Activity-based Carbon Footprint Modeling of the manufacturing processes of Intimate Apparel Products

建构内衣产品作业基础碳足迹模型

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Introduction 简介

Activity-based Carbon Footprint Modeling of the Manufacturing Processes of Intimate Apparel Products (ACFM) aims at providing an understanding of the carbon emission status-quo of the manufacturing processes of intimate apparel products, so that carbon reduction opportunities can be identified.

This software dissects the manufacturing processes of most sought intimate products into activity-based carbon footprint constituting modules, then to model, gather, analyze and disclose the activity-based carbon footprints of the apparel products.

建构内衣产品作业基础碳足迹模型 (下称： ACFM) 的数据，以确保用户可以明白内衣产品制造工艺的碳排放现状，从而可以了解碳减排机会及识别低碳竞争优势的发展。

此软件将常见内衣产品的制程解剖成模块，然后建构作业基础碳足迹模型，经收集相关数据后，以产业数据库的形式有效地储存，再透过一个客制化的计算机程序，进行分析和汇报。

Why is this software required? 为何需要此计算工具？

Since carbon footprint calculation system specifically for intimate apparel product could not be easily found, this software helps users to identify, analyze and report the carbon footprints of the most sought intimate apparel products so that significant carbon reduction opportunities for the development of low carbon competitive advantages can be identified. This innovative and practical approach, together with the customized computer program will allow maximal flexibility and cost effectiveness in carbon footprint disclosure that fits the characteristics and demand of today's intimate apparel industry.

Advantages of using this tool:

- In alignment with government regulations of carbon reduction, users can understand better about energy consumption in each production activity and carbon emission performance in their companies and factories.
- According to reports generated from the software, users can set policies for reducing energy and emission in all production activities of their companies and

factories, resulting in a better cost control and corporate efficiency.

- Comparing with Life Cycle Assessment (LCA) approach, ACFM possesses the advantages of simple, user-friendly, maximal flexibility and cost effectiveness in carbon footprint calculation.
- Users can compare the performance and distribution of carbon footprint in different orders or styles.
- Users can compare and record the carbon footprint in different months, so as to enhance competitive advantage by observing the trend.
- To provide opportunity to reduce carbon emission of the entire supply chain.

由于现时专门为内衣产品度身订做的碳足迹模型十分少见，此创新且务实的碳足迹可帮助用户识别，分析及汇报主要内衣产品的碳排放，可有效优化厂商在实践时的灵活性和成本效益，非常符合当今内衣产业的特质及需求。

使用此工具的好处：

- 为配合政府的减碳政策，用户可以了解企业和工厂内各主要活动的能源消耗及碳排放表现。
- 用户可根据报表的分析，为企业和工厂各主要活动订出减排及节能的方案，从而加强成本控制及企业效率。
- 与生命周期评估（LCA）方法相比，此工具以简单，容易使用，灵活性高和高成本效益的方法为用户计算碳排放。
- 用户可比较不同订单或产品款式碳排放的表现及分布。
- 用户可比较及记录不同月份企业的碳排放，检视其碳排放趋势来提升竞争优势。
- 为用户提供整条供应链节能减碳的机会。

Major users 主要用户

This software might be used by:

- The 10 manufacturing types of corporate identified in the intimate apparel industry
- Departments in-charge of energy saving
- Units who need to report their energy utilization
- Other energy consumption units
- GHG accounting consulting companies, third-party certification companies and research institutions

- Planners of regional low-carbon development or low-carbon action program

此计算工具可被以下单位使用：

- 十个内衣业的生产类别的企业
- 各级节能控排主管部门
- 需要上报能源利用状况的单位
- 其他用能单位
- 从事温室气体核算的咨询公司、第三方认证公司和相关研究机构
- 地区低碳发展规划或低碳行动方案的编制者

Basic calculation concept 基本计算原理

- Carbon emission of manufacturing activities (P) 生产活动的碳排放(P):

$$P = \sum_{f=1}^{n} \left(E_f K_f + E_f A_f + E_f C_f \right)$$

where f = fuel type, E_f =emission factor of fuel per kg, K_f = fuel consumed by key equipment, A_f = fuel consumed by auxiliary equipment, C_f = fuel consumed in corporate level

以上 f=能源种类, E_f =该能源种类每公斤的碳排放系数, K_f =主要设备的的能源消耗, A_f =辅助设备的能源消耗，C_f =企业活动的能源消耗

- Carbon emission of external transportation(T) 外部运输的碳排放(T):

$$T = \sum_{f=1}^{n} \left(E_d T_f \right)$$

where E_d =emission factor of vehicle type per km, T_f = distance travelled in external transportation

以上 E_d =运输工具的每公里的碳排放系数, T_f =外部运输的距离

- Carbon emission of material (M) 材料的碳排放(M):

$$M = \sum_{m=1}^{n} (E_m M_m)$$

where m = material type, E_m=emission factor of raw material per kg, M_m= material consumed

以上 m =材料的种类，E_m=该材料每公斤的碳排放系数，M_m=材料使用量

- Carbon emission of Intimate Apparel Product (I) 内衣产品的碳排放(I):

  $I = P + T + M$

ACFM Overview ACFM 概览

Project boundary 项目边界

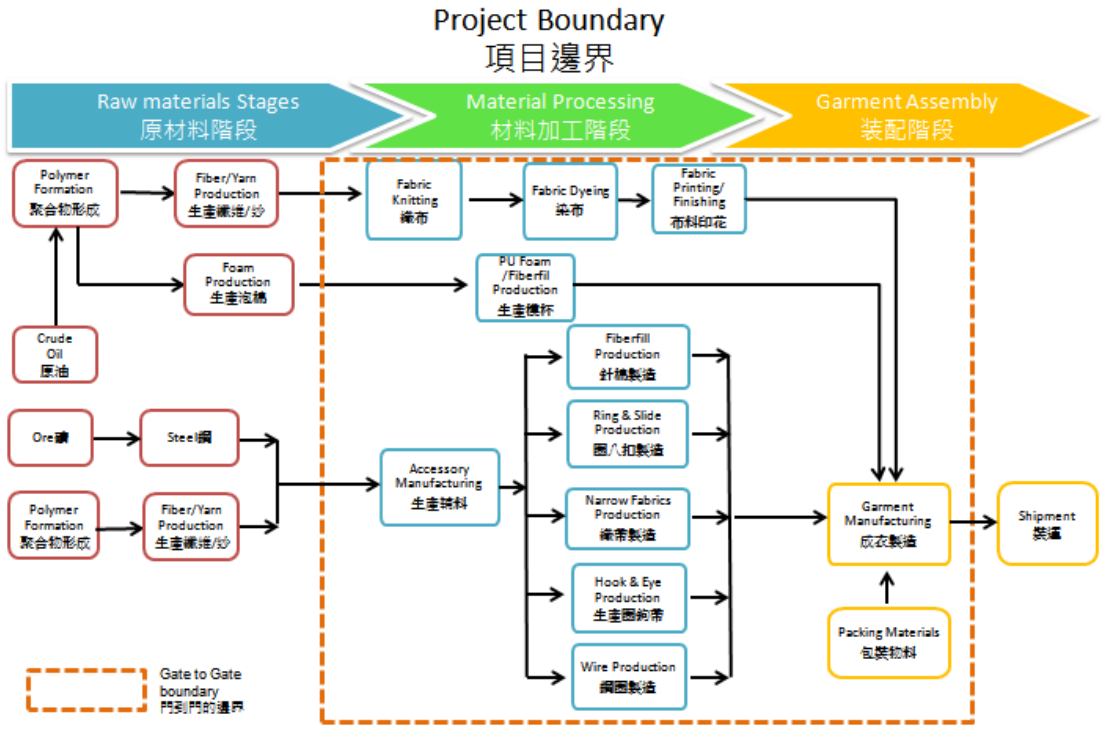

Figure 1 Project Boundary 图 1.项目边界

"Gate to Gate" approach which means calculating carbon emission from textile material processing to garment manufacturing within factories' gate was set as the project boundary. Since raw materials were out of the boundary, its calculation of

carbon emission would be optional to users and its carbon emission factors were obtained from literature.

采用“门到门” 的边界，指包括计算材料生产到成份生产过程内的碳排放。由于材料并不在此边界之内，所以其碳排放的计算是由用户选择是否提供，而其二氧化碳系数是由文献中取得的。

Operational boundary 营运边界

Direct emission & Indirect emission 直接排放及间接排放

- Direct GHG emissions are emissions from sources that are owned or controlled by the reporting corporate, e.g. emissions from factory stacks, manufacturing processes and vents, and from corporate-owned/controlled vehicles.
- Indirect emissions are emissions that are a consequence of the activities of the reporting corporate, but occur from sources owned or controlled by another corporate, e.g. emissions from the production of purchased; electricity and contract manufacturing.

- 直接排放：由核算企业直接控制或拥有的排放源所产生的排放。
- 间接排放：由核算企业的活动所导致的，但由其他企业直接控制或拥有的排放源产生的排放。例如：购入电力和承包商工序。

Scope I, II, III 范围 I, II, III

According to Greenhouse Gas Protocol[1], the definitions of Emission boundary are listed below:

- Scope I accounts for direct GHG emissions from sources that are owned or controlled by the reporting corporate.
- Scope II accounts for indirect emissions associated with the generation of imported/purchased electricity, heat, or steam.

[1]宋然平,杨抒,孙淼. (2012). GHG Protocol Tool for Energy Consumption In China (Version 2.0).

- Scope III allows for the treatment of other indirect emissions that are a consequence of the activities of the reporting corporate, but occur from sources owned or controlled by another corporate.

根据温室气体核算体系[1]，排放范围的定义如下：

- 范围 I：由核算企业直接控制或拥有的排放源所产生的排放。例如企业拥有或控制的锅炉燃煤排放、车辆燃油排放和工艺过程排放。
- 范围 II：核算企业自用的外购电力、蒸汽、供暖和供冷等产生的间接排放。
- 范围 III：核算企业除范围二之外的所有间接排放，包括价值链上游和下游的排放。例如购买原材料的生产排放、售出产品的使用排放等等。

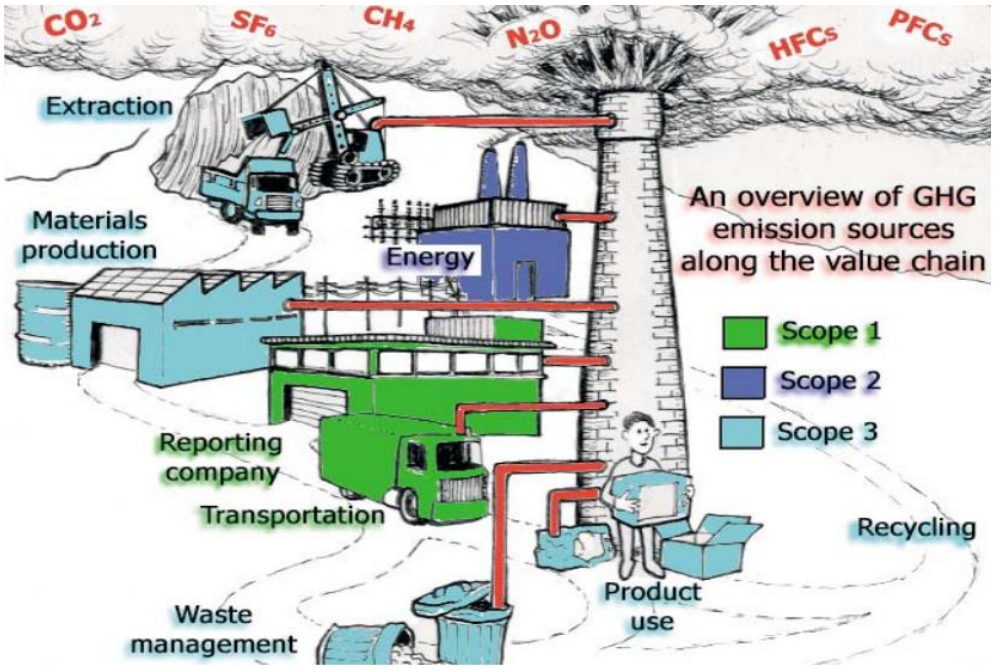

Figure 2 Overview of GHG emission sources along the value chain

图 2. 供应链的碳排放范围概观

Different activity levels 不同活动层面

In the ACFM model, the carbon emissions are mainly dissected and reported according to different activity levels. Compare with Scope I, II, III reporting, this could allow users to identify carbon reduction opportunities at different aspects more easily. The 3 activity levels are:

- Energy consumption of key production activities (K): Major activities that are necessary applied to the product in the course of production.

- Energy consumption of auxiliary facilities along production (A): Major facilities that are operating along execution of production but not applying in production. Such consumption has no direct relationship to production.
- Energy consumption from corporate operation (C): Major facilities that are operating outside the production area but within the factory site.

Besides the above 3 levels, there are carbon emissions within the supply chain of intimate apparel products but from sources other than production activities. Because some of such data are not directly controlled by the corporate (such as carbon mission from subcontract key production activity, production of material, fuel combustion from material import and fuel combustion from external transportation), and some activities are favorable to the environment in other viewpoints (such as effluent treatment), ACFM would report these data separately from the above mentioned K/A/C scope. Depending on the comprehensiveness of data collected by each corporate, the software would allow users to input these data optionally. Reports will preset these data in separate sections.

根据本项目的模型，碳排放会被剖析为不同活动层面，并作分别汇报。比较范围 I, II,III 的报告方式，用户可以更清楚识别出于不同层面的减碳机会。三个活动层面分别为:

- 主要生产活动的能源消耗(K): 生产活动中主要的工序的能耗。
- 辅助生产活动的能源消耗(A): 辅助进行主要生产活动的能耗，不是直接参与生产流程。
- 企业活动的能源消耗(C): 生产活动范围外，但包括在工厂内的能耗。

除了以上 3 个活动层面外，内衣产品的供应链当中会包括从其他活动来源产生的碳排放。但因为这些数据通常不是由公司直接控制（如外包活动的碳排放，生产材料的碳排放，材料进口的燃料消耗的碳排放和外部运输的燃料消耗的碳排放），和一些活动是在其他方面有利于环境保护的（如污水处理），ACFM 会把这些数据从上述的三个范围区分开。因应每企业所能收集的数据的全面性不同，软件系统将允许用户选择性输入这些数据。报表亦会分别列出计算结果。

	Key production activities (K) 主要生产活动	Auxiliary facilities (A) 辅助生产活动	Corporate operation (C) 企业活动	Independent report 独立报告
Scope I 范围 I	1. Fuel combustion from boiler (for specific key activity) 主要活动锅炉的燃料消耗	1. Fuel combustion for production servicing activities 服务生产活动的燃料消耗	1. Fuel combustion from internal transportation 内部运输的燃料消耗	1.Direct emission from effluent gas 废水处理产生气体的直接排放
	2. Fuel combustion from electricity generator (for specific key activity) 主要活动发电机的燃料消耗		2. Fuel combustion for cooperate activity (e.g. canteen) 企业活动的燃料消耗 (如食堂)	
			3. Fuel combustion from electricity generator 发电机的燃料消耗	
Scope II 范围 II	1. Electricity consumed by key machines in key production activity 主要生产活动中主要机器的燃料消耗	1. Electricity consumed by auxiliary facilities in key activity 主要活动中辅助设施的电力消耗	1. Electricity consumed in other non-production areas in factory 工厂内的非生产范围的电力消耗	1. Electricity consumed by machines in effluent treatment facility 污水处理设备的电力消耗
	2.Purchased production water 购入生产用水	2.Eletricity consumed in production assisting zone 服务生产活动	2.Purchased domestic water in other non-production areas in factory	

		的电力消耗	工厂内的非生产范围的购入生活用水	
	3.Purchased steam 购入蒸气	3.Purchased domestic water for production assisting zone 服务生产活动的购入生活用水		
Scope III 范围III	1.Subcontract key production activity, electricity consumed by key machines (optional) 外包活动的主要生产活动中主要机器的电力消耗 (可选提供与否)		1.Waste 废物	1.Emission from production of material 生产材料的排放
			2.Paper 纸张	2.Fuel combustion from material import 材料进口的燃料消耗
				3.Fuel combustion from external transportation 外部运输的燃料消耗

Table 1 Comparison of carbon emission under each different activity level and scope

表 1. 各活动层面和各范围的碳排放对照

Flow of data input 输入流程

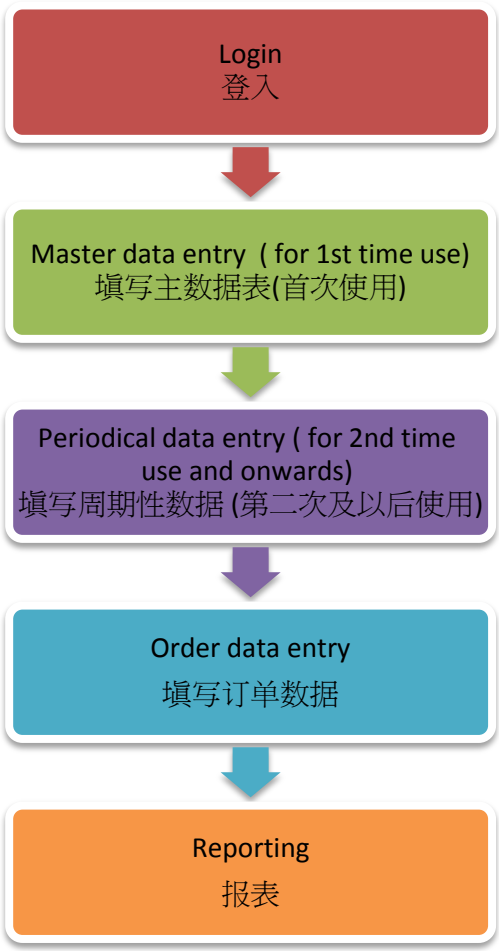

Figure 3. Flow of system data input

图 3. 系统数据输入流程

After login, users have to input all the data under the master tables if it is used for the first time. Then, fill in the periodical data monthly. Next, fill in order data. At last, the reporting function will be able to generate reports according to user requirements. Refer to table below for more details.

用户在登入后，如是首次使用，需要先填写主数据表内的数据。然后按月填写周期性数据。最后，在需要记录订单时填写订单数据。报表功能便可以输出用户所需报表。详情请参阅下表。

Type of software Data 系统数据类别	Software Input items 系统输入项目
Master Data 主数据表	➢ Key activities 重点活动 ➢ Auxiliary facilities 辅助设施 ➢ Corporate information 公司资料 ➢ Production machineries 生产机械 ➢ Types of fuel 燃料类别
Periodical data 周期性资料	➢ Overall energy consumption 整体能源消耗 ➢ Energy consumption of auxiliary facilities 辅助设施的能源消耗 ➢ Energy consumption of corporate level 企业营运能源消耗 ➢ Effluent treatment 污水处理 ➢ Monthly production information 每月生产资料 ➢ Monthly holiday information 每月假日资料
Order Management 订单管理	➢ Product & order information 产品及订单资料 • Product Type 产品类别 • Order Quantity 订单数量 • Product Features 产品主要特点

Contact Information 联络方法

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