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Modeling both direct and indirect environmental load of purchase decisions: a web-based tool addressing household metabolism

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ABSTRACT

Consumer awareness is continuously increasing towards pro-environmental behavior. Thus, we developed a web-based environmental feedback tool *EcoRunner*, which is designed for Swedish households aiming at increasing the awareness in a more pro-environmental direction. The conceptual model of *EcoRunner* has been developed based on top-down and bottom-up approaches connecting economic activities within a household to environmental pressures (both direct and indirect). In addition, the development of the tool includes a multi-level model aiming at better tailor-made advice to consumers. In this paper, we examine the *EcoRunner* tool with average single Swedish household expenditures as well as explore options for reductions and systems effects. Analysis shows that *food and non-alcoholic beverages*, *fuel* for personal transport (e.g. car) and *air* transports have significant environmental pressures. In addition, this study suggests that *EcoRunner* could be used in education systems as an environmental feedback tool to enlighten consumers motivation and change consumption patterns.

Software availability

Name of software: EcoRunner

Developers: Collaboration of Industrial Ecology, KTH; Centre for Consumer Science, University of Gothenburg; and Service Research Center, Karlstad University.

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Availability and Online Documentation: Freely available at: http://ecorunner.industrialecology.se.

Year first available: 2011.

Type of Software: Web-based software.

Hardware required: Any modern PC.

Software required: Mac OS X, Windows, Linux (tested on Windows 7 and Mac OS X 10 (and later) for IE, Firefox, Google Chrome and Safari).

Language: Swedish.

1. Introduction

In recent years, interest in consumers (both private and public) as well as the role of the consumers has been gradually increased in terms of sustainable development in Sweden and the EU. The so-called Integrated Product Policy (IPP) (Rehfeld et al., 2007; CEC, 2003; Heiskanen, 2002; EC, 1998) is a catchall set of perspectives and (mostly existing) measures to decrease environmental pressures. One part of the IPP is looking at existing and possible new measures for influencing the development of private and public consumption in a more sustainable direction, e.g. by influencing the volume or structure of consumption today and also by influencing the entry of new products/technologies that offer a more sustainable alternative within product groups.

Consumer activities centered on households can be linked to patterns of inputs and outputs of the economy and thus to the associated environmental pressures[1] of economic activities. Since the major proportion of consumer activities takes place within

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[1] European Environmental Agency uses environmental indicators associated with the DPSIR framework (Driving forces, Pressure, State, Impact, Response) indicators for reporting activities to policy makers (Smeets et al., 1999). In this study, we use the DPSIR semantics. According to the framework, environmental footprints are used as an indicator of 'pressures'.

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households (Jones and Kammen, 2011; Björck, 2010; McKenzie-Mohr, 1999), it is households (rather than individual consumers) that determine a large proportion of resource consumption. The term *household metabolism* (Moll et al., 2005) refers to both the demand for resources, i.e., the direct flows of resources through households (including various emissions), and the supply of resources, i.e., the materials and energy indirectly required to realize these flows (e.g. in mining, production of materials, construction of houses, and manufacturing goods).

During the past fifteen years, it has become increasingly obvious that indirect energy use (the energy needed to produce goods and services used in industries, in the transport sector and in retail), is as important as direct use (e.g., fuels for cars) when it comes to household metabolism. For example, Vringer and Blok (1995) found that of the total average energy demand for a Dutch household, 54% was indirect.

Reinders et al. (2003) found that the indirect proportion of total energy requirements per average household in 11 European countries ranged from 36 to 66%. In Indian households, half of energy use was indirect (Pachauri and Spreng, 2002) and a study from Brazil showed that 61% was indirect (Cohen et al., 2005). There is overwhelming evidence that for households to realize their full energy saving potential, indirect energy has to be considered. Of all energy use in a country, around 60–70% can usually be attributed to household metabolism. Energy use is the main contributor to anthropogenic emissions of greenhouse gases.

In order to make everyday behavior more environmentally friendly, external barriers must be overcome, such as non-existent feedback on indirect pressures of consumption (Gardner and Stern, 1996). In addition, internal barriers such as lack of knowledge and commitment must be overcome. There has been an optimistic belief that the availability of information would foster environmentally sound behavior among the general public. However, it has been found that there is no automatic link between knowing and doing. Norms, values and feelings have been shown to be a vital part of the picture (Lundgren and Naturvårdsverket, 2000; Biel, 1996). Feedback directly tied to people's own behavior has been shown to be more effective than general information and prompts. Feedback by information is an important policy instrument for behavioral change when it is directed at a well-defined target group and presents information/advice in close relation to relevant behavior.

Over the last decade, there has been much development in terms of aids and tools for analyzing the indirect environmental pressures of products. These range from detailed Life-Cycle approaches with huge databases being assembled, over Input-Output-based measures to simple public domain calculators for estimating the direct and indirect energy requirements for certain purchases and actions. Existing studies of household metabolism (Hertwich, 2011) have mostly used Input-Output analysis (IOA), which is a method conducive for quick appraisal but not detailed enough for modeling changes. Thus, we developed a tool based on environmentally extended economic IOA (a top-down approach) (Minx et al., 2009; Nansai et al., 2009, 2012) and environmental footprints (Frostell, 2013) in a product/service level in a life cycle perspective (a bottom-up approach) considering both the direct and indirect metabolism. We named the tool *EcoRunner*[2] (Frostell et al., 2011).

EcoRunner is a web-based environmental feedback tool that was developed for Swedish households with the aim of increasing awareness and, consequently, changing behavior in a more pro-environmental direction. A number of similar footprint calculators, for example, The Climate Account (TCA, 2013), GoodGuide,[3] Shopgun,[4] CoolClimate,[5] Ecological Footprint,[6] are available in the Internet. However, they are either based on environmentally extended economic IOA or based on environmental footprints in a product/service level. Furthermore, some of them are based on very aggregated simplified assumptions, for example, *How much fruit and vegetables do you eat, including fruit juice?* (TCA, 2013). In addition, these tools are capable of estimating some of the economic purposes in daily life to environmental footprint. On the other hand, *EcoRunner* is based on *Classification of Individual Consumption by Purpose* (COICOP[7]). Here, the user can organize their weekly/monthly/yearly expenditures with environmental footprints and can compare their improvements towards environmentally benign purchase decisions. Further, *EcoRunner* runs two models: consumers' economic input to environmental pressures (top-down model at household level) and product footprints for comparing products (bottom-up model at product level in a life cycle perspective). Furthermore, this tool may complement other tools by calculating energy and emission footprints at the individual and/or household level. Moreover, it contains more detailed information about the products and services while informing on how to cut emission and energy consumption by advising on the environmental pressures of specific purchase decisions (i.e., comparing the products). In this way, *EcoRunner* aims at influencing individual consumers and households towards a change in consumption patterns that contribute to a more sustainable life style.

The aim of this paper is to describe the *EcoRunner* modeling tool of both direct and indirect environmental pressures of household purchase decisions and to explore options for reductions and systems effects. It focuses on two objectives: (i) presenting the structure and development of *EcoRunner*, (ii) exploring reduction options by analyzing an average single Swedish household expenditure and corresponding environmental footprints in terms of energy use, global warming potential (CO_2eqv), and nitrogen oxides.

2. Methodology

An overarching idea of the *EcoRunner* modeling is to connect economic activities within a household to environmental pressures (both direct and indirect) to make an environmentally benign purchase decision. Emission intensity of a product/service or a product/service group based on a national input output analysis (IOA) could capture both economic activities and associated direct as well as indirect environmental pressures (Minx et al., 2009). However, environmentally extended IOA lacks a detailed analysis at product level (Fischer-Kowalski et al., 2011). In addition, consumers need to understand the environmental pressures from specific purchase decisions, for example purchasing tomatoes from Sweden or Spain, to have a pro-environmental behavior. Here, product footprints based on life cycle inventories could give a detailed information at product level, but it cannot capture indirect environmental pressures at a household purchase level. Thus, we conceptualize an overarching hybrid model based on top-down (e.g., IOA) and bottom-up (i.e., product footprints in a life cycle perspective) approaches considering both the direct and indirect metabolism.

3. *EcoRunner* tool

3.1. A conceptual model

3.1.1. Overarching requirements

The tool needs to show the household's (or an individual's) metabolism at two different main levels:

Level 1 The overall metabolism for a household or an individual would be divided into (i) a number of main categories, (ii) each one

[2] http://ecorunner.industrialecology.se.

[3] http://www.goodguide.com.

[4] http://www.shopgun.se.

[5] http://coolclimate.berkeley.edu/carboncalculator.

[6] http://myfootprint.org/en/.

[7] http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5.