VALUING THE NET BENEFIT OF DELL'S MORE SUSTAINABLE PLASTIC USE AT AN INDUSTRY-WIDE SCALE

Prepared by Trucost

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CONTENTS

EXECUTIVE SUMMARY

PROJECT CONTEXT & SCOPE

Dell is working to help reduce plastic waste and electronics waste by integrating recycled plastic that has been previously used in computer products into the design of its OptiPlex 3030 All-in-One. This use of closed-loop plastic creates demand for plastic from used computers and helps reduce computer disposal.

Dell had previously quantified the greenhouse gas emissions savings derived from using closed-loop plastic, but wanted to expand that analysis in the following ways:

1. Measure the net benefit for other environmental impacts (e.g. human health, air and water pollution, ecotoxicity) of the closed-loop plastic, compared to traditional plastic
2. Value the environmental net benefit in terms of natural capital—the stock of natural resources that makes human life possible and upon which businesses rely to produce goods and services
3. Scale these benefits to larger applications, including utilizing closed-loop plastic throughout Dell's product line and throughout the electronics industry
4. Prepare a framework for incorporating social and financial impacts into the net benefit valuation in the future

The project goal was to quantify the environmental benefits of Dell's closed-loop plastic system in monetary terms of dollars of natural capital. Dell engaged Trucost to quantify and value these benefits.

NATURAL CAPITAL & NET BENEFIT

Natural capital is the world's stock of natural resources that makes human life possible and upon which businesses rely to produce goods and services. Businesses depend on non-renewable resources (e.g. fossil fuels, minerals), renewable resources and services (e.g. freshwater, pollination) and natural capital's absorption of operational by-products (e.g. water and air pollution, waste). Business activities can damage natural capital with long-term economic and social consequences (e.g. the impact of climate change on agriculture). Moreover, these consequences can manifest themselves as physical, regulatory and reputational risks for companies.

One of the most useful ways for companies to account for these risks is to quantify the environmental impacts generated by their activities—internal operations, upstream supply chain and downstream product use and disposal—and then convert those impacts into monetary values. Valuation metrics can be integrated within traditional financial assessment frameworks and performance tracking, helping companies support the business case for environmental initiatives. An important mechanism for quantifying a company's impacts on natural capital is measuring the difference between "business as usual" and the effect of a more sustainable product, business model or activity. This difference is called the "net benefit" of the sustainability initiative.

KEY FINDINGS

Table 1 presents the environmental impacts in natural capital values and the net benefit of Dell's closed-loop ABS (acrylonitrile-butadiene-styrene) compared to virgin ABS. Table 2 presents similar data for Dell's closed-loop ABS and traditional recycled PET (polyethylene terephthalate). These impacts have been scaled to Dell's annual use of closed-loop ABS.

Table 1: Natural Capital Values of Environmental Impacts: Virgin ABS & Closed-loop ABS

Environmental impact		Virgin ABS	Closed-loop ABS	Net benefit of closed-loop ABS
Human health	Human health	-$1,045,000	-$392,000	+62%
	Respiratory effects	-$186,000	-$172,000	+8%
Energy & fossil fuels	Climate change	-$1,173,000	-$686,000	+42%
	Fossil fuel depletion	-$60,000	-$21,000	+65%
Air pollution	Smog	-$538,000	-$517,000	+4%
	Air pollution	-$82,000	-$78,000	+5%
Water & land pollution	Water pollution	-$44,000	-$28,000	+36%
	Ecotoxicity	-$14,000	+134,000	+1,057%
Cumulative		**-$3,143,000**	**-$1,760,000**	**+44% +$1,383,000**

Table 2: Natural Capital Values of Environmental Impacts: Recycled PET & Closed-loop ABS

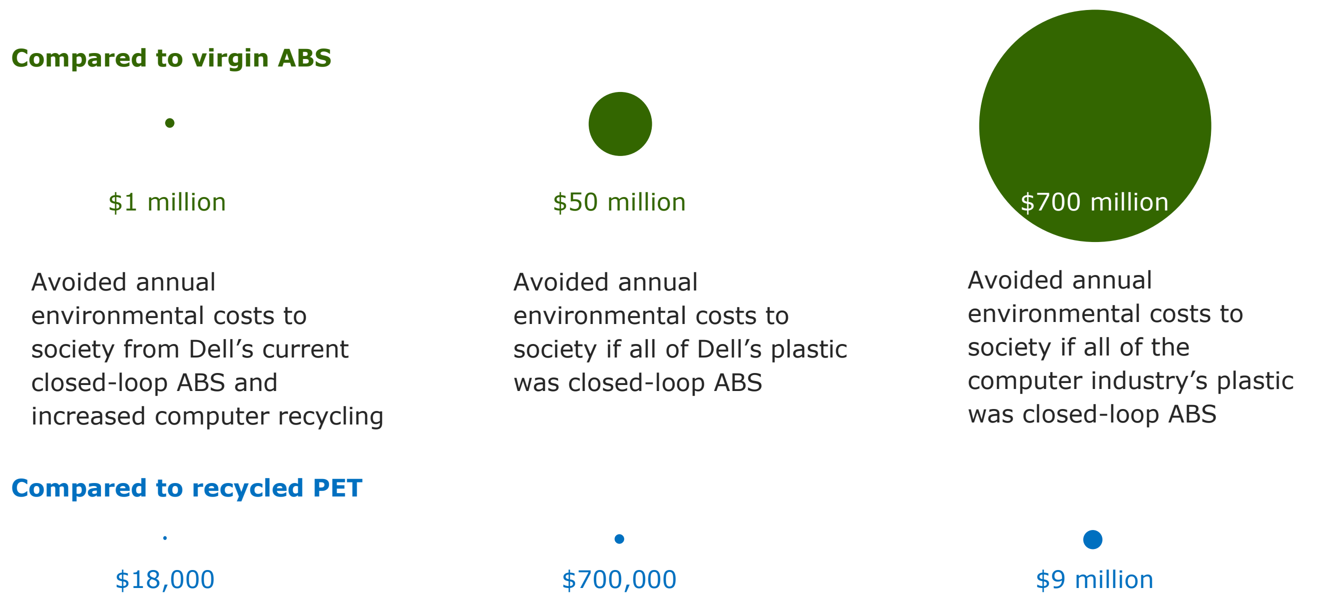
Environmental impact		Recycled PET	Closed-loop ABS	Net benefit of closed-loop ABS
Human health	Human health	-$621,000	-$392,000	+37%
	Respiratory effects	-$132,000	-$172,000	-30%
Energy & fossil fuels	Climate change	-$543,000	-$686,000	-26%
	Fossil fuel depletion	-$20,000	-$21,000	-5%
Air pollution	Smog	-$367,000	-$517,000	-41%
	Air pollution	-$62,000	-$78,000	-26%
Water & land pollution	Water pollution	-$27,000	-$28,000	-4%
	Ecotoxicity	-$6,000	+134,000	+2,507%
Cumulative		**-$1,777,000**	**-$1,760,000**	**+1% $17,000**

The results show that Dell's closed-loop plastic has a 44% ($1.3 million annually) greater environmental benefit compared to virgin ABS, while only a 1% ($17,000 annually) benefit over recycled PET. The improved benefit relative to virgin ABS is clear. However, the natural capital values of the closed-loop ABS and recycled PET are equivalent, given the uncertainty in the underlying environmental impact data and valuation coefficients.

Of critical importance to the net benefit of Dell's closed-loop plastic is increased recycling of computers—diverting them from disposal—to recover and recycle the used plastic. The closed-loop plastic's human health and ecotoxicity impacts are smaller because of the increased computer recycling and the resulting decrease in the emission of hazardous substances.

As shown in Figure 1 below, increasing the volume of plastic from Dell's current annual use of closed-loop ABS to all plastic used by Dell and all plastic used by the computer industry results in avoided environmental costs to society from approximately $1 to $50 million per year for Dell and $700 million per year for the industry, compared to virgin ABS. Comparing the closed-loop ABS to recycled PET yields scaled benefits of approximately $700,000 per year for Dell's overall plastic use and $9 million per year for the computer industry's plastic use.

Figure 1: Comparing Scaled Benefits for Larger Applications



RECOMMENDATIONS

Based on the results of this analysis, we recommend the following next steps that Dell should consider implementing with regard to its closed-loop plastic.

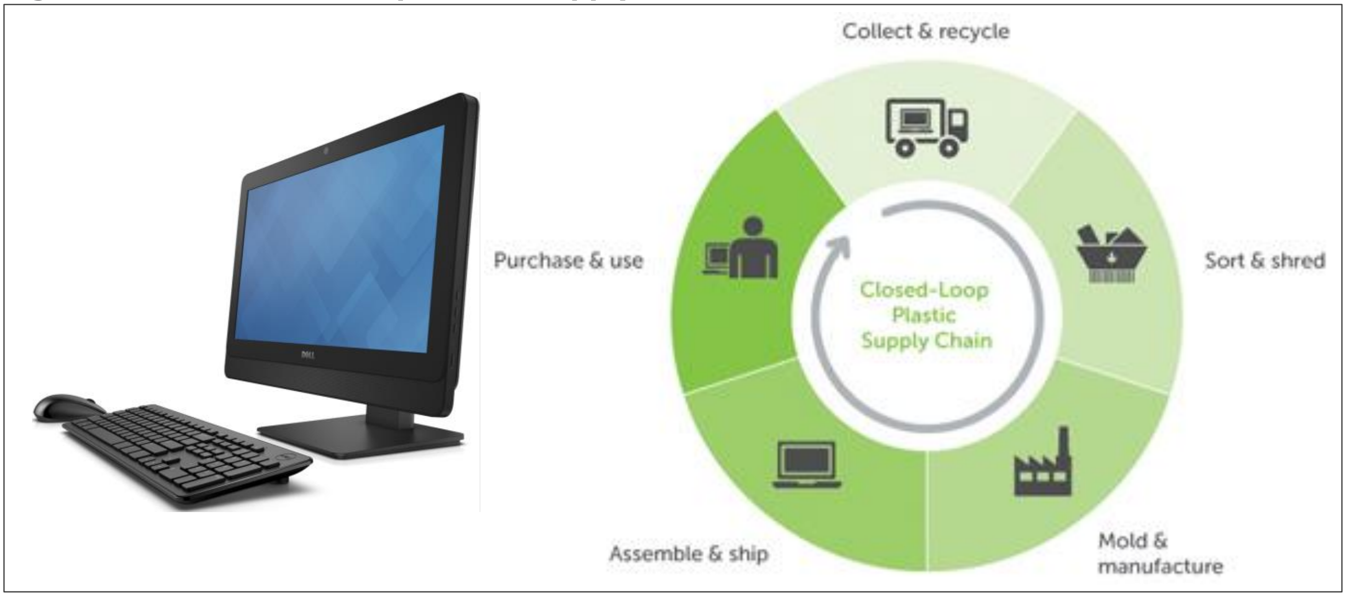
1. Communicate to stakeholders the avoided environmental costs of the closed-loop plastic
2. Expand the manufacturing and use of closed-loop plastic within Dell's products
3. Evaluate the net benefit of closed-loop plastic by refining data for the life cycle models and measuring social and financial impacts

1. INTRODUCTION

1.1 PROJECT CONTEXT

Dell is working to help reduce plastic waste and electronics waste by integrating recycled plastic that has been previously used in computer products into the design of its OptiPlex 3030 All-in-One (see Figure 2 below and Figure 3 on the following page). This use of closed-loop plastic creates demand for plastic from used computers and helps reduce computer disposal.

Figure 2: Dell's Closed-loop Plastic Supply Chain

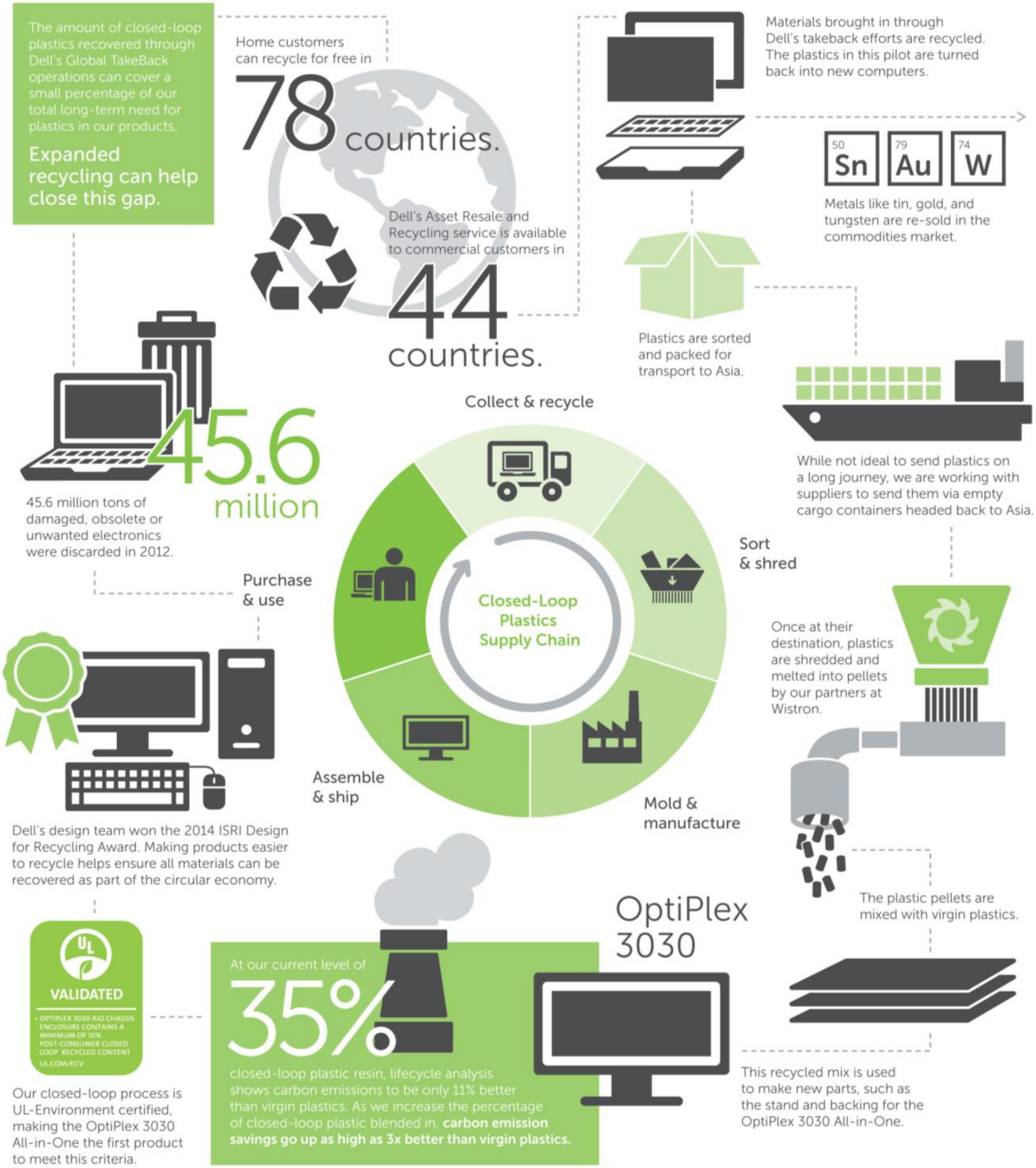


Dell's leadership in recovering and reusing plastic from used computers is important for transitioning the larger electronics industry toward circular business models, by proving that innovative material cycling and the associated stakeholder relationships can be achieved. Moving from business as usual for product life cycles to more sustainable life cycles can deliver significant benefits but will involve changes throughout supply chains, product design and manufacturing, customer engagement, and post-use collection and recycling.

Dell had previously quantified the greenhouse gas emissions savings derived from using closed-loop plastic, but wanted to expand that analysis in the following ways:

1. **Measure the net benefit for other environmental impacts** (e.g. human health, air and water pollution, ecotoxicity) of the closed-loop plastic, compared to traditional plastic
2. **Value the environmental net benefit in terms of natural capital**—the stock of natural resources that makes human life possible and upon which businesses rely to produce goods and services
3. **Scale these benefits to larger applications**, including utilizing closed-loop plastic throughout Dell's product line and throughout the electronics industry
4. **Prepare a framework for incorporating social and financial impacts** into the net benefit valuation in the future

Figure 3: Dell's Closed-loop Recycling Process



Source: www.electronicstakeback.com/2014/06/12/dell-introduces-first-computer-made-with-plastics-from-recycled-electronics

1.2 PROJECT SCOPE

The project goal was to quantify the environmental benefits of Dell's closed-loop plastic system in monetary terms of dollars of natural capital. The results will be used by Dell to communicate to customers, investors, and other stakeholders. Dell engaged Trucost to quantify and value these benefits. Trucost utilized data from Dell and its supplier for the closed-loop plastic—including material ingredients and manufacturing energy use—and data from the ecoinvent database for virgin and recycled plastics that can be used for the same purpose.

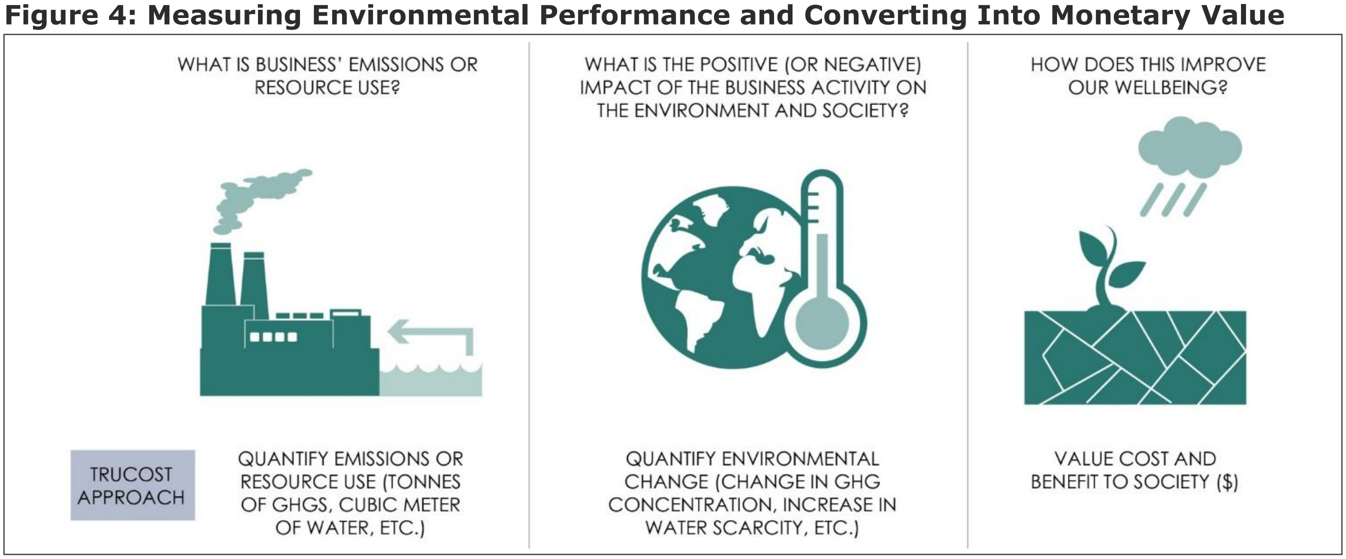
2. VALUING NATURAL CAPITAL & NET BENEFIT

2.1 VALUING NATURAL CAPITAL

Natural capital is the world's stock of natural resources that makes human life possible and upon which businesses rely to produce goods and services. Businesses depend on non-renewable resources (e.g. fossil fuels, minerals), renewable resources and services (e.g. freshwater, pollination) and natural capital's absorption of operational by-products (e.g. water and air pollution, waste). Business activities can damage natural capital with long-term economic and social consequences (e.g. the impact of climate change on agriculture). Moreover, these consequences can manifest themselves as physical, regulatory and reputational risks for companies.

One of the most useful ways for companies to account for these risks is to quantify the environmental impacts generated by their activities—internal operations, upstream supply chain and downstream product use and disposal—and then convert those impacts into monetary values. An impact's valuation reflects the cost or benefit of a specific practice based on its use of or emissions to natural capital. The monetary value helps identify the value not captured in traditional financial markets and incorporate these into decision-making (as reflected in Figure 4 below).

Figure 4: Measuring Environmental Performance and Converting Into Monetary Value



Natural capital valuation can help companies identify material environmental impacts, compare and sum different impacts, and optimize inputs, production locations and processes. Valuation metrics can be integrated within traditional financial assessment frameworks and performance tracking, helping companies support the business case for environmental initiatives. Reporting in monetary terms also simplifies communication of valuation findings and sustainability performance to a broad range of stakeholders, especially since they are expressed in a common unit of measure (i.e. USD).

2.2 MEASURING NATURAL CAPITAL NET BENEFIT

An important mechanism for quantifying a company's impacts on natural capital is measuring the difference between an existing product, business model or activity and a more sustainable alternative. This "net benefit" calculation involves the following four-step approach (further details are available in Appendix: Analysis Methodology):

1. **Define the systems: existing product or activity versus an alternative**
   - Existing system 1: Virgin ABS (acrylonitrile-butadiene-styrene)
   - Existing system 2: Recycled PET (polyethylene terephthalate)
   - Alternative system: Dell's closed-loop ABS
2. **Measure the environmental impacts of each system**
3. **Convert the impacts of each system into monetary terms**
4. **Calculate the systems' difference in impact, which is the net benefit**

3. KEY FINDINGS

3.1 ENVIRONMENTAL IMPACTS & NET BENEFIT OF PLASTIC ALTERNATIVES

Table 3 on the following page presents the environmental impacts in physical units (e.g. kilograms of carbon dioxide equivalents), for virgin ABS and Dell's closed-loop ABS, along with the net benefit of the closed-loop ABS. The impacts have been scaled to Dell's annual use of closed-loop ABS. These results illustrate the actual environmental impacts of material selection decisions. Table 3 also demonstrates the challenge of comparing different environmental impacts, since their physical units vary.

Converting physical units into natural capital values—with the common metric of dollars—enables a company to more easily compare environmental impacts, calculate the relative net benefit and set objectives for ongoing improvement. Table 4 presents the environmental impacts converted from physical units into natural capital values, for virgin ABS and closed-loop ABS, along with the net benefit of the closed-loop ABS.

Tables 5 and 6 provide the environmental impacts for recycled PET and Dell's closed-loop ABS, along with the net benefit for the closed-loop ABS.

Table 3: Physical Units of Environmental Impacts: Virgin ABS & Closed-loop ABS

Environmental impact		Virgin ABS	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health (*comparative toxic units for human health*)	-0.76 CTU_h	-0.28 CTU_h	+63%
	Respiratory effects (*kg of particulate matter equivalents, up to 2.5 μm*)	-3,959 kg PM2.5-eq	-3,656 kg PM2.5-eq	+8%
Energy & fossil fuels	Climate change (*kg of carbon dioxide equivalents*)	-8,757,000 kg CO_2-eq	-5,123,000 kg CO_2-eq	+42%
	Fossil fuel depletion (*MJ surplus*)	-18,416,000 MJ	-6,538,000 MJ	+65%
Air pollution	Smog (*kg of ozone equivalents*)	-410,300 kg O_3-eq	-394,400 kg O_3-eq	+4%
	Air pollution (*kg of sulfur dioxide equivalents*)	-39,100 kg SO_2-eq	-37,000 kg SO_2-eq	+5%
Water & land pollution	Water pollution (*kg of nitrogen equivalents*)	-7,800 kg N-eq	-5,000 kg N-eq	+36%
	Ecotoxicity (*comparative toxic units, ecotoxicity*)	-20,100,000 CTU_e	+194,600,000 CTU_e	+1,066%

Note: The environmental impacts have been scaled to Dell's annual use of closed-loop ABS.

Table 4: Natural Capital Values of Environmental Impacts: Virgin ABS & Closed-loop ABS

Environmental impact		Virgin ABS	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health	-$1,045,000	-$392,000	+62%
	Respiratory effects	-$186,000	-$172,000	+8%
Energy & fossil fuels	Climate change	-$1,173,000	-$686,000	+42%
	Fossil fuel depletion	-$60,000	-$21,000	+65%
Air pollution	Smog	-$538,000	-$517,000	+4%
	Air pollution	-$82,000	-$78,000	+5%
Water & land pollution	Water pollution	-$44,000	-$28,000	+36%
	Ecotoxicity	-$14,000	+134,000	+1,057%
Cumulative		**-$3,143,000**	**-$1,760,000**	**+44% +$1,383,000**

Note: The environmental impacts have been scaled to Dell's annual use of closed-loop ABS.

Table 5: Physical Units of Environmental Impacts: Recycled PET & Closed-loop ABS

Environmental impact		Recycled PET	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health (*comparative toxic units for human health*)	-0.39 CTU_h	-0.28 CTU_h	+29%
	Respiratory effects (*kg of particulate matter equivalents, up to 2.5 μm*)	-2,802 kg PM2.5-eq	-3,656 kg PM2.5-eq	-31%
Energy & fossil fuels	Climate change (*kg of carbon dioxide equivalents*)	-4,052,000 kg CO_2-eq	-5,123,000 kg CO_2-eq	-26%
	Fossil fuel depletion (*MJ surplus*)	-6,251,000 MJ	-6,538,000 MJ	-5%
Air pollution	Smog (*kg of ozone equivalents*)	-280,200 kg O_3-eq	-394,400 kg O_3-eq	-41%
	Air pollution (*kg of sulfur dioxide equivalents*)	-29,300 kg SO_2-eq	-37,000 kg SO_2-eq	-26%
Water & land pollution	Water pollution (*kg of nitrogen equivalents*)	-4,800 kg N-eq	-5,000 kg N-eq	-4%
	Ecotoxicity (*comparative toxic units, ecotoxicity*)	-8,100,000 CTU_e	+194,600,000 CTU_e	+2,507%

Note: The environmental impacts have been scaled to Dell's annual use of closed-loop ABS.

Table 6: Natural Capital Values of Environmental Impacts: Recycled PET & Closed-loop ABS

Environmental impact		Recycled PET	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health	-\$621,000	-\$392,000	+37%
	Respiratory effects	-\$132,000	-\$172,000	-30%
Energy & fossil fuels	Climate change	-\$543,000	-\$686,000	-26%
	Fossil fuel depletion	-\$20,000	-\$21,000	-5%
Air pollution	Smog	-\$367,000	-\$517,000	-41%
	Air pollution	-\$62,000	-\$78,000	-26%
Water & land pollution	Water pollution	-\$27,000	-\$28,000	-4%
	Ecotoxicity	-\$6,000	+134,000	+2,507%
Cumulative		**-\$1,777,000**	**-\$1,760,000**	**+1% \$17,000**

Note: The environmental impacts have been scaled to Dell's annual use of closed-loop ABS.

The results show that Dell's closed-loop plastic has a 44% ($1.3 million annually) greater environmental benefit compared to virgin ABS, while only a 1% ($17,000 annually) benefit over recycled PET. The improved benefit relative to virgin ABS is clear. However, the natural capital values of the closed-loop ABS and recycled PET are equivalent, given the uncertainty in the underlying environmental impact data and valuation coefficients.

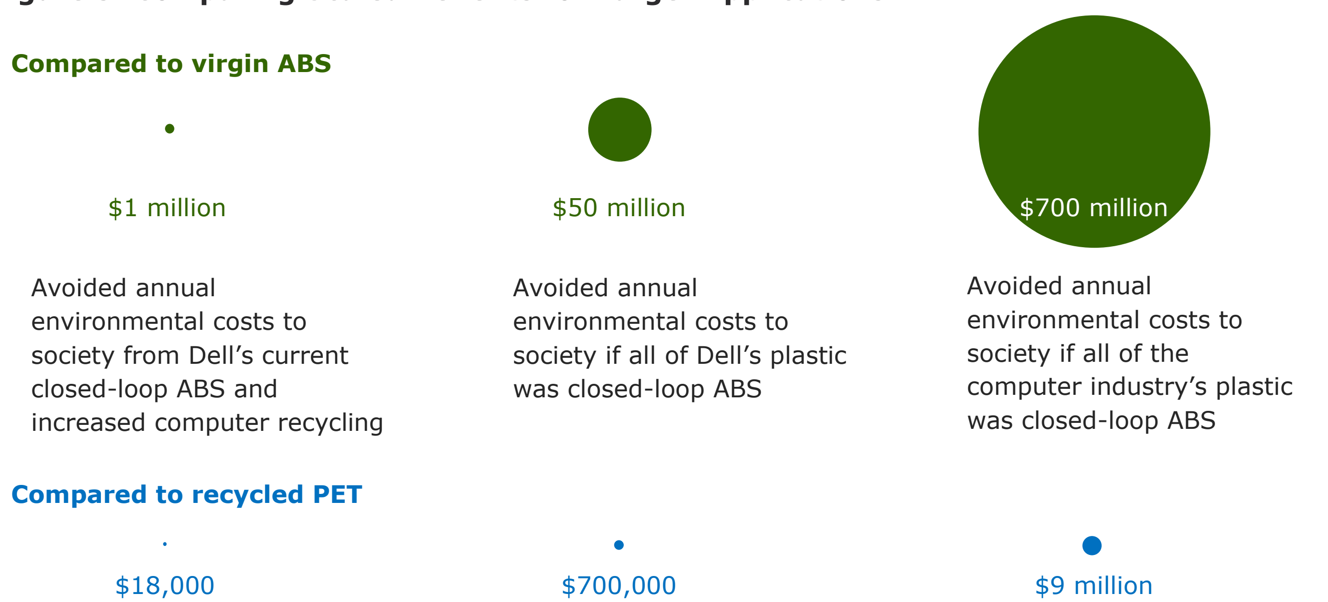
Of critical importance to the net benefit of Dell's closed-loop plastic is increased recycling of computers—diverting them from disposal—to recover and recycle the used plastic. The closed-loop plastic's human health and ecotoxicity impacts are smaller because of the increased computer recycling and the resulting decrease in the emission of hazardous substances. These human health and ecotoxicity benefits are a significant differentiator of the closed-loop ABS that Dell should consider communicating to its stakeholders and the larger industry.

3.2 NET BENEFITS SCALED TO LARGER APPLICATIONS

In order to reflect the potential environmental benefit of expanding Dell's closed-loop plastic, Trucost scaled the plastic's net benefits for both the company's and the personal computer industry's use of plastics in products—specifically desktops, notebooks, monitors, all-in-one computers, servers, thin clients, tablets and printers.

As shown in Figure 5 below, increasing the volume of plastic from Dell's current annual use of closed-loop ABS to all plastic used by Dell and all plastic used by the computer industry results in avoided environmental costs to society from approximately $1 to $50 million per year for Dell and $700 million per year for the industry, compared to virgin ABS. Comparing the closed-loop ABS to recycled PET yields scaled benefits of approximately $700,000 per year for Dell's overall plastic use and $9 million per year for the computer industry's plastic use. These results demonstrate the achievable benefits at full deployment and underscore the worth of increasing the production and use of Dell's innovative plastic.

Figure 5: Comparing Scaled Benefits for Larger Applications



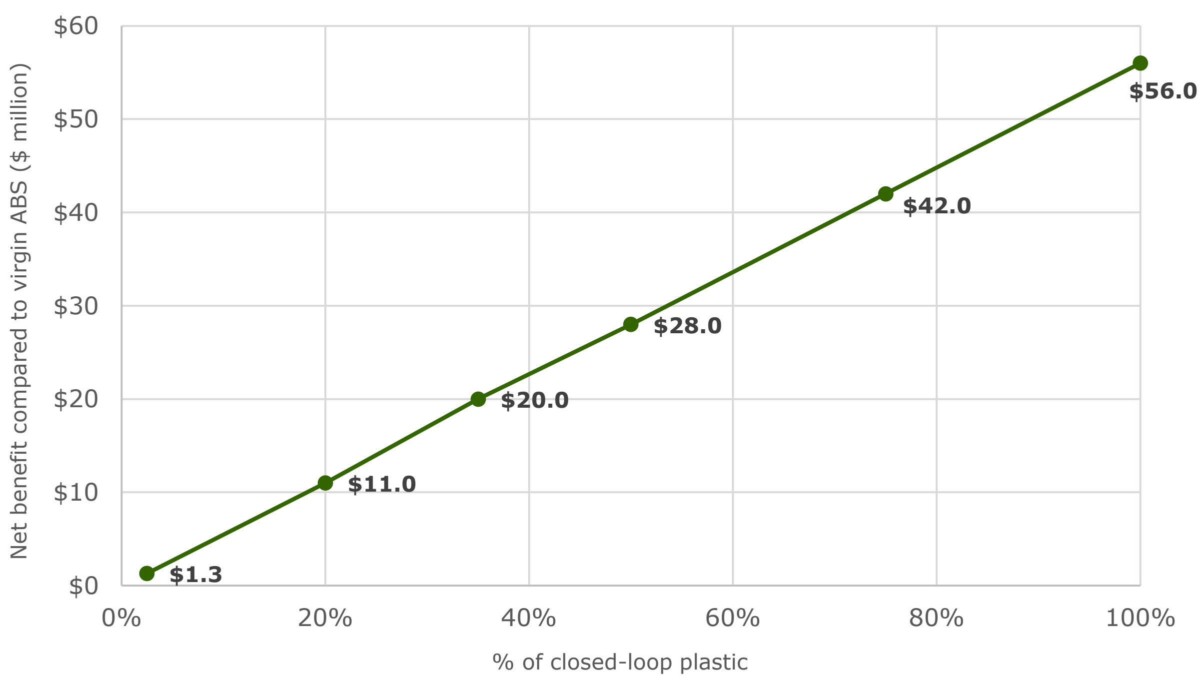
3.3 FUTURE SCENARIOS FOR INCREASED USE OF CLOSED-LOOP PLASTIC

In order to evaluate increasing the use of closed-loop plastic, Table 7 and Figure 6 below present the net benefits that could be realized by replacing larger percentages of Dell's overall plastic with closed-loop ABS over time. These scenarios show the net benefits of closed-loop ABS relative to virgin ABS because the impacts of recycled PET are consistent with the impacts of closed-loop ABS.

Table 7: Scenarios of Increased Use of Closed-loop Plastic Within Dell's Products

Scenario [% closed-loop plastic]	Amount of closed-loop plastic (kg)	Net benefit, relative to virgin ABS
Current [2% of Dell's plastic use]	1.4 million	$1.3 million
Scenario #1 [20% of Dell's plastic use]	11.3 million	$11 million
Scenario #2 [35% of Dell's plastic use]	19.8 million	$20 million
Scenario #3 [50% of Dell's plastic use]	28.3 million	$28 million
Scenario #4 [75% of Dell's plastic use]	42.5 million	$42 million
Scenario #5 [100% of Dell's plastic use]	56.7 million	$56 million

Figure 6: Scenarios of Increased Use of Closed-loop Plastic Within Dell's Products



Annual avoided environmental costs increase for each of the scenarios, as the volumes of closed-loop plastic grow. These results can be combined with the financial costs of sourcing closed-loop plastic to consider the broader impacts of this decision for material production, product design and post-use product recovery. In addition, these avoided annual environmental costs to society can be communicated to Dell's stakeholders.

4. RECOMMENDATIONS

Based on the results of this analysis, we recommend the following next steps that Dell should consider implementing with regard to its closed-loop plastic.

1. **Communicate to stakeholders the avoided environmental costs of the closed-loop plastic.** The natural capital benefits support the business case for continued investment in closed-loop plastic. The avoided environmental impacts should be factored alongside the financial costs of Dell's plastic sourcing and product design decision-making. Furthermore, environmental benefits—especially the human health and ecotoxicity benefits—can be shared with external stakeholders to demonstrate Dell's sustainability commitment and leadership.

2. **Expand the manufacturing and use of closed-loop plastic within Dell's products.** The environmental net benefit substantiates the importance of increasing Dell's use of closed-loop plastics within products and enhanced efforts to collect post-use computers for recycling. The natural capital opportunities at full-scale utilization within Dell's products and the larger computer industry further underscore the role that closed-loop plastic can take in the future. Dell should communicate its success and leadership to the computer industry and help explore how to collaboratively expand computer recycling and closed-loop material use.

3. **Evaluate the net benefit of closed-loop plastic by refining data for the life cycle models and measuring social and financial impacts.** The life cycle impacts measured in this analysis are based on a combination of collected data for production of the closed-loop plastic and average data for the other plastics and life cycles. The quantified impacts can be more precise by using specific data for the materials' life cycle stages. Trucost recommends that Dell collect and utilize actual life cycle data wherever possible. This data may be valuable for stakeholder communications as well—for example, tracking data on Dell's influence on computer recycling rates can be useful for stakeholder messaging. Trucost also recommends that Dell enhance the net benefit analysis in the future by incorporating metrics and data for social and financial impacts. Closed-loop material recovery and reuse can have positive effects on these metrics. The Appendix presents a framework for how social and financial impacts may be added to the analysis.

APPENDIX: ANALYSIS METHODOLOGY

ASSESSMENT PROCESS

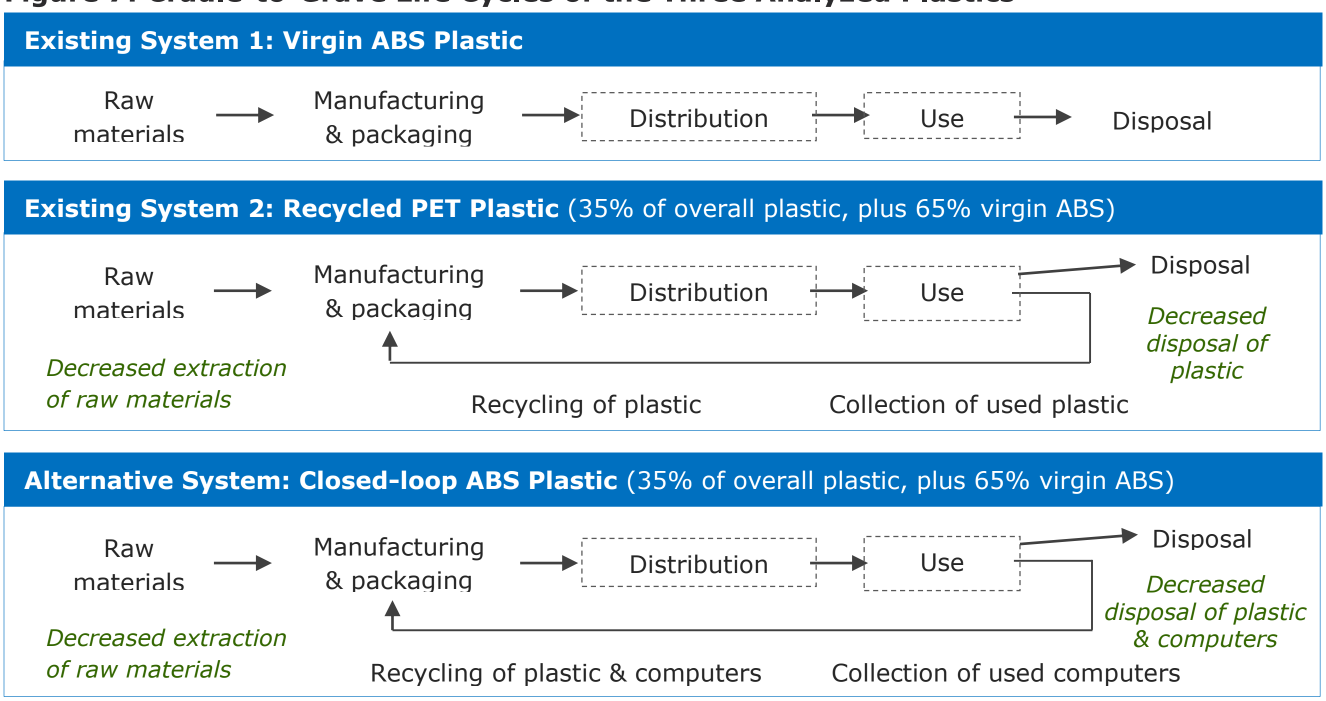
Trucost measured the environmental impacts of Dell's closed-loop, post-use ABS (acrylonitrile-butadiene-styrene) plastic, virgin ABS and recycled PET (polyethylene terephthalate, which is readily available in the market and can be used in computer bodies) using life cycle analysis (LCA) models and valuation data. This research quantified the net benefit of the closed-loop plastic compared to the other two plastics, using the following approach:

1) Calculated cradle-to-grave environmental impacts using LCA data from Dell's supplier of its closed-loop plastic and from LCA databases for the virgin ABS and recycled PET
2) Converted physical impacts into natural capital costs using Trucost's valuation coefficients, which measure the significance of each environmental impact in monetary terms

COMPARING ALTERNATIVE PLASTICS USING LIFE CYCLE ANALYSIS

Either closed-loop ABS or recycled PET can be used to replace up to 35% of the virgin ABS in computer bodies. Trucost's LCA models account for this mixture of plastic types. The differential impacts among the plastics result from the avoided mining and disposal based on the recycled content and, additionally, from the avoided disposal of computers themselves associated with the collection of material to manufacture Dell's closed-loop plastic. The different life cycles are reflected in Figure 7 below, which show the cradle-to-grave models used to identify and measure the environmental impacts for a functional unit of 1 kilogram of plastic.

Figure 7: Cradle-to-Grave Life Cycles of the Three Analyzed Plastics



Dashes show stages assumed to be equal among systems and therefore, are not included in the LCA model. Green shows stages partially avoided due to material recycling.

LCA DATA

Dell and Wistron—supplier of the closed-loop ABS—provided data on the manufacturing of plastic pellets containing the recycled plastic, including material inputs, energy use, water consumption, packaging and transportation of the recycled ABS and virgin ABS. They also provided energy use data for processing the closed-loop ABS after its use in a computer and recollection.

Data for the production of material inputs was sourced from the ecoinvent v3 database and used in the LCA modeling software SimaPro v7. The impact assessment method employed was TRACI v2.1.

MODEL ASSUMPTIONS

- Manufacturing process for the plastic pellets was considered consistent among the closed-loop ABS, recycled PET and virgin ABS
- Credit was given for the avoided production of virgin ABS and applied within both the closed-loop ABS and recycled PET life cycles, since either of those materials can replace virgin ABS in a computer body
- The phases of distribution and use were not modeled for any of the plastics since they were assumed to be consistent across the life cycles
- Credit for the avoided waste treatment of used ABS and used computers was applied to the closed-loop ABS life cycle
- Credit for the avoided waste treatment of PET plastic was applied to the recycled PET life cycle
- Disposal rates for the final products were assumed to be the same for each plastic's life cycle

COMPONENTS OF THE LCA MODELS

Table 8 below outlines some of the key components of the LCA models developed to compare the virgin ABS, recycled PET and closed-loop ABS.

Table 8: Components of the Cradle-to-Grave Life Cycles of the Three Analyzed Plastics

LCA model component	Virgin ABS	Recycled PET	Closed-loop ABS
Materials inputs	▪ 100% virgin ABS (**transport**: Taiwan to China) ▪ Additives, chemicals ▪ Paper packaging	▪ 35% recycled PET (**transport**: global) ▪ 65% virgin ABS (**transport**: Taiwan to China) ▪ Additives, chemicals ▪ Paper packaging	▪ 35% recycled ABS (**transport**: global) ▪ 65% virgin ABS (**transport**: Taiwan to China) ▪ Additives, chemicals ▪ Paper packaging
Manufacturing & packaging	▪ Electricity (specific to processing) ▪ Water ▪ Paper packaging	▪ Electricity (specific to processing) ▪ Water ▪ Paper packaging	▪ Electricity (specific to processing) ▪ Water ▪ Paper packaging

(continued on the following page)

LCA model component	Virgin ABS	Recycled PET	Closed-loop ABS
Distribution	*Not included in the LCA model*		
Use	*Not included in the LCA model*		
Collection & recycling of materials	*Not included in the LCA model*	▪ Collection of used material ▪ Decreased waste treatment of PET plastic (proportional to the amount of recycled plastic) ▪ Decreased production of virgin ABS (equal to recycled PET amount, which is replacing the ABS)	▪ Collection & manual dismantling of collected computers ▪ Decreased waste treatment of ABS plastic & desktop computers (proportional to the amount of recycled plastic) ▪ Decreased production of virgin ABS (equal to recycled ABS amount)

CONVERTING PHYSICAL IMPACTS INTO NATURAL CAPITAL VALUES

Trucost has developed and continually updates numerous valuation coefficients to translate the environmental impacts measured by LCA research into natural capital values. Applying these coefficients, Trucost derived a monetary value for the damage caused to society or decrease in well-being associated with the emission of pollutants or use of natural resources.

Various techniques exist to assign a value to a change in a physical environmental impact and calculate the costs and benefits in monetary terms. Techniques span from observing behavior on already-existing alternative markets as a proxy; for example, the amount of money spent on aquatic recreational activities, or creating artificial markets by asking the population its willingness-to-pay for the existence of wildlife habitat. Table 9 on the following page summarizes natural capital valuation techniques that can be used.

All the approaches are equally valid and Trucost chose valuation techniques based on data availability and suitability. Trucost has been consistent in its application of valuation techniques across all end points. For example, the change in life expectancy has been valued the same regardless of whether it is caused by malnutrition due to water depletion or by the ingestion of contaminated food due to water pollutants.

Table 9: Methodologies Used for Valuing Environmental Impacts

Valuation technique	Description
Abatement cost	The cost of removing a negative by-product for example, by reducing the emissions or limiting their impacts.
Avoided cost / Replacement cost / Substitute cost	Estimates the economic value of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. Most appropriate in cases where damage avoidance or replacement expenditures have or will be made (Ecosystem Valuation, 2000).
Contingent valuation	A survey-based technique for valuing non-market resources. This is a stated preference/willingness-to-pay model in that the survey determines how much people will pay to maintain an environmental feature.
Direct market pricing	Estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. This method uses standard economic techniques for measuring the economic benefits from marketed goods based on the quantity purchased and supplied at different prices. This technique can be used to value changes in the quantity or quality of a good or service (Ecosystem Valuation, 2000).
Hedonic pricing	Estimates the economic value of ecosystem services that directly affect the market price of another good or service. For example proximity to open space may affect the price of a house.
Production function	Estimates the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. Most appropriate in cases where the products or services of an ecosystem are used alongside other inputs to produce a marketed good (Ecosystem Valuation, 2000).
Site choice / Travel cost method	A revealed preference/willingness-to-pay model which assumes people make trade-offs between the expected benefit of visiting a site and the cost incurred to get there. The cost incurred is the person's willingness to pay to access a site. Often used to calculate the recreational value of a site.

Value is highly contingent on local conditions. In order to estimate costs or benefits in a context when no study exists, Trucost relies on the value transfer method. In this method, the goal is to estimate the economic value of ecosystem services or impacts by transferring available information from completed studies to another location or context by adjusting for certain variables. Examples include population density, income levels and average size of ecosystems, to name just a few.

Best practice guidelines for value transfers have been set out by UNEP in a document entitled *Guidance Manual on Value Transfer Methods for Ecosystem Services* (Brander, 2004). Trucost endeavors to follow these guidelines in all its value transfer calculations, where possible. It is important to note, however, that value transfers can only be as accurate as the initial study (Ecosystem Valuation, 2000). In some instances, studies from different ecosystems and geographies have had to be ubiquitously used throughout a valuation methodology due to data availability and data quality.

Table 10 below summarizes the context for each natural capital valuation and the valuation coefficients that were applied for the Dell impact analysis. Since production of the closed-loop ABS is occurring in China, China-specific valuation coefficients were used for all impact categories except for climate change, smog, and fossil fuel depletion, for which global average valuation coefficients were used.

Table 10: Natural Capital Valuations Used in This Analysis

Environmental impact (units)	**Natural capital context**	**Natural capital valuation coefficient** (per kg of impact)
Human health (*comparative toxic units for human health*)	▪ **Carcinogenic**: toxicological risk and potential impacts of carcinogenic chemicals that are released during the life cycle ▪ **Non-carcinogenic**: toxicological risk and potential impacts of non-carcinogenic chemicals that are released during the life cycle	$658,519 carcinogenic $2,007,177 non-carcinogenic
Respiratory effects (*kg of particulate matter equivalents, up to 2.5 μm*)	Impacts on the human respiratory system are primarily due to the presence of particulate matter, which is a complex mixture of organic and inorganic substances of varying dimensions	$47.06
Climate change (*kg of carbon dioxide equivalents*)	Generation of emissions that contribute to global climate change	$0.134
Fossil fuel depletion (*MJ surplus*)	The damages in this category are linked to non-renewable primary energy consumption	$0.003
Smog (*kg of ozone equivalents*)	Ground level ozone is created by various chemical reactions that occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight, which may lead to photochemical smog formation	$1.311
Air pollution (*kg of sulfur dioxide equivalents*)	Potential for the release of airborne chemical emissions that acidify ecosystems and thus, disrupt their chemical equilibrium, including loss of species biodiversity and loss of soil productivity	$2.103
Water pollution (*kg of nitrogen equivalents*)	Aquatic eutrophication is the process of a waterbody becoming over-enriched in dissolved nutrients, which stimulates the growth of aquatic plant life and often results in the depletion of dissolved oxygen	$5.621
Ecotoxicity (*comparative toxic units, ecotoxicity*)	This measure refers to the potential for biological, chemical or physical stressors to affect ecosystems	$0.0007

LIMITATIONS

The analysis was restricted by the availability of reliable date particularly in the following areas:

- End-of-life treatment of used computers laptops
- Energy and materials consumed during PET recycling
- Disposal treatment of non-recycled PET bottles

Actual operational data and primary data were used wherever possible.

APPENDIX: NATURAL CAPITAL VALUATION FRAMEWORK

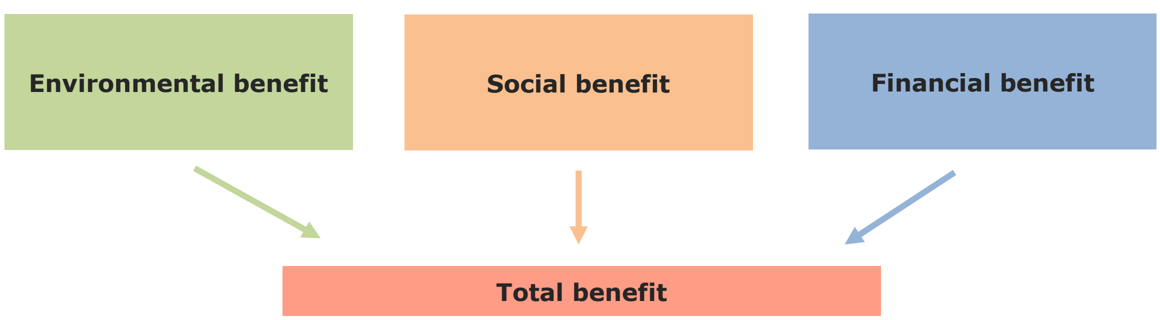
To expand the measurement of net benefits of closed-loop plastic recovery, production and use, social impact metrics can be incorporated into the valuation framework and analysis. Similar to measuring how business activities have environmental impacts, activities can be analyzed for how they utilize social and human capital, by applying appropriate key performance indicators (KPIs). These social impact frameworks still are emerging and further refinement will help improve their application over time. In the short term, companies should ensure they recognize and address social impact metrics in their sustainability initiatives, as well as focus on these metrics as they continually enhance their valuation frameworks.

Valuing social and human capital impacts follows the same basic steps as for environmental impacts:

1. Similar to the natural capital impact drivers, the first step is to understand what drivers affect social and human capital and selecting KPIs that measure impacts on these forms of capital
2. Identify the consequence of a specific impact in terms of social and human capital
3. Value, in monetary terms, the social and human capital impacts of the organization's activities

Example areas of how a business can affect social and human capital include employee training, workplace health and safety, charitable community outreach, and public health education. Companies that have undertaken social impact measurement include AkzoNobel and Infosys, which address their societal effects and initiatives.[1,2]

In the same way, financial impact metrics and data can be added to the expanded analysis, to more fully capture the total benefits generated by a more sustainable product or process. Examples of positive financial impacts from a material reuse initiative may include increased employment for product collection and reprocessing, enhanced valuation of a company associated with its reputational improvement and improved financial bottom line by undertaking innovative sustainability programs, and capitalization of the mechanisms for recovering used products and recycling their component materials.



[1] Infosys. *Sustainability*. www.infosys.com/sustainability/social-contract

[2] AkzoNobel. *AkzoNobel Report 2014: Measuring Our Impact in 4D*. report.akzonobel.com/2014/ar/case-studies/sustainable-business/measuring-our-impact-in-4d.html

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ABOUT TRUCOST

Trucost is an expert consultancy, helping companies, investors, governments, academics and thought leaders to understand the economic consequences of natural capital dependency. Trucost's world leading data and insight enables clients to identify natural capital dependency across companies, products, supply chains and investments; manage risk from volatile commodity prices and increasing environmental costs; and ultimately build more sustainable business models and brands. Trucost's approach not only quantifies natural capital dependency, it also put a price on it, helping clients understand environmental risk in business terms. Trucost approaches and econometric models are informed by an external Academic Advisory Panel, comprised of the world's leading environmental economists.

Since 2001, Trucost has been at the forefront of using natural capital accounting for business applications including work with the Natural Capital Coalition and United Nations Environmental Programme to measure and monetize environmental costs and business impacts related to water scarcity, as well as other uses of natural capital by business. The company has developed an extensive library of valuation datasets and models, and its data and tools inform the research for the annual State of Green Business report and are used to assess the environmental risks of over $18 trillion in assets under management. Since 2011, Trucost has been engaged by more than 50 clients to apply natural capital accounting including helping PUMA and parent company Kering to deliver the world's first Environmental Profit and Loss Account. Trucost's specialized tools measure and monetize water risks in business supply chains. To date, the company has analyzed environmental risks of more than 500,000 suppliers, representing more than $100 billion in procurement.

To learn more about Trucost, visit www.trucost.com or contact northamerica@trucost.com for North American enquiries and info@trucost.com for rest of world enquiries.

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