EUROPE Model Application to Material and Energy Flows to Improve the Resource Economy

An Optimization Guide for Academics and Practitioners

Jan Stenis

Scientific Research Publishing

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The purpose of an organization is to enable ordinary humans' beings to do extraordinary things.

—Peter Drucker

Abstract

The equality principle and its mathematical expression—the model for Efficient Use of Resources for an Optimal Production Economy (the EUROPE model)—constitute the foundation for an array of papers that started to be published at the beginning of the millennium. This book is based on Dr. Jan Stenis's licentiate dissertation (2002) and his doctoral thesis (2005c), plus many papers published after Dr. Stenis's defense of his thesis. The present work describes how the EUROPE model can be used to optimize the resource economy, related to producing entities of many kinds.

The results show that it is possible to apply the equality principle to materials, as well as to intangible issues, to make the utilization of resources more efficient and thereby promote the survival of our species and facilitate the preservation of our culture. The EUROPE model provides management with a tool to simultaneously monitor, manage and evaluate its activities by studying the development over time of a constructed shadow cost, a versatile key factor, that mirrors the status of the phenomenon of interest in terms of economy, technology, and harmful environmental impact. This approach highlights the transformation of inputs into marketable products that can be sold on the market.

It is shown how Dr. Stenis's EUROPE model can improve the resource economy, from a machine in a workshop, up to the national level. The application of the EUROPE model promotes equity since

the model facilitates the equalization of access to natural resources between parties.

The EUROPE model is applicable to production activities that show an inflow of inputs that are transformed, followed by the discharge of a flow of products plus a residual flow. The EUROPE model can optimize flows through a 'black box', which is a certain unit with inflows and outflows.

The EUROPE model promotes an increased equity for distributing natural resources to everyday citizens, as well as to the production lines of major corporations. This work shows how the EUROPE model's possible realm of applicability, step by step, has been expanded to encapsulate ever more areas of commercial interest, to improve the people's quality of life.

Abstract (in Swedish)

Jämställighetsprincipen, och dess matematik: the Model for Efficient Use of Resources for an Optimal Production Economy, EUROPE-modellen, låg till grund för en rad av artiklar som publicerades från och med millennieskiftet. Denna bok bygger på dr Jan Stenis licentiatavhandling (2002) och hans doktorsavhandling (2005) samt ett större antal artiklar som publicerats efter Jans disputation. Detta verk handlar om hur EUROPE-modellen kan användas för att optimera resursekonomin relaterat till producerande enheter.

Resultaten visar att jämställighetsprincipen kan tillämpas på såväl materiella som immateriella frågor för att göra utnyttjandet av naturresurser mer effektivt i syfte att främja vår arts överlevnad, samt det långsiktiga bevarandet av vår kultur. EUROPE-modellen ger företags ledningen ett användarvänligt verktyg för att samtidigt övervaka, styra och utvärdera sina aktiviteter genom att studera hur en fiktiv skuggkostnad, ett mångsidigt nyckeltal, utvecklas över tiden. Detta nyckeltal speglar den ekonomiska, teknologiska och miljömässiga statusen hos de intressanta objekten. Detta angreppssätt betonar omvandlingen av företagets input till produkter.

Det visas hur Jans EUROPE-modell förbättrar resursekonomin, från en maskin i en fabrik, upp till den nationella nivån. Modellen främjar rättvisan genom att underlätta en likvärdig tillgång till naturresurser för aktörer.

EUROPE-modellen är användbar på producerande verksamhet som har ett inflöde av råvaror som bearbetas och som släpper ut ett huvud-flöde av produkter, samt ett restproduktflöde. EUROPE-modellen kan optimera flöden i en "svart låda", dvs. en administrativ enhet med in- och utflöden.

EUROPE-modellen gynnar en ökad rättvisa vid fördelningen av tillgångar och naturresurser, både till vanliga medborgare och för bearbetning i större koncerners produktionslinjer. Detta verk visar hur EUROPE-modellens möjliga användningsområden successivt har utvidgats till att omfatta allt fler områden av kommersiellt intresse, i syfte att förbättra folkets livskvalité.

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Preface

The equality principle and its mathematical expression—the model for Efficient Use of Resources for an Optimal Production Economy (the EUROPE model)—constitute the foundation for an array of scientific papers that started to be published at the beginning of the new millennium. Dr. Jan Stenis's licentiate thesis, published in 2002, and Dr. Stenis's doctoral thesis, published in 2005, contained the seven first papers. Then, Dr. Stenis collaborated with Professor William Hogland to publish papers on the EUROPE-model (see Figure 1).

The results of this research show that it is possible to apply the equality principle to materials, as well as to intangible issues, to make the utilization of natural resources more efficient and thereby promote the survival of our species and the preservation of our culture. Dr. Stenis's EUROPE model, the mathematical expression of the equality principle, provides an easy-to-use tool to simultaneously monitor, manage and evaluate the activities to transform inputs into marketable products, which can be sold on the market.

It shows how the EUROPE model can improve the resource economy, all the way from a machine in a workshop, up to the planetary level (see Figure 2). Application of the EUROPE model promotes equity since this model facilitates the equalization of citizens' access to natural resources.

The EUROPE model is applicable to production with inputs into a unit that are transformed in 'the black box', which discharges products plus residuals. Thus, the EUROPE model can optimize flows that occur when something is produced in a unit exhibiting an input and an output.

Dr. Stenis's licentiate thesis
Industrial wastes management
Joint production development

Dr. Stenis's doctoral thesis
Cost-benefit industry analysis
Contribution margin analysis
The polluter pays principle
Construction waste economy
Reverse osmosis plants

Postdoc. applications
Landfill management
Solid wastes economy
Anthropogenic loads
Waste baling schemes
Bale storage burning
The WAMED model
Global capital flows
Global manufacturing
Global energy flows
Reuse and recycling
Ore rock mining
Landfill mining
Urban mining
Space mining
Ocean currents
Flow analysis
Water flows
Transportation
Megacity supplies
Practical application
Ocean food webs
Preserved cosmos

Figure 1. The stepwise expanded applications of the EUROPE model

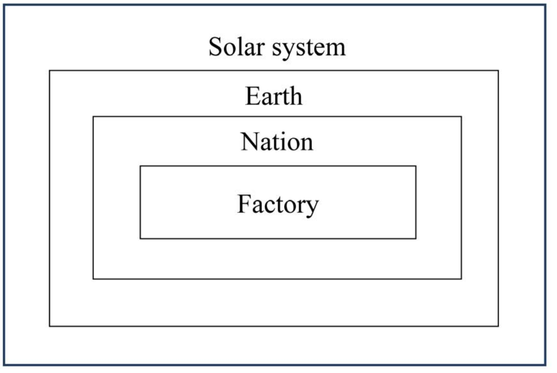


Figure 2. The stepwise expanded areas that the EUROPE model has been applied across

Preface (in Swedish)

Jämställighetsprincipen och dess matematiska uttryck: The model for Efficient Use of Resources for an Optimal Production Economy, EUROPE-modellen, låg till grund för en lång rad av vetenskapliga artiklar som började publiceras för bedömning av hur industriavfall kan hanteras. De sju första artiklarna ingick i Jan Stenis licentiatavhandling som framlades 2002 och i Jans doktorsavhandling, som kom 2005. Därefter samarbetade Jan med professor William Hogland kring artiklar om EUROPE-modellen (Figur 3).

Resultaten visar att jämställighetsprincipen kan tillämpas på såväl materiella som immateriella frågor för att göra utnyttjandet av naturresurser mer effektivt i syfte att främja vår arts överlevnad samt det långsiktiga bevarandet av den mänskliga kulturen. Jans EUROPE-modell utgör det matematiska uttrycket för jämställighetsprincipen, och ger ett användar-vänligt verktyg för att samtidigt övervaka, styra och utvärdera aktiviteter, för att omvandla företags input till kommersiella produkter som kan säljas.

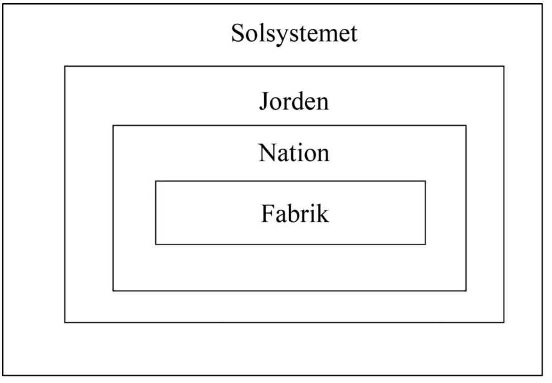
Det visas hur EUROPE-modellen kan förbättra resursekonomin från en enstaka maskin i en verkstad, upp till planetsystemets nivå (Figur 4). Tillämpning av EUROPE-modellen främjar rättvisan, eftersom denna modell underlättar en likvärdig tillgång till naturresurser för olika aktörer.

Jans licentiatavhandling
Biprodukter vid industriproduktion
Vidareutveckling av joint production

Jans doktorsavhandling
Kostnads-intäktsanalys
Täckningsbidragsanalys
The Polluter PaysPrinciple
Byggbranschens avfall
Reverse osmosis (eng.)

Post doc.-tillämpningar
Deponidriftskötsel
Fast avfallsekonomi
Mänsklig belastning
Balningsanläggningar
Bränder i balupplag
WAMED-modellen
Globala kapitalflöden
Global industrialism
Elenergiströmmar
Återanvändningen
Materialåtervinning
Traditionell gruvdrift
Gruvdrift i deponier
Gruvdrift i stadsmiljö
Gruvdrift i solsystemet
Djuphavsströmsbevarande
Teoretisk flödesanalys
Vattendistribution
Transportekonomi
Megacity-leveranser
Praktisk tillämpning
Näringskedjor i haven
Universums bevarande

Figur 3. Den stegvis utvidgade tillämpningen av EUROPE-modellen



Figur 4. Det utvidgade geografiska området som EUROPE-modellen har tillämpats på

EUROPE-modellen är användbar på producerande verksamhet med inflöden till en enhet av råvaror som bearbetas i "den svarta lådan" som släpper ut produkter samt ett restproduktflöde. EUROPE-modellen kan optimera flöden i en producerande enhet med ett inflöde och ett utflöde.

Reading Instructions

Explanations

1. 'Residuals' are the quantity left over at the end of a process; a remainder remaining as a residue (The Free Dictionary 2021).

2. 'Shadow cost' is a monetary value assigned to a resource, good or service, which is not based on actual market exchanges, but is mathematically derived from indirect data (Your Dictionary 2021).

3. 'Resource' is an input (e.g., raw material, people, machinery) which is combined with other inputs to supply a good or a service, or available supply, especially money (The Free Dictionary 2021).

4. 'Equity' is the state or quality of being just and fair, or just something that merely is just and fair (The Free Dictionary 2021).

5. 'Efficiency' is the ability to produce something without wasting materials, time, and energy; be efficient (Merriam-Webster 2021).

Relation to earlier work

The proposed theory has been commented upon at Dr. Jan Stenis's defense of his doctoral thesis, as well as by people from industry. According to an extensive literature research by the author, a scientific design very similar to the equality principle and the EUROPE model has never been developed.

The structure of the work

This work is divided into five major parts (see Figure 5). Each described application of the equality principle is given its own space, in the study.

The present work investigates management options to obtain practical tools to solve management problems in industry. A review is presented of the previous results. The modifying of the EUROPE model is mainly evaluated from an economic perspective, to enable a presentation of the applicability of the equality principle to management issues. Conclusions are provided, theory developments and recommendations are given.

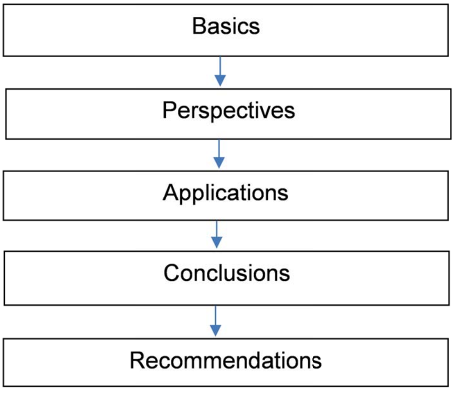


Figure 5. The structure of the work

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Material and Energy Perspectives

The micro level perspective

Corporations transform material inputs into regular products that can be sold on the market. Machinery in production lines requires energy. The EUROPE model optimizes the resource economy of the production in industrial workshops. It has successfully been applied across, for example, mechanical and bulk industry and the construction sector, as well as waste baling schemes (Stenis 2002a, 2005ab; Stenis & Hogland 2014ab, 2018d).

The national and regional level perspective

Currencies, goods, and energy flow between nations. The EUROPE model was adapted to optimize the flows of industrial products, and energy supply.

A nation's wealth is improved by efficiently exploiting its natural resources. The EUROPE model was modified to facilitate the mining of ore, landfill mining and the exploitation of resources in urban environments.

Resources are reused and returned to anthropogenic circles, according to the circular economy. The EUROPE model promotes the reuse and recycling of industrial resources, at the local level, in nations and globally.

Material and energy in the Earth perspective

Albert Einstein proved mathematically that matter can be transformed to energy and vice versa. One result of this insight was the atomic bomb. Professor Einstein hence won the Second World War for the Allied forces.

Scientists debate what the correct definition of life is, but intelligent life is regarded as the most precious phenomenon in universe. However, life without energy in any form is unthinkable. Thus, life is condensed energy that also is matter and the whole universe is alive, one way or the other.

The equality principle provides a practical, and easy to grasp, tool to optimize organisms' handling of energy and matter. However, it doesn't matter if a solution is technically viable, if it is not profitable! The equality principle promotes life, considering the necessity to reflect on ethics.

Application of the Equality Principle

The general principle of the EUROPE model

The equality principle is expressed in mathematical terms as:

The Efficient Use of Resources for an Optimal Production Economy (EUROPE model):

$$Proportionality\ Factor\ (PF) = A\ /\ (B + C) \qquad (1)$$

where, A is the residual fraction of interest to reduce or even eliminate; B is the total amount of regular products; and C is the total amount of residuals applied within a logical system boundary (e.g., a machine, production line or factory) in a common unit (e.g., monetary value, physical weight, volume, energy, or the time used).

So-called shadow costs are obtained to additionally allocate to the unwanted fractions of interest. If these constructed shadow costs are considered in estimations, budgets, and forecasts etc., an economic incentive occurs to reduce these residuals, because the shadow costs have a negative impact on the bottom line in the profit and loss account and in companies' ledgers.

This principle of 'punishing' activities that show an imperfect utilization of their purchased resources has implications on the resulting need for developing more efficient technological solutions and performing better from an environmental point of view, due to fewer harmful substances being produced. Unwanted energy wastes can be reduced by applying the EUROPE model. Both material and intangible flows are optimised.

It is possible to optimize the utilization of natural resources and energy sources in space. The exploitation of metals and minerals on other worlds can be optimised by the EUROPE model to allocate shadow costs to planets.

An efficient exploitation of material substances and energy is important since metals and minerals become ever costlier to excavate on Earth. When moving into space, a good resource economy is also vital.

The equality principle is regarded as a viable alternative to the prevailing ideological and spiritual beliefs for accomplishing a more altruistic global society. The equality principle is brought forward as a means, among others, to prepare mankind for the harmonic global village by providing the necessary finances through imposing economic incentives.

The existing ideologies and beliefs are regarded as inadequate to obtain this. The application of the equality principle across mainly production activities of all kinds provides a mathematically based alternative to most competing teachings that usually just increase the suffering. Logical science and market forces, combined with fair legislation, are promoted as viable ways to increase general happiness and freedom.

The application of the EUROPE model

Basic framework of the EUROPE model

The EUROPE model is a mathematical formula that determines the degree of shadow costs to *additionally* allocate to residuals to reduce and/or recover them. This creates economic incentives to reduce the targeted waste fractions, which can be recovered at the source. The production cost can be lowered if the waste fraction of interest is a utility. The extraction of substances of commercial interest can be optimised or improved. The shadow costs are inserted into the profit and loss accounts, budgets, and estimations of the current actor, according to the following principle:

$$Shadow\ cost\ (SC)\ =\ Proportionality\ factor\ (PF)\ *\ Total\ cost\ (TC)\ *\ Weight\ factors\ (W) \tag{2}$$

$$PF\ =\ A\ /\ (B\ +\ C)\ =\ (Value\ -\ Cost)\ /\ (the\ total\ \text{‘}goods\text{’}\ +\ the\ total\ \text{‘}bads\text{’}) \tag{3}$$

$$A = the\ fraction\ to\ reduce\ to\ improve\ the\ unit\text{’}s\ resource\ efficiency \tag{4}$$

$$B = \ all\ the\ valuable\ products\ in\ the\ output\ of\ the\ unit\ of\ interest \tag{5}$$

$$C = \text{all the unwanted residuals that reduce the organization's result} \quad (6)$$

$$TC = \text{the total cost of: that organization, or; the system breaking down} \quad (7)$$

$$W = Wair, Wsoil \text{ and/or } Wwater = \text{the weight factors to consider A's impact} \quad (8)$$

Unit: monetary currency, kilogram, liter and/or joule.

The weight factors (W) are figures without a unit expressing management's concern for the air, soil and/or water. W_{air}, W_{soil} and/or W_{water} are determined based on management's perspective or the demands of public authorities.

Theoretical foundations of the EUROPE model

A lower amount of constructed shadow costs is allocated to A the smaller SC is. If SC is larger, the incentives to reduce A are greater and the consideration of SC improves the environmental and technological standards and the company's profits. A is reduced by allocating the SC connected to it to the budget and accounting system of a company. This creates economic incentives for the company to promote the reduction at source of A. This corresponds to the desired functionality of the flow of natural resources from the mines to the final customers. Thus, the EUROPE model is an economic instrument because it involves economic incentives.

The constructed shadow costs are a tool that can improve economic, technological, and environmental efficiency when the model is applied to different projects. The selected shadow cost levels must not be the most optimal cost levels in the traditional economic sense but must be set at a level that will give management incentives to improve the activities related to the residual issues. Nevertheless, the term ‘optimization’ could be relevant because the EUROPE model logically allocates shadow costs to the different waste streams that are to be minimized.

The production units of different branches of domestic industry, a whole nation or an entire trade bloc will be forced to become more efficient by applying source reduction in line with the EUROPE model. In the waste management case, this source reduction will positively affect the flow of municipal solid waste (MSW) to be utilized. Compared with the situation where the EUROPE model is not applied, the economic and environmental performance will be improved, and technology will be advanced when there are fewer residual products or losses occurring.

Manual for practical application of the EUROPE model

The application of the EUROPE model involves the addition of shadow costs to the costs of entities. Greater shadow costs are added to streams of greater economic and/or environmental significance. Resource efficiency is improved by a step-by-step reduction or recovery of the A fractions. This procedure reduces the shadow costs if A is a useful fraction that yields revenues. The cost development is studied over time to make the production more cost effective. The manual guiding the practical application of the EUROPE model involves the following steps, exemplified in **Table 1**:

1. Determine which residuals to pinpoint, step by step, by estimating the values of A.

2. Calculate the PF by estimating B and C using the company's bookkeeping system.

3. Determine the suitable TC and/or the total breakdown cost from the company's ledgers.

4. Determine the weight factors (%) for the company's impact on air, soil and/or water.

5. Insert the constructed SC into the accounting system and budgets of the company.

6. Determine the SC for additional A fractions that are of commercial interest.

7. Study the development of SC to monitor, manage and evaluate the performance of A.

8. Take actions to make the system more efficient if SC increases over time.

Table 1. Schematic profit and loss account of a company employing shadow costs

Revenues − (Costs + SC)
Result − SC

If the company's economic performance increases over time because SC decreases, in response to management implementing the required reforms, it means that the firm's performance regarding waste has improved, or vice versa. Note that SC is a constructed variable, but useful when employed.

Manufacturing industry—how to apply the equality principle to the mechanical industry

Contribution margin analysis (CMA) is a method of fundamental importance in the business context. It involves the assumption that, within certain limits, the fixed cost of a product is independent of the number of units manufactured or sold, and only the variable cost changes. The contribution margin (CM) of a product can be defined as the difference between the sales revenue and the variable cost of the product in question. The CM tends to be calculated as follows:

1. The unit sales price of the product is estimated.

2. The variable cost of a single unit of the product is estimated.

3. The contribution margin for a single unit of the product is estimated as the difference between the sales price and the variable cost

for that unit.

4. The assessment of the profitability is based on the relation of the estimated contribution margin to either the resources required or the minimum acceptable contribution margin.

CMA is used mainly for short-term decisions concerning the resources available at the time. For the use of CMA, the following conditions should remain constant within the relevant period:

- the product mix or product assortment,
- the demand for the product, or consumer preferences for it; and
- the manufacturing capacity, where the maximum amount that can be produced remains constant.

Usually, it is a question of making use of existing plants and workforce as profitably as possible. The issue is whether the income from the waste fraction in question covers the fixed cost or not. If it is assumed that manpower is available, the decision of whether to commercialize a waste fraction can be facilitated by assessing the contribution margin connected with it, as shown in **Table 2**.

If a positive value is obtained on the bottom line, this generally means that the waste fraction in question should be turned into a product and not simply dumped or discarded. Assessment of the specific income and the specific fixed and variable costs, which is an important step, can be carried out with the use of the traditional economic theory. This can be described as follows:

Table 2. Scheme for estimating the contribution margin for the fraction of waste sold

	Income from sale of the fraction sold
–	Variable cost of the fraction sold
=	Contribution margin covering the fixed cost
–	Specific fixed cost of the fraction in question
=	Contribution margin after deduction of costs traceable to the fraction = Operating income

$$TC = f(x) = FC + VC = FC + k1 * x,$$

$$\text{where } k1 = (dy/dx) \text{ for VC} \quad (9)$$

$$TR = f(x) = k2 * x, \text{ where } k2 = (dy/dx) \text{ for TR} \quad (10)$$

where TC is the total cost; FC is the fixed cost; VC is the variable cost; TR is total revenue.

Setting TC = TR allows one to obtain the critical point for the quantity of waste (in liters, kg, tons etc.) required in purely economic terms to justify collection of the fraction in question. This is the point at which, as profit increases, the revenue equals the total cost.

Examples of the kinds of FC that may be involved are depreciation, interest, rent, electricity, and wages, some of which may have to be divided between different waste fractions. This can be done in terms of the volume or weight of the waste fraction, the time normally required to produce it, or the quantity or cost of raw materials used.

Treating each waste fraction as a product involves adding the quantities of the various waste fractions to the output, as shown in the denominator of Equation (3), which is used for apportioning costs to separate fractions for a production or administrative unit (e.g., the entire company, separate divisions or workshops, individual machines etc.). This assignment involves multiplying Equation (3) by the total FC to obtain the FC for the waste fraction in question. Equation (3) represents the basis of the EUROPE model, condensed to Equation (1):

$$A \,/\, (B + C) \tag{1}$$

where, A is the quantity of the waste fraction in question produced; B is the quantity of normal product output; and C is the sum of the quantities of the different waste fractions considered.

The VC of a waste fraction depends on factors such as the manpower or handling time required for collecting it, and the cost of the raw materials or energy consumed in the process in which it is produced. If the VC attributable to a given fraction cannot be determined, costs can be allocated, as for the FC above, in proportion to the weight or volume of the fraction, or to the amount of raw material or time consumed in producing it, by multiplying the respective VC by Equation (3). The term k_1 in Equation (9) is obtained by dividing the estimated total cost of the waste fraction by the amount produced, for the time and the production unit in question. It is not unusual, due to economies of scale, for the VC to either increase or decrease progressively as the quantity increases. If such a situation is found, this should be considered.

If the TR for a fraction cannot be determined, the procedure is either to implement Equation (3), in a manner like that for FC and VC above, or to calculate k_2 in Equation (10) by estimating the income stemming from the waste fraction and dividing this by the number of units, in tons, liters etc., of the waste fraction produced during the corresponding period.

After FC, VC and TR have been obtained for a waste fraction, the operating income, or contribution margin, is estimated; for example, as income per unit of waste produced. This operating income is incorporated into current wastes, after all relevant internal estimates of a short-term nature have been made, such as those for product costs. In this way, the existence of the waste fraction in question affects the estimate of the desired operating income. In the case of *n* waste fractions, the total contribution margin can be calculated as follows:

$$CMtot = \Sigma\,(CMj\; xj) \tag{11}$$

where, CM_{tot} is the total contribution margin of the *n* waste fractions; CM_j is the contribution margin per unit of waste fraction *j* calculated using Equation (3) involving shadow costs; $xj \geq 0$, the number of tons, liters etc. of waste fraction *j*; and $j = 1, 2, 3, \ldots, n$.

The total contribution margin, or operating income, according to

Equation (11), when calculated for a waste management scenario, can be used as input for short-term product cost and investment assessment to deal with a more complex waste management situation (Stenis 2005b).

Construction industry—how to apply the equality principle to the construction industry

In the following section, the most common methods for estimating product costs are considered, together with ways in which they can be adjusted for use in estimating the true internal costs of waste fractionation. The methods are analyzed critically as regards their suitability for construction waste management. It should be noted, however, that not all methods are applicable to all waste management situations. The reviewed methods are listed in **Table 3**.

Table 3. Reviewed methods

I. Cost-benefit analysis
1. Method of overhead rates based on normal capacity
2. Average cost estimation method
3. Equivalent method of cost estimation
4. Absorption costing method
5. Activity-based costing (ABC) method
II. Contribution margin analysis

Cost-benefit analysis

Method of overhead rates based on normal capacity

Mathematically, the problem can be described as follows:

$$TC = f(x) = FC + VC = FC + k1 * x,$$

$$\text{where } k1 = (dTC/dx) \tag{12}$$

$$TR = f(x) = k2 * x, \text{where } k2 = (dTR/dx) \tag{13}$$

where, TC is the total cost; FC is the fixed cost; VC is the variable cost; TR is the total revenue; and x is the number of units, tons, liters etc., of a certain waste fraction.

Setting TC = TR obtains the point for the quantity of waste required to justify collection of the fraction in question. In terms of accounting practices, the costs are allocated as follows:

$$TC/item = [Estimated\ VC \ / \ Calculated\ quantity\ of\ items] + [Estimated\ FC \ / \ Normal\ quantity\ of\ items] \tag{14}$$

This estimation method is useful when applied to companies that produce only one product (Stenis 2005a).

Average cost estimation method

The average cost estimation method can be used when considering a company producing one product only. It involves simply dividing the total cost for the period in question by the total production during that period, resulting in the cost per tons, or liter etc. This work proposes that when applying the average cost estimation method, the cost of a given waste fraction is determined by multiplying Equation

(1) by the actual or budgeted average cost for the period.

Equivalent method of cost estimation

The third method to be considered in connection with the separation of waste fractions is the equivalent method of cost estimation. This can be applied to companies producing a limited number of products, based on the same raw material with similar procedures. The calculation of the equivalent rate for a product is carried out according to Equation (15):

$$(Normal\ cost\ per\ unit\ for\ a\ given\ product)\ /\ (Normal\ cost\ per\ unit\ for\ the\ product\ with\ the\ lowest\ cost\ per\ unit) \quad (15)$$

Absorption costing method

The absorption costing method involves a step-by-step analysis of the contribution of the separate costs to the final cost units, considering: the distribution of direct costs in the final cost units; the distribution of indirect overhead costs in the sub-organizations; and the distribution of the costs of the sub-organizations in the final cost units. Estimates for a given product are made as shown below, where DM is the direct material costs; MO is the material overhead costs; DL is the direct labor costs; PO is the production overhead costs; AO is the administrative overhead costs; SO is the sales overhead costs; and S, G & A rate is the sales, general service, and administrative expenses.

Table 4. Basic set-up for the absorption costing method

	DM (Direct material costs)
+	MO (= DM * Absorbed indirect material costs rate)
+	DL (Direct labour costs)
+	PO (= DL * Absorbed production overhead costs rate)
=	Production costs
+	AO + SO (= Production costs * S, G & A rate)
=	**Total cost**

Activity-based costing (ABC) method

The ABC method is the fifth method to be reviewed. If many of the costs are non-volume-based, the ABC method is applicable. The aim is to trace costs to products or services instead of arbitrarily allocating them. Since costs are often linked to the number of transactions involved in the activity in question, ABC is also called transaction-based costing.

Applying the allocation principles contained in Equation (1) to estimation methods described above redistributes the cost of the regular products to waste. This does not necessarily result in an increase in the *total* cost volume for the company involved. Also, it does not directly link the avoidance of waste with the incentive to reduce the total cost as specified in the consolidated profit and loss account. Weights can be applied to adjust the costs connected with a waste to its environmental impact, based on scientific evidence and/or in terms of societal aims such as authorities' ambition to promote equity in different ways. Environmental shadow costs should be used in combination with the cost allocations (Stenis 2004).

Contribution margin analysis

Contribution margin analysis (CMA) involves that the fixed cost of a product is independent of the number of units manufactured or sold, and only the variable cost changes. The contribution margin of a product can be defined as the difference between the sales revenue and the variable cost of that product in question. The decision of whether to commercialize a given waste fraction can be facilitated by assessing the contribution margin connected with it, as shown in **Table 2**.

If a positive value is obtained on the bottom line, this means that the waste fraction should be turned into a product and not dumped or discarded (Stenis 2005b).

Joint production—how to apply the equality principle to by-products

Joint production theory concerns the optimal output proportions to obtain when products and wastes are jointly produced in the same process. Joint production theory makes use of the linear programming technique. Application of this method involves considering different scenarios. A waste fraction may be studied by application of the equality principle in each production scenario, which involves different waste fractions with various revenues and costs.

This allows the problem to be expressed as follows (Stenis 2002a), adapted to the production of waste.

Find the values of $x_1, x_2, \ldots, x_n$ that will:

$$\text{Maximize } z = (p1' + p1'')\, x1 + (p2' + p2'')\, x2 + \ldots + (pj' + pj'')\, xj \quad (16)$$

where, p_j' is the profit per unit of product *j* or of input *j*; and p_j'' is the profit from the waste related to one unit of product *j* or input *j*, subject to the following constraints:

$$a11x1 + a12x2 + \ldots + a1nxn + b1 \quad (17)$$

$$a21x1 + a22x2 + \ldots + a2nxn + b2$$

$$am1x1 + am2x2 + \ldots + amnxn + bm$$

where, $xj > 0,\ j = 1, 2, \ldots, n$ and a_{mn} are constant coefficients of production.

This allows the most profitable product mix of the *n* products and the related wastes to be calculated, and the total profit to be estimated by multiplying the calculated profit-maximizing amounts of the product by the marginal contribution of each of the *n* products and the related wastes, expressed as follows.

Find the values of $x_1, x_2, \ldots, x_n$ that will:

$$\text{Maximize } CMtot = (CM1' + CM1'')\, x1 + (CM2' + CM2'')\, x2 + \ldots + (CMj' + CMj'')\, xj \quad (18)$$

where, CM_{Tot} is the total marginal contribution of the product and waste mix; CM_j' is the marginal contribution per unit of product *j* or of the input *j*; CM_j'' is the marginal contribution from the waste related to one unit of product *j* or of input *j*, subject to the following constraints:

$$a11\,x1 + a12\,x2 + \ldots + a1n\,xn + b1 \tag{19}$$

$$a21\,x1 + a22\,x2 + \ldots + a2n\,xn + b2$$

$$am1x1 + am2x2 + \ldots + amnxn + bm$$

where, $xj > 0$, $j = 1, 2, \ldots, n$ and a_{mn} are constant coefficients of production.

What is new in this approach is the maximization stipulated in Equations (16) and (18), which reflects the assumption of a product and the related wastes representing a unit (Stenis 2002a).

Polluter pays principle—how to apply the equality principle to the polluter pays principle

A common way to cope with the pollution aspect of the waste problem is to apply the polluter pays principle (PPP). The polluter carries the costs of the pollution prevention and control measures, decided by public authorities to ensure that the environment is maintained in an acceptable state.

At the Rio de Janeiro summit in 1992, the United Nations Conference on Environment and Development (UNCED) stated that "Governments, … should apply the PPP whenever appropriate, … through setting waste management charges at rates that reflect the costs of providing the service and ensure that those who generate the wastes pay the full cost of disposal in an environmentally safe way" (UNCED, 1992, *Report of the United Nations Conference on Environment and Development*, Ch. 21).

In a business economics context, a step to apply this principle would be to allocate the costs for making the production process environmentally friendly—the environmental adjustment costs—to the residual products involved.

Equation (1), when multiplied by the environmental adjustment costs, yields the costs connected with waste that refer to an industrial activity with environmental repercussions, to induce corporate waste-reduction incentives which lead to cleaner production processes. If firms were charged the shadow cost associated with pollution of a given type, they would adjust to this so that the desired environmental standard would be met to create environmental improvement (Stenis & Hogland 2002).

Mining—how to apply the equality principle to mining

Ore mining application

National optimization of ore mining

The global production of a commodity, and the national and global production of residuals from traditional mining and excavation activities of that commodity, are inputs to Equation (20). The global cost for mining and excavation of the commodity, $TC_{commodity}$, is required. This gives:

$$PFnational = Anational / (Bnational + Cnational) \qquad (20)$$

where, $PF_{national}$ is the proportionality factor for a nation with respect to a commodity; $A_{national}$ is the quantity of the residuals from a nation's production of a commodity; $B_{national}$ is the quantity of the regular production of that commodity globally; and $C_{national}$ is the quantity of all the residuals of the production of the commodity globally within a suitable administrative unit. Unit: kilogram, liter, joule, or monetary value.

$PF_{national}$ is multiplied with $TC_{commodity}$ to obtain the shadow cost to allocate to a nation's government budget enforced by international authorities. This item is denoted the national resource exploitation optimization fee ($REXOF_{national}$), although 'cost' is an alternative.

The $REXOF_{national}$ will force the nation to utilize the commodity of study in a more cost-effective way due to the economic incentive that is induced by an increase in the PSBR. And the more of the $REXOF_{national}$ that is allocated to a nation's budget, the less cost effective that nation's exploitation of the commodity is in relative terms, and a greater economic incentive is imposed on that nation to become more cost effective and produce less mining and excavation residuals connected to the utilization of the commodity. The environment will be improved due to less environmental degradation from residuals that are reduced in quantitative terms.

Global optimization of ore mining

The global production of mining and excavation activities, and the global production of residuals from mining and excavation activities, are inputs to Equation (1). The global cost for mining and excavation, TC_{global}, is required.

Equation (1) gives:

$$PFglobal = Aglobal / (Bglobal + Cglobal) \qquad (21)$$

where, PF_{global} is the proportionality factor for a nation with respect to all its commodities; A_{global} is the quantity of the residuals from the production of the commodities for a nation; B_{global} is the quantity of the production of all commodities globally; and C_{global} is the quantity of all the residual fractions produced globally within a suitable production or administrative unit. Unit: kilogram, liter, joule, or monetary value.

PF_{global} is multiplied with TC_{global} to obtain the shadow cost to allocate to a nation's government budget. This item is the $REXOF_{global}$.

$REXOF_{global}$ forces a nation to utilize its resources in a more cost-effective way due to the economic incentives induced by an increase in the PSBR. And the more $REXOF_{global}$ that is allocated to a nation, the less cost effective that nation's exploitation of its natural resources is in relative terms, and a greater economic incentive is imposed on that nation to become more cost effective and produce less mining and excavation residuals. The environment will be improved due to less environmental degradation from produced residuals that are reduced in quantitative terms. $REXOF_{global}$ can be allocated in proportion to the weight, volume, energy, or the value of the studied resource by multiplying the PF by the TC.

Weights for theory applied to ore mining

The application of the EUROPE model according to Equation (1) redistributes some of the cost of normal products to residuals. This does not necessarily result in any increase in the *total* cost for a nation and it does not directly link the avoidance of residuals with the incentive to reduce total expenditures, as specified in government budgets. Weighting can be used to adjust the costs associated with a residual of national economic interest according to its environmental impact, based on scientific evidence and/or overall societal aims.

For example, a factor of 1.2 can be multiplied by the shadow cost if a certain residual motivates a 20% mark-up to provide an extra incentive to reduce it. 'Environmental shadow costs' should be used in combination with the cost allocation principle, which is useful to internally redistribute costs associated with residuals between different nations even without the use of environmental impact weighting. This results in competition between nations.

The methodology gives nations an economic incentive to reduce residuals to improve their budgets. The incentive has an impact on, for example, short-term public cost estimates, budgets and forecasts used as a basis for state loan applications and information to stakeholders.

Multiple ore mining resources

In the case of *n* resources, the total shadow cost is calculated as follows:

$$TSCtot = \Sigma\ (TCj\ Wj) \tag{22}$$

$$i = 1, 2, \dots, resource\ j$$

where, TSC_{tot} is the total shadow cost of the *n* resources; TC_j is the total cost of resource *j* employing Equations (2) and (3); $W_j \geq 0$, the weight conferred to resource *j* (a dimensionless decimal number); and *j* is 1, 2, …, *n*, within an administrative unit during a certain period. Unit: kilogram, liter, joule, or monetary value.

Summarized theory for ore mining

The findings can be collocated in the general Equation (23) in the case of *n* resources:

$$SSCtot = \Sigma\ ((Ax\ /\ (Bx + Cx)) * TCj * Wj) \tag{23}$$

$$i = 1, 2, \dots, resource\ j$$

where, SSC_{tot} is the summarized shadow cost of the *n* resources; A_x is the quantity of a certain residual to be optimised; B_x is the quantity of the regular production; C_x is the quantity of all the residuals of the regular production; TC_j is the total cost of resource *j*; $Wj \geq 0$, the weight conferred to resource j (a dimensionless decimal number); x is the national and global scale, respectively; and $j = 1, 2, \ldots, n$, within a suitable production or administrative unit during a certain period. Unit: kilogram, liter, joule, or monetary value.

Equation (23) is useful for simultaneously optimizing the resource economy, the technology used and the environmental conditions when undertaking mining and excavation projects for material commodities. Lower shadow costs allocated to a mining and/or excavation entity implies a more efficient handling of the resource in question, since it represents less advantageous but constructed costs that occur when applying the EUROPE model across different production processes.

The shadow costs as expressed by Equation (23) constitute the basis for continuously reviewing, monitoring, and evaluating the performance of the current projects in the form of a key factor for application on different geographical scales. There appears to be no specific obstacles to applying the proposed methodology to the mining and waste industries with emphasis on optimization of the resource economy. The methodology suggested can hence be applied to different optimization efforts of all traditional mining, excavation, and waste-related activities (Stenis & Hogland 2011, 2016b).

Landfill mining application

A definition of landfill mining could read as follows: the excavation and removal of materials from an active or closed sanitary facility for the purposes of the recycling, use, reuse, sale, energy utilization or composting, including recovery and amendment of soil, the processing of excavated material from old landfills and making new landfill volumes available, as well as utilizing energy resources (Stenis & Hogland 2014a).

If manpower is available, the decision of whether to commercialize a waste fraction or not can be facilitated by assessing the connected contribution margin as shown in **Table 2**.

If a positive value is obtained on the bottom line, this generally means that the waste fraction in question should be turned into a product and not simply discarded.

Weighting can be used to adjust the costs associated with a waste to reflect its environmental impact. 'Environmental shadow costs' should be used in combination with the cost allocation principle in defining environmental standards. Even *without* the use of such environmental impact weighting, the cost allocation principle is useful for redistributing costs associated with waste between different landfills of a company. This results in a competition between different landfills, which enhances environmental improvement and economic profit.

This gives companies an economic incentive to reduce the occurrence of certain waste fractions in landfills to improve their contribution margin estimates by commercializing those fractions. This incentive impacts short-term product cost estimates, budgets and forecasts used for loan applications, and information to company stakeholders. Above all, the environment will be improved due to less waste being discarded to nature.

Urban mining application

The urban mining concept is a necessity to create attractive, sustainable cities for modern people who demand healthy dwellings. Mining virgin resources deep down in the ground is becoming ever more expensive. There are now more raw materials accumulated in houses and infrastructure than it is possible to mine using traditional methods. Mining activities are likely to be adapted accordingly. More emphasis is on exploitation of previously extracted minerals.

The Ultimate Zero Waste concept is the uttermost method to handle wastes. This concept, developed by the author, encourages recovery of materials lost during the lifecycles of manufactured products and now available in sinks, such as landfills and sediments of rivers. The Ultimate Zero Waste Concept is a continuation of the previously launched Beyond Zero Waste Concept, invented by William Hogland, inspired by Jan Stenis.

All waste, materials and chemical compounds that have been lost, such as sludge, slag, harbour sediments etc., can return to anthropogenic loops. By implementation of the Ultimate Zero Waste concept, the toxic substances could be removed from the current ecological circuits. Special focus is on fractions that show the least profitability among those on the scrap market.

'Urban mining' is defined by the author as the recovery of materials and compounds of commercial interest from daily generated waste, existing urban constructions, and substances that throughout history have escaped from the anthropogenic closed loops and circuits (Stenis & Hogland 2014b).

Urban mining means handling many different waste fractions at the same time. In the numerator of Equation (1) this is expressed by employing a sum as shown in Equation (24):

$$A = \sum Ai \text{ = the sum of the } n \text{ different waste fractions to be optimized} \quad (24)$$

$$i = 1, \ldots, n \text{ where } n > 0 \text{ (integer)}$$

Unit: kilogram, liter, joule, currency etc.

A denotes such materials that, with today's recovery and extraction methods, cannot be taken care of in an economically feasible way. In the denominator, the multitude of considered fractions is expressed by the following sum:

$$C = \sum Ck \text{ = the sum of the } l \text{ different residuals, the total 'bads'} \quad (25)$$

$$k = 1, \ldots, l \text{ where } l > 0 \text{ (integer)}$$

Unit: kilogram, liter, joule, currency etc.

C denotes the second order of residuals that can be recovered with a higher cost, with the help of advanced recovery methods and/or the third order of residual fractions that can be recovered with a profit in the future. B, the first term in the denominator in Equation (1), denotes the collocated goods. B denotes the first order of residual fraction that has the best economic value to the lowest waste management cost, or that can be commercialized with the easiest method.

$B = \sum Bj$ = the summarized *m* regular products produced together with $\sum A_i$ and $\sum C_k$ (26)

$j = 1, \ldots, m$, where $m > 0$ (integer)

Unit: kilogram, liter, joule, currency etc.

Summarized, the case of many different waste fractions is expressed in Equation (27):

$$PFx = [\sum Ai \,/\, (\sum Bj + \sum Ck)] * EIFx \,/\, RRFx \,/\, GWFx \qquad (27)$$

$i = 1, \ldots, n$; $j = 1, \ldots, m$; $k = 1, \ldots, l$; $n > 0$; $m > 0$; and $l > 0$ (integers)

where, PF_x is the proportionality factor for the whole waste management scenario, to be multiplied with TC_x for the urban mining project x, to obtain the cost that should burden the *n* waste fractions in A to achieve an incentive to optimize extraction of the *n* components.

EIF_x is the environmental impact factor (dimensionless) for the object of urban mining in question and considers the project's impact on its surroundings as compared to other objects in its category regarding the pollution of air, soil, and water. An EIF of 1.0 represents the average urban mining object in these aspects and is the standard value.

RRF_x is the relative representativeness factor (dimensionless) for the object of urban mining in question and considers the project's representativeness as compared to other objects in its category regarding the object's geographical and social position in the neighbourhood and its availability for demolition. An RRF of 1.0 represents the average urban mining object in these aspects and is the standard value.

GWF_x is the general weight factor (dimensionless) for the object of urban mining in question and considers the project's relative importance in financial and technological terms as compared to similar objects. A GWF of 1.0 represents the average urban mining object in these aspects and is the standard value.

The actual values of EIF, RRF and GWF to be used could be obtained, for example, via public statistics or the private companies' internal databases. Or they can be set based on the experience of professionals in the industry in question.

By employing Equation (28), SC is obtained that burdens the accounts of the urban mining project x. The management of x is provided with a tool that increases the economic incentives to make the urban mining activities more cost effective and at the same time allows the managers to monitor, review and evaluate this process to make it gradually more efficient by optimizing the different fractions in order of their declining relevance.

$$SCx = PFx * TCx = [\sum Ai / (\sum Bj + \sum Ck)] * EIFx / RRFx / GWFx * TCx \quad (28)$$

The shadow cost SC_x is to be used as a flexible tool to optimize the urban mining project x by additionally influencing the economic system and the daily decisions of the company in question.

The methodology is useful as a tool to obtain a decision basis for authorities such as municipal planning and building committees, granting allowances to demolish and construct houses, roads and bridges based on the investigations made by town planning offices (Stenis & Hogland 2014b).

Conclusion on *mining* in *general*

The equality principle can provide a management basis for mining of residuals in general, not least landfill mining of the hidden resources in waste dumps all over the world. Applying the EUROPE equation to budgets produces a negative impact on the PSBR. This is due to the internal shadow cost associated with residuals, which in turn is due to the TC assigned to the residuals. An incentive for source reduction occurs when the economic incentives promote more efficient equipment to enable a more efficient usage of the natural resources that are purchased to produce the products, when the organization in question turns the raw material into goods.

There is a transfer of costs from the 'goods' to the 'bads' when applying the EUROPE model. However, no known estimation method yields result that are completely valid.

Nevertheless, a link is created between losses and the residuals through cost redistribution and weighting of environmental impacts, caused by the shadow costs imposed on the unwanted residuals. Economic pressure is exerted on the actors to introduce measures that reduce waste at source and increase useful materials. Such measures enhance production efficiency.

This reduces the production of residuals and the degree of distortion that occurs in cost allocation. This is due to the co-ordination as regards accounting principles, as the geographical area in which the approach is employed is enlarged.

Apart from improving the economy, a main purpose of applying the equality principle in the mining context is to conserve the environment. In the long run and on a global perspective, environmental conservation and maximization of profits tend to be consistent with one another.

The current approach is not limited to industrial phenomena of the types considered here. The methodology suggested is applicable to any industry producing wastes.

A new way of regarding waste from an economic perspective is promoted. The residuals in the calculations are equalized with the regular products in strictly economic terms. This encourages the development of alternatives to, for example, traditional taxation practices.

The aim is to increase the economic incentives to reduce industrial waste and change attitudes towards residuals. This study is intended to promote a change in the perceived status of mining and industrial waste through emphasizing the financial impact of shadow costs on budgets and to improve conditions for the resource-transforming industry.

A link is established between budgetary costs and the produced residuals that redistributes costs between regular products and the related residuals from production. Economic pressure is exerted to introduce measures to reduce wastes at source. This will improve the resource economy more than if various means to increase efficiency are applied later.

Forecasts, budgets, and receipt and expenditure accounts that governments present will be negatively affected by the excessive occurrence of residuals and the failure to utilize these productively when the EUROPE model is employed. Both official recommendations and voluntary environmental agreements regarding the assessment of industrial wastes are needed due to increased attention for the latter. Nations will improve their productivity.

The perceived status of mining waste changes through the financial implications of the expenditures and receipts involved and the use of shadow costs. The approach is to be adopted by the authorities and accompanied by a paradigmatic shift in the perception of waste.

This development is accompanied by better ways of reducing residuals and utilizing the waste fractions produced. A contribution is made to the waste-reducing ambitions of, for example, the EU.

The strength of the methodology is its general approach that employs an 'umbrella solution'. This makes the model independent of, for example, current technological solutions and the fluctuating ambitions of actors, since phenomena are expressed in monetary terms.

The weight factors introduced give room for ambitions related to, for example, environmental policy. The major attraction of the model is its ability to induce industrial and environmental changes and to redistribute wealth, through expressing reality in monetary terms.

A weakness of the work is its imperfect precision concerning which actors are affected most. The precision in the calculations can be improved by designing auxiliary algorithms to be integrated within the EUROPE model and improving the scope and accuracy.

The distribution of wealth is influenced by the model. This is a result of the tool being likely to reshuffle revenues and profits from mining activities through increasing efficiency where it is most needed. The nations showing the less cost-effective mining industry will encounter the heaviest punishments enforced by international actors to improve the utilization of their assets. These nations are likely to improve their government budgets more than others.

The distribution of wealth from exploitation of resources and commodities is affected. The nations that display the least profitable industry will benefit most. Equity is promoted.

Decision makers on the global level can apply the results in daily life and the consequences will be noticed nation by nation. The methodology ensures deliberation from the influence of valuations related to global warming and trade emissions, social and equality aspects, and gender problems. This is due to the theory being based on a logical reasoning that mathematically optimizes the economy, the technology used and its impact on the environment. Valuations can be expressed in terms of the proposed weight factor approach that gives room for managers' and authorities' view.

The validity of the method developed here is regarded to be satisfactory due to the common theory of business administration and economics being used as the basis for the results. The extensive experience of the usage of the applied economic theory points in this direction.

The economics focuses on pollution-related aspects. The theory affects the public finances by increasing the PSBR. Traditional resource economy practices would not have given the same economic incentive to improve the management of waste residuals when exploiting the ore. Nor would application of the traditional resource economy have forced nations to utilize their total resources in a more cost-effective way, due to the induced economic incentives.

The launched methodology improves the exploitation of resources and commodities. For economic reasons, it minimizes wastes and maximizes the utilization of raw materials.

The absence of proper economic tools in the mining industry has caused a slow development, compared with the IT industry. The economic tool proposed promotes the faster development and modernization of the mining industry. The result increases profitability and improves the production apparatus, combined with more caring for nature, including the soil, air, and waters.

The equity of the distribution of natural resources is improved on all levels. The industrial sectors and nations producing with less efficiency, for economic reasons, become more efficient producers as regards their economic, technological, and environmental performance.

The tool is developed for management of resources with emphasis on the residual economy. The tool is mainly intended to be used by public officials and high-ranking decision makers in industry. Suggested end users for the methodology and related major aspects are as follows:

- global authorities, such as the United Nations, the OECD, and the

International Monetary Fund, wanting a tool for monitoring a nation's industrial performance to improve its cost effectiveness and environmental impact related to the exploitation of natural resources.

- governments wanting an appraisal tool to evaluate the performance of plants that considers the international neighborhood to avoid protest actions and mass hysteria.
- governments wanting to design new industrial legislation.
- international environmental courts that fix punishments related to a nation's impact.
- national authorities, such as EPAs, wanting to apply industrial legislation; and
- parties wanting to estimate and monitor ecological impacts with respect to the estimated, occurring and prevented emissions and pollution, in monetary terms.

Profitability, technology, and the environment can simultaneously be optimised for a certain nation, as well as for the whole globe, by implementation of the current findings. The implementation process of the findings promotes the living conditions on Earth in general, through the general improvement that the resulting economic incentives induce.

The most important feature in the analysis system is its impact on the decision-making process due to the shadow costs occurring when implemented, and its simplicity. The financial outcomes of the tool will be noticeable throughout nations and their public budgets, due to the REXOF factor putting pressure on governments to improve industrial performance.

The model enables reviewing, monitoring and evaluation of mining. Nations will experience social and security benefits, due to the stabilizing impact of an improved economy.

The methodology induces efficient use of resources through providing economic incentives that promote source reduction of residuals. The features of the research are as follows:

1. It increases the efficiency of the use of resources and commodities through optimization.

2. It increases the cost effectiveness and equity of resource and commodity exploitation.

3. It decreases the negative impact of residuals on the environment and human health.

4. It provides an investment appraisal tool for the implementation of exploitation projects.

5. It analyses the damages from the implementation of mining and excavation schemes.

The conclusions on mining based on the findings are as follows:

1. The research improves the cost aspects of residual management.

2. The findings improve the cost effectiveness and resource-equity.

3. Economic incentives improve the utilization of resources.

Summarized, the outcomes and benefits when applying the EUROPE model on mining are as follows:

1. It provides a principle for estimation of shadow costs to promote exploitation of resources.

2. Economic incentives are developed for the mining and excavation industry to save costs.

3. There is a reduction of industrial residuals at source, leading to less industrial waste.

4. Extended environmental good will result, due to proper mining waste management.

5. The status of mining waste will be enhanced, due to economic equalization with products.

6. There is a shift of paradigms, equality between residuals and products, in economic terms.

7. A decreased impact of residuals on human health will be seen, while increasing profits.

8. It provides a tool for waste management decision-making, at the national and global levels.

9. It is based on the well-known theory of business administration

and economics.

10. The equality principle is valid and reliable when estimating the 'real' costs.

The theory for management of residuals from the exploitation of natural resources and commodities was investigated. These results are useful to improve the cost effectiveness of industrial production.

It is recommended to use the EUROPE model, based on the equality principle, as follows:

1. for studying the residuals from mining and excavation activities.

2. when deciding whether to invest in schemes for the exploitation of natural resources.

3. to reduce unwanted, and sometimes harmful, substances arising through industrial production.

4. to improve the cost effectiveness and equity related to environmental improvements.

5. for the management of residuals from the exploitation of natural resources in general (Stenis & Hogland 2016b).

Energy Resources—how to apply the equality principle to energy resources

Fundamentals of energy resources theory

Energy spillages mean economic and nature value losses. Less efficient utilization of energy resources means increased costs for energy supply and excessive use of commodities to produce energy for industrial and household purposes. The use of energy by, for example, district heating and cooling must be economized to achieve an efficient industrial production and obtain improved living conditions. The term ‘energy spillage’ denotes the energy that is not used for its intended purpose but escapes through energy losses and is wasted, excluding energy consumption, conversion, and heat losses (Stenis & Hogland 2015a).

The launched methodology facilitates this development by supplying management with a tool for economizing on the energy spillages, mainly on larger scales. The presented model provides a versatile key factor that can be used as an indicator for how well the activity is progressing.

Energy Economy Optimization (EEO) models enable the exploration of future decision options to provide a relevant policy basis. EEO models constitute a tool for decision makers for short-term decisions with long-term effects, considering future uncertainties.

A new cost structure provides incentives for exploitation of energy resources. The author’s novel idea only loosely relates to the environmental economics way of thinking about these issues. Environmental economists usually try to estimate the shadow cost of residuals, if properly implemented. This method gives adequate and, in theory, optimal incentives. The author of this study only loosely relates to this way of thinking because the methodology represents a brand-new energy concept.

No previous studies have been made of how to—by using just one key factor—monitor, measure and evaluate the performance of activities related to energy spillages. The present work is important for the global economy, the process of developing new technology and the environmental conditions worldwide. The author provides methods that managers can use to increase the cost efficiency of schemes for usage of energy. Thereby, the equity of resources is promoted when they are exploited.

General theory for economizing on energy spillage

The total usage of energy and the energy spillage plus the recycling and recirculation of energy spillage from energy-related activities are inputs to Equation (1). The total cost for energy resources (TC_{energy}) is required. Equation (1) gives:

$$PFenergy = Aenergy / (Benergy + Cenergy) \tag{29}$$

where, A_{energy} is the quantity of the total spillages from the energy usage in a certain unit; B_{energy} is the quantity of the total regular energy usage; and C_{energy} is the quantity of all the spillages of the regular energy usage. Unit: € or $ etc.

$$ENEC = Shadow\ cost\ allocated\ to\ Aenergy = PFenergy * TCenergy \tag{30}$$

PF_{energy} is multiplied by TC_{energy} to obtain the shadow cost to allocate to a certain budget. This entity is denoted the energy economizing cost (ENEC).

The ENEC will force the entities to recycle and recirculate their energy resources in a more cost-effective way and reduce energy leakage due to the economic incentives that are induced by the need to borrow money. And the more ENEC that is allocated to a unit, the less cost effective that unit's usage of its energy resources will be. Thus, more economic incentives will be imposed on that unit to become more cost effective and produce less energy waste. The environment will be improved due to less environmental degradation from energy spillage.

National energy economizing

The energy usage of activities and production statistics related to traditional energy applications and the deployment of so-called green energy within the nation in question are inputs to Equation (32). The total national expenditures (TC_{nation}) are required.

Data from the nation's profit and loss account is required to calculate the optimal amount of a certain energy spillage. Thereby, a reduction at the energy source of a nation can be economized from the point of view of energy usage and the environment. This gives:

$$PFnation\ energy\ =\ Anation\ energy\ /\ (Bnation\ energy\ +\ Cnation\ energy) \quad (31)$$

where, $PF_{nation\ energy}$ is the proportionality factor for the nation in question; $A_{nation\ energy}$ is the quantity of the energy spillage produced in a certain major facility, branch, or industrial complex; $B_{nation\ energy}$ is the quantity of the total regular national energy output; and $C_{nation\ energy}$ is the total quantity of all the nation's regular energy spillages. Unit: € or $ etc.

$$NAENEC = Shadow\ cost\ allocated\ to\ Anation\ energy = PFnation\ energy * TCnation \quad (32)$$

$PF_{nation\ energy}$ is multiplied by TC_{nation} to obtain the shadow cost to allocate to a nation's government budget enforced by suitable international authorities. This item is denoted the national energy economizing cost (NAENEC) (see **Table 5**).

Table 5. The public finances for a representative nation

EXPENDITURE
Expenditure on goods and services
Transfer payments
Debt interest
NAENEC
TOTAL RECEIPTS
Value added taxes (VAT) and other indirect taxes
Income taxes
Social security contributions
Other receipts and royalties
Corporate taxes and rates
GENERAL GOVERNMENT BORROWING REQUIREMENT (GGBR)
PUBLIC CORPORATIONS
PUBLIC SECTOR BORROWING REQUIREMENT (PSBR)

Global energy economizing

The global energy usage of activities and production statistics related to residuals within the company are inputs to Equation (34). The total global expenditures (TC_{global}) are required.

Data from Earth's profit and loss account is required to calculate the optimal amount suitable for a certain energy spillage. A reduction at the energy sources of the Earth can be optimised from the point of view of energy usage economy and the environment. Equation (1) gives:

$$PFglobal\ energy = Aglobal\ energy\ /\ (Bglobal\ energy + Cglobal\ energy) \quad (33)$$

where, $A_{global\ energy}$ is the total quantity of the energy spillages from the production of a certain nation; $B_{global\ energy}$ is the quantity of the regular global energy production; and $C_{global\ energy}$ is the quantity of all the energy spillages of the regular global production. Unit: € or $ etc.

$$GLOENEC = Shadow\ cost\ allocated\ to\ Aglobal\ energy = PFglobal\ energy * TCglobal \quad (34)$$

$PF_{global\ energy}$ is multiplied by TC_{global} to obtain the shadow cost to allocate to a certain nation's government budget. This item is denoted the global energy economizing cost (GLOENEC) and is applied in **Table 6**, according to the use of NAENEC in Table 5.

Table 6. The public finances of Earth

REVENUES
GLOBAL EXPENDITURE
Expenditure on goods and services
Transfer payments
Debt interest
GLOENEC
RESULT

Consequences of application of the energy theory

The NAENEC and GLOENEC will force the nation in question and the whole globe to economize on its flow of energy due to the economic incentive induced by an increase in the resulting need for loans and hence decreased cash assets or an increase in the final PSBR, respectively. The purchased energy input is likely to be utilized in a more cost-effective way due to the economic incentive induced by a profit decrease.

The more of the NAENEC and GLOENEC that is allocated to a nation's budget, the less cost effective that nation's energy usage is. Thus, more economic incentive is imposed on that nation to become more cost effective and produce less energy spillages. The environment will be improved due to less environmental degradation from side effects of the energy spillages, such as unwanted heating and steam pollution connected to the industry complex in question.

Data from the nation's public finances enables calculation of the optimal amount of the energy spillage of a branch or an industrial complex. The energy usage of a whole nation can be economized on from an economic and environmental point of view.

Weights for theory applied to energy use

For example, a factor of 1.2 can be multiplied by the initially obtained shadow cost if a certain kind of spillage is expected to motivate a 20% mark-up to provide an extra incentive to reduce its unwanted existence. What can be termed 'environmental shadow costs' should thus be used in combination with the cost allocation principle in defining environmental standards.

Economizing on multiple energy resources

In the case of *n* energy resources, the TC is calculated as follows:

$$TCn\ energy\ resources\ =\ \Sigma\ (TCj\ *\ Wj) \tag{35}$$

$$i\ =\ 1, 2, \ldots, resource\ j$$

where, $TC_{n\ energy\ resources}$ is the total cost of the *n* energy resources; TC_j is the total cost of energy resource *j* employing Equation (3); $W_j \geq 0$, the weight conferred to energy resource *j* (a dimensionless decimal number); and *j* is 1, 2, …, *n* within an administrative unit during a certain period. Unit: €, $, £ etc.

Summarized energy resources theory

In summary, the theoretical findings of this section can be collocated in the general Equation (36) in the case of *n* (energy) resources regarded:

$$SCtot = \Sigma\,((Ax\,/\,(Bx + Cx)) * TCj * Wj) \qquad (36)$$

$$i = 1,2,\ldots,resource\ j$$

where, SC_{tot} is the total shadow cost of the *n* energy resources; A_x is the quantity of the energy spillage produced in a certain unit; B_x is the quantity of the regular energy production; C_x is the quantity of all the energy spillages of the regular production; TC_j is the total cost of energy resource *j* employing Equation (3); $Wj \geq 0$, the weight conferred to resource *j* (a dimensionless decimal number); x is the national and/or global energy; and $j = 1,2,\ldots,n$ within an administrative unit during a certain period. Unit: € or $ etc.

Equation (36) is useful for economizing at higher levels on the resource economy, the technology used and the environmental conditions when undertaking energy projects. Lower shadow costs allocated to energy-using entities imply a more efficient handling of the energy resource, since they represent less disadvantageous costs when applying the EUROPE model.

Conclusion on energy resources issues

The results of this study show the viability of the model for the management of residuals when energy resources are exploited. The research shows utility when focusing on economic and pollution aspects of production activities. The work explores the economics of exploitation of energy resources and how to economize on these, from an efficiency point of view, emphasizing resource economy.

The methodology enables an efficient use of energy through providing economic incentives that promote source reduction. The main features of the author's research on energy issues are as follows:

- It reduces the impacts of spillages and improves the health of the population.
- It provides a tool for investment appraisal support of exploitation projects.
- It enables a comparative analysis of damages in schemes, on larger scales.
- It increases the efficiency of the use of natural resources and commodities.
- It increases the cost effectiveness and equity when exploiting resources.

The major conclusions are as follows:

1. The research is useful for management of the residuals from energy resources.

2. The findings will improve cost effectiveness and equity on all higher levels.

3. The economic incentives improve the utilization of resources.

The present study investigates the management of residuals from energy resources. The results show usefulness for improving cost effectiveness and equity, on all higher levels. This represents a possibility to adapt the proposed methods to a practical context. This statement is reinforced by the shadow costs put into the public finances (Table 5) and finances of Earth (Table 6).

The methodology is applicable to policy analysis. The equality principle can be modified for management of energy residuals. Applying this principle produces a negative impact on the profit and loss accounts from the shadow cost assigned to the residuals. The cost levels must not be the most optimal level, but they must help management to improve the activities.

The nature of the methodology is different from simply regarding costs of energy use. The difference is that the EUROPE model is used to impose shadow costs on energy residuals. This approach represents an alternative to traditional estimation methods. This approach should be a contribution to the existing methods that can be applied to energy matters.

The results in this study provide an alternative way of approaching economic problems related to energy, to obtain an economizing on energy flows by using the EUROPE model to accomplish a reduction of energy spillages. The shadow costs per unit might be substantial. The outcome is illustrative when applying the equality principle on different scales.

The methodology is useful for economizing on energy-related activities. Equation (36) represents a key factor for reviewing, monitoring, and evaluating the status of the resource economy, the technology used and the environmental conditions. Direct linking between economic losses and energy spillages through cost redistribution and weighting of environmental impact induce an economic pressure on the actors to introduce measures that are effective in reducing waste at source. Such measures also enhance production efficiency and technology development through the economic incentives.

This reduces both the number of residuals and the distortion in cost allocation. This is due to increased co-ordination of the accounting principles when the geographical area of employment of the suggested approach is enlarged. A trade-off occurs between the demand for scientific exactness of the economic methods and the environmental benefits.

The equality principle can be applied to optimize profits and the resource economy. Thereby, the main purpose is to conserve the environment. Experience shows that promotion of environmental protection and maximization of profits benefit one another (Lidgren 1993).

The approach appears to be applicable to any activity producing energy spillages. It should not be limited to the phenomena considered here.

The present study promotes new views of waste, from an economic perspective, by increasing the economic incentives to reduce energy spillage. This will promote a change in the status of residuals through the emphasis of the financial impact of shadow costs.

The introduced methodology links budgetary costs and the emergence of residuals by redistributing costs between regular products and residuals. The national and global actors experience pressure to introduce measures that emphasize the reduction of wastes at source. Production efficiency and profitability are enhanced.

Forecasts, budgets, and expenditures will be affected to create incentives to reduce residuals and promote utilization. Both official recommendations and voluntary environmental agreements are needed to improve the sustainability and productivity of resource usage.

The study contributes to a change in the perceived status of energy wastes, through emphasizing the expenditures and receipts due to the use of shadow costs. Hopefully, the presented approach will be adopted by authorities such as the United Nations, OECD, and the International Monetary Fund, supported by a paradigmatic shift of the perception of waste.

Better ways of reducing residuals and utilizing fractions can emerge. A contribution can be made to the waste-reducing ambitions of central authorities, to achieve sustainability.

The major strength of the proposed methodology is its general approach that provides an umbrella solution based on common economic theory. This makes the model independent of technological and ideological parameters that are encompassed in the monetary terms used.

The weight-factor approach enables environmental ambitions. The weapon of the model is its ability to induce industrial and environmental policy changes and the redistribution of wealth through expressing reality in monetary terms that encompass most parameters.

A result of implementing the introduced approach would be the influence on the distribution of wealth, regardless of political deadlocks. The tool will reshuffle profits from the activities through increasing efficiency where it is most needed. The actors showing the least cost-effective performance will encounter the heaviest economic incentives. These less cost-efficient actors will, over time, improve their budgets more than others, in relative terms.

The global distribution of wealth connected to the exploitation of energy resources and commodities will be affected. The actors that display the least profitable production apparatus will benefit most. The economic incentives promote equalization of the efficiency of the national systems for production. Global equity is hence promoted.

The major potential end users of the approach are as follows:

- major organizations that want a tool for monitoring energy issues and as a means of correction.
- governments wanting to evaluate energy phenomena to avoid protest actions.
- governments that want to design innovative environmental legislation.

- international environmental courts that decide upon impact punishments.
- national authorities, such as EPAs, that want to apply environmental legislation.
- parties that want to estimate and monitor the ecological impact of actors.

The methods are valid because the common theory of business administration and economics is used. The work is reliable because the performed studies support the introduced methodology.

Recommendations on energy issues

1. Use the EUROPE model before deciding whether to invest in schemes for energy resources, to study the economy of energy spillages from such activities to reduce harmful emissions and improve cost effectiveness and equity.

2. Apply the EUROPE model to the management of residuals from the exploitation of energy resources in general, and of spillages from such activities.

Benefits of applying the theory to energy issues

In summary, the benefits of the present study are as follows:

1. Elaboration of a principle for estimation of shadow costs to exploit energy resources.

2. Creation of incentives for the industry and other actors to save costs.

3. Reduction of residuals at source, leading to less industrial energy spillage.

4. More environmental good performed by the actors because of improved waste management.

5. Enhanced status of waste, equivalent to regular products in economic terms.

6. Promotion of a novel shift of waste management paradigms.

7. An approach to decrease the impact of residuals on the environment and health.

8. Development of a tool to enable decision-making in waste management at higher levels.

9. Theory based on comprehensive concepts for business administration and economics.

10. The use of the equality principle to estimate the 'real' costs shows validity and reliability (Stenis & Hogland 2015a).

Recycling and recirculation—how to apply the equality principle to the reuse of resources

Fundamentals of recycling and recirculation theory

Recycling of materials and chemicals is an issue of big importance.

Most citizens have contributed to the recirculation of these resources. There are leakages from anthropogenic cycles, leading to valuable materials ending up in landfills, the sedimentary layers of lakes and in oceans. These substances may affect the environment in a negative way, in addition to the economic losses. Optimization efforts in the recycling and recirculation of resources are hence beneficial.

The objective is to provide a framework that managers at various levels can use to obtain guidelines for how to increase the cost efficiency of recycling and recirculation activities and similar schemes, by using the EUROPE model based on the equality principle. The equity of the distribution of natural and energy resources and commodities should be promoted, based on optimization of the occurrence of residuals and spillages when they are exploited.

A cost structure provides incentives for the optimal exploitation of natural and energy resources. The launched approach does not relate to the way that environmental economists think. They try to estimate the shadow cost of residuals, which gives adequate and in theory optimal incentives, if properly implemented. The author does not consider how the approach is related to the traditional way of thinking because the methodology is new.

General theory for recycling and recirculation applications

The residuals of natural resources are regarded as a regular product output, described in Equation (1). This equation is used for the allocation of costs and revenues to a certain resource residual through multiplication of PF by the total costs and revenues to be allocated by splitting them up:

$$PF = (A - Rec) / (B + C) \tag{37}$$

$$X = Corporateinternal\ shadow\ cost\ additionally\ allocated\ to\ A = PF * TC \tag{38}$$

$$TC = Total\ costs = Fixed\ costs + Variable\ costs = FC + \mathrm{VC} \tag{39}$$

$$Rec < A - PF\ (B + C) \tag{40}$$

$$Rec < A - (X * (B + C) / TC) \tag{41}$$

$$Max\ rec = Maximal\ potential\ of\ the\ possible\ recirculation = \sum PFi * TC \tag{42}$$

$$Min\ A = Minimum\ required\ residual\ quantity\ A = Rec + PF * (B + C) \tag{43}$$

where, PF is the proportionality factor (a dimensionless mathematical fraction); A is the quantity of the residuals from a certain resource or commodity to be reduced, the 'bad'; Rec is the recycled and/or recirculated quantity of A, the 'bad' to be optimised; B is the quantity of the regular resource output, the sum of the 'goods'; C is the sum of the quantities of all the different residual fractions produced, all the 'bads'; and $i = 1, 2, \dots, n$ in order of the estimated, descending and collocated economic and/or environmental relevance. Unit: €, $, £ etc.

When applying Equation (38) a suitable production or administrative unit must be defined, depending on the circumstances. The system's limit is set in a flexible way, due to the administrative level, from a single company up to the entire planet. The circumstances guide management when deciding on the physical scale on which to apply the EUROPE model.

Theoretical foundations for recycling and recirculation

The larger that Rec is, the lower the shadow cost that is to be allocated to A. Thus, recycling and recirculation of A are rewarded. The environment and profits are improved if the relevant shadow cost is used, and appropriate action taken. The maximal amount to recycle and/or recirculate of a certain fraction of a certain branch can be calculated by using input data from, for example, a whole nation's public finances. The rate of recycling and/or recirculation of an actor can, in parallel, be optimised from the point of view of resource usage economy and the environment.

National optimization of recycling and recirculation

The production and energy usage of activities and production statistics related to residuals at a national level are inputs to Equation (44). The total national expenditures (TC_{nation}) are required as inputs to induce the economic incentives of interest.

To calculate the maximal amount of a phenomenon that is suitable to recycle and/or recirculate, data from the nation's public finances are required. The rate of recycling and/or recirculation can be optimised from a resource economy point of view. This gives:

$$PFnation = (Anation - Recnation) / (Bnation + Cnation) \quad (44)$$

where, PF_{nation} is the proportionality factor for the nation in question; A_{nation} is the quantity of the residuals or spillage produced within a major facility, branch or industrial complex within the nation; Rec_{nation} is the net recycled and/or recirculated quantity of A_{nation}, considering the export of recyclables by deducting this from all the nations that ship to other countries for recycling; B_{nation} is the quantity of the regular output in the nation; and C_{nation} is the quantity of the residual and spillage fractions within the nation. Unit: € or $ etc.

$$\begin{aligned} NAROC &= Shadow\ cost\ allocated\ to\ Anation \\ &= PFnation * TCnation \end{aligned} \quad (45)$$

$$\begin{aligned} &Total\ receipts + Public\ corporations - Expenditure - NAROC \\ &< \\ &Public\ sector\ borrowing\ requirement\ (PSBR) \end{aligned} \quad (46)$$

$$\begin{aligned} NAROC < {} & Total\ receipts + Public\ corporations - Expenditure \\ & - Public\ sector\ borrowing\ requirement\ (PSBR) \end{aligned} \quad (47)$$

$$\begin{aligned} &Recnation < Anation - \\ &(NAROC * (Bnation + Cnation) / TCnation) \end{aligned} \quad (48)$$

$$\begin{aligned} &Min\ Anation = Minimum\ required\ residual\ quantity\ Anation = \\ &Recnation + (NAROC * (Bnation + Cnation) / TCnation) \end{aligned} \quad (49)$$

PF_{nation} is multiplied by TC_{nation} to obtain the shadow cost allocated to a nation's government budget. This item is denoted the national recirculation optimization cost (NAROC) (see **Table 7**). The maximal potential possible recirculation in the nation is $Max\ Recnation = \Sigma PFnation\ i * TCnation\ i$.

Table 7. The public finances for a representative nation

EXPENDITURE
Expenditure on goods and services
Transfer payments
Debt interest
NAROC
TOTAL RECEIPTS
Value added taxes (VAT) and other indirect taxes
Income taxes
Social security contributions
Other receipts and royalties
Corporate taxes and rates
GENERAL GOVERNMENT BORROWING REQUIREMENT (GGBR)
PUBLIC CORPORATIONS
PUBLIC SECTOR BORROWING REQUIREMENT (PSBR)

Global optimization of recycling and recirculation

Global production and energy-usage and -generation statistics related to residuals within the nation in question are inputs into Equation (50). The total global expenditures (TC_{globe}) are required as inputs to induce the economic incentives of interest.

To calculate the maximal amount of a phenomenon that is suitable to recycle and/or recirculate, data from the global public finances are required. The rate of global recycling and/or recirculation can be optimised from a resource usage economy point of view. Equation (1) gives:

$$PFglobe = (Aglobe - Recglobe) / (Bglobe + Cglobe) \quad (50)$$

where, PF_{globe} is the proportionality factor for the nation in question for the globe; A_{globe} is the total quantity of the residuals from production within a nation on the globe; Rec_{globe} is the recycled and/or recirculated quantity of A_{globe}; B_{globe} is the quantity of the regular output for the globe; and C_{globe} is the quantity of the residuals of the global output. Unit: € or $ etc.

$$GLOROC = Shadow\ cost\ allocated\ to\ Aglobe = PFglobe * TCglobe \quad (51)$$

$$Total\ global\ receipts + Public\ corporations\ of\ the\ earth - Global\ expenditure - GLOROC < Public\ sector\ borrowing\ requirement\ (PSBR)\ of\ Earth \quad (52)$$

$$GLOROC < Total\ global\ receipts + Public\ corporations\ of\ Earth - Global\ expenditure - Public\ sector\ borrowing\ requirement\ (PSBR)\ of\ Earth \quad (53)$$

$$Recglobe < Aglobe - (GLOROC * (Bglobe + Cglobe) / TCglobe) \quad (54)$$

$$Min\ Aglobe = Minimum\ required\ residual\ quantity\ Aglobe =$$

$$Recglobe + (GLOROC * (Bglobe + Cglobe) / TCglobe) \quad (55)$$

PF_{globe} is multiplied by TC_{globe} to obtain the shadow cost allocated to a nation's government budget. This item is denoted the global recirculation optimization cost (GLOROC) and is applied in **Table 8** according to NAROC in Table 7. The maximal potential of global recirculation of metal and mineral commodities is given by $Max\ Recglobe = \Sigma PFnation\ i * TCglobe$.

Table 8. The public finances of Earth

GLOBAL EXPENDITURE
Expenditure on goods and services
Transfer payments
Debt interest
GLOROC
TOTAL GLOBAL RECEIPTS
Value added taxes (VAT) and other indirect taxes
Income taxes
Social security contributions
Other receipts and royalties
Corporate taxes and rates
GENERAL GLOBAL GOVERNMENT BORROWING REQUIREMENT (GGGBR)
PUBLIC CORPORATIONS OF EARTH
PUBLIC SECTOR BORROWING REQUIREMENT (PSBR) OF EARTH

Consequences of theory applied to recycling and recirculation

The NAROC and GLOROC will force the nation in question and the whole globe to recycle and recirculate their flows of residuals, energy, and commodities in a certain branch and across a whole nation in a more cost-effective way. This is due to the economic incentive induced by an increase in the need for loans or an increase in the final PSBR for the company or nation, respectively. The purchased material and intangible inputs are likely to be utilized in a more cost-effective way because of the economic incentives that are induced by an unfavourable decrease in the final profit.

Data from the nation's public finances enable calculation of the maximal amount to recycle and/or recirculate for a major facility in a region, branch, or industry. The rate of recycling and/or recirculation of a nation can be optimised from a resource economy point of view.

Fundamentals of energy recycling and recirculation theory

Optimization of recycling and recirculation of energy

The total usage of energy and the energy spillage, plus the recycling and recirculation of energy spillage from energy-related activities, are inputs into Equation (56). The total cost of energy-related resources (TC_{energy}) is required. This is applicable on regional, national, and global levels. Equation (1) gives:

$$PFenergy = (Aenergy - Recenergy) / (Benergy + Cenergy) \quad (56)$$

where, A_{energy} is the quantity of spillages from the energy usage in a unit; Rec_{energy} is the recycled and/or recirculated quantity of A_{energy} of the same unit; B_{energy} is the quantity of the regular energy usage; and C_{energy} is the quantity of the spillages of the energy usage. Unit: € or $ etc.

$$ENROC = Shadow\ cost\ allocated\ to\ Aenergy$$
$$= PFenergy * TCenergy \quad (57)$$

$$Min\ Aenergy = Minimum\ required\ residual\ quantity\ Aenergy = Recenergy + (ENROC * (Benergy + Cenergy) / TCenergy) \quad (58)$$

PF_{energy} is multiplied by TC_{energy} to obtain the shadow cost allocated to an estimation and/or budget. This value is denoted the energy recirculation optimization cost (ENROC).

The ENROC forces entities to recycle and recirculate their energy resources in a more cost-effective way because of the economic incentives induced by an increase in the final (G)PSBR and/or need to take up loans. The more ENROC that is allocated to a certain unit, the less cost effective that unit's usage of its energy resources is, in relative terms. Thus, an economic incentive is imposed on that unit to become more cost effective and produce fewer energy-related residuals. The environment will be improved because of less degradation from residuals.

The maximal recirculation of the energy-related activities is given by Max $Rec_{energy} = \Sigma PF_{energy\ i} * TC_{energy}$.

Weights for recycling and recirculation of energy spillage

Weightings can be used to adjust the costs associated with a residual or spillage to reflect its environmental impact, based on scientific evidence and/or in terms of overall societal aims. For example, a factor of 1.2 can be multiplied by the initially obtained shadow cost if a certain kind of residual or spillage is expected to motivate a 20% mark-up to provide an extra incentive to eliminate it. 'Environmental shadow costs' should be used in combination with the cost allocation principle in defining environmental standards. Even without the use of such impact weightings, the cost allocation principle is useful as a means of redistributing costs associated with different residuals between different nations. This gives competition between actors.

Multiple energy resources for recycling and recirculation

In the case of *n* (energy) resources, the total shadow cost can be calculated as follows:

$$TSCtot = \Sigma\,(TSCj * Wj) \tag{59}$$

$$i = 1, 2, \dots, resource\ j$$

where, TSC_{tot} is the total shadow cost of the *n* resources; TSC_j is the total shadow cost of resource *j*; $Wj \geq 0$, the weight conferred to resource *j* (a dimensionless decimal number); and $j = 1, 2, \dots, n$ within an administrative unit during a certain period. Unit: € or $ etc.

Summarized recycling and recirculation theory

The findings can be summarized by Equation (60) in the case of *n* (energy) resources:

$$SSCtot = \Sigma (((Ax - Recx) / (Bx + Cx)) * TCj * Wj) \qquad (60)$$

$$i = 1, 2, \ldots, resource\ j$$

where, SSC_{tot} is the summarized shadow cost of the *n* resources; A_x is the quantity of the residuals or spillage produced in a certain unit; Rec_x is the net recycled and/or recirculated quantity of A_x within the same unit, considering the export of recyclables by deducting this from all the nations that ship to other countries for recycling; B_x is the quantity of the regular production; C_x is the quantity of the residuals of the regular production; TC_j is the total cost of resource *j*; $Wj \geq 0$, the weight conferred to resource *j* (a dimensionless mathematical fraction); x is the national and/or global level and energy; and $j = 1, 2, \ldots, n$ within an administrative unit during a certain period. Unit: €, $, £ etc.

Equation (60) is useful for optimizing the resource economy, technology and the environment when undertaking recycling and recirculation of commodities. Lower shadow costs allocated to a recycling and recirculating entity imply a more efficient handling of the resource. Thereby, they represent less 'punishing' shadow costs when applying the EUROPE model.

This provides management with a tool to review, monitor and evaluate the performance of its recycling and recirculation projects by employing the EUROPE model. The resulting shadow cost from Equation (60) constitutes a key factor that provides instant feedback. The lower the shadow costs allocated to an unwanted residual, the better the actors can utilize their resources because there is less of that residual arising. This promotes profitability and better technology due to the increased resources required to make the production apparatus more efficient. The result is a cleaner environment because of less unwanted waste being produced.

Discussion of the theory for recycling and recirculation

General perspectives on the recycling and recirculation theory

This study considers the optimization of the recycling and recirculation of matter and energy. The results show the viability of financial incentives for environmentally friendly management of residuals when natural resources are exploited. Note that the impact of residuals on the environment and ecosystems varies by location. The shadow costs that emerge when applying the theory can have a different impact on the surroundings, depending on where this takes place.

The work applies the equality principle to recycled and recirculated matter and energy spillage. The methodology is applicable to higher policy analysis contexts for recycling and recirculation, producing all types of residuals. The approach is applicable to any major industrial activity producing physical wastes and energy spillages.

Forecasts, budgets, and receipt and expenditure accounts are affected, to avoid excessive occurrence of residuals and to promote their utilization. Both official recommendations and voluntary environmental agreements are needed about the assessment of industrial wastes. Such developments promote the sustainability and productivity of resource use.

This work changes the status of material and energy wastes associated with the use of shadow costs. The approach can be adopted by international authorities, accompanied by a paradigmatic shift in the perception of waste.

The EUROPE model based on the equality principle has the advantage that it allocates incentive-increasing shadow costs based on its inherent logics. The easy-to-understand mathematics decides how much of the total cost mass to allocate to the residuals compared with the total output from 'the black box' of the production unit. This way of portioning costs constitutes the basis for how management reviews, monitors, and evaluates its professional activities. Instead of considering full societal costs or optimizing the technology used, the author suggests allocating incentive-increasing shadow costs in a way that ensures economic solutions as well as providing a management tool. The versatile EUROPE model appears to be unique among models developed by academics, industrialists, or other parties, due to the shadow costs employed to improve the environment and the energy economy. Economic instruments such as the EUROPE model are very seldom used to optimize recycling and recirculation activities; technical aspects of these activities are emphasized.

The strength of the methodology is its approach that provides an 'umbrella solution' based on common economic theory. This makes the application of the model independent of technological and ideological parameters, encompassed in the monetary terms.

The shadow costs from the model are indicators of the performance of the business. Equation (60) gives a key factor for reviewing, monitoring, and evaluating the performance of recycling and recirculation. The weight factor enables environmental goals to be set.

The actors on different organizational levels showing the least cost-effective performance will encounter the heaviest economic incentives when the fictive shadow costs of the model are applied. These less cost-efficient actors improve their budgets more than others, in relative terms. Furthermore, global equity is promoted.

Major users of the recycling and recirculation approach

- Major organizations that monitor environmental performance and means of correction.
- Governments that want a tool for investment appraisal to evaluate a plant's performance.
- Governments that want to design innovative environmental legislation.

- International environmental courts that decide upon punishments for a nation's impacts.
- National authorities, such as EPAs, that want to apply environmental legislation.
- Miscellaneous parties that want to estimate and monitor the ecological impact of actors.

The validity of the method is satisfactory because of the traditional business administration and economic theory being used. The extensive practical usage of the economic theory supports the validity of the approach. The reliability is acceptable because of the published studies that support the methodology. Case studies highlight the practical value of my research.

Further research will emphasize the development of mathematical models to increase the precision of the estimations. Financial incentives will constitute the means to reduce the wastage of commodities, implemented at regional and global levels.

Conclusion, recommendations, and benefits of the theory

The research focuses on the economic and pollution-related aspects of production. It explores the economics of the exploitation of natural and energy resources, and how to optimize this from an efficiency point of view. The methodology gives an efficient and sustainable use of resources through economic incentives that promote source reduction of various residuals.

The main features of the research on recycling and recirculation

1. It reduces the impact of residuals on the environment and improves the health.

2. It provides a tool for investment appraisal support to be implemented on exploitation projects.

3. It enables analysis of the estimated, actual, and prevented damages of industrial schemes.

4. It increases the efficiency of the use of natural resources and commodities.

5. It increases the cost effectiveness and equity when exploiting natural and energy resources.

The major conclusions on recycling and recirculation

1. The research is useful for optimization of residuals from natural and energy resources.

2. The findings improve the cost effectiveness and equity at higher policy analysis levels.

3. The economic incentives improve the utilization of resources and redistribute wealth.

Recommendations for recycling and recirculation

1. Use the EUROPE model to study the residuals from schemes for

natural and energy resources, to reduce wastes at source by induced economic incentives at mainly larger geographical and higher organizational levels.

2. Apply the EUROPE model to the management of residuals from exploitation of natural and energy resources in general and of wastes and spillages from such activities.

Summarized benefits of the recycling and recirculation theory

1. Elaboration of a principle for estimation of shadow costs for exploitation of resources.

2. Creation of economic incentives for industry and other actors to save costs.

3. Reduction of residuals at the source, leading to less industrial waste and spillage.

4. More environmental good performed by the actors because of improved waste management.

5. Enhanced status of material and intangible waste, equivalent to regular products.

6. Promotion of a novel shift of waste management paradigms based on economics.

7. An approach to decrease the impact of residuals on the environment and health.

8. A tool for information support to enable decision-making in waste management.

9. Theory based on common principles of business administration and economics theory.

10. Estimation of the 'real' costs shows validity and reliability at higher levels (Stenis & Hogland 2016a).

Ocean currents—how to apply the equality principle to preservation of ocean currents

Fundamentals of ocean current preservation theory

General theory for preservation of ocean currents

The water flow in the currents and the, possibly dangerous, water flow spillage from these currents are inputs to Equation (61). The total cost for ocean currents flow reduction or changing directions ($TC_{current}$) is required. The energy losses in the halted or deviated currents are encompassed in the seawater volumes that the model implies as being heat energy capacity.

$$PFcurrent = 1 / [Acurrent / (Bcurrent + Ccurrent)] \qquad (61)$$

where, $A_{current}$ is the quantity of the ocean current water flow to be preserved; $B_{current}$ is the quantity of the total regular, main ocean current water flow; and $C_{current}$ is the quantity of all the possibly dangerous flow spillages from the regular, main ocean current or its reductions. Unit: millions m^3 of seawater flow per second (Sv).

$PF_{current}$ is multiplied by $TC_{current}$ to obtain the shadow cost to allocate to an estimation and/or budget. This entity is denoted the current preservation and care keen cost (CUPCAKE).

$$CUPCAKE = Shadow\ cost\ allocated\ to\ Acurrent = PFcurrent * TCcurrent \quad (62)$$

CUPCAKE will force the concerned entities to preserve the ocean currents and reduce the leakage of unwanted forms of water flows, due to the economic incentives induced by the need to borrow money. This borrowing is due to the modified budget of these entities increasing when CUPCAKE is added to the expenditures. The more of CUPCAKE that is allocated to a unit, such as the budget of the EU, the less cost effective that unit's preservation of the important ocean currents in question will be, in relative terms. Thus, more economic incentives will be imposed on that unit to become more cost effective and to produce fewer negative outcomes of all kinds, that jeopardize the preservation of the ocean current system.

In this way, the climate will become better stabilized, and the environment will become improved globally with fewer hurricanes and flooding. Environmental degradation will decrease.

CUPCAKE is inserted into the accounts of the units according to the principles of a general trade bloc in **Table 9**. This constructed shadow cost constitutes a tool for managing, monitoring, and evaluating ocean currents, regardless of the technology used to alter them.

Table 9. The modified public finances of the EU

EXPENDITURE
Smart and inclusive growth and jobs, plus, solidarity between EU regions
Agriculture and rural development, plus sustainable growth: natural resources
Security and citizenship
Global Europe
Administration
Other special instruments
CUPCAKE per each of the member countries in the EU
TOTAL RECEIPTS
Proportion of member states' gross national income (GNI)
Value added tax (VAT)
Customs duties on imports from outside the EU
Other
GENERAL GOVERNMENT BORROWING REQUIREMENT (GGBR)

Consequences of the theory applied to ocean currents

CUPCAKE will force the trade blocs, such as the EU and the North American Free Trade Agreement (NAFTA), to economize on the flow of substances that are dangerous for maintaining the ocean currents. This is accomplished through the economic incentive that is induced by an increase in the need for loans and hence decreased cash assets that lead to an increase in the PSBR. The preferable water input to the crucial currents is likely to be utilized in a more cost-effective way due to the economic incentive that is induced by a final profit decrease for the trade blocs. The reduced profitability is due to the employed shadow costs.

The more of CUPCAKE that is allocated to a certain trade bloc's budget as a profit-reducing cost item, the less cost effective that trade bloc's current preservation is, in relative terms. Economic incentives are imposed on that trade bloc to become more cost effective and to produce less potentially dangerous water-flow spillages, or to not harm the important currents in the ocean conveyor belt. The environment will be improved, in a regional and global context, due to less environmental degradation from side effects of the dangerous water-flow wastes. Examples of such side effects are unwanted atmospheric heating and river pollution, connected to the utilization of the major industrial complexes in question.

Data from the trade bloc's public finances enables calculation of the optimal amount of the spillages from a branch or an industrial complex. Thus, the impact on ocean currents of a whole continent can be improved from an economic and environmental point of view.

Weights for preservation of ocean currents

The application of the EUROPE model according to Equation (1) redistributes in an inverted way a portion of the costs for normal products, in this case the regular flow of the Gulf Stream, to spillages, that is the important ocean sub-currents, by allocating the constructed shadow costs to the residuals, here the ocean current by-flows. The redistribution takes place in proportion to the relative size of the currents as compared with the total output of the production unit, in this case the ocean conveyor belt. Weighting adapts the costs associated with an ocean current to its climate and environmental impact, based on scientific evidence, or in terms of societal aims depending on managers' judgements or preferences.

For example, a factor of 1.1 can be multiplied by the original shadow cost if a dangerous water flow motivates a 10% mark up to provide an extra incentive to reduce its existence. 'Environmental shadow costs' should be used, combined with the cost allocation principle in this work, to define environmental standards.

If environmental impact weighting is not applied, the cost allocation principle is useful for redistributing costs connected to water flows between trade blocs by multiplying the obtained PF by the TC, to arrive at a logical portion of the total cost mass to in an inverted way be carried by a water flow of greater importance. This results in competition between the trade blocs, which improves the environment and profits. These actors are given an economic incentive to maintain the ocean currents and reduce the unwanted flows, to improve their financial statements. The incentive impacts cost estimates, budgets and forecasts used as a decision basis for loan applications, and information to stakeholders of financial importance.

Preservation of multiple ocean currents

In the case of *n* currents, the TC is calculated as follows:

$$TCn\ currents = \Sigma\,(TCi * Wi) \qquad (63)$$

$$i = 1, 2, \ldots, current\ j$$

where, $TC_{n\ currents}$ is the total cost of the *n* currents stopping or changing directions; TC_i is the total cost of current *i* stopping or changing direction, employing Equation (3); $Wi \geq 0$, the weight conferred to current *i* (a dimensionless decimal number); and $j = 1, 2, \ldots, n$ within an administrative unit, during a certain period. Units: €, $, etc. and Sv.

Summarized theory for preservation of ocean currents

The findings are collocated in general in Equation (64) in the case of *n* ocean currents:

$$CUPCAKEtot = \Sigma\,([1 / (Ai / (Bi + Ci))] * TCi * Wi) \quad (64)$$

$$i = 1, 2, \ldots, ocean\ current\ j$$

where, $CUPCAKE_{tot}$ is the total shadow cost of the *n* ocean currents stopping or changing directions; A_i is the quantity of the important water flow in an ocean current *i*; B_i is the quantity of the regular ocean current water main flow that produces A_i; C_i is the quantity of all the spillages or losses of the regular ocean current flow B_i that have a negative impact on A_i; TC_i is the total societal cost of ocean current *i* stopping or changing direction; $W_i \geq 0$, the weight conferred to current *i* (a dimensionless decimal number); and *j* is 1, 2, …, *n* within an administrative unit during a certain period. Unit: €, $ etc., and Sv.

Equation (64) is useful at larger geographical levels, such as the European Commission caring for the climate in Western Europe, simultaneously economizing on resource usage, advancing the technology used and improving the environmental conditions when undertaking projects to preserve ocean currents. Lower CUPCAKE shadow costs allocated to trade blocs' accounting systems implies a more efficient handling of the ocean current in question, since it represents less disadvantageous costs occurring when applying the EUROPE model. All kinds of technological solutions are encapsulated in the monetary units of the model.

$CUPCAKE_{tot}$ is inserted into the profit and loss accounts of the EU, according to the principles shown in Table 9. This constructed, but useful, shadow cost constitutes a tool for simultaneously managing, monitoring, and evaluating all activities that influence the ambition to preserve, for example, the Gulf Stream, which is to avoid evacuation of Scandinavia.

In practice, this means avoiding oil spillages from drilling that disturb or destroy the water pump east of Greenland, which is a precondition for the functioning of the ocean conveyor belt. Different wastewater discharges and solid wastes, such as plastic, could have a negative impact on the ocean current systems. This impact can be mitigated by the methodology based on monetary units, which covers all technological aspects of the problem.

Study features for preservation of ocean currents

This work applies economic theory to the unwanted or reduced flow of important ocean currents. The results show the viability of its use for management of ocean currents, as regards resources.

The research shows utility when focusing on the economic and pollution impacts of production activities on the ocean conveyor belt. The work explores the economics of the ocean currents and how to economize on this, from an efficiency and resource economy viewpoint.

The methodology enables an efficient use of natural resources. This is accomplished through providing economic incentives that promote source reduction of anthropogenic activities that degrade ecosystems. The main features of the author's performed research are as follows:

- It reduces the impact of the ocean current residuals that harms the ocean currents.
- It provides a tool to evaluate exploitation that affects the ocean conveyor belt.
- It analyses the estimated, actual, and prevented damages to the ocean conveyor belt.

- It increases the efficiency of use of natural and energy resources and commodities.
- It increases cost effectiveness and global equity, to avoid climate changes (Stenis & Hogland 2015b).

Water distribution—how to apply the equality principle to transportation of water resources

Fundamentals of water resource distribution theory

General theory for improvement of water distribution

The flows of water-based resources in pipes and the unwanted losses and spillages from these flows are inputs to Equation (65). The total cost of the water stopping flowing ($TC_{\text{water transport}}$) is required. Equation (1) gives:

$$PFpipe\ i = Ai / (Bi + Ci) \tag{65}$$

where,

Ai = $\text{Cost}_{\text{change in water pipe friction i}}$, $\text{Cost}_{\text{change in water pipe diameter i}}$, $\text{Cost}_{\text{change in water pipe average speed i}}$, $\text{Cost}_{\text{change in water pipe flow i}}$, $\text{Cost}_{\text{evaporation flow i}}$, $\text{Cost}_{\text{change in energy contents in water pipe flow i}}$, $\text{Cost}_{\text{changed water quality flow i}}$, $\text{Cost}_{\text{water flow tax i}}$, $\text{Cost}_{\text{water flow fee i}}$, $\text{Cost}_{\text{water flow fuel cost increase i}}$, $\text{Cost}_{\text{labor cost increasei}}$, $\text{Cost}_{\text{lack of spare parts i}}$, $\text{Cost}_{\text{environmental impact on air i}}$, $\text{Cost}_{\text{environmental impact on land i}}$ and/or $\text{Cost}_{\text{environmental impact on water i}}$ in pipe i = the ‘bad’ to be optimised or at least reduced;

Bi = value of the annual total water transportation flow in pipe i = sum of the total 'goods', including the change in gross domestic product (GDP) for the current region due to improved water transportations considering the regional changes in social benefits and the reduced risk of wars due to jeopardized water access.

$$Ci = \\ Cost\ change\ in\ water\ pipe\ friction\ i + \\ Cost\ change\ in\ water\ pipe\ diameter\ i + \\ Cost\ change\ in\ water\ pipe\ average\ speed\ i + \\ Cost\ change\ in\ water\ pipe\ flow\ i + Cost\ evaporation\ flow\ i + \\ Cost\ change\ in\ energy\ contents\ in\ water\ pipe\ flow\ i + \\ Cost\ changed\ water\ quality\ flow\ i + Cost\ water\ flow\ tax\ i + \\ Cost\ water\ flow\ fee\ i + Cost\ water\ flow\ fuel\ cost\ increase\ i + \\ Cost\ labor\ cost\ increase\ i + Cost\ lack\ of\ spare\ parts\ i + \\ Cost\ environmental\ impact\ on\ air\ i + \\ Cost\ environmental\ impact\ on\ land\ i\ and/ \\ or\ Cost\ environmental\ impact\ on\ water\ i\ in\ pipe\ i = \\ sum\ of\ the\ total\ 'bads'.$$

$PF_{pipe\ i}$ is multiplied by $TC_{water\ transport\ i}$ to obtain the shadow cost to allocate to a certain estimation and/or budget. This entity is denoted the water transportation flow cost (WATERLOST):

$$WATERLOSTi = Shadow\ cost\ allocated\ to\ Ai \\ = PFpipe\ i * TCwater\ transport\ i \qquad (66)$$

$$WATERLOSTi = Shadow\ cost\ i = SCpipe\ i = PFpipe\ i * TCwater\ transport\ i * Wair\ impact\ i * Wland\ impact\ i * Wwater\ impact\ i \quad (67)$$

$WATERLOSTi$ = [(Cost$_{\text{change in water pipe friction i}}$, Cost$_{\text{change in water pipe diameter i}}$, Cost$_{\text{change in water pipe average speed i}}$, Cost$_{\text{change in water pipe flow i}}$, Cost$_{\text{evaporation flow i}}$, Cost$_{\text{change in energy contents in water pipe flow i}}$, Cost$_{\text{changed water quality flow i}}$, Cost$_{\text{water flow tax i}}$, Cost$_{\text{water flow fee i}}$, Cost$_{\text{water flow fuel cost increase i}}$, Cost$_{\text{labor cost increase i}}$, Cost$_{\text{lack of spare parts i}}$, Cost$_{\text{environmental impact on air i}}$, Cost$_{\text{environmental impact on land i}}$ and/or Cost$_{\text{environmental impact on water i}}$)/

$$(Bi + Cost\ change\ in\ water\ pipe\ friction\ i + Cost\ change\ in\ water\ pipe\ diameter\ i + Cost\ change\ in\ water\ pipe\ average\ speed\ i + Cost\ change\ in\ water\ pipe\ flow\ i + Cost\ evaporation\ flow\ i + Cost\ change\ in\ energy\ contents\ in\ water\ pipe\ flow\ i + Cost\ changed\ water\ quality\ flow\ i + Cost\ water\ flow\ tax\ i + Cost\ water\ flow\ feei + Cost\ water\ flow\ fuel\ cost\ increase\ i + Cost\ labor\ cost\ increase\ i + Cost\ lack\ of\ spare\ parts\ i + Cost\ environmental\ impact\ on\ air\ i + Cost\ environmental\ impact\ on\ land\ i\ and/or\ Cost\ environmental\ impact\ on\ water\ i)] * TCwater\ transport\ i * Wair\ impact\ i * Wland\ impact\ i * Wwater\ impact\ i \quad (68)$$

$$TCwater\ transport\ i =$$

$$the\ total\ cost\ of\ flow\ i\ halted\ due\ to\ blocked\ trade\ route\ i\ and/ or\ the\ disaster\ i\ or\ force\ majeure\ causing\ losses\ along\ pipe\ i \quad (69)$$

The weight factors $W_{air\ impact\ i}$, $W_{land\ impact\ i}$ and $W_{water\ impact\ i}$ allow management to consider environmental protection along water pipeline *i*.

Unit: monetary currency for a monthly, quarterly, or annual period.

$WATERLOST_i$ is additionally inserted into the budgets or the profit and loss accounts of the trade bloc in question. WATERLOST will force these entities of interest to promote a more efficient transport system due to the emerging shadow costs, which, if taken seriously, put pressure on the actors to improve the water transportation conditions. The model also facilitates water being more likely to be delivered at the right time, in the right quantity and of a sufficient quality by employing economic incentives to improve the water distribution efficiency.

Estimation of impact on GDP of developed water transport

The changes in GDP due to application of the EUROPE model on water transportation issues can be estimated by Equation (70), applied here to the economic changes that occur when the water transport systems are developed:

$$GDPafter = GDPprevious * (1 + ((PFprevious - PFafter) / PFprevious)) \quad (70)$$

where, GDPprevious is the GDP in the trade bloc before water transport improvements; GDPafter is the GDP in the trade bloc after water transport improvements; PFprevious is the PF for transports to and from the trade bloc before water transport improvements; and PFafter is the PF for transports to and from the trade bloc after water transport improvements.

Illustrating examples of how Equation (70) works in practice are given:

a) If PF decreases from 1.0 to 0.8 when water transportation becomes more efficient, then GDP increases by 0.2.

b) If PF increases from 1.0 to 1.2 when efficiency decreases, then GDP decreases by 0.2.

The changes in GDP accordingly reflect changes in PF.

Consequences of the theory applied to water distribution

The proposed theory improves the efficiency of water transport systems. This improvement is due to the economic incentives that are induced by the need to borrow money if the modified budgets of these entities increases when WATERLOST is added to the expenditures in the company ledgers.

The more of WATERLOST that is allocated to the budgets, the less cost effective the transport system will be, in relative terms, and the more economic incentives will be imposed on the trade bloc to become more cost effective and produce less costly disturbances of water transport. The environment will be improved with fewer emissions due to less environmental degradation stemming from more cost-effective water transport routes, which can continuously be evaluated. The constructed shadow cost constitutes a tool for managing, monitoring, and evaluating water transports, regardless of the actual technology used to improve them.

The WATERLOST will force the trade bloc in question to economize on, for example, its time losses that are dangerous to maintaining the water flow in a cost-effective way. The different kinds of losses to be considered are reviewed in the cost terms in Ai and Ci of Equation (65). This improved efficiency is due to the economic incentive that is induced by an increase in the need for loans for establishing the ongoing water transportation development process in question. Thus, an unwanted decrease in cash assets occurs when an unfavourable increase in the final PSBR is induced by WATERLOST. The transportation facilities are hence likely to be utilized in a more cost-effective way due to the economic incentive that is induced by a final profit decrease for the trade blocs due to the employed shadow cost WATERLOST.

The more of WATERLOST that is allocated to a trade bloc's budget as a profit-reducing cost item, the less cost effective that trade bloc's water transports are, in relative terms, and the more economic incentive is imposed on that trade bloc to become more cost effective and produce fewer dangerous efficiency losses. The environment will be improved, mainly in a regional and global context, due to less environmental degradation from occurring side effects of the produced water transport flow wastes, such as in the submerged pipes connected to the utilization of the transport routes in question. Environmental impacts, connected to the transportation systems' impacts on air, soil and water, are considered via sort less weights.

Data from the trade bloc's public finances enables calculation of the optimal amount of the spillages of a certain water transport route. The impact of the losses of a whole continent can simultaneously be improved from an economic and environmental point of view.

When applying the EUROPE model, the allocation procedure will not necessarily result in any increase in the total cost for the involved actors. Therefore, weighting can be used to adapt the costs associated with a water flow to its impact. The basis for the weighting can be scientific evidence or overall societal aims, depending on top managers' judgements.

Multiple water transport route theory

In the case of *n* channels, basins, pipes, and/or tunnels, the TC is calculated as follows:

$$TCn\ pipelines = \Sigma\,(TCi * Wi) \qquad (71)$$

$$i = 1, 2, \dots, j$$

where, TCn pipelines is the total cost of the *n* water transport routes stopping or changing directions; TCi is the total cost of pipeline i collapsing, employing Equation (69); $Wi \geq 0$, the dimensionless weight conferred to pipeline i; and $j = 1,2,\ldots,n$ within a suitable production or administrative unit during a certain period. Unit: €, $ etc. and tons.

Summarized water distribution theory

The theoretical findings of this study can be collocated in Equation (72) in the case of n water transport channels, basins, pipes and/or tunnels:

$$WATERLOSTtot = \Sigma\,((Ai\,/\,(Bi + Ci)) * TCi * Wair\ impact\ i * Wland\ impact\ i * Wwater\ impact\ i * Wi \qquad (72)$$

$$i = 1,2,\ldots,j$$

where, Ai is the quantity of the transport spillage in a certain water transport route i, Bi is the quantity of the regular transport main water flow in question that produces, for example, Ai; Ci is the quantity of all the unwanted transport flow spillages or losses of the regular water main flow Bi that have a negative impact on Ai; TCi is the total cost of transport route i stopping or changing direction, employing Equation (71); $Wi \geq 0$, the weight conferred to the impact on the air, land and water by residual i and the managers' valuation of the importance of residual i (a dimensionless fraction); and $j = 1,2,\ldots,n$ within a suitable and defined production or administrative unit during a certain time period. Unit: €, $ etc. and m^3 or tons.

Equation (72) is useful at higher administrative and larger geographical levels for simultaneously economizing on resource usage, advancing the technology used and improving the environmental conditions when water transport systems are developed. Lower WATERLOST shadow costs allocated to a trade bloc's accounting systems implies a more efficient handling of the current water flow, since it represents less disadvantageous but constructed costs that occur when applying the EUROPE model. All kinds of technological solutions are encapsulated in the monetary units being used (Stenis & Hogland 2018a).

Transport economy—how to apply the equality principle to transportation

$$PFtransportation = Ai \,/\, (Bi + Ci) \tag{73}$$

$$TRANSLOSTi = transportation\ flow\ shadow\ cost\ allocated\ to\ Ai = PFi * TCi \tag{74}$$

$TRANSLOST_i$ is inserted into the public budgets, estimations, and forecasts of the trade bloc of interest, containing the considered transport route *i* to induce economic incentives to improve.

$$TRANSLOSTtot = \Sigma\,(Ai \,/\, (Bi + Ci)) * TCi * Wair\ impact\ i * Wland\ impact\ i * Wwater\ impact\ i \tag{75}$$

$$i = 1, 2, \ldots, j$$

where, A_i is the quantity of the transport waste in a certain transport route i; B_i is the quantity of the regular transport main flow in question that produces, for example, A_i; C_i is the quantity of all the unwanted transport flow spillages or losses of the regular cargo main flow B_i that have a negative impact on A_i; TC_i is the total cost of transport route i stopping or changing direction; $Wi > 0$, the weight conferred to impact on air, land and water by residual i and managers' valuation of the importance of residual i (a dimensionless fraction); and $j = 1, 2, \ldots, n$ within a suitable and defined administrative unit during a certain time period. Unit: currency and tons.

Ai = $Cost_{time\ delay\ i}$, $Cost_{deterioration\ i}$, $Cost_{pilferage\ i}$, $Cost_{corruption\ i}$, $Cost_{custom\ duty\ i}$, $Cost_{tax\ i}$, $Cost_{fee\ i}$, $Cost_{fuel\ increase\ i}$, $Cost_{energy\ loss\ i}$, $Cost_{labour\ cost\ increase\ i}$, $Cost_{environmental\ impact\ on\ air\ i}$, $Cost_{environmental\ impact\ on\ land\ i}$ and/or $Cost_{environmental\ impact\ on\ water\ i}$

$$
\begin{aligned}
Ci = {} & Cost\ time\ delay\ i + Cost\ deterioration\ i \\
& + Cost\ pilferage\ i + Cost\ corruption\ i \\
& + Cost\ custom\ duty\ i + Cost\ tax\ i + Cost\ fee\ i \\
& + Cost\ fuel\ increase\ i + Cost\ energy\ loss\ i \\
& + Cost\ labour\ cost\ increase\ i \\
& + Cost\ environmental\ impact\ on\ air\ i \\
& + Cost\ environmental\ impact\ on\ land\ i\ and \\
& /or\ Cost\ environmental\ impact\ on\ water\ i
\end{aligned}
$$

TCi = the total cost of war i due to blocked trade route i and/or the natural disaster i causing significant regional economic losses along trade route *i*.

The weight factors $W_{air\ impact\ i}$, $W_{land\ impact\ i}$ and $W_{water\ impact\ i}$ allow management to consider environmental protection in region *i* (Stenis & Hogland 2018bc).

Megacity supply—how to apply the equality principle to supply chains

The flow loss shadow cost (FLOWLOST) is defined as:

$$FLOWLOST = \Sigma\,(Ai\,/\,(Bi + Ci)) * TCi * Wair\ impact\ i * Wland\ impact\ i * Wwater\ impact\ i * Wi \qquad (76)$$

where, $i = 1, 2, \ldots, j$; FLOWLOST is the total shadow cost of the *n* flow systems' inefficiencies; A_i is the quantity of the spillages in a certain flow system *i* (the 'bads'); B_i is the quantity of the regular main utility flow in question that produces, for example, A_i (the 'goods'); C_i is the quantity of all the possibly unwanted system flow spillages or losses of the regular main utility flow B_i that have a negative impact on A_i (the 'bads'); TC_i is the total societal cost of flow system's *i* inefficiency employing Equation (7); $Wi \geq 0$, the weight conferred to the impact of flow system *i* related to air, land and water based on scientific evidence or in terms of the societal aims depending on the managers' judgements or personal preferences (a dimensionless fraction); and $j = 1, 2, \ldots, megacity\ m$ within a suitable and defined administrative unit during a certain time. Unit: €, $ etc.

FLOWLOST is additionally inserted into the public budgets, estimations, and forecasts of a studied trade bloc. It will force that trade bloc to ensure an efficient flow of necessities within the bloc. The general principle is that the lower that FLOWLOST is, the more efficient the flow of supplies to the megacities in the trade bloc will be. A lower FLOWLOST allocated to the trade bloc's accounting systems implies more efficient handling of the bloc's supply flow, since it represents lower disadvantageous costs. FLOWLOST constitutes a tool that management can use to simultaneously monitor, manage, and evaluate its supply projects' performance.

FLOWLOST constitutes a tool for estimation of how the flows of necessities within a trade bloc with many megacities should be organized. The greater the potential for reducing the different A_i in a city, the greater the efforts should be to make the flows into and out of that city more efficient. The megacities within the trade bloc can become more prosperous and the supply flows will be optimised, featuring a combined supply improvement. Businesses will thrive if the EUROPE model is used to efficiently provide megacities with goods (Stenis et al. 2019b).

Ore mining waste—how to apply the equality principle to food webs

Fundamentals of ore mining waste theory

Important basic facts of the food web theory

Frequently, dam disasters occur around the world. As a result, hundreds of families are displaced, and many cities suffer from water shortages. A food web is defined as the natural interconnection of food chains and a graphical representation of what-eats-what in an ecological community, such as rivers and oceans. The EUROPE model mitigates the negative impact of ore mining on rivers and oceans. This research provides a better understanding of how natural resource management could be facilitated through the application of an economic instrument for reducing ore mining spillage.

Theory for reduction of ore mining pollution

Food-web care shadow cost (FOODWEBCAST) is defined as:

$$FOODWEBCASTtot = \Sigma\ [Ai/\ (Bi + Ci)] * TCi \qquad (77)$$

$$i = 1,2, \dots, river\ and/or\ ocean\ current\ j$$

where, $FOODWEBCAST_{tot}$ is the total shadow cost of the *n* rivers and/or ocean currents being polluted; A_i is the quantity of the unwanted river or ocean current nutrients (the ‘bad’); B_i is the quantity of the important nutrients in a river or the ocean current *i*; C_i is the quantity of all regular river or ocean current nutrient flows; TC_i is the total cost of a river or ocean current *i* being polluted by A_i; and $j = 1,2, \dots, n$ in a suitable and defined production or administrative unit during a certain time. Unit: kg, € or $ etc.

$FOODWEBCAST_{tot}$ is additionally inserted into the budgets or accounts of the relevant economic entity, for example, a trade bloc, to induce an economic incentive to reduce A_i and preserve life on Earth by increasing the PSBR. The higher the quantity of the harmful nutrients in the river or ocean current *i*, the more of $FOODWEBCAST_{tot}$ is allocated to the polluter.

Equation (77) enables estimation of shadow costs to be inserted into the economic systems of larger institutions. The model allows managers to have a comprehensive picture of the economy, technology, and environment.

Benefits of applying the equality principle to food webs

The major benefit of the model lies in the reduction of shadow costs (SCs) related to mining waste management. This positively impacts on ore mining performance in technical, economic, and environmental terms.

As a key indicator, the SC shows changes over time in the effective use of mining resources. If the SC increases, this calls for actions from the company in terms of implementation of technical measures required to improve performance. The SC is a warning signal indicating how the toxicity of mining wastes might change over time. Studying the SC helps to determine the magnitude of measures that need to be implemented. A high SC value shows that major changes are required. Changes in the SC point to how effective mining waste management could build up soil nutrients and decrease the pollutants in rivers or ocean currents. The relationship is linear between

A and FOODWEBCAST.

The SC in the model does not show the value of mining equipment, nor does it consider how much money the company has in its bank account. However, the SC indicates how efficiently the company uses its resources to produce non-toxic compounds and allows mining companies to evaluate their use of resources over time. The model can be used as an economic tool to prevent disasters, like the Mariana dam disaster in Brazil in 2015.

Investment in ore production machinery decreases the toxicity of mining wastes by decreasing harmful nutrient levels over time. If the SC increases, correcting measures might be taken to preserve food webs. The SC provides a single, key indicator that summarizes the economic, environmental, and technological performance of most mining companies and other industries.

Conclusion on applying the equality principle to food webs

The EUROPE model can be applied to the management of mining wastes to reduce their effects on food webs and mitigate the negative impact on rivers and oceans. It is useful for environmental issues in general, and particularly for maintenance and reinforcement of food webs in waters.

The approach's novelty is the use of shadow costs to create economic incentives for improvement of mining waste management. Further research could develop mathematical models that better describe food web pollution issues, such as gaseous pollution around mines (Stenis & Hogland 2019a).

Practical application—how to apply the equality principle to real conditions

Fundamentals of the practical application theory

General theory for practical application of the EUROPE model

The EUROPE model is a mathematical formula that determines the degree of shadow costs that should be additionally allocated to wastes to reduce and/or recover them. This creates economic incentives to reduce these targeted waste fractions, which can either be recovered at source, or the production cost can be lowered if the waste fraction of interest is a utility to be maximized. In the latter case, the extraction of substances of commercial interest can be optimised or improved. The shadow costs are inserted into the profit and loss accounts, budgets, and estimations of the relevant actor—in the case study, the MSW firm—according to the following principle:

$$Shadow\ cost\ (SC) = Proportionality\ factor\ (PF) * Total\ cost\ (TC) * Weight\ factors\ (W) \quad (78)$$

$$PF = A / (B + C) = (Value - Cost) / (the\ total\ `goods' + the\ total\ `bads') \quad (79)$$

where, A is the fraction to reduce to improve the production unit's resource efficiency; B is all the valuable products in the output of the current 'black-box' production unit; C is all the unwanted residuals that reduce the result of the organization; TC is the total cost mass of the actor in question, or the total cost of the current system breaking down; and W is W_{air}, W_{soil} and/or W_{water} that are the weight factors to consider the impact of A on the air, soil and/or water. Unit: monetary currency, kilogram, liter and/or joule.

The weight factors (W) are dimensionless expressing the management's concern for the air, soil and/or water. W_{air}, W_{soil} and/or W_{water} is determined based on management's perspective or the demands of public authorities.

Practical foundations for application of the EUROPE model

A lower constructed shadow costs is allocated to A if SC is small. If SC is larger, the incentives to reduce A are greater and consideration of SC results in the environmental and technological standards, and the company profits, being improved. A is reduced by allocating the SC connected to A to the budget and accounting system of a company. This creates substantial economic incentives for the company to promote source reduction of A. In the industrial context, this corresponds to the functionality of the important flow of natural resources from the mines to customers. Thus, the EUROPE model is an economic instrument because it involves economic incentives.

The constructed shadow costs in the suggested approach are a versatile tool that can improve the economic, technological, and environmental efficiency when the proposed model is applied to projects. The shadow cost selected must not be the most optimal in the traditional economic sense, but they must be set at a level that will give management incentives to improve the activities related to the residual issues. However, the term 'optimization' could be relevant because the EUROPE model logically allocates shadow costs to the different waste streams, that are to be minimized.

The production units of different branches of domestic industry, a whole nation or an entire trade bloc will be forced to become more efficient by applying source reduction in line with the EUROPE model. In the waste management case, this source reduction will positively affect the flow of MSW to be utilized. Compared with the situation where the EUROPE model is not applied, the economic and environmental performance will be improved, and the technology in use will be advanced when there are fewer residual products or losses being produced.

Manual for practical application of the EUROPE model

The application of the EUROPE model involves the addition of shadow costs to the costs of the entities, with greater shadow costs added to those cost streams of greater economic and/or environmental significance. Resource efficiency is improved by a step-by-step reduction or recovery of the A fractions identified. This procedure reduces the shadow costs if A yields revenues. The cost development is studied over time to assist in making the production more cost effective. The manual guiding the practical application of the EUROPE model involves the following steps:

1. Determine which residuals to pinpoint, step by step, by estimating the values of A.

2. Calculate the PF by estimating B and C using the company's bookkeeping system.

3. Determine the suitable TC and/or the total breakdown cost from the company's ledgers.

4. Determine the dimensionless weight factors for the company's impact on air, soil, or water.

5. Insert the SC into the accounting system and budgets of the company.

6. Determine the SC for additional A fractions that are of commercial interest.

7. Study the development of SC to monitor, manage and evaluate the performance of A.

8. Take actions to make the system more efficient if SC increases over time.

Case study: A municipal solid waste management firm

The case study concerns a medium-sized Swedish municipal solid waste (MSW) management company. An exchange rate of $1 = SEK8 (September 2017) is used throughout. The numbers in the study are approximated.

The residuals coming to the MSW company are divided into the following flows: (i) the household wastes collected by the citizens themselves in a coloured bag that go to a plant to produce biogas for vehicle fuel and district heating; (ii) the low-energy wastes that are combusted to power the city; and (iii) the high-energy wastes that go to the cement industry. The final, rejected bio manure fraction from the biogas plant may be commercially important as it can be used as fertilizer by farmers to improve the soil structure. This case study shows how the system mainly for production of biogas can be improved by employing the estimated SC value. Using the SC value simultaneously assists the company to make the biogas production more efficient, to increase the extraction of biogas from food wastes and, ultimately, to maximize the recovery of wastes and minimize all the residuals. Note that the EUROPE model is usually used to decrease the amount of the residual A in the numerator. Here, it is shown how the EUROPE model can increase the efficiency of production when A is a utility that increases the revenues. This is accomplished by the EUROPE model optimizing the production cost when A is manufactured. The constructed SC connected to A enables management to optimize A, while monitoring, managing, and evaluating the extraction of food waste-related biogas over time. This is accomplished through the term 'value − cost' in the numerator of Equation (79), which optimizes the whole scenario.

Note that one ton of fermented food waste yields 972 kWh of biogas energy. In Sweden, 1 kWh is worth approximately SEK1 ($0.13). Thus, one ton of fermented food waste is worth approximately SEK1000 ($130). Based on the 2016 data provided by the MSW company in the case study, the following values are inputs for the EUROPE formula:

A = *biogas from food wastes* = *value* − *cost*;

A = value of the biogas energy per ton food waste − cost to produce biogas substrate per ton of food wastes;

$A = SEK1000 - SEK450 = SEK550$ (ca. $71) per ton;

B = total value of the company according to the balance sheet;

B = SEK250 million (MSEK250);

C = total operational cost according to the profit and loss account, used here to approximately represent the total 'bads';

C = MSEK15;

TC = MSEK150; and

Wair = 1.1; Wsoil =1.3; Wwater = 0.7, with the weights estimated as subjective judgements based on the author's and professionals' personal experiences to obtain reasonable weight values for the

MSW company.

These values inserted into Equation (78) yield the following shadow cost for food waste:

$$SCfood\ waste = [(SEK1000/ton\ of\ food\ waste - SEK450/ton\ of\ food\ waste) * 2000\ tons\ of\ food\ waste\ /\ (MSEK250 + MSEK15)] * MSEK150 * 1.1 * 1.3 * 0.7 = SCfood\ waste = (MSEK1.1\ /\ MSEK265) * MSEK150 * 1.0 = 0.0042 * MSEK150 = kSEK623\ (ca. k\$80) \quad (80)$$

Table 10 shows how the resulting shadow cost $SC_{food\ waste}$ of k$80 is applied in practice.

Table 10. Schematic profit and loss account of a medium-sized MSW company employing shadow costs

Revenues
Costs
$SC_{food\ waste}$ (k$80)
Result (k$80)

Features for practical application of the EUROPE model

The A term ‘value − cost’ in the numerator considers how efficient the MSW company is in keeping the cost of producing biogas down and, at the same time, increasing the extraction of biological gas, hence improving profits. If $SC_{food\ waste}$ decreases from one year to the next, this indicates that innovative technical solutions are required to reduce the production cost. If $SC_{food\ waste}$ increases over time, it indicates that management is performing well.

By studying the development of A over time, management is informed about how to manage the first flow of residuals that households place into colored bags that are used to produce biogas at their local MSW plant. Therefore, changes in the term ‘value − cost’ in the numerator in Equation (79) reflect whether biogas is being produced in a cost-effective manner (cost) and how large the gas exchange (value) from the household waste is. If cost increases and value decreases, then the SC decreases, which indicates that consultation with the company’s technicians is required to determine actions to improve the system to produce biogas.

SC indicates when the company in question should initiate activities to improve and increase biogas production. Recommended measures to improve the biogas production efficiency could be investing in better machinery or educating citizens about how to sort waste appropriately. The size of the change in ‘value − cost’ shows to what degree and how quickly these measures should be implemented. In addition, this term in the numerator in Equation (79) expresses how effectively the local households are using the colored bag waste system. For example, if the cost term decreases, this indicates a decrease in the costs involved in the colored bag system for biogas production, and vice versa. Thus, the model provides information about the societal resource efficiency. In response to a reduction in SC, a company could take measures including: (i) the provision of information to households about how to sort and maximize the amount of wastes sorted by using the colored bag system; (ii) improving the technology for biogas production to produce more biogas per unit of wastes, by investing in new machinery; and (iii) increasing the number of production alternatives to enable the sorting of biogas wastes from the high- and low-energy fractions, which are combusted.

By employing currency units in Equation (78), the model reveals technical problems. For the case study MSW company, management inserts k$80 into the accounting system and budget, according to the manual. The objective is to monitor, manage, evaluate, and improve the company's performance of the commercialization of biogas from food wastes. For a certain amount of received food wastes by the MSW company, a decreased $SC_{food\ waste}$ for the next year indicates a need to improve the production apparatus. How efficient the company is at making biogas out of food wastes is expressed by the current cost to produce biogas.

If the MSW company can produce more biogas from a certain amount of fermented food waste, this is incorporated in Equation (78) because the value term in Equation (79) will increase over time and raise the $SC_{food\ waste}$ value. By using the EUROPE model, the MSW company can observe how the costs of producing biogas from food waste change and how much biogas is produced from one ton of fermented food waste. If the MSW company receives more food waste, then $SC_{food\ waste}$ increases. For a given amount of food waste, Equation (1) enables MSW companies to assess performance.

If the MSW company's economic performance increases over time because $SC_{food\ waste}$ increases, it means that the firm's performance regarding food waste has improved, or vice versa. Although the $SC_{food\ waste}$ is a constructed variable, it is useful if taken seriously.

Conclusion on practical application of the EUROPE model

General conclusions on the practical application theory

The study's research contribution involves the development of a versatile economic tool that enables managers to better understand how their companies can become more economically, environmentally, and technically efficient. This tool has been shown to be of use to small- and medium-sized enterprises, particularly MSW companies, and to help them improve the wellbeing of their municipalities. The work contributes to the literature by providing novel solutions to promote the optimization of resource efficiency and to assist MSW managers, and managers in other industries, to improve their company's performance. This improved management situation in industry is the major value of knowledge added.

The EUROPE model gives a versatile theory to waste managers. The novelty of the approach is the innovative usage of the shadow cost constructed to create economic incentives for improvement of the functionality of waste management systems. The launching of a single, key indicator, to simultaneously monitor most aspects of interest for waste management systems, is a highlight. The most interesting findings are the method to facilitate industrial managers' policy decisions and the positive impact on the economic, environmental, and technological development. The method aids managers to reduce spillages and waste in industries and improve resource efficiency.

Main conclusions on practical application of the EUROPE model

The main conclusions are as follows:

1. The research is of practical use to reduce residuals from industry and MSW firms.

2. Cost effectiveness and equity increase because of the reduced risk of spillages.

3. The economic incentives that arise due to the shadow costs improve the utilization of resources.

4. Managers can apply economic instruments to prevent abandoning of polluted areas.

5. Managers obtain an economic instrument to monitor, manage and evaluate companies.

Benefits of using the manual for practical application

1. The EUROPE model and the application method in the manual provide managers with a tool for economic management.

2. The method provides a comprehensive single indicator that is easy to estimate.

3. The method assists companies to simultaneously assess and improve their economic, environmental, and technological performance.

4. The model is applicable to the MSW industry and to other industrial activities.

5. The method is based on economic theory from recognized studies (Stenis & Hogland 2018d).

Main Conclusions on the Equality Principle

1. The equality principle can successfully be applied to the flows of materials and energy to reduce residuals at source.

2. The EUROPE model, based on the equality principle, can improve the resource economy.

Further Research on the EUROPE Model

In 2020, Dr. Jan Stenis developed the Naturally Optimised Revenue Demand in Communities (NORDIC) model (Stenis 2020abcde, 2021bc). The NORDIC model has been applied to improve the efficiency of major organizations, to improve the Swedish education system and increase the wellbeing of the workforce, improve the Swedish climate, and reduce the crime rate in Sweden, plus improve migration to this country, where Jan lives. But the present work describes applications of the EUROPE model.

Recommendations on the Equality Principle

1. Apply the equality principle to the flows of materials and energy to reduce residuals at source.

2. Apply the EUROPE model, based on the equality principle, to improve the resource economy.

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Forever and Ever

Another time,
another place,
plenty of nickel and dime
and much more space.

Another Vision
for a better life
with a bold Mission,
without any strife.

Another Love
to glorify altruism,
inspired from Above,
reduces the schism.

Another Saviour
for Universe of Man,
with good behaviour
as humanity can!

Jan Stenis

Optimistic

EUROPE Model Application to Material and Energy Flows to Improve the Resource Economy describes how the Efficient Use of Resources for an Optimal Production Economy EUROPE model promotes the living conditions by providing economic incentives to improve the industrial resource economy for the benefit of mankind. The work is based on the scientific papers on the EUROPE model published by Dr Jan Stenis 2000-2021.

The EUROPE model is applicable to very many activities that transform their input into utilities. The present book appeals to academics interested in policy redesigning, and practitioners who want insights into how to best utilize the taxpayers' and industries' money. The main purpose is to increase the cost-efficiency of resource usage to give the people a better life.

Dr Jan Stenis is Scientific Researcher in Sweden. His research focuses on public policy and the resource economy. He holds a PhD in Engineering from Lund University, Sweden, and an MSc in Management Science from Imperial College, Technology and Medicine, UK, through a scholarship from Chalmers University of Technology, Sweden. He received the Environmental Award from the Swedish Association of Graduate Engineers in 1998. The EUROPE model is an economic instrument invented by Dr Stenis and aimed at resource economics to improve people's life quality. In 2011, Dr Stenis became member of The Swedish Writers' Union. He joined The Swedish Haiku Society 2018. Dr Stenis's motto is ***Love and Knowledge***

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