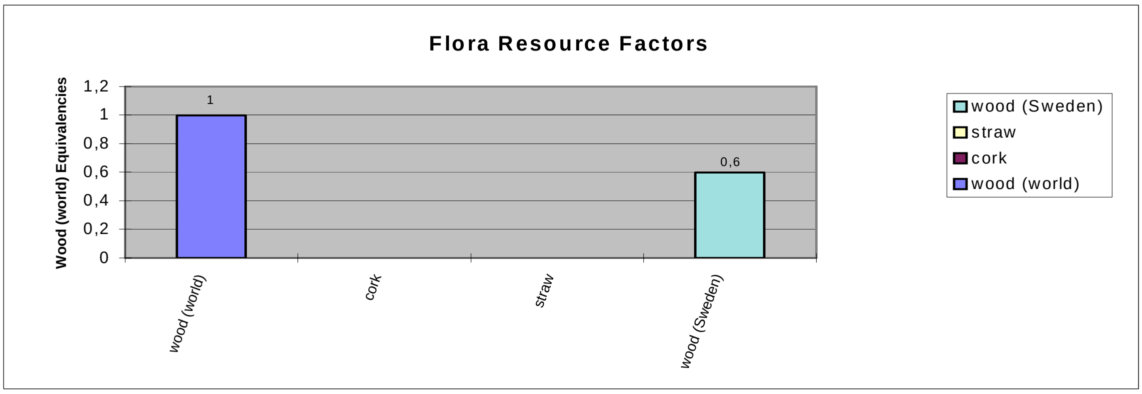


Fig. 6 Resource Factor for Flora expressed in Copper Equivalencies

5 EcoEffect Resource Factor (RF)

5.1 Resource Consumption Factors

By following the former process, we end up in a set of resource factors for each Resource Category Reference and, for each natural resource within the respective Resource Category.

RESOURCE FACTOR			
METALS	**rf**	Category Equivalency (*)	**Resource Factor RF**
copper	**1**	**1**	**1**
aluminium	**0,59**	1	**0,59**
cadmium		1	
chromium	**0,33**	1	**0,33**
cobalt		1	
iron	**0,68**	1	**0,68**
lead	**1**	1	**1**
nickel	**0,67**	1	**0,67**
silver		1	
tin		1	
zinc	**1,04**	1	**1,04**
FUELS	**rf**	Category Equivalency	**Resource Factor RF**
oil	**1**	**0,73**	**0,73**
coal	**0,49**	0,73	**0,35**
natural gas	**0,71**	0,73	**0,52**
peat	**0,35**	0,73	**0,25**
uranium	**0,408**	0,73	**0,3**
wood-fuels	**0,23**	0,73	**0,17**
MINERALS	**rf**	Category Equivalency	**Resource Factor RF**
sand	**1**	**0,6**	**0,6**
cement	**0,77**	0,6	**0,46**
clay	**0,58**	0,6	**0,35**
granite		0,6	
gravel	**1**	0,6	**0,6**
gypsum	**0,72**	0,6	**0,43**
marble		0,6	
phosphate	**1,60**	0,6	**0,95**
FLORA	**rf**	Category Equivalency	**Resource Factor RF**
wood (world)	**1**	**0,38**	**0,38**
cork		0,38	
straw		0,38	
wood (Sweden)	**0,62**	0,38	**0,23**

(*) As metals are the Reference Category the Category Equivalency = 1

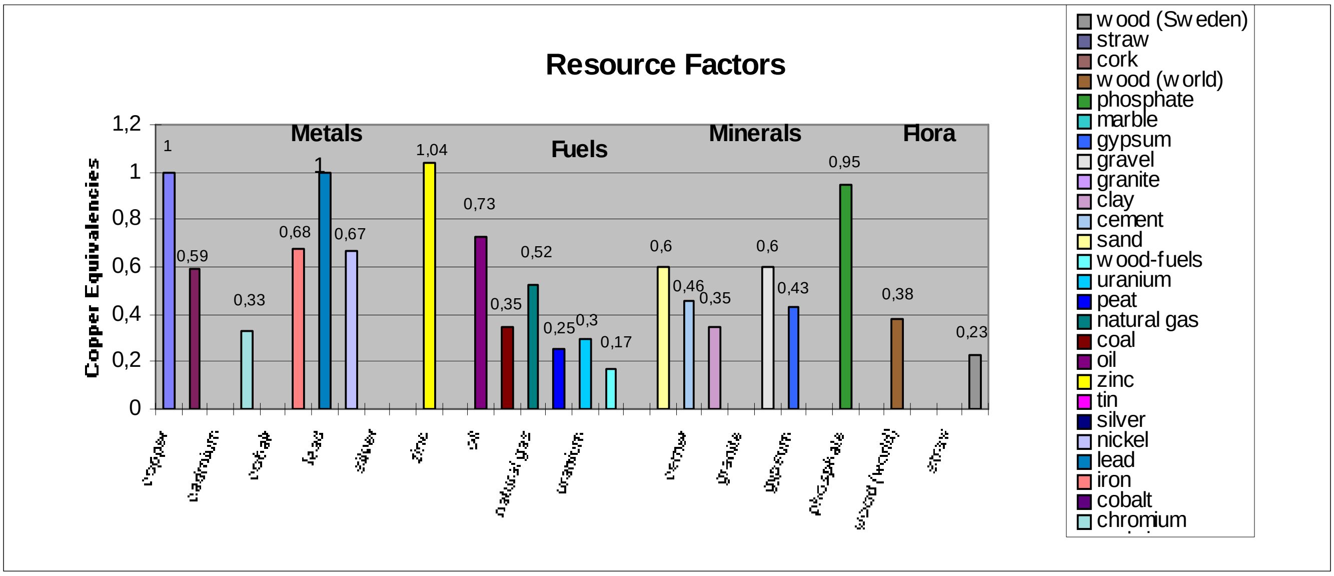


Fig. 7 Resource Factor for Natural Resources in Copper Equivalencies

5.3 Default values

The obtained EcoEffect Resource Factor values are based in world average data from different sources, which means that some of the assumptions and simplifications done could not respond to the specific site situations.

These values have, therefore, to be considered as default values for the Resource Factor and they could be modified for the specific site data when they are available.

5.4 Global, local/regional and site case values.

Finally, some natural resources should be assessed in a regional/local scale where the extraction is taking place, e.g. wood, etc. In that case, site based data when available, should be preferably used instead of the proposed default values.