

**AIRDYE® ENVIRONMENTAL PROFILE**  
**LIFE CYCLE ASSESSMENT**



## WHAT IS AIRDYE®?

AirDye® technology manages the application of color to textiles without the use of water. It is today's sustainable alternative to traditional dyeing and decorating processes.

### AIRDYE® TECHNOLOGY CREATES NEW DESIGN CAPABILITIES:

#### Dye Contrast



#### Dye Squared



#### Print 2 Dye



#### Print 2 Print



### WHY FOR THE WORLD?

AirDye® technology from Colorep®, Inc., a California-based sustainable technology company, is a solution our planet needs today and for many tomorrows.

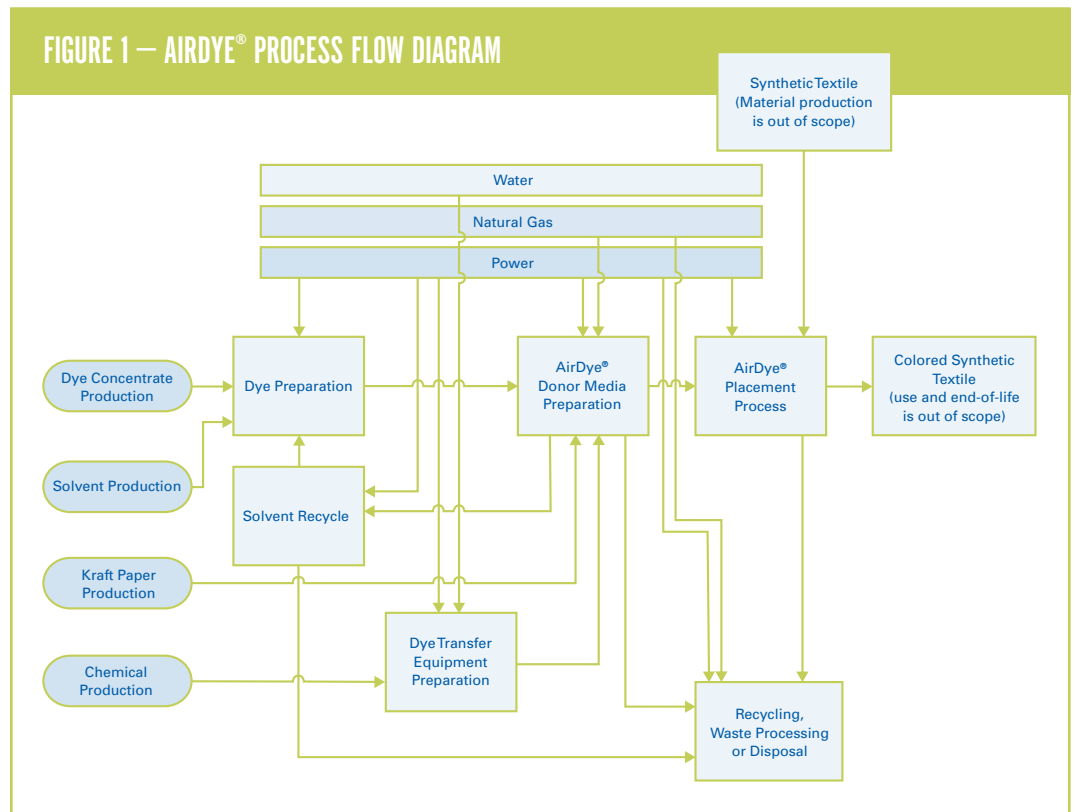
#### AirDye® technology:

- Does not pollute water in the color application process. By using air instead of water to convey dye, no hazardous waste is emitted and no water is wasted.
- Greatly reduces energy requirements, thereby lowering costs and satisfying

the strictest standards of global responsibility.

- Does not use boilers, screen printing machines, drying ovens, or cleaning and scouring chemicals, thereby eliminating major sources of pollution.
- Eliminates water in the color application step and simplifies the process, creating revolutionary possibilities of new industry and employment in unfarmable, arid regions of the world.
- Gives consumers a way to choose style and sustainability at a realistic price at the point of purchase, thereby initiating world change.

FIGURE 1 — AIRDYE® PROCESS FLOW DIAGRAM



## WHY FOR BUSINESS?

Business today must achieve high quality, lower costs, be competitive, and meet customer demand for environmentally responsible products that are attractive.

### AirDye® technology:

- Is easy to specify, reduces cost, offers beauty and quality, and reduces environmental impact.
- Offers style without sacrifice. There is no dye-lot variation, no post-dye washing or treatments, and no minimum quantity.
- Offers exciting new options:
  - Dye different colors on opposite sides of fabric.
  - Dye fabric a solid color.
  - Dye one side a solid color and the opposite side a print.
  - Dye one side of fabric with a print and the opposite side with another print.
  - Dye opposite sides of fabric with the same print.

## HOW DOES IT WORK?

Conventional dyeing, such as vat dyeing or cationic dyeing, can produce visually acceptable results. On the down side, it uses polluting chemicals, a huge amount of precious water, and does not provide permanent coloration. Sublimation printing has been used to decorate synthetic

textiles, but this process has limited application.

AirDye® technology produces superior results compared to sublimation printing and conventional dyeing, but that is just the beginning of its advantages. AirDye® technology also reduces detrimental impacts on the environment. And, because the dye is *in* the fiber rather than *on* the fiber, bleach and cleaning agents can't get to it; so colors look richer and last longer. The result is more beautiful colors and maximum color durability, with substantially less water and discharged chemicals.

### Dyeing – Toxic from the start. Until AirDye®.

Four thousand years ago man used water to carry dye to a piece of fabric. Early water pollution was born. Since then, more and more chemicals have been added to color and treat fabric, producing ongoing and ever-worsening water pollution.

In the mid-twentieth century, new fibers such as nylon and polyester were developed. These new "high tech" fibers were difficult to dye, so even more chemicals were added to water baths to carry the dyes. These chemicals often ended up in the world's lakes, rivers, and oceans,

causing horrific damage. What's more, traditional dyeing uses an astonishing amount of water. Amounts vary, but coloring fabric can take anywhere from 56 to 600 times the weight of the fabric in water (that's 7 to 75 gallons of water per pound of fabric). Traditional dyeing pollutes, and it continues to consume vast amounts of the world's increasingly scarce supply of fresh water.

The dyeing of synthetic textiles consumes 2.4 trillion gallons of water a year, enough to fill 3,700,000 Olympic-sized swimming pools. It also uses more than 2.8 trillion megajoules of energy per year, enough to power more than 12 percent of the homes in the United States each year. Finally, textile dyeing produces 568 million metric tons of greenhouse gases (GHG) annually, more than 94 million passenger vehicles emit each year.

### AirDye® technology. Answer to a 4,000-year-old problem.

AirDye® technology is a revolutionary new way to carry dye to fabric and other mediums.

The result is luxuriously brilliant color and a world-changing positive impact on our planet's energy and water shortage.

## HOW IT WORKS: MICROSCOPIC PHOTOS OF THE NECK SECTION OF A DYED SYNTHETIC T-SHIRT



› **Standard Sublimation**  
The dye does not penetrate the fibers but rather sits on top where it can easily wear off. White fiber shows after cutting or needle penetration.



› **AirDye® Controlled Penetration**  
Using our proprietary Sibius™ Dyes, penetration is deeper. Colors are richer and colorfastness is better. Penetration control is used with *Dye Contrast*, *Print 2 Dye*, and *Print to Print* products.



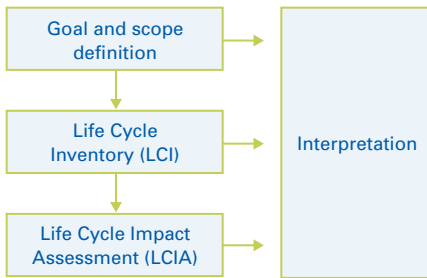
› **Conventional Dyes**  
After treatment in an aqueous dye-bath and post-dye washing, the fibers show complete dye penetration. Colorfastness and adherence is low to moderate when exposed to cleaning agents.



› **AirDye® Complete Penetration**  
AirDye® is so advanced that it colors not only the yarn but also thousands of filaments in each piece of yarn, yielding rich, brilliant colors. Complete penetration is used with *Dye Squared* products.



FIGURE 2 — THE LCA PROCESS



## LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) studies involve the collection, assessment, and interpretation of data from an environmental perspective over a product's life cycle (production, use, and end-of-life).

Studies can evaluate:

- the entire product life cycle, often referred to as cradle-to-grave or cradle-to-cradle studies, or
- parts of a product life cycle, referred to as cradle-to-gate or gate-to-gate studies.

The LCA conducted to create the data contained in this Environmental Profile encompasses the AirDye® process from production of raw materials (dye, paper, solvent, and so on) to the preparation of dye-donor and the final coloration process. It also includes the end-of-life of the dye-donor paper. Because AirDye® is intended to replace traditional color application processes, the production, use, and end-of-life phases of the finished fabric itself were not included.

The ISO 14040 series of standards cover the methodological steps for conducting an LCA. The AirDye® LCA studies follow the 14040 methodology, as shown at a macro level in Figure 2.

## GOALS AND SCOPE

This project included a complete cradle-to-gate LCA study for the coloration of a linear meter of polyester fabric, consistent with ISO 14040 series LCA standards.<sup>1</sup> The functional unit for the transfer of color to standard 62-inch-wide (roll form) polyester fabric was 1,000 kg of colored

polyester at three different fabric weights (3.5 oz/m<sup>2</sup>, 7.75 oz/m<sup>2</sup>, and 12 oz/m<sup>2</sup>).

Data gathered for this study represents operations at Colorep's facilities during 2006. The purpose of the project was to assess the environmental performance of Colorep's AirDye® process relative to traditional color application processes. The analysis examined how the various aspects of the process contribute to environmental inputs and outputs such as water and energy, as well as to indicators such as greenhouse gas production, from a cradle-to-grave perspective. The results of the study have been critically reviewed according to the requirements of ISO 14040 for studies that will be publicly communicated. The LCA generated data will be used to improve the AirDye® process as it is developed and refined.

## LIFE CYCLE INVENTORY

The Life Cycle Inventory (LCI) analyzes multiple environmental aspects of the inputs and outputs of a product system. Depending on the goal and scope definition, data may be collected first-hand from measurements and estimates of key activities, or will be based on information drawn from existing LCA databases. For this LCA, the majority of inventory data was collected on-site and modeled using GaBi 4.3™ LCA software. Data included or excluded from the study is dependent on the system boundaries identified during the goal and scope definition. The LCA system boundaries for the study are described in Table 1 and Figure 3.

<sup>1</sup> ISO 14040 (2006). Environmental management – Life cycle assessment – Principles and framework. International Organization for Standardization, Geneva.  
ISO 14044 (2006). Environmental management – Life cycle assessment – Requirements and guidelines management environmental. International Organization for Standardization, Geneva.

A Sensitivity Analysis was performed to determine the effects of increases in process efficiency for the traditional method with respect to water and energy use. The effect of variability in paper weight was also investigated. The results of the Sensitivity Analysis did not change the conclusions of the study, even when a “worst case” assessment was performed. The sections on the following pages provide an overview of the LCIA results for the production of 1,000 kg of

colored polyester fabric at three different fabric weights, using AirDye® Donor generated at Colorep’s plant (Transprint™) in Harrisonburg, VA.

Comparative data for this study was generated by ENEA (Italian National Agency for New Technologies, Energy, and the Environment) as part of the “Towards Effluent Zero” project<sup>2</sup>, and is also referenced in EU Best Practice documents for textile coloration<sup>3</sup>. It represents the

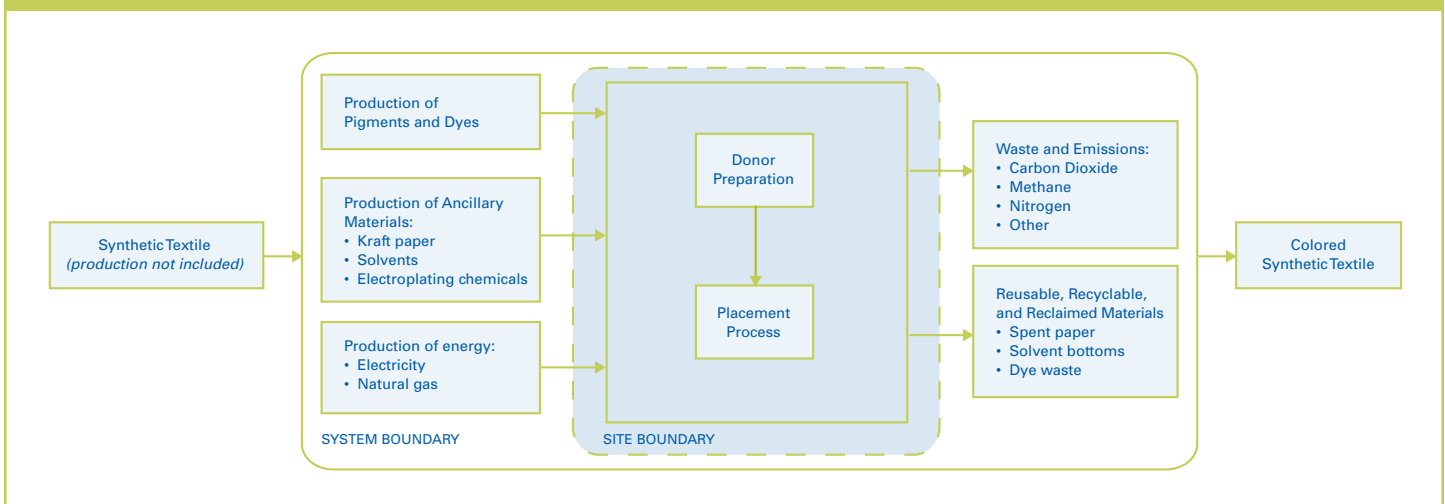
complete LCI associated to the coloration of fabrics across ten European facilities (five in Italy and five in Belgium) in 2002. This was the only source of publicly available, detailed, quantitative life cycle data that could be located. Other public data on fabric coloration processes, such as those published by the World Bank<sup>4</sup> and the State of California<sup>5</sup>, suggest that global averages for water and energy use are much higher than the values used for the purposes of this comparative study.

**TABLE 1 – LCA SYSTEM BOUNDARY**

INCLUDED	EXCLUDED
<ul style="list-style-type: none"> <li>➤ Raw materials required for the color application process*</li> <li>➤ Processing of materials in the production of AirDye® Donor</li> <li>➤ Internal recycling loops of dye and solvent materials during coloring process</li> <li>➤ Energy production*</li> <li>➤ Donor paper end-of-life</li> </ul>	<ul style="list-style-type: none"> <li>➤ Capital equipment and maintenance</li> <li>➤ Overhead (heating, lighting) of manufacturing facilities when easily differentiated</li> <li>➤ Human labor</li> <li>➤ Synthetic textile manufacture and scouring processes</li> <li>➤ Internal transportation of materials</li> <li>➤ Transportation of raw and processed materials to Colorep®</li> <li>➤ Transportation of finished AirDye® Donor</li> <li>➤ Use of fabric</li> <li>➤ Fabric end-of-life</li> </ul>

\*LCI data was included for background and process materials from the GaBi 4.3™ software database.

**FIGURE 3 – LCA SYSTEM BOUNDARY DIAGRAM**



<sup>2</sup> Information on the ENEA “Towards Effluent Zero” (TOWEFO) study is available at: [http://spring.bologna.enea.it/towefo/results\\_public\\_area/result\\_public\\_area.htm](http://spring.bologna.enea.it/towefo/results_public_area/result_public_area.htm)

<sup>3</sup> European Union Reference Document on Best Available Techniques for the Textiles Industry; Integrated Pollution Prevention and Control (IPPC), 2003. Available at: <http://eippcb.jrc.ec.europa.eu/>

<sup>4</sup> Pollution Prevention and Abatement Handbook; Word Bank Group, 1998.

<sup>5</sup> Analysis of the Potential Benefits of Recycled Water Use in Dye Houses; Prepared for the Central Basin Municipal Water District and the State of California Department of Water Resources; 2005.

## LIFE CYCLE IMPACT ASSESSMENT

LCIA is used to determine the contribution of the LCI information to the potential environmental impact it represents. Estimates for potential environmental impacts are organized under four main impact categories (shown to the right in Table 2).

These impact categories were selected based on:

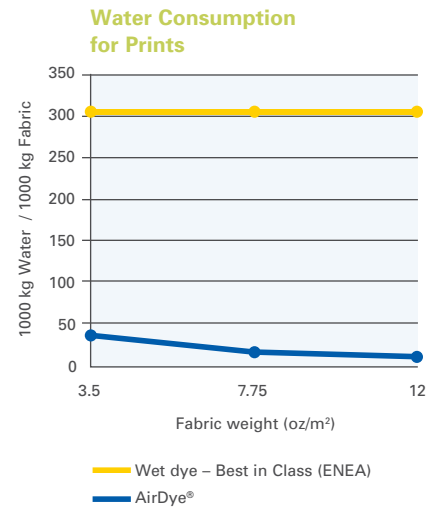
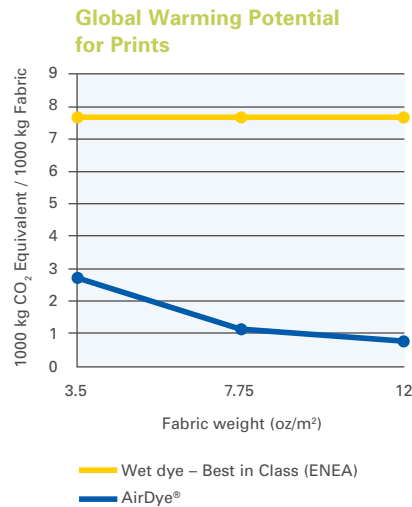
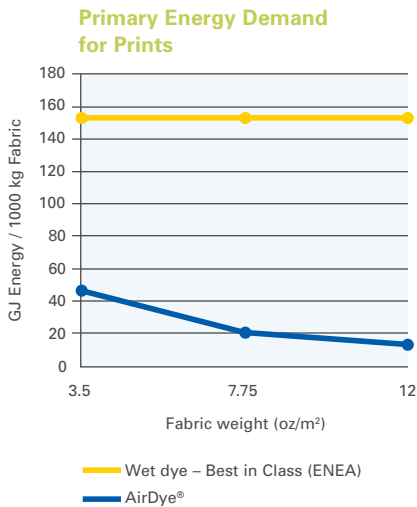
- the primary concerns of Colorep’s stakeholders, and
- environmental issues the AirDye® technology addresses.

TABLE 2 — LCIA CATEGORIES

IMPACT CATEGORY	DESCRIPTION
> Primary Energy Demand	A measure of the total amount of primary energy extracted from the earth, including natural gas, electricity, and other sources, taking into account the efficiency of electric power and heating processes.
> Greenhouse Gas Emissions*	A measure of greenhouse gas emissions such as CO <sub>2</sub> and methane, from all processes included in the scope of the LCA, including energy generation, paper, and other background material production, and calculated using the IPCC 2001 Global Warming Potential Index (GWP100).
> Water	A measure of the total water draw required as input across all processes, including paper manufacture and energy generation.
> Water Pollution / Eutrophication Potential*	A measure of emissions that cause eutrophying effects to the environment, characterized by an increase in chemical nutrients (nitrogen and phosphorus) that can cause excessive plant growth and decay — leading to further effects such as lack of oxygen and severe reductions in water quality and populations of aquatic life.

\*Impact calculation methodology defined by: Bare et al., TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts JIE, MIT Press, 2002.

## AIRDYE® VS WET DYE: ENERGY, WATER CONSUMPTION, AND GLOBAL WARMING COMPARISONS FOR PRINTS



## CONCLUSION

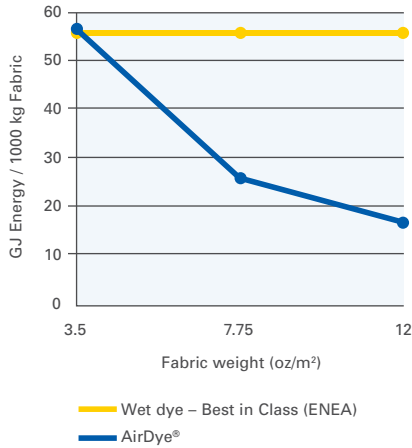
The AirDye® process radically reduces the environmental profile of the color application process while improving the use phase performance of the finished fabric. By removing the requirement of water at the point of color application,

AirDye® technology creates a significant opportunity to localize production for regions of the globe that lack the water resources traditional methods require. Because traditional processes require considerable energy to heat the water and dry the fabric, AirDye® technology

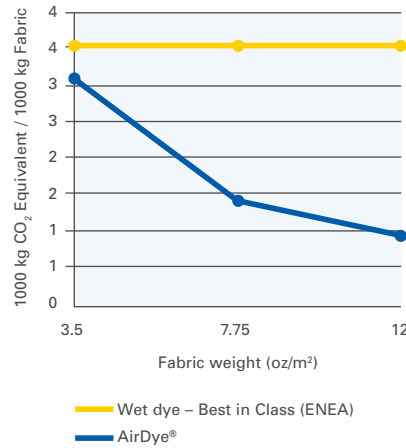
also significantly reduces the energy required at the point of color application. As AirDye® technology matures, we expect to see additional benefits from increased efficiency in power usage, power source, and the direct application of dye without a donor media.

# AIRDYE® VS WET DYE: ENERGY, WATER CONSUMPTION, AND GLOBAL WARMING COMPARISONS FOR SOLID COLORS

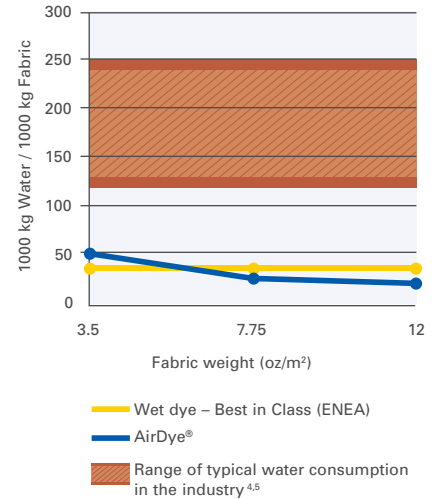
**Primary Energy Demand for Solid Colors**



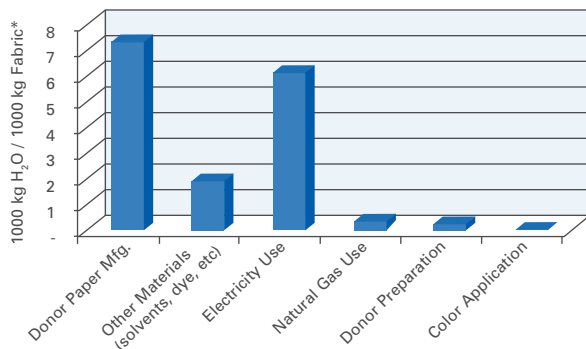
**Global Warming Potential for Solid Colors**



**Water Consumption for Solid Colors**



## LOCATION OF WATER DRAW IN THE PRODUCT SYSTEM



\*Results produced at 7.75 oz/m<sup>2</sup> fabric weight

## TABLE 3 — SUMMARY OF RESULTS

Compared to the Best in Class Wet Dye Process Described by the ENEA LCI, the AirDye® Process (7.75 oz/m<sup>2</sup>)

REDUCES	FOR PRINTS	FOR SOLID COLORS
> Water Use	95%	29% – 88%**
> Energy Use	86%	64%
> Global Warming Potential	84%	60%

\*\*29% per the ENEA LCI, 88% compared to typical industry water consumption<sup>4,5</sup>, using the midpoint of the range shown in the figure above.

By transforming the color application process, AirDye® enables unit production methods that dramatically reduce the need for large inventories of finished products.

With AirDye®, the late introduction of color and decoration thus enables a wider selection of choices for consumers

and manufacturing processes that are closer to the point of purchase while reducing the financial costs and environmental impacts of overproduction and imprecise forecasting. This technology is competitively positioned for use in many product sectors, such as imprinted apparel, performance apparel,

architectural textiles, home fashions, and floor coverings. AirDye® is a clear response to an increasing awareness of the environmental impacts associated with traditional dye application processes and a new technology for improving the process of coloration and decoration of textiles.



[www.airdye.com](http://www.airdye.com)

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**Disclaimer:** The data reported in this AirDye® Environmental Profile includes off-site activities and environmental impacts (such as power generation, solvent refining, and paper production) that are appropriate for Life Cycle Assessment studies. Consequently, the inclusion of such aspects must be considered when comparing the information included in this profile to other reported data on the AirDye® process that are not based on the same boundary conditions. For more information, please see Table 1 – LCA SYSTEM BOUNDARY on page 3 of this Profile.

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