

# THE POTENTIAL OF UBICOMP TECHNOLOGIES TO DETERMINE THE CARBON FOOTPRINTS OF PRODUCTS

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## ***Abstract***

*Several problems exist in accurately quantifying the greenhouse gases (GHG) which result from the production, transportation, usage, and recycling of products. We review in this paper the current attempts at measuring GHG emissions and investigate the potential of UbiComp technologies in improving the state of the art in carbon footprint calculation and in communicating the result to consumers. This has potential benefits on consumer awareness and behaviour and can also foster competition among companies towards higher energy and resource efficiency.*

## **1. Introduction**

Companies measure energy usage and greenhouse gas (GHG) emissions to comply with regulations, to assess their performance in an energy-constrained economy, and to participate in a growing carbon market [8]. Moreover, some organizations also identified the value of communicating the carbon footprint<sup>1</sup> of their products to end consumers who increasingly consider environmental aspects in their purchasing decisions [4]. However, a number of challenges need to be addressed when determining GHG emissions for individual products or services. In particular, it is difficult to capture all relevant emissions along the product's lifecycle and to account for the variations in footprints of individual instances of products, such as spatial, temporal, and supplier variations. In this contribution, we propose a solution that leverages UbiComp technologies in order to dynamically track a product's carbon footprint along its life-cycle and make it easily accessible to the consumer. The benefit of such a solution is that it enables comparisons on many levels, for example between variations of the same product, between products from different manufacturers, and between different companies upstream in the value chain. Consumers can then exert pressure by selecting the least carbon-intensive products. We provide a review of methods used to measure GHG emissions in section 2 and outline in section 3 where UbiComp technologies can help. We conclude in section 4.

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<sup>1</sup> "The carbon footprint is a measure of the total amount of CO<sub>2</sub> emissions that is directly and indirectly accumulated over the life stages of a product." [11]

## **2. State of the art in measuring energy usage and GHG emissions**

We review in this section the approaches used to determine the emissions of companies (supply side) and tools that calculate emissions due to the consumption by individuals (demand side).

### **2.1. Supply-side approaches**

There are several standards and guidelines used by companies in order to quantify and report their GHG emissions. The most prominent standard is the GHG corporate protocol [8], used by the majority of the FT500 companies and serving as the basis for most GHG guidelines and programs. This protocol is accompanied by tools that help companies to calculate their emissions. Various other tools exist in the context of GHG reporting programs such as CARROT for participants in the California Climate Action Registry [3] and SEIT which is provided with the DoE 1605b voluntary reporting program [6]. Furthermore, software vendors offer enterprise solutions for carbon and energy management, e.g. Environmental Compliance by SAP [9].

There has recently been some effort to calculate the carbon footprint of some particular products using a supply-chain-wide approach. Prominent examples are the pilots conducted by Carbon Trust together with brands such as Walkers and Trinity Mirror [4]. Furthermore, CarbonCounted provides an online application for brand owners, also for the purpose of calculating a product's footprint [5]. These two examples differ in many aspects which makes it impossible to accurately calculate and compare a product's footprint, such as whether they include all GHG emissions or only CO<sub>2</sub> and whether they consider offsets. They do not take the energy usage at the retailer into consideration, or do so in a very coarse-grained way. Neither takes home usage into account. These issues make it impossible to accurately calculate and compare a product's footprint. Finally, when different suppliers have different footprints, or when there are temporal or spatial variances between different instances of a product, average numbers are used, which results in inaccurate results. Examples include fruits bought off-season which require six months of chilled storage or products being shipped half way across the globe.

### **2.2. Demand-side Approaches**

Many carbon calculators are available to determine the carbon footprint of an individual or a household. According to Bottrill [1], the calculators give an annual result based on one data entry per activity, thus not taking seasonal or lifestyle fluctuations into consideration. The author adds that the tools are falling short of accurately monitoring people's energy use and providing the feedback required. In the field of monitoring energy usage, there are several projects that provide accurate numbers by conducting measurements on household devices. For example, Kuckuck is a project which uses sensor data to display domestic energy consumption [10]. The Device-Level Power Monitoring system [7] comprises monitoring units that plug into power outlets enabling per-device electricity monitoring. Despite such projects that measure the energy usage of different devices at home, this usage is not meant to be attributed to the products that require them, for example the energy used by a washing machine or a refrigerator is not distributed, respectively, among the clothes and foods inside. In effect, the energy usage at home cannot be accumulated to the total carbon footprint of a product which until now is focusing only on the supply-side calculations. In the next section we will describe how products can have one dynamic carbon footprint which is easily accessible to users.

### 3. The potential of UbiComp

To calculate a dynamic carbon footprint, we need a mechanism that links information about emissions with the products that required them, namely by assigning to each item its share of the emissions of each emitting process. This can be achieved via the unique identification of items, e.g. via the Electronic Product Code (EPC) [2]. Items with an EPC number can be tracked from manufacturing along the supply chain and until the retailers, with the possibility to add dynamic information – such as the carbon emitted at each partner – to the EPC Information Services (EPC IS). With unique identification in place, the share of yet-disregarded life-cycle stages of the product's footprint can be quantified and attributed to the items that required them. For example, the same EPC number can be used to identify items beyond the point of sale, where intelligent devices can attribute their consumed energy to the items using it. Unique identification can also make the product footprint easily accessible, e.g. to a consumer on his mobile phone. After including all the product life-cycle stages, we would be able to consolidate the emissions and assign them to individual items or other entities. This approach therefore comprises two stages. The first stage is an information gathering stage that can be realized by a publish/subscribe system in which process owners publish the process information and users (including items) can be subscribed to the processes they are part of. The second stage is an on-demand calculation of an item's footprint based on the available process/item information. Our initial research indicates that only minor changes are necessary to use EPC Information Systems for the purpose of carbon footprint management.

### 4. Conclusion

We reviewed in this paper the available approaches in measuring GHG emissions and noted their shortcomings in contributing to the accurate quantification of carbon footprints of products. We then highlighted the potential of UbiComp technologies in contributing to this effort. Such technologies can also make the carbon footprint of products conveniently accessible to consumers. This enables consumers to exert pressure on the brand owner to decrease the footprint and it helps influence their own behavior at home in order to keep the footprint as low as possible. Also, if companies can compare the carbon-intensity of products from different suppliers, they can exert pressure by selecting partners with the least carbon-intensive products.

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## **Motivation**

This paper comprised a brief review of measures to calculate carbon emissions and possible ways to make carbon footprints more accurate by including the various product lifecycle stages. Since our focus is on providing the consumers with the appropriate information to empower them in the decision-making process, the key question is which information consumers need, how to retrieve it, and how consumers will be influenced by it. Also important is the optimal medium and form of presenting the information and how to measure their feedback including possible third-order effects. We are eager to discuss such questions in the workshop and learn from others' experiences. More information about us and other related research can be found at [www.bits-to-energy.ch](http://www.bits-to-energy.ch).

## **Authors' Biographies**

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