4 Data Collection

4.1 Methodology

According to (Frischknecht, Steiner, & Jungbluth, 2009), the Ecological Scarcity Method may be described as follows:

The Ecological Scarcity Method weights environmental impacts, i.e. pollutant emissions and resource extractions, with what are known as "Eco Factors". The Eco-Factor is derived from environmental legislation or corresponding policy targets. In its basic form, it follows the procedure of DIN EN ISO 14040. The eco-factor is defined as follows for each environmental impact:

Formula 1: Calculation of an eco-factor

$$eco - factor = \underbrace{K}_{\text{Characterization (optional)}} \cdot \underbrace{\frac{1 \cdot UBP}{F_n}}_{\text{Normalisation}} \cdot \underbrace{\left(\frac{F}{F_k}\right)^2}_{\text{Weighting}} \cdot \underbrace{c}_{\text{Constant}}$$

where: K = characterization factor of a pollutant or resource;
Fn = normalisation flow: current annual flow, relative to the respective country;
F = current flow: current annual flow, relative to the reference area;
Fk = critical flow: critical annual flow, relative to the reference area;
c = constant (10^{12}/y): ensures that numerical values that are easy to represent are obtained;
EP = eco-point: unit for the assessed environmental impact.

Characterization factors are determined for pollutants and resources which can be associated with a specific environmental impact (for example the greenhouse effect). This involves relating the effect of a specific pollutant (for example the greenhouse effect of methane) to the effect of a reference substance (in this example carbon dioxide).

The purpose of **normalisation** is to adapt the scarcity situation (weighting) to current emissions/resource extractions in a region. Normalisation adapts (normalises) the evaluation to national conditions. Normalisation is therefore performed on the basis of the entire annual pollutant emissions/resource extractions of the country in question.

S. Ahbe et al., *The Ecological Scarcity Method for the European Union*,
AutoUni – Schriftenreihe 105, https://doi.org/10.1007/978-3-658-19506-9_4

The final **weighting** of pollutants/resources or of characterised environmental impacts is performed on the basis of their "ratio to the environmental objective" or "**ecological scarcity**". This is achieved by relating the entire present flows of an environmental impact (current flows) to the maximum flows of the same environmental impact which are considered admissible for the purposes of environmental policy targets (critical flows). Depending on the nature of the environmental target or environmental legislation, this is carried out either on the basis of individual substances (environmental impacts) or (characterised) environmental impacts.

Scarcity (weighting) is a dimensionless quantity solely determined by the ratio of current to critical flow. The absolute magnitude of the flows has no influence on the weighting.

Factor c is identical for all Eco Factors and serves to simplify presentation, permitting a more manageable order of magnitude and including the time dimension which remains from the quantity units and to which it relates on a magnitude basis.

Being the result of characterization, normalisation and weighting, the **Eco Factors** represent the political and legislative assessment of the ecological significance of the pollutants. The unit for the eco-factor is "eco-points (EP) per unit quantity", for example "EP/g SO_2". Multiplying the eco-factor by the quantity of emission or consumption provides the eco-points per impact which are aggregated, i.e. summed, across all impacts.

Formula 2: Calculation of eco-points

$$EP = eco - factor * quantity$$

Some Eco Factors may be derived in a number of different ways. For the Ecological Scarcity Method, the principle is that in each case the highest of the resultant Eco Factors is used. Weighting is thus performed on the basis of the dominant assessable environmental impacts.

4.2 Principles for Deriving Eco Factors

The following principles for deriving Eco Factors are taken from the Swiss Federal Office for the Environment publication on the ESM (Frischknecht, Steiner, & Jungbluth, 2009).

4.3 Use for Characterization Factors

The fundamental condition for using characterization factors is that the characterization should be in line with the legislative intent.

In addition:

a) the characterization factors used should be scientifically recognised;
b) characterization factors may be derived from policy objectives.

4.3.1 Determination of Normalisation

The current flows used for weighting are generally identical to the flows to be used for normalisation. If, however, a characterization is carried out with regional or temporal differentiation, the current flow and normalisation flow will differ if the environmental target is not also formulated on the basis of the characterised emissions. The characterised flow comprises only those substance flows for which the Eco Factors are determined via the characterization. In accordance with the highest eco-factor principle, Eco Factors are only ever assessed in relation to the most stringent target. If another target is more stringent for a given flow, normalisation may no longer contain this flow.

4.3.2 Determination of Weighting

National annual flows are generally used for weighting. Depending on the matter in hand, site-specific, regional, national, continental or global or seasonal or annual current and critical flows may be used for certain environmental problems. Flows are quantified either as individual substances or as environmental impacts in accordance with environmental targets and compatibly with normalisation. The weighting term is unitless, which means that current and critical flows must be stated in the same units. The weighting function is also quadratic for spatially and temporally differentiating Eco Factors. Current flows must always be determined in terms of the reduction target. The reference basis for current and critical flows should be identical. Current flow must be calculated in accordance with the target or the critical flow. Current flow is usually identical to the normalisation flow. Critical flows are generally based on politically binding objectives (which should in turn be based on scientific findings). These are primarily officially set protection targets (annual loads, ambient limit values). In the absence of direct official stipulations, political declarations of intent which are as binding as possible are used as the basis.

4.3.3 Eco-Factor Determination

Being the result of characterization, normalisation and weighting, Eco Factors represent the political and legislative assessment of the ecological significance of the pollutants. For example, emissions of various heavy metals into the air, soil and water

are each assessed with a dedicated eco-factor which is (ideally) calculated from the respective current and critical flows. This usually means that a different eco-factor is obtained for emission of a single pollutant into water, air or soil. These differences reflect differing statutory requirements and current impacts.

4.3.4 Temporal Aspects of the Eco-Factor Dermination/ Time Horizons

Statutory stipulations, e.g. ambient limit values for air pollutants, generally do not contain an explicit time horizon, other than in transitional provisions. They apply from their effective date onwards. In the case of political stipulations, by contrast, specific targets may be defined for particular points in time. When determining an eco-factor, if several policy objectives with (very) different time horizons exist, then based on an appraisal of the current political situation, either one of the points in time should be selected or an intermediate point in time should be determined by interpolation.

Because the definition of target values is staggered in terms of both timing and subject, the "baselines"[1] as the starting points for minimization targets may differ greatly from one another depending on the environmental impact in question. It should be ensured in each case that the most recent definition is applied when determining the Eco Factors.

Note: The present report “Ecological Scarcity Method for the European Union” makes use of the targets and thus also the time horizons of the EU environmental authorities. It is in the nature of things that, for the authorities, these horizons each depend on the state of research and planning, implementation scenarios, urgency, current political relevance and votes as well as other factors. These scheduling variables differ for different environmental impacts, sometimes resulting in implementation targets with different time frames.

4.4 General Data Situation

Collecting the European eco-factor data set for the Ecological Scarcity Method primarily involves two major aspects:

- obtaining a statistical record of the actual state of annual loads and consumption figures and
- articulating the political will with regard to intended future conditions in the region under consideration.

1 i. e. years used as a basis for reference (frequently then set as 100%).

The EU procedure for collecting EU data is described in EEA 2009, which outlines the processes involved in requesting, checking and correcting the submissions from the individual countries. The EEA points out that there are gaps in the data. This is due to different levels of development of individual countries' recording systems and to new accessions by countries in which EU-compatible recording systems have yet to be established.

Similarly, not all environmental targets have yet been articulated in an operationally uniform way as desirable states for all major impacts. Quality targets sometimes compete with procedural targets while binding targets sometimes compete with non-binding ones. Some of the time horizons set for the objectives are also very different, since these definitions depend on the nature and duration of the reduction programmes, as well as on international coordination efforts and sometimes also on changing basic technological conditions and possibilities for countering the environmental impacts in question.

4.4.1 Reccording the Actual State

The data from participating countries are compiled and aggregated in various programmes at the EU level. These data are collected at regular intervals, checked for completeness, subjected to plausibility checking during compilation and, if necessary, corrected with the assistance of the individual countries. These data are then also made publicly available.

4.4.2 Articulating Political Will

Political will is articulated and environmental policy targets thus defined at the EU level through the competent authorities. The European Commission has a number of Directorates-General which, working together with the associated authorities and institutes, devise targets in the fields of air pollution, water contamination, climate protection, resource scarcity, waste and others and implement them politically. Identical or similar measures are also implemented in the individual countries unless existing European Union targets are explicitly adopted.

4.4.3 Discussion of Procedure

At the project planning stage, the aim was to determine a set of Eco Factors for the entire EU-28 as a geographic region with its own environmental policy. Over the course of the project, it became clear that very large volumes of data are also available for individual EU countries arising from current environmental policy, social and national government activities. With certain limitations, these data make it possible to determine the respective Eco Factors at the national level too (cf. section 3.3.5).

On completion of the various analytical steps, the project partners were in agreement that, despite the mentioned limitations, it is certainly meaningful to determine the individual countries' Eco Factors and list them in the present study. This is justified by the better geographic resolution of environmental policy efforts and natural landscape circumstances, such as the very different availability of water in the individual countries, and by the consequently greater acceptance of the data by local companies.