



ENVIRONMENTAL ASSESSMENT - GOTTEN ACROSS TO INDUSTRIAL DESIGNERS

N. Bey

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1. Background and Motivation

This paper describes a method for environmental assessment in design, the Oil Point Method (OPM). Background and motivation for the development of the method were:

- The increasing importance of environmentally improved products, both for markets and society
- Lack of methodological know-how for environmental assessment among designers
- Lack of readily available and appropriate environmental data
- The existence of both know-how and data, however only in diversified and difficult-to-understand forms
- The need for designers in industry to have basic skills in performing rough quantitative environmental assessments in their daily work

2. The Oil Point Method (OPM)

2.1 Purpose of the OPM

Design of environmentally optimised products – or just ‘Design for Environment’, DFE - generally requires some sort of environmental assessment in order to determine the most favourable alternative in quantitative terms. Making environmental assessments of products or systems can, however, be a very complex matter when performed as a full formal Life Cycle Assessment (LCA). Reason for this circumstance is that, in a formal LCA, the environmental impact is usually expressed in contributions to environmental impact categories like Global Warming, Ozone Depletion, Acidification, consumption of non-renewable resources, etc. And a product will always contribute to a number of different environmental impact categories, which are difficult to add together and to compare with one another.

For the designer or product developer, however, the exact size and character of these environmental consequences are of minor importance. He or she rather wants to know, “where the problems are”, and approximately what magnitude they have. More precisely: Designers’ environmental interest mainly lies in determining the problematic parts of the product and of the product life cycle, and they need to roughly quantify those “problems” in order to make comparisons - without having to be environmental specialists themselves. For those purposes, assessment methods that are based on environmental indicators are an appropriate means, especially in the decisive early stages of product development. The Oil Point Method described here is such an indicator-based method.

Due to their suitability for product development and design, a number of such methods have been developed, e.g. the Swedish EPS [Ryding et al. 1995], the Dutch Eco-indicator [Goedkoop 1995], and

the German MIPS [Schmidt-Bleek 1998]. They all use specific indicators which quantify “environmental impact per mass”, or “per volume”, or “per kilowatt-hour”, etc. Those indicators are defined by environmental specialists.

A major problem of all indicator-based methods is, therefore, that the designer who is doing the development work alone - e.g. as a freelance assignment - is immediately “left alone” when indicator values, e.g. for a certain material, are missing. Asking environmental specialists for help in such a situation disturbs the creative process with all its consequences. A main reason for developing the Oil Point Method has been to cope with this data problem – while maintaining the advantages of an indicator-based method.

2.2 Recommended application of the OPM

The Oil Point Method (OPM) was developed with focus on industrial designers and their specific requirements such as ‘no or only very simple calculations’ and ‘preferably quick results’ (compare [Bakker 1995, Bey/Lenau 1998]). However, also engineering designers can use it to make rough environmental assessments – especially in the very early stages of the development process. Although the OPM incorporates elements from formal LCA, is not an LCA method but rather a tool that shall assist in making decisions on the level of “orders of magnitude”.

A typical application would be the comparison of different alternative materials for a given product or component, e.g. a metal and a polymer. Another example is given further down. Oil Point calculations are also useful when trying to roughly quantify environmental consequences of whole electro-mechanical products, e.g. a car or a TV-set.

Using the OPM as the only means to determine environmental performance is not recommended in cases where chemical aspects are likely to be decisive, e.g. for textiles. Here, possible implications by chemicals should be cross-checked with e.g. lists of dangerous or undesirable substances etc. The Danish Environmental Protection Agency, for instance, provides such lists via its website.

2.3 How the OPM works

2.3.1 Fossil fuel consumption as measure for environmental consequences

Inspiration for the Oil Point Method came from experienced LCA specialists, who often use energy data for rough initial overviews. In most cases this gives a useful picture of which part of the product or its life cycle environmental implications occur and how severe they are. This holds true because today’s energy production mix, e.g. for electricity production, is based on fossil fuel combustion, and this, in turn, is very often the main cause for contributions to Global Warming, Acidification and other major impact categories.

Therefore, the OPM uses requirements of fossil fuels - precisely crude oil - as a measure to roughly quantify environmental consequences related to, for instance, a certain component or the whole product. The definition for Oil Points is given below (**eq. 1**).

$$1 \text{ Oil Point (OP)} = \text{Energy content of 1 kg crude oil} = 45 \text{ MJ} \quad (1)$$

Indicators in the OPM are defined as the crude oil requirement per kilogram of material, per volume or per kilowatt hour. For example, the polymer HDPE (high-density polyethylene) equals 1.8 OP/kg, from ca. 81 MJ/kg energy content (comprising calorific value plus processing energy). Some Oil Point indicators are given in **Table 1**.

A complete list with over 120 indicators can be found under www.designinsite.dk, together with a spreadsheet file for rough calculations. The list comprises all materials classes as well as typical processes taking place during the manufacturing, transport, use and end-of-life stage.

Table 1. Some Oil Point indicators [Bey 2000]

Material or process	Value	Unit
Carbon steels	1	OP/kg
Aluminium (100% primary)	4.4	OP/kg
Aluminium (100% recycled)	0.2	OP/kg
HDPE plastic (material and processing)	1.8	OP/kg
Wood, all kinds	0.5	OP/kg
Electricity (European average)	0.25	OP/kWh

2.3.2 Reduced problem with missing data

As mentioned earlier, lack of readily available and appropriate environmental data, namely indicator values, is a main potential obstacle when using indicator-based methods. In the OPM this obstacle is reduced in two ways:

1. A comprehensive set of OPM indicators is freely accessible on the Internet (www.designinsite.dk).
2. Missing indicators can, in principle, be determined by the designer him- or herself, either by finding required energy data e.g. on the Internet, in literature, etc. or even by estimating the missing Oil Point indicator, for instance based on existing indicators.

Examples: A missing indicator for 50% recycled aluminium can be estimated as the mean value between those for 100% primary and 100% recycled material. An estimate for a missing indicator for a certain natural material, e.g. bamboo, can be based on the value for wood.

2.3.3 “Three by three” steps

An Oil Point evaluation comprises three steps (see **fig. 1**). Each step has three elements:

1. The first step helps the designer to FOCUS exactly on the object that he or she wants to evaluate.
2. The second step assists the designer when he or she wants to actually EVALUATE alternative solutions.
3. The third step suggests the designer to INTERPRET the results and see them in a broader perspective.

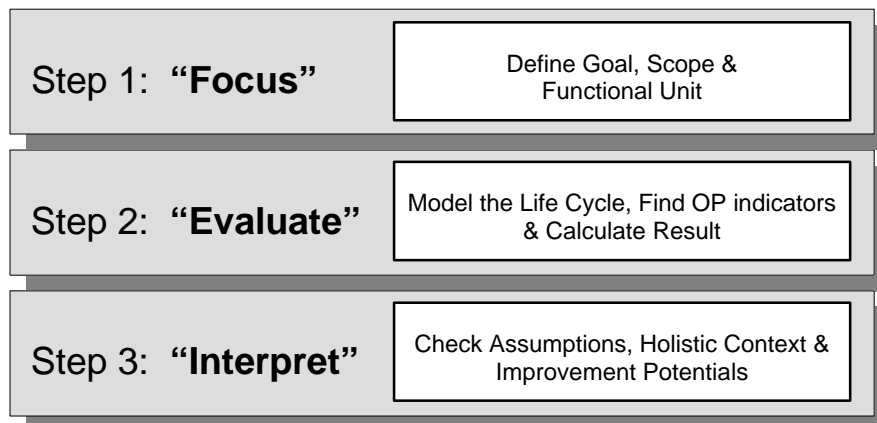


Figure 1. The three steps of an Oil Point evaluation

In Step 1 the designer has to answer three questions:

- “Which decision do you want to support with the evaluation?”
A typical answer may be: “The decision upon the material for a component, e.g. steel or aluminium”. Hereby, the ‘Goal’ for the evaluation is clarified.

- “Which product system do you consider?” By answering this question, the designer defines the ‘Scope’, i.e. the life cycle processes that are included in the evaluation. Usually, one will look at all stages in the life cycle of the product. One may, however, also just focus on a single stage or two. Also, one may choose to omit certain similar components when comparing two products. Example: When comparing materials for window frames, the glass pane and the components for the opening mechanism can be assumed to be similar in both alternatives and can thus be omitted.
- “What is the Functional Unit you evaluate?” Hereby, the designer defines the service, which the product performs for the customer. The so-called Functional Unit describes, exactly what shall be compared (usually by mentioning quantitative, qualitative, temporal and spatial aspects). All options compared have to match with this Functional Unit. This makes sure that the compared products, components or services actually are comparable.

In Step 2, the designer will EVALUATE the alternatives by doing three things:

- “Determine the product system you want to evaluate.” The product system comprises all life cycle processes and their relations. It is simplified as a list of the life cycle processes that have been chosen in Step 1. One should also mark all items, which one is not sure of and which, therefore, can only be assumed or estimated. Such uncertain elements can for instance be the approximate weight of a certain component or the end-of-life scenario. In Step 3, it will be enough to check only these uncertain elements in order to get an idea of how trustworthy the results are.
- Next is “Find Oil Point indicators” for all life cycle processes in the product system. The primary source should be the list given in the spreadsheet file mentioned earlier. If necessary, missing Oil Point indicators may be determined or estimated in the ways explained earlier.
- “Calculate results” finishes the second step. This is done by multiplying Oil Point indicators and amounts occurring in the life cycle. One will get separated values for each life cycle stage and for the product as a whole. **Table 2** shows an example.

Table 2. Calculation of Oil Points [OP], shown by means of a plastic window frame with steel core

Life cycle stage	Material or Process	Amount	Oil Point indicator	Result
Material	plastic-granulate	6 kg	1.5 OP/kg	9.0 OP
Production	electroplated steel	6 kg	0.7 OP/kg	4.2 OP
Manufacturing	electricity	3.7 kWh	0.25 OP/kWh	0.9 OP
All Transport	truck transport	20 ton-km	10 OP/1000 ton-km	0.2 OP
Use	(no painting etc.)	-	-	0 OP
End-of-life	(landfilling)	-	-	0 OP
			TOTAL:	14.3 OP

In Step 3, the designer will INTERPRET the results from Step 2.

Again, one has to do three things:

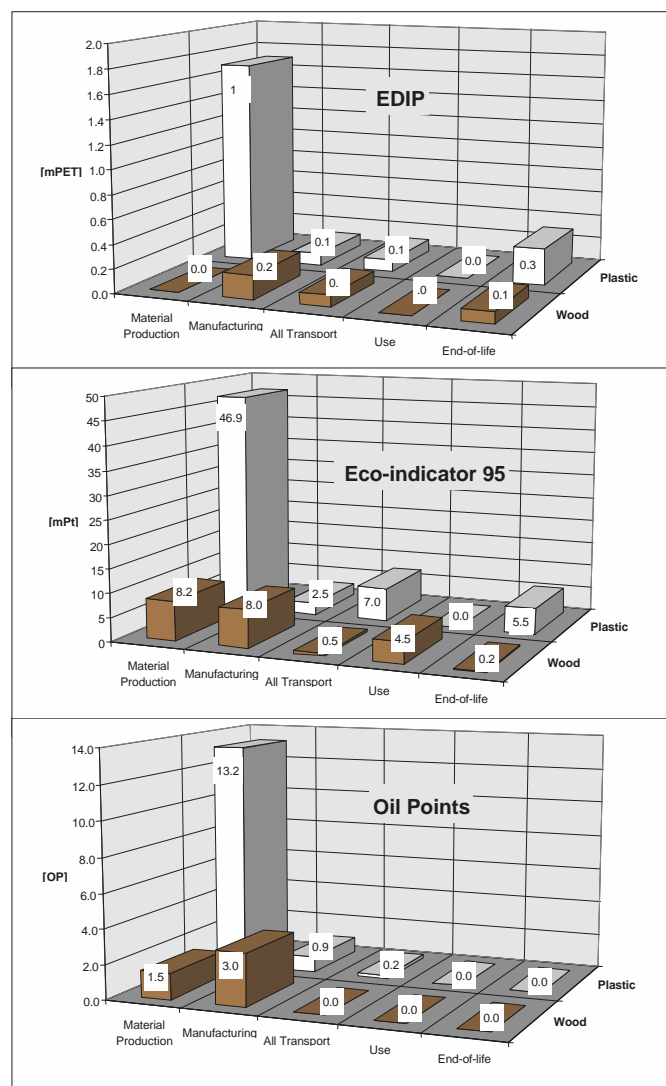
- “Check the uncertainties in the evaluation”. This may sound more difficult than it actually is: There will always be some uncertain elements in the product system. They were marked during Step 2. One can now vary the assumptions in extreme ranges and in this way check, how much influence each uncertain element has on the overall result. For potentially highly influential elements one may decide to look for better information.
- “See the result in a holistic perspective.” Here, one basically checks how important the decision at hand actually is from an overall viewpoint. Seeing the result in a holistic perspective, one may find out that it may not be worthwhile to go into detail for a component at hand because the environmental performance is dominated by the product the component is part of. For instance, it becomes less important to determine the environmentally least harmful material for a window frame, if one is aware of the fact that the environmental impact related to heat loss through the window pane can be estimated to about 600 OP, i.e. more than 40

times (!) that of the “worst” material. ‘Production volume’ is another holistic aspect: The higher the production volume, the more important minor differences get and the higher the overall environmental impact grows (incl. possible ‘rebound effects’, relevant e.g. for mobile phones).

- “Seek improvement potentials.” In this last element, the designer analyses the result with questions in mind such as “Where in the life cycle would an improvement be most effective?”. In the example with the window frames, improving the window pane would clearly be the better option in terms of Design for Environment.

2.4 Outcome of Oil Point evaluations

In case studies, results from the Oil Point Method have been compared with results from two other methods: the LCA method EDIP [Wenzel et al. 1997] and the Eco-indicator 95 method [Goedkoop 1995]. The comparison of two window frames made from wood vs. PVC with steel core is shown below. As **figure 2** shows, there is a fairly good consistency between the results. The overall conclusion would in all cases clearly be in favour of the wooden frame.



**Figure 2. An example with materials for window frames:
Oil Points lead to similar overall conclusions as two other assessment methods
(The shown aggregation of the EDIP result is not part of the method and is done for this comparison only.)**

3. Empirical Testing, Conclusions and Further Work

The Oil Point Method has been integrated into the existing, Internet-based design support tool 'Design inSite' [Lenau 96] in the form of a few descriptive pages and a downloadable spreadsheet file which incorporates all three steps and two examples (Sweaters and window frames). So far, four in-depth case studies/interviews have been performed in order to investigate the applicability of the OPM by designers who don't have specific environmental knowledge. The test persons were confronted with the hypothetical situation to choose the environmentally preferable alternative between steel and aluminium as main material for a car door. Without any given time limit, the tests always lasted between about 30 and 60 minutes.

Main outcomes were that all test persons found the method with its 1-2-3 structure straight forward and easy to understand. However, after having found the spreadsheet file, most test persons started calculations right away, without going through all elements of Step 1. In general, modelling the product system (in Step 2), i.e. determining the different processes and amounts in the life cycle, made problems. One person "got stuck" here and apparently forgot to perform Step 3 afterwards. All determined steel as the better material for the car door as such. Those who checked the "holistic context" in Step 3, became aware of the dominating influence of the use stage in the environmental profile of the overall system, i.e. the car, and that the aluminium door had clear advantages in this broad perspective. All asked for more examples but were confident to have a "good enough, 10-minutes result".

Overall results from the tests indicate that the medium Internet and the method as such are appropriate to get data and principles of environmental assessment across to designers. It seems, however, that the already simplified structure of the Oil Point Method still is too complicated for designers. Therefore, the original LCA elements "Goal", "Scope" and "Functional Unit" will be included in the OPM in another way. Other suggested improvements based on the case studies and specific comments from the designers are being implemented at the moment and additional user tests are planned.

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Niki Bey, Assistant Research Professor, Ph.D.
Technical University of Denmark, Department of Manufacturing Engineering and Mangement
Building 424, 2800 Lyngby, Denmark
Telephone: (+45) 4525 4809
Telefax: (+45) 4525 4803
Email: niki@ipl.dtu