PLASTICS MARKET WATCH

WATCHING: CONSUMER TECHNOLOGY

PLASTICS' INNOVATIVE CHAPTER IN THE CONSUMER TECHNOLOGY STORY

PLASTICS
INDUSTRY ASSOCIATION

BETTER INDUSTRY. BETTER WORLD.

January 2017

Special thanks to the Consumer Technology Association (CTA)™ for their guidance and input on this Consumer Electronics Plastics Market Watch Report.

In addition, thank you to members of various committees of the Brand Owners, Material Suppliers and Processors Councils and the Recycling Committee for their guidance and input.

Materials compiled, written and edited by William (Bill) Mashek, with editorial assistance from Kim Holmes, Terry Peters and Kendra Martin, Plastics Industry Association (PLASTICS).

Plastics Market Watch

Watching: Consumer Technology

Plastics' Innovative Chapter in the Consumer Technology Story

A series examining the business of plastics, including demographics, economics, policy developments and technological trends in specific plastics end markets.

Contents

Forward

The Plastics Industry Association's (PLASTICS') Plastics Market Watch reports provide forward-looking data and insights on key plastics industry end markets. The series examines the business of plastics, including demographics, economics, policy developments, and technological improvements for markets including automotive and transportation, healthcare and medical devices, packaging, building and construction, automotive recycling, and bioplastics.

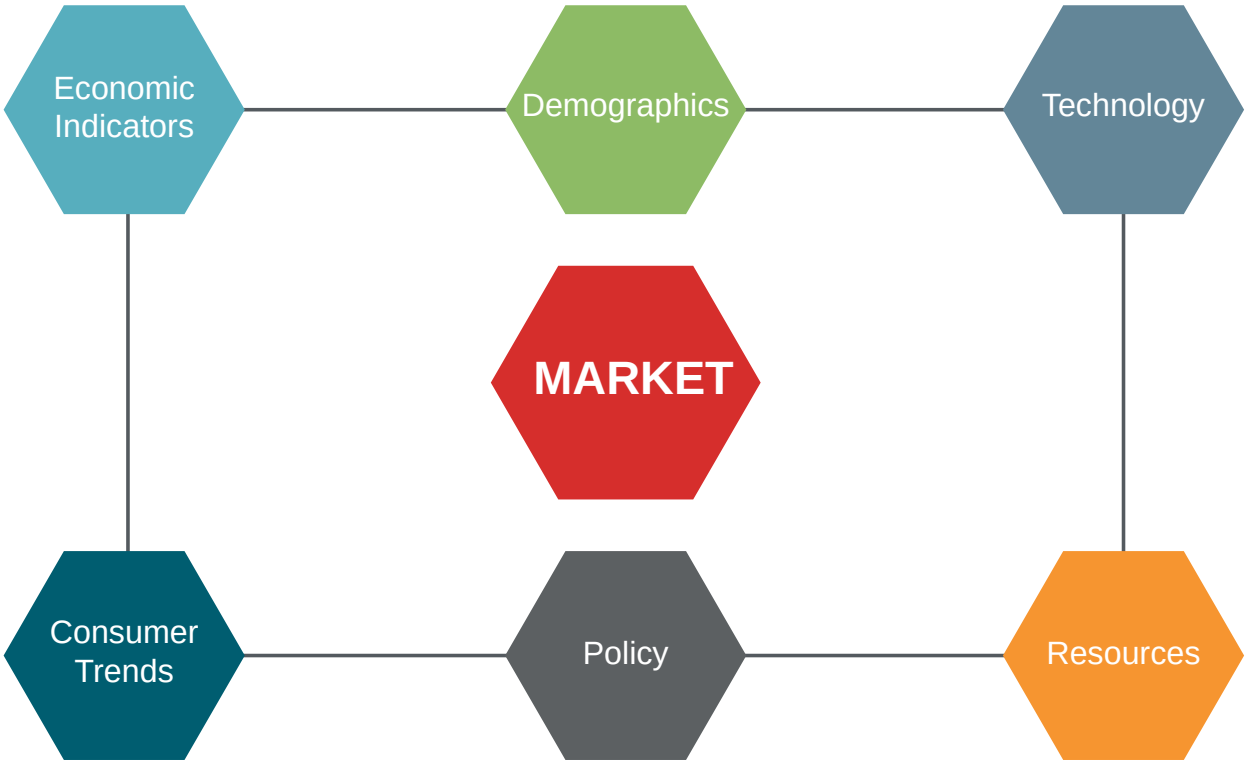
In each sector report, we offer an analysis of the demographics, economics and technology that are shaping key end markets in plastics. In future issues, like Bottling, we will offer insights on plastics' growing role as the leading container for beverages, foods and household goods, and other consumer goods.

Given the role that plastics play in today's modern society, Plastics Market Watch reports offer a holistic picture of our technology—from beginning-of-life resins and polymers to end-of-life management and recycling efforts. Our industry and members have a responsibility to explain the whole picture of plastics and our industry; too often the role of plastics is overshadowed by other technologies or misunderstood. For the average consumer—like a car buyer or a homebuyer—plastics' contribution to their purchase is likely underestimated, but plastics are essential for a vehicle's performance, gas mileage and styling, and a home's insulation, wiring and pipes. The role of plastics within the consumer technology space is the same story: other parts of a television, drone or gaming system attract the attention of users, but plastics are essential to their design, function and performance.

Plastics Market Watch Reports Available:

- Automotive and Transportation
- Healthcare and Medical Devices
- Packaging
- Building and Construction
- Automotive Recycling
- Bioplastics

Chart 1
Key Drivers for End Markets



PLASTICS wants to explain plastics' role for our society as well as provide our members with forward-looking analysis of our key markets in terms of economic and demographic analytics that chart out our future. Consumer electronics exemplifies the challenge our industry faces in articulating our contributions to a sector; at first blush, consumer electronics is a Silicon Valley-centric industry defined by the Internet, software and applications, chips and advanced technology that is transforming our economic and social landscapes. But on closer analysis, plastic is a key contributor to the Consumer Electronics sector because of its protective, light weighting properties, insulation and wiring qualities, and the flexible, safe design properties that are increasingly being used in products that consumers hold and use every hour of the day for their business, communication, health and entertainment.

This Plastics Market Watch report will offer members a current and forward-looking analysis of the Consumer Electronics sector in terms of economic, demographic and technology trends in the sector—as well as public policy issues that are shaping the future of the sector.

PLASTICS wants these Plastics Market Watch reports on key industry sectors to be a component of member companies' strategic planning and intelligence gathering process. We welcome feedback and questions from members and look forward to presenting our papers and insights at future PLASTICS gatherings and meetings.

Introduction

Introduction

Every January, more than 165,000 people from around the world gather in Las Vegas for CES®—the world's gathering place for all who thrive on the business of consumer technology. CES is widely recognized as the top trade show in the U.S. and a global powerhouse—and groups like PLASTICS (that has its own 60,000 attendee event) look at this show with admiration.

CES is an annual platform for companies to showcase their new products and innovations; news coverage of the show not only dominates technology news and social media discussions, it carries over to business shows, nightly news broadcasts and front-page reporting in mainstream news publications.

The Consumer Technology Association (CTA)™ had 3,887 exhibitors at CES 2016, attracting a Who's Who of the consumer technology sector, from SONY and Samsung to automotive manufacturers and drone developers. Across the 20 product categories and 26 marketplaces, you will find notable players in the plastics value chain who attend CES to highlight their products' key role in manufacturing the products featured on the cover of *WIRED* or *Technology Review*.

But more importantly, when you walk the show floor and pull back from the gee-whiz factor and futuristic demonstrations of new technologies, you start to see plastics and polymers. Everywhere.

2017 CES Best of Innovation Honorees

Apply Vision

Cubit

EyeQue Personal Vision Tracker

Goodix Live Fingerprint Detection Sensor

HP Spectre 13

Integrated Connectivity Cluster

Lenovo Phab 2 Pro

Lenovo Yoga Book (Android)

LINK AKC Smart Dog Collar

Mars by Crazybaby

Moto Mods

Nemonic

Nighthawk X10 R9000 Smart WiFi Router

Obsidian 3d Panoramic Camera

OSSIC X

Paradigm Persona 9H

POWERUP FPV—Paper Airplane VR Drone

Predator Z301CT Monitor

ReSound ENZO2™

Robo R2 High-Performance Smart 3D Printer with Wi-Fi

S3 Solid State LiDAR Sensor

Sleep Number 360 Smart Bed

Smart Remote by Sevenhugs

SVS SB16-Ultra Subwoofer

The Z—Gaming Mouse.

Tilt Brush

Tobii Dynavox PCEye Mini with Eye Tracker

uBolt A Secure personal identity wearable bracelet

XGIMI Z4 Aurora Screenless TV

Xooloo Digital Coach

> People don't see plastics in consumer electronics initially, but once people recognize that there are items in their life that would be impossible without plastics, people's opinions change about their importance.
>
> *—Terry Peters, PLASTICS Industry Association*

In fact, looking at the annual CES Best of Innovation award honorees for best designs and engineering advancements, plastic is essential to the engineering, design, function, features and performance of cutting-edge technologies.

Whether encased in plastic, like the Predator Z301CT Monitor or utilizing plastics in their design like the Nighthawk Wifi Router, plastics are everywhere at CES and are an essential material in the leading innovative products in the consumer electronics marketplace.

The products showcased at CES are wide ranging—and so too are the Consumer Technology Association's different divisions and committees. CTA divides its members—and sectors—into the following groups, and each has essential components using plastics:

Accessories Division

Audio Division

Communications Committee

Content and Entertainment Council

Digital Imaging Division

Disruptive Innovation Council

Health and Fitness Technology Division

Retailer Council

Small Business Council

Startups

TechHome Division

Vehicle Technology Division

Video Division

Wireless Division

The explosion of new and market changing electronics products would not have been possible without plastics; a material so functional it provides the framework for innovation in design. Computers, mobile telephones, televisions and game consoles depended upon plastics for structure, circuit boards, wiring and next-generation developments.

Technology companies turn to plastics for durable, lightweight and affordable properties; according to the American Chemistry Council, "plastics deliver an incredible range of performance benefits. Their unique combination of performance properties inspires innovation on two fronts: the development of new and better products and the more efficient use of resource."

But these properties are not immediately evident to consumers. In research PLASTICS conducted last year, focus group participants most commonly associated plastics with bottles and disposable packaging; but when exposed to mobile phones, heart monitors, blood bags and plastics from other applications, there was a realization that plastics are the only material that can be used to manufacture these products and applications. A PLASTICS survey of the general population found strong agreement with the statement, "Without plastics, most of the electronic devices we use each day would not be on the market."

"Plastics and polymers have driven innovation," said Terry Peters, PLASTICS' vice president of Technical and Industry Affairs. "People don't see plastics in consumer electronics initially, but once people recognize that there are items in their life that would be impossible without plastics, people's opinions change about their importance."

Consumer technology has been in constant state of change and development over the past several decades—it is a rapidly innovative industry where next-generation applications are rolled out on a nearly annual schedule. The internal workings of devices have increased in speed and capabilities while shrinking in size and weight; at the same time, wireless services and technologies have transformed how we use applications today. The hand-held mobile phone is one of the best examples of these transformations. But mobile phones are not an isolated example and plastics have been essential to the miniaturization and light weighting of many consumer electronic products.

Innovation across the consumer technology sector continues, moving toward interconnectivity and new areas such as wearables and drones; so while a new phone may use fewer plastics in its casing, new plastic market opportunities grow in other new areas, such as wearable technology. Further, the kinds of plastics and polymers being used with consumer technology devices continues to diversify as the plastics industry responds to manufacturer needs.

Wearable fitness and activity trackers that measure heart rate, sleep habits, number of steps and distance traveled have transitioned from a "first-adapter" technology just a few years ago to a near mandatory accessory for many consumers. According to a 2014 report by Citigroup, the market for wearable technology could grow to $30 billion in the coming years, meaning more smartwatches and activity trackers will need to be designed, made and sold as demand increases.

The innovation in plastics helps propel the development of consumer electronics technologies: weight reductions, safety, miniaturization, design flexibility, performance and greater energy efficiency over the course of a product's life, are all brought to the forefront with plastic. But as next-generation technologies are introduced every year at CES, the consumer technology sector faces challenges confronting other industries, such as end-of-life management and recycling for its products as well as public policy issues like how consumers can work with patent-protected technologies and designs.

Consumer technology (and business technology) is a major economic force around the world with the pace of innovation outmatching nearly every other sector; plastics have a seat at this dynamic table. "No other sector relies so much on innovation as consumer electronics. Innovation is the life blood of this industry as innovation cycles get shorter and shorter to avoid the setting in of buyer fatigue," said Kendra Martin, PLASTICS' senior director of Industry Affairs.

This Plastics Market Watch will explore this growing market for plastics and forecast opportunities and new areas where plastics and polymers will be called on to be partners in innovation for new products and technologies.

The Use of Plastics in Commercial Electronics

The Use of Plastics in Commercial Electronics

When consumer electronics—phonograph, radio and television—were first introduced by Magnavox, RCA and others from the 1940s to '50s, the cabinetry for the systems were wood and seen as furniture in the home. As manufacturers transitioned to plastic, the electronics were frequently made to simulate wood cabinets using injected molded plastic and coatings. That is fortunately no longer the case and gone are the days when plastic was associated with cheap, particularly as companies—electronic and plastics—develop and introduce new plastics to consumers.

With today's consumer electronics, plastics are an asset in terms of design and consumer appeal. Across the consumer electronics spectrum, and with widespread market acceptance and enthusiasm, plastics offer benefits no other material can replicate. According to the ACC, "Plastics enable many of our favorite electronics to do more with less."

Advancements of consumer electronics are being matched by new formulations of plastics and polymers. PLASTICS' Terry Peters said, "More sophisticated, lighter, durable plastics and formulations are being developed to serve manufacturer needs; while responding to a growing focus on sustainability. The number of plastics used in consumer electronics is diverse—and growing to support new products, like wearable technology. Plastics are a go-to material for consumer electronics design and manufacturing for its electrical and heat insulation, durability and light weight, design flexibility, cost and recyclability."

Richard Krock, vice president of Regulatory & Technical Affairs of the Vinyl Institute, sums up the role of plastics in consumer electronics broadly: "First and foremost, plastics provide safety in the design and construction of electronics. Many plastics have electrical insulating properties and some have flame retardant characteristics, either inherent or through the use of flame retardant additives. Secondly, plastics allow more freedom in the design and color and styling for the enclosures. Thirdly, the tactile feel of plastics are warm, and for touch parts, flexible materials give an easy touch. Plastics also provide a variety of other form, fit, function characteristics not possible with other materials in addition to providing an economical solution to complex manufacturing details and processes."

"Plastics have evolved from being considered a 'cheap' cover or housing material to highly engineered composite materials for structural elements and elastomers offering excellent haptics and perceived quality," said Susan Jackson, BASF senior manager of Global Communications Performance Materials. Plastics are providing design and styling freedom that benefits a user's experience—or haptics—in how a unit feels during use.

According to Plastics News, PolyOne Corp. ramped up its GLS Thermoplastic Elastomers (TPEs) for growth in the consumer electronics market, and specifically for wearables, a few years ago. The PLASTICS member company introduced a new material, called Versaflex CE, that bonds to polycarbonate and blends of acrylonitrile butadiene styrene that are often used in consumer electronics. These qualities, along with the fact that Versaflex resists scratches and

Plastics Used in Consumer Electronics and Electrical Equipment

According to the British Plastics Federation, the following plastics are commonly used in electrical equipment and consumer electronics:

Acrylonitrile butadiene styrene: telephone handsets, keyboards, monitors, computer housings

Aikyd resins: circuit breakers, switch gear

Amino resins: lighting fixtures

Epoxy resins: electrical components

Ethylene vinyl acetate: freezer door strips, vacuum lean hoses, handle-grips

Phenol formaldehyde: fuse boxes, knobs, switches, handles

Polyacetal: business machine parts

Polyamide: food processor bearings, adapters

Polycarbonate: telephones

Polyesters: business machine parts, coffee machines, toasters

Polyethylene: cable and wire insulation

Polymethyl methacrylate: hi-fi lids, windows on tape decks

Polymethyl pentane: circuit boards, microwave grills

Polyphenylene oxide: coffee machines, TV housings

Polyphenylene suiphide: hairdryer grilles, element bases, transformers

Polystyrene: refrigerator trays/linings, TV cabinets

Polytetrafluoroethene: electrical applications

Polyvinyl chloride: cable and wire insulation, cable trunking

Styrene acrylonitrile: hi-fi covers

Urea formaldehyde: fuse boxes, knobs, switches

exposure to chemicals (like sunscreen) that come into contact with something worn on someone's wrist, make it perfect for use as a wristband for these devices.

"Our mission is to create advanced material solutions that keep up with the next generation of consumer electronics," Michelle Hearn, global marketing director of PolyOne GLS Thermoplastic Elastomers told PLASTICS Magazine. "Our wide range of material technologies allows us to develop a specific solution based on the precise requirements for an application."

PolyOne is responding to the consumer electronics market and meeting the manufacturing design needs of leading edge companies at the forefront of a new technology. But opportunities exist for plastics and manufacturers throughout the consumer electronic space—including the wires that connect and energize so many technologies.

Consumers and tech innovators are increasingly asking wires to do more than just transmit data or a small amount of power; new wires that are being installed to transmit power are also being asked to transmit data through the same cord. The dual capabilities of these wires generate more strain and heat, enough of which could start fires. That's why cables need to be properly insulated with a plastic material that's durable enough to handle the strain of the modern consumer's and modern builder's demands.

Daikin's Fluorinated Ethylene Propylene (FEP) is a polymer developed for the kind of next generation wiring that's increasingly being put to use in today's consumer technology applications. The material itself maintains a continuous service temperature up to 200 degrees Celsius and provides excellent electrical properties, high chemical stability, low friction, long term weathering protection and very good low-temperature properties; all characteristics that make it ideal for insulating wires and ensuring they operate reliably and safely.

PLASTICS has studied the downstream use of plastics by different industries over the years, including consumer electronics, and in particular computer terminals and computer peripherals. The 2016 Size & Impact Study uses the INFORUM Program from the University of Maryland, an input-output model, which traces plastic products to the final user; PLASTICS has been able to segment the value of plastic to a product's final value.

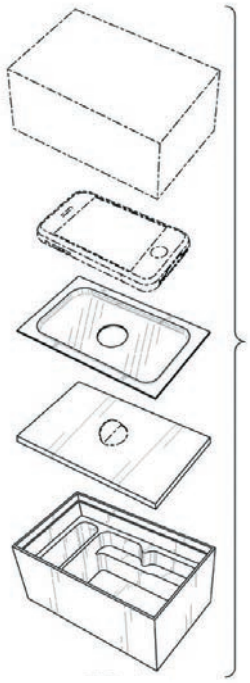
The table below ranks final demand industries by cents worth of plastic products contained per dollar's worth of final product—called "plastics intensity." While some industries have over 10 cents worth of plastic products per dollar of value, and some have much less, the average across all industries is 1.3 cents per dollar of value.

Computer terminals and other computer peripherals rank highly in terms of final demand and plastics content, but only 5.5 cents per dollar of final demand; while plastics are important to the computer, other components are clearly more valuable to the technology.

Table 1

Plastic Products Content of Final Demand by Industry, 2014 (Ranked by Plastics Intensity—Cents per Dollar of Final Demand)

Rank		Millions of Dollars		Cents per $ of Final Demand
		Final Demand	Plastics Content	
1	All Plastic Products	37,284	39,353	105.5
2	Soft Drinks and Ice	41,939	6,124	14.6
3	Mattresses, blinds and shades	11,743	1,630	13.9
4	Snack Foods	30,297	3,603	11.9
5	Seasonings and dressings	13.944	1,466	10.5
6	Coffee and Tea	12,042	1,164	9.7
7	Ophthalmic Goods	9,611	888	9.2
8	Sign Manufacturing	7,854	663	8.4
9	Household and Institutional Furniture	46,294	3,470	7.5
10	All other transportation equipment	4,589	333	7.3
11	Power-driven handtool manufacturing	7,993	568	7.1
12	Toilet Preparations	37,695	2,595	6.9
13	Manufacturing and reproducing magnetic and optical media and software	2,022	126	6.2
14	Soap and cleaning compounds	38,012	2,241	5.9
15	Household refridgerators and home freezers	8,190	476	5.8
16	Paper Bag and Coated and Treated Paper	6,220	350	5.6
17	Computer terminals and other computer peripherals	28,381	1,559	5.5
18	Office Supplies (Except Paper)	3,415	187	5.5
19	Office Furniture (Including Fixtures)	19,624	1,047	5.3
20	Household Laundry Equipment	6,055	315	5.2
21	Other Major Household Appliances	3,318	161	4.9
22	Lawn and Garden Equipment	6,958	335	4.8
23	Surgical and Medical Instruments	33,546	1,606	4.8
24	Wood Kitchen Cabinet and Countertops	1,020	49	4.8
25	Totalizing Fluid Meters and Counting Devices	3,144	145	4.6
	All Other Industries	19,872,907	190,318	1.0
	Total	**20,294,098**	**260,771**	**1.3**



Source:
www.edibleapple.com

Products and the Boxes They Come In

Consumer technology companies are also turning to plastics for their packaging design, and companies such as Apple have patents protecting their packages. Steve Jobs, Apple's former CEO, was "fascinated by packaging" according to Cult of Mac, and when the iPhone was first introduced with 200 patents, its packaging patent was also awarded to Jobs and 16 other designers at the company.

Cult of Mac wrote, "The iPhone's box certainly is elegant. Pull off the top, and the iPhone is presented to its new owner sitting on a slab of glossy plastic, like an expensive watch. Hidden underneath are its accessories and instructions."

Future Trends: Technology + Innovation + Plastics

Future Trends: Technology + Innovation + Plastics

Twice each year, the Consumer Technology Association updates its forecast of more than 100 consumer technology products; some have been in homes for decades, such as televisions and radios, while others including drones and wearables have only started to make their impact on consumers—and society. The rapid innovation and product cycle of introducing new technologies and models has become a characteristic of the consumer technology industry and a reason behind the success of CES.

The CTA forecasts are benchmarks for the industry and others to understand the shift and growth of consumer electronics. The comprehensive reports review the following categories:

Table 2

CTA Forecast Reports

Category	Examples of Technology
Video Technology	Televisions, digital imaging (cameras, camcorders), video components (DVD, Blu-ray, set-top boxes)
Information Technology	Laptop, desktop, notebook personal, tablet computers, monitors, printers, 3D printers
Audio Technology	Audio systems and separates components, compact audio systems, home theater, multi-room audio video systems, soundbars, portable audio entertainment, headphones
Communication Devices	Home telephones, smartphones, standard wireless phones, PDAs
Electronic Gaming	Gaming hardware/software, e-toys, virtual reality/augmented reality hardware
Automotive Electronics	Entertainment devices, information and security systems, navigation
CT Accessories and Media	Accessories, drones, home robots, pet tech, blank media
Home Technology	Home security solutions, connected home technologies, digital assistants
CT Wearables	Health and fitness technology, wearables, smartwatches

Table 3

Projected Growth for Five Largest Revenue Categories

Revenue ($ Millions)	2015	2016	2017
Smartphones	$52,916	$55,012	$53,167
Tablets	$20,425	$19,347	$18,721
LCD TV	$18,804	$19,248	$19,705
Laptops	$17,112	$15,802	$15,321
Desktops	$5,399	$4,576	$4,396
Total	**114,656**	**113,985**	**111,310**
% of Total Industry	**52%**	**51%**	**49%**
Total Industry (Wholesale)	**221,115**	**223,928**	**225,116**

The largest revenue products are those already in the hands of most Americans and households: Smartphones, tablets, LCD televisions, laptop computers and desktop computers. Interestingly, of these major consumer technology products, only LCD televisions are projected to increase sales revenue in 2017 as 4K Ultra HD TVs continue to attract consumers. For the other leading revenue products, particularly laptop and desktop computers, there is a relatively flat line in terms of revenue in recent years and looking ahead.

But while the revenues of established, mass-market products are looking at stagnant or declining revenues for 2017, new technology and systems are continuing to lift the consumer electronics industry. More consumers are looking toward 360 cameras, 3D printers, 4K Ultra HD televisions, connected home technologies, drones, wearable health and fitness technology, and other consumer-focused technologies that didn't exist on the consumer market just five years ago.

For many of these new technologies, interconnectedness and the sharing of information and data between technologies is a push behind the new innovations. This Internet of Things (IoT) is everywhere at CES, as connected devices and technologies are taking hold in the home, and car, and on our bodies.

Table 4

New Category Revenue Projections and Growth Impact (Revenue in Millions)

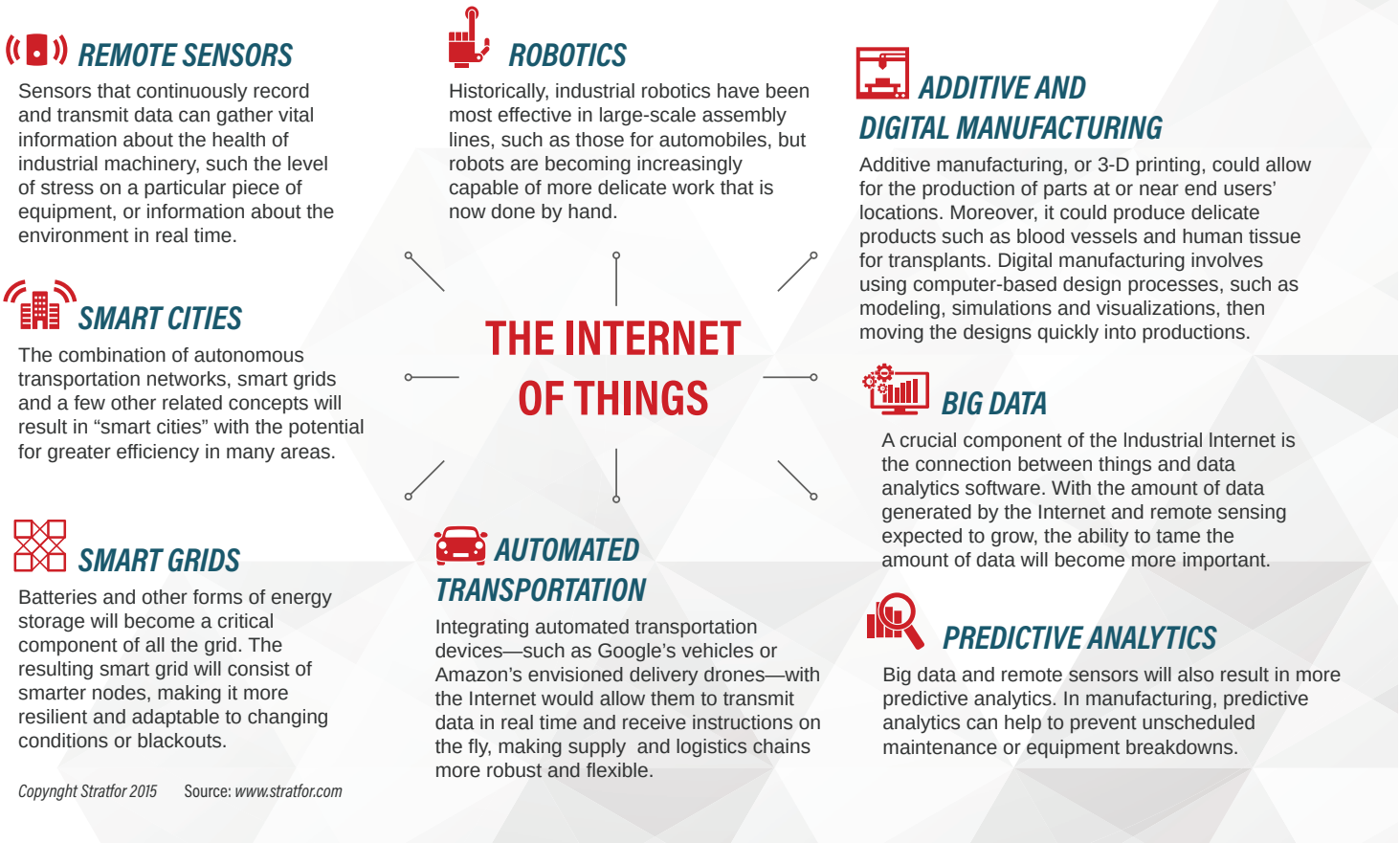
	2015	2016	2017
Connected Thermostats	$242	$313	$363
Smartwatches	$3,052	$2,808	$2,359
Health and Fitness Tech	$1,928	$2,855	$3,482
3D Printers	$110	$148	$214
4K Ultra HD	$7,673	$12,932	$15,664
Drones	$443	$799	$1,296
Home Robots	$811	$960	$1,074
IP Cameras	$87	$116	$154
VR/AR Eyeware	$100	$432	$1,080
Smart Home Systems	$317	$408	$497
Smart Locks	$219	$240	$260
Standalone Digital Assistants	$298	$392	$806
Pet Tech	$75	$91	$113
360 Cameras	$7	$31	$65
Total Emerging Categories	**$15,363**	**$22,524**	**$27,427**
Growth	**176%**	**47%**	**22%**
Total Industry Revenue (Wholesale)	**$221,115**	**$223,928**	**$225,116**
Minus Emerging Categories	**-15,363**	**-22,524**	**-27,427**
	$205,752	**$201,404**	**$197,689**
Growth	**-3.5%**	**-2.1%**	**-1.8%**

IoT technology and the use of embedded sensors is pushing the envelope on developing new solutions to improve lives through increased efficiency, energy and cost savings, improved health and safety, and other real-life needs. According to CTA Chief Economist Dr. Shawn DuBravac, technology companies and innovators are entering an important phase of experimentation for Internet-enabled objects.

Currently, only an estimated three in 10 U.S. houses have smart home devices, according to a survey by CNET and Coldwell Banker; but within five years, homebuyers will expect Smart Home technology and it will become the "new norm," particularly as millennials purchase homes. Currently, nearly half of millennials own smart home devices, and 81 percent indicated they would be more likely to buy a home that had interconnected home technology capabilities than one without it.

Chart 2

The Internet of Things



 Source: *www.stratfor.com*

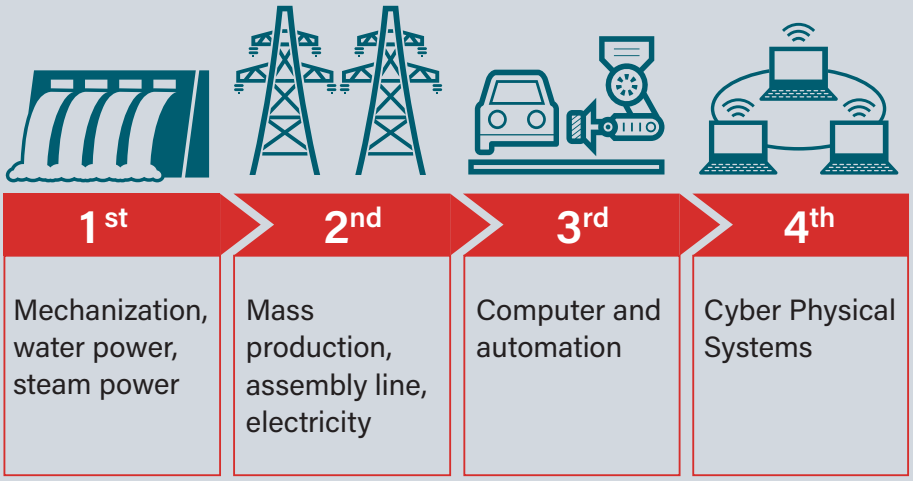
Still, while it is expected that IoT technology will take hold in the U.S.—not every application will be a slam-dunk with wide consumer acceptance. CTA's DuBravac predicts an important experimentation phase will take shape in the coming years and that ultimately consumers will decide with their wallets which IoT technologies thrive and shape lives and which are flashes in the pan.

A part of IoT's development, "ambient sensors" are increasingly becoming a part of consumer electronics, finding their way into Smartphones, homes and appliances. "We have switched to an array of sensors that are continuously monitoring," DuBravac told VentureBeat. "You empower environments, setting a dishwasher to run at a time when the energy costs are lower or when you are away from home."

Sensors will monitor consumers and how they interact with their electronics and devices, and in the coming years, will anticipate an owner's movements and needs from cooling and heating individual rooms—like the kitchen during the early morning and the bedroom at night. DuBravac predicts 50 billion objects will be interconnected in the coming years. As an example of connected home innovation, consumers can monitor their home's security, temperature, lighting—even prepare a pot of coffee or play music fitting their mood—before they actually set foot in the front door.

Chart 3

Industry/Manufacturing



Source: Kendra

At the K Show in Dusseldorf, Germany in October 2016, the plastics industry had an opportunity to see Industry 4.0 up close. An automation trend in manufacturing that utilizes technology and data exchange, the German-developed process is frequently seen as industry's response to the IoT.

Initially developed by SIEMENS and the German Government, Industry 4.0 creates what has been called a "smart factory" where an entire facility (from machines and supply chains to maintenance and shipping) are integrated and connected, sharing analytical data, focused on reducing downtime and waste.

Key to the success of Industry 4.0—like the IoT—is the adoption of sensors into equipment and machines to share data and information as well as make decisions on all stages of the manufacturing process without human intervention.

Sensors allow for real time analysis and decision making that can have a profound impact on the supply chain, decreasing manufacturing costs and improving quality. A number of German manufacturers have adopted tenets of Industry 4.0 in their factories, including BASF, Bosch and Daimler.

Manufacturing has evolved over the past two centuries, and Industry 4.0 is beginning to take hold around the world in a number of industries.

Technology Trends Highlights

Video Technology

For several years, video technologies have been the third largest category in terms of revenue, with televisions (notably LCD Flat Panels) being the dominant, growing technology sector. Screen sizes continue to increase along with crisper images, but total revenues for video technology have been flat.

Looking at viewing patterns, televisions are no longer the screen of choice for all consumers; millennials are increasingly turning toward tablets, laptop computers and smartphones to view their programming with on demand services. Furthermore, smaller screen LCD televisions (less than 40 inches) have seen a sharp decline in sales in recent years. The growth of 4K UHD sets will be the strong suit of video technology as nearly 40 percent of all televisions sold in 2016 were 4K according to CTA, and by 2020, 75 percent of all television shipments are expected to be 4K UHD. The larger, flat televisions rely on plastics to keep the 60-inch screens (and even bigger sizes) light so they can be positioned on walls; the larger screens also require more plastics on the back panels.

Digital camera revenues have dropped dramatically over the past several years as consumers increasingly utilize their smartphones for taking photos and videos rather than carry another piece of technology. To illustrate this point, when Apple's iPhone was first introduced in 2007, the camera technology on the smartphone was not a marketing highlight. Today's iPhone is equipped with two cameras (front and back) and the photo capabilities dramatically improved, helping to spur the growth of new applications like Snapchat and Instagram. Action camcorders, such as GoPro, have steadily grown in revenues in recent years while 360 degree cameras just started to make a mark in the digital imaging category that is used for immersive video reality experiences.

For video components, like DVD and Blu-ray, revenues have been declining slightly over the past four years as consumers generally have multiple options for viewing content—including streaming options that have gained popularity. Set-top boxes (Cable/Multi-System Operator MSO Receivers, Direct Broadcast Satellite DBS Receivers, and Streaming Media Players) continue to be the dominant revenue driver for all video components—although revenues have been declining as well. Changing viewing habits—and technology offerings from cable companies and satellite services—will continue to impact the revenues in this category as competing technologies seek to appeal to viewers.

Information Technology

Over the past four years—and into the future—IT (Desktop PCs, Laptop and Notebook PCs, and Tablet PCs) has been the largest technology category in terms of revenue—although its dominance has been declining slightly. Overall, the personal computer industry is undergoing significant change, as 68 percent of U.S. households own a laptop computer and more than 50 percent have a desktop computer. Tablets, introduced just seven years ago, are now in 59 percent of households.

While ownership rates have climbed in recent years, sales of the computers and tablets have dropped as consumers are increasingly using their smartphones for internet access and access to applications. A developing trend and a revenue bright spot is 2-in-1 computers such as the Microsoft Surface that combine laptops with detachable tablets and technology that allows writing on the surface of the tablet.

Interconnectedness of devices and technologies is an opportunity for the category, as tablets could become the control panel for a connected home. Further acceptance and growth of other technologies—like virtual reality (VR)—could spur increased utilization of computing technologies.

3D printing, which made a great splash with its introduction a few years ago, continues to be a nascent market looking for its niche, like the micro-customization trend. At CES, there has been a significant presence of 3D printer companies. While sales have been increasing, it will likely be a decade according to the CTA's DuBravac before the full impact of the technology is recognized. A number of colleges and universities currently have 3D technology, but how corporations and consumers will use 3D printing will need to shake out in the coming years. And while it does not appear to be a strong consumer play, it will continue to impact design, production and mass customization.

Audio Technology

Consumer audio habits are changing—at the home and on the go. Audio separates components have seen steady decline in terms of revenue and units sold over the past several years. A growing audio technology—Soundbars—is being paired with televisions and the growth of home theater technologies. Meanwhile the use of Bluetooth, Wi-Fi and streaming services have boosted the sale of mid-range receivers and wireless speakers. Still, headphones and in-ear products are the go-to technology for many millennials who want mobility with their music and entertainment.

Communication Devices

Wireless communications, and particularly handheld smartphones first introduced in 2003, have been transformative devices and technology. Worldwide, there are approximately 3 billion smartphone subscriptions—by 2020, there will be an estimated 6.1 billion (70 percent of the world's population using a smartphone) according to Ericsson's Mobility Report.

Today, almost half of U.S. households have "cut the cord" to their copper wire telephone service and exclusively use wireless phones and smartphones. But after yearly growth, smartphone revenues are expected to drop in 2017; for years, new applications and features (like fingerprint sensors, sharper screen resolution, photo and video capabilities, clearer sound, and longer battery life) pushed the envelope for new phones and upgrades, but that is no longer the case. Now, it is estimated that the upgrade cycle for smartphones has gone from 18 months to 21 months, slowing revenues. In addition, it is expected that Chinese-based companies and others will increase competition for smartphones in the U.S., further pushing down prices and revenues.

Electronic Gaming

The most exciting development—and growth opportunity—for electronic gaming has been virtual/augmented reality (VR/AR). CES 2016 showcased VR's and AR's growing potential—the show's gaming and virtual reality space grew 68 percent and featured 46 exhibitors, including the likes of Facebook and NASA. In just four years, VR/AR units sold have gone from 40,000 in 2003 to an estimated 2,136,000 units in 2017. While VR/AR has had some fits and starts in terms of consumer experience and delivery of units, some analysts believe the current generation of VR/AR units could be the holiday gift of choice for many consumers in 2016.

Home Technology

Interconnectedness of devices and IoT is taking hold in American homes, from digital assistants like Amazon's Echo and Alexa Voice Service that was introduced in 2015 to electronic doorlocks, connected thermostats and other appliances that can tell homeowners when the refrigerator is low on milk. Connected home technologies will ship an estimated 9.5 million units in 2016—a 29 percent increase from 2015 according to CTA. Home security solutions, however, have been the consistent leader in terms of revenue over the past several years—and it continues to grow annually.

Wearables

Heart rate monitors strapped around the chest were the training tools of elite athletes several years ago. Today health and fitness wearable technology, smartwatches and hearables (advanced in-ear technology) are increasingly common, and unit growth for the technology is expected to grow in double digits year-over-year through 2020. Still, despite the growth and the development of technology going from a heart monitor and step counter to a comprehensive fitness, GPS tracker, sleep monitor and provider of other health-related data, the wearable market is still in a nascent and exploratory environment waiting to identify the compelling technology that will push wearables to widespread adoption. How wearable data is collected, analyzed and shared is key to its breakthrough; health stats are not useful if they are not actionable and shared with the right people.

Future Trends: Economics

Future Trends: Economics

While revenues for dominant technologies (smartphones, tablets, LCD televisions, laptop computers and desktop computers) in the consumer technology sector have been flat or declining, there continues to be strong promise and optimism among companies and savvy-tech consumers.

According to CTA, new categories of technology comprise a significant portion of industry growth. In fact, "without these new categories, industry revenue growth would be negative (2.1 percent in 2016 and 1.8 percent in 2017). It stands to reason these products (as well as future products) will continue to help grow the industry as household ownership of several product categories reach their maximum penetration rate."

The economic and social impact consumer technology has had around the world is hard to overestimate. Consumer technology products experienced year-after-year double-digit growth and expansion, as devices found their way into the hands of consumers and businesses around the world. The combination of hardware innovations and new software applications has been a remarkable economic engine for the sector and the broader economy that has adopted the technology for their products and industry.

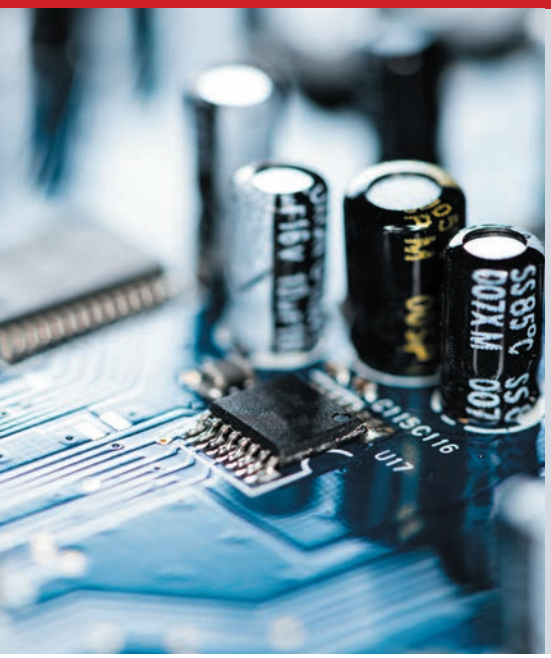
CTA's analysis of household penetration rates of consumer technology—which products have reached widespread U.S. consumer adoption, and which nascent technologies have potential growth opportunities.

Table 5

Household Penetration Rates

			*	Jan 2012	Jan 2013	Jan 2014	Jan 2015	Jul 2016
Audio Technology	Audio Separates/ Systems	Compact Audio Systems		28%	26%	25%	23%	21%
		Home and Clock Radios		98%	98%	96%	95%	95%
		Home CD Player		40%	39%	38%	36%	35%
		Home Theater System/ Surround		39%	40%	41%	41%	41%
		Soundbars	*	8%	11%	11%	16%	20%
	Portable Entertainment	Bluetooth-Enabled Speakers	*	—	25%	30%	31%	35%
		MP3 Speaker Docks	*	44%	44%	42%	37%	37%
		Portable Media/ MP3 Players		45%	52%	46%	42%	41%
Automotive Electronics	Entertainment Devices	Car CD Players	*	77%	74%	75%	74%	72%
		Satellite Radios		25%	23%	21%	20%	19%
		Video Entertainment Systems (Automotive)		17%	19%	20%	21%	23%
	Information and Security	In-Dash Navigation		16%	17%	16%	16%	18%
		Portable Navigation Device	*	46%	44%	42%	39%	40%
Communication Devices	Home Communications	Home Internet Access		78%	78%	78%	78%	78%
		Home Network (Wired or Wireless)		54%	61%	62%	64%	64%
		VoIP Adapters		14%	13%	12%	11%	10%
	Portable Communications	Smartphones	*	46%	58%	64%	72%	74%
		Standard Wireless Telephones	*	67%	60%	51%	43%	37%
Electronic Gaming	Electronic Gaming Hardware	Home Gaming Console	*	49%	51%	49%	45%	40%
		Portable Gaming Console	*	31%	27%	25%	24%	22%
Information Technology	Computer Printers	Computer Printers	*	78%	77%	63%	63%	63%
	Modems/Broadband Gateways	Modems/Broadband Gateways		74%	75%	75%	75%	76%
	Personal Computers	Desktop Computers	*	68%	63%	58%	55%	53%
		Laptop/Notebook PCs	*	63%	65%	66%	67%	68%
		Personal Computer (Any Type)		90%	90%	90%	88%	88%
		Tablet PCs	*	22%	39%	45%	54%	59%
Video Technology	Digital Imaging	Action Camcorders	*	—	—	—	9%	9%
		Camcorders	*	42%	38%	31%	28%	26%
		Digital Cameras		74%	73%	66%	64%	63%
	TV Sets and Displays	4K Ultra HDTV	*	—	—	1%	2%	3%
		DTV		88%	89%	89%	90%	91%
		HDTV (720p+)		87%	88%	89%	90%	90%
		LCD Flat Panel	*	72%	74%	75%	75%	77%
		Smart TV	*	9%	15%	24%	43%	46%
	Video Components	Blu-ray Players		26%	29%	31%	32%	34%
		Cable/Multi-System Operator (MSO) Receivers		42%	41%	42%	42%	42%
		Component DVD Players/ Recorders		92%	88%	87%	85%	82%
		Digital Video Recorders (DVRs)		47%	47%	47%	47%	46%
		Streaming Media Players	*	18%	24%	24%	29%	34%

** Data derived from CTA's 18th Annual Consumer Technology Ownership and Market Potential Study, April 2016.*



Moore's Law

In 1965, Gordon Moore, the co-founder of Intel, made a prediction that would economically help define the modern technology revolution. From an observation that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented, Moore predicted that this trend would continue for the foreseeable future.

As Intel describes today, "Performance—aka power—and cost are two key drivers of technological development. As more transistors fit into smaller spaces, processing power increased and energy efficiency improved, all at a lower cost for the end user. This development not only enhanced existing industries and increased productivity, but it has spawned whole new industries empowered by cheap and powerful computing."

In Plastics News, Economics Editor Bill Wood wrote that the Federal Reserve Board's industrial production index reported a short-term quarterly burst for computer equipment in 2016—and the potential for a seven year high for the sector. Wood expects computer products will be flat overall in 2016 compared to the previous year, but could show moderate growth in 2017.

Wood wrote that U.S. investment and production levels for computers has been flat over the past several years; "One theory for the plateau is that the production of these products has migrated to other countries. I believe this is one of the long-term issues in this industry, but that does not explain why domestic companies are not increasing their investment in these products, regardless of where they are manufactured."

CTA's pulse of the industry is similar, predicting a 1.3 percent total industry growth for 2016 with wholesale revenues reaching $223.9 billion.

Smartphones continue to be the top consumer technology product; 2016 smartphone revenues are estimated to be $55 billion, up four percent from the previous year.

Another impact on pricing and investment is deflationary pressures on consumer electronics, according to CTA's DuBravac. Deflationary pressures have made technologies and applications more accessible; as an example, high-definition televisions, when first introduced, were priced over $20,000. Today, 4K Ultra HD 60-inch screens can be had at a fraction of that cost—and while 4K UHD televisions are currently growing approximately 40 percent year over year and will likely continue to enjoy double-digit growth in the coming years, the price points of the units have decreased in recent years.

Inflationary pressures in consumer technology happen across the supply chain, from processors to plastics—and savings have been pushed to the consumer. Furthermore, economies of scale, manufacturing advancements and competition throughout the supply chain have all benefited the consumer. Manufacturers in emerging markets are also bringing to market quality products and technologies at lower price points—attracting their domestic consumer as well as consumers in developed nations seeking lower cost products.

According to experts, major citable reasons for the exponential growth of consumer technology are increasing disposable incomes, expanding middle class population and growing internet penetration rate. In the U.S., disposable income is being used to make early-adopter consumer purchases; in the developing world, the growing middle class and increased wireless Internet access is tied to the growth of consumer technology sales.

Future Trends: Demographics

Future Trends: Demographics

> With the flattening of growth in mature markets, more attention and revenue will come from the Chinese, Indian and African markets.

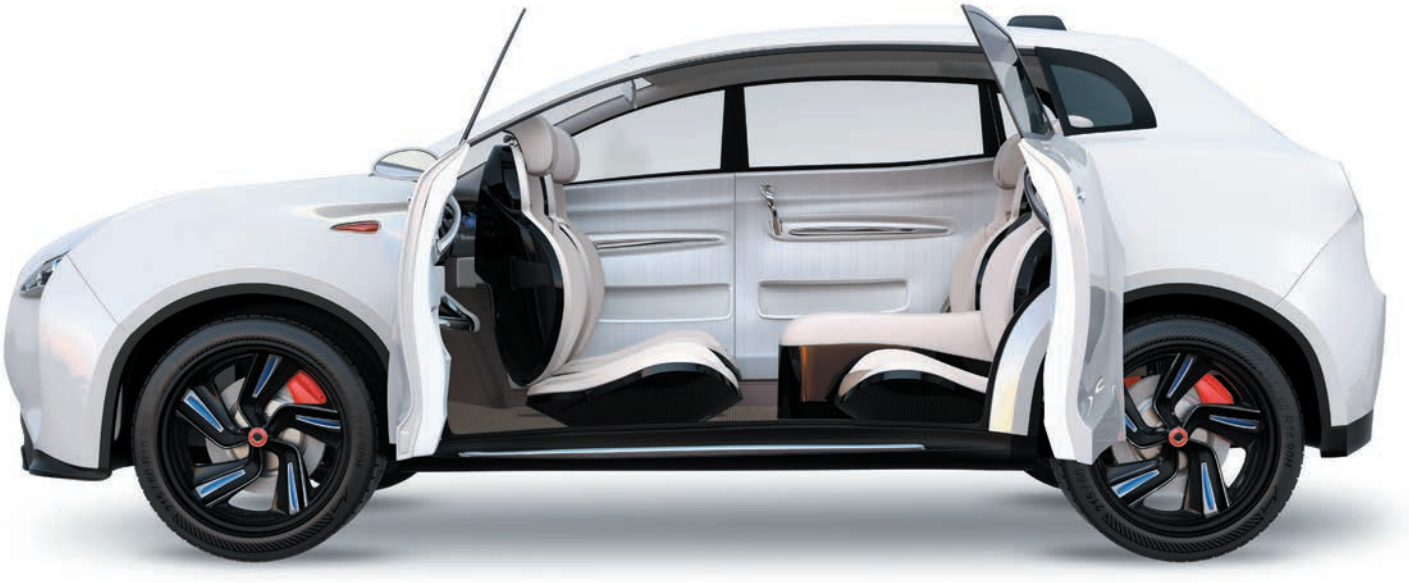
The days of North America's dominance in terms of consumer technology market share are over—although its early adopter consumers continue to use higher levels of disposable income to purchase the new products and technologies entering the marketplace like wearables and gaming systems. Western Europe and developed Asian nations have also matured dramatically in recent years in terms of consumer market revenue growth; and now both have experienced declines in recent years in the revenues associated with IT technologies (personal computers, laptops, tablets, etc.)

With the flattening of growth in mature markets, more attention and revenue will come from the Chinese, Indian and African markets. New technologies in these emerging markets has been met with widespread consumer acceptance and adoption—for some consumers in these nations, wireless telephones and communications are the norm. In addition, growing urban populations in China and the Asia-Pacific markets will help drive demand for connectivity and consumer electronics.

The slightly declining global technology spending in recent years is attributable to a number of issues according to CTA's Global Technology Market Update. The strong dollar and economic weakness—including China's slowdown in the past few years—has impacted the sales of consumer technologies as well the saturation points of mainstay electronics like tablets, smartphones, laptops and personal computers.

In the emerging markets, such as China, domestic manufacturers are introducing applications to their consumers with current technology, but at a lower price point. The competition is putting costs pressures on established manufacturers around the world. The low-growth, margin compressed sector is also at the same time, rapidly evolving with new, disruptive technologies—manufacturers will need to produce products and compete in this challenging environment.

Predicting the path and growth rate of consumer technology is not a slam-dunk; nobody knows exactly how the marketplace will unfold—and how quickly some new applications are adopted (smart homes, driverless cars, etc.) in diverse markets. Consumer technology companies will be operating with some uncertainty in the coming years as consumer dollars shift among product categories and emerging technologies take hold.



In the U.S., there is a bit more certainty—or understanding—of the consumer electronics marketplace and the groups that have adapted to new technologies and eagerly await new models and breakthrough applications. A Gallup Survey from 2014 divided the U.S. into four groups based upon their adoption and usage of consumer electronics: Super Tech Adopters, Smartphone Reliants, Mature Technophiles, and Tech Averse Olders.

Just under one-third of American adults were "Super Tech Adopters," the early or first adopter of technology group that is likely to own a variety of devices and use them extensively. Gallup reported among Super Tech Adopters, all of them have a smartphone, 99 percent have wireless Internet at home, 95 percent have a laptop computer, 86 percent have an iPod or MP3 music player, 78 percent have a tablet and 67 percent have a desktop computer.

Super Tech Adopters average age is 39—and most are college graduates (54 percent) and 72 percent are employed full or part time.

"Smartphone Reliants" according to Gallup represent 19 percent of Americans: 93 percent of this population have a smartphone, 65 percent have a laptop and most have wireless at home. However, this group is less affluent and less likely to have technologies like tablets, e-readers, MP3 or music systems or subscribe to streaming services. This group likely relies upon their smartphone for music and entertainment.

The third group—"Mature Technophiles"—have slightly higher incomes and formal education, and therefore have several electronic devices for work and entertainment is also a natural target for consumer electronics marketers. Their average age, 50, likely attributes to their aversion to smartphones.

Thirty percent of Americans, according to Gallup are "Tech Averse Olders" averaging 58 years. Smartphone adoption is not extensive in this group—only 16 percent have a smartphone and the only consumer electronic technology they have embraced are DVDs and similar video entertainment offerings.

Table 6

Demographic Profile of Consumer Electronics Owners in the U.S. (Based on Four Special Consumer Electronics Groupings)

	Super Tech Adopters	Smartphone Reliants	Mature Technophiles	Tech-Averse Olders
% of U.S. Adults	31%	19%	22%	28%
Men	51%	42%	52%	49%
Women	49%	58%	48%	51%
18 to 34 Years	41%	48%	20%	11%
35 to 54 Years	43%	26%	39%	29%
55 and Older	15%	27%	41%	60%
Average Age	39	40	50	58
Less than $30,000	12	30	18	56
$30,000 to $74,999	34	46	50	36
$75,000 or More	53	23	33	8
College Graduate	54	27	37	10
Some College	31	33	28	21
No College	25	39	34	68
Employed	72	48	45	35
Retired	6	10	29	40
Homemaker	5	11	13	9
Student	13	17	6	1
Unemployed/ Disabled	4	13	7	14

Based on December 5–8, 2014 Gallup poll with 1,031 national adults, aged 18 and older
Source: GALLUP

Gallup also links income inequality in the U.S. to the significant electronics disparity in the country. But age—and the comfort level of technology associated with age—is also a linkage to blocking access to new technologies according to the polling company.

According to U.S. Census Bureau estimates in 2015, Millennials have now surpassed Baby Boomers as the nation's largest living generation, with an estimated 75.4 million. Baby Boomers number just below Millennials at 74.9 million, and the shift has an impact on the groups identified by Gallup. The Millennial generation continues to grow as young immigrants expand its ranks and Boomers' decline in numbers through deaths and the decline of elderly immigrants entering the county.

The behavior of Millennials is shaping key developments in the consumer technology space. According to DuBravac, "Broadly speaking, they have a focus on renting services, like with UBER and not owning cars. They are a global cohort with a mobile, active lifestyle. They are marrying later and postponing home-buying or other major purchases."

Millennial viewing habits have indeed impacted consumer electronics as many younger Americans consume entertainment from on-demand streaming services to their handheld devices (smartphones, laptops and tablets) rather than watching movies, sports and programming on televisions.

CTA's DuBravac sees the economic divide being a major differentiator in consumer technology usage as well, "There is a bifurcated population in the U.S., those with discretionary incomes are purchasing fitness trackers and new technology offerings while the core products (personal computers, smartphones, tablets, televisions, laptops) are owned by the mass market. Emerging technologies mostly fall into that discretionary spending category."

Future Trends: Public Policy & Sustainability

Future Trends: Public Policy & Sustainability

The speed of innovation in the consumer technology sector is remarkable; start-ups continue to push the envelope of change and new product creations. As technology and the industry have evolved, OEMs have been challenged to consider the management of their products at end-of-life as part of their broader business model. This became a priority of increasing relevance back in the early 2000s, when non-governmental organizations (NGOs) such as Greenpeace were scrutinizing companies on a variety of environmental attributes, one being voluntary take-back programs. What was once a voluntary activity has evolved into a regulatory compliance issues for OEMs who now must meet product stewardship goals in over 25 states.

In 2015, a record-setting 700 million pounds of consumer electronics was recycled through CTA's eCycling Leadership Initiative that collects electronics at more than 8,300 collection locations across the U.S. The Initiative started in 2010 with 300 million pounds of electronics recycled and has grown annually in terms of participation and recycled material. Through the collaboration of manufacturers, retailers, recyclers, collectors, state and local governments, the amount of e-scrap collected and recycled has continued to increase in the U.S.

> "The light-weighting of products which took off during the 2000s is finally showing up in recycling program statistics."
>
> *—Walter Alcorn, CTA VP of Environmental Affairs and Industry Sustainability*

"While we have seen dramatic increases in the amount of consumer electronics recycled during the past decade, now we are seeing year-over-year decreases in the states with the most mature electronics recycling systems" says Walter Alcorn, CTA VP of Environmental Affairs and Industry Sustainability. "The light-weighting of products which took off during the 2000s is finally showing up in recycling program statistics."

PLASTICS is engaged with other trade associations and industry groups in developing guidelines and standards for the consumer technology sector and its growing usage of plastics.

End-of-Life Issues

The end-of-life (EOL) issues with consumer electronics have the attention of the industry, NGOs, regulators like the U.S. Environmental Protection Agency and United Nations, and consumers themselves. There are a number of reasons that the issue of electronics recycling has garnered so much attention. First and foremost, electronics contain valuable resources such as gold, silver, palladium, copper and rare earth metals. These precious metals are the desired commodities that make the electronics recycling process profitable. Second, a lot of attention has been given to ensuring that electronics recycling is done in a way that presents minimal risk to the environment and human safety.

Obsolete electronics are sometimes known as e-waste, or are commonly referred to as e-scrap. As consumers upgrade the technology devices in their lives at a rapid rate, new systems have emerged to collect and reuse mobile devices in particular, and to recover the embodied resources of retired devices. Smartphones and enterprise laptops have horizons on their usage and can be retired from first use in as little as 24 months. Add in televisions, computers and peripherals, servers and tablets and it is easy to see how the e-scrap industry has grown so large, so quickly in the U.S. and around the globe. The Institute of Scrap Recycling Industries (ISRI) estimates the total electronics recycling business is a more than $20 billion operation with more than 4 million tons of e-scrap processed and recycled annually in the U.S. For comparison purposes, less than 1 million tons of e-scrap was recycled in 2002.

> We are using more and more IT products and devices, which means that there's an increasing need to recycle the resources that go into the products. To us, circular economy is not only about circular resource use, it's about being wiser in the way we use natural resources.
>
> *—Louise Koch, corporate sustainability lead of Dell EMC Europe, Middle East and Africa (Source: Greenbiz)*

E-scrap is made up of largely recyclable materials like metals, glass and plastics (also known as e-plastics). While these seem like rather simple material categories, the materials in electronics are in fact, quite complex. For example, a laptop could have half a dozen different types of plastics. And the e-scrap category as a whole can contain up to 60 elements from the periodic table. Some of those materials are quite valuable, and some are materials of environmental concern if not managed properly. Of the e-scrap collected in the U.S. each year, it is estimated that more than 80 percent is recycled, reused or refurbished domestically—and only 17.2 percent (by weight) are exported. Some NGOs, like the Basel Action Network (BAN) have pushed to curb the export of e-scrap from the U.S. but proposals in Congress have not gained traction for a number of reasons. Groups like BAN are concerned that electronics sent to developing countries will not be recycled with the same environmental controls that are in place in the U.S. and other OECD countries.

Environmentally responsible management of e-scrap is a priority for all stakeholders. To ensure that proper recycling best practices are in place, both in the U.S. and abroad, the industry has worked closely with the U.S. EPA to develop a set of standards designed to mitigate any risk to human health and the environment during the e-scrap dismantling and reclamation process. The R2, or Responsible Recycler standard (**https://sustainableelectronics.org/r2-standard**) was spearheaded by the EPA and developed through a broad industry stakeholder process. The second standard to emerge in the marketplace was the e-Stewards standard (**http://e-stewards.org**), developed by BAN, which differs in several respects including further restrictions on the international shipment of certain commodity classes to developing countries.

Design for Environment/ Design for Recycling (DfE/DfR)

Design for Environment (DfE) / Design for Recycling (DfR) has been an equally important priority for many OEMs like HP and Dell; all of which have made DfE / DfR a pillar of their product development cycle.

At CES, the Consumer Technology Association has recognized electronics products for innovation in Eco-Design and Sustainable Technologies for several years, looking at new products from the perspective of features that make them safe for the environment, such as efficient and clean energy use; manufacturing processes that reduce use the of environmentally relevant substances (e.g., lead, mercury); durability/end-of-life (reuse, refurbish, remanufacture, recycle); and/or resource conservation.

HP's DfE program, initiated in the early 1990s, focuses on energy efficiency, materials innovation (use of less material, increase recycled and recyclable content, and use materials with lower environmental impact), services (designing service models to reduce environmental impacts and increase product longevity through support), and end-of-life options (making responsible return and recycling easier).

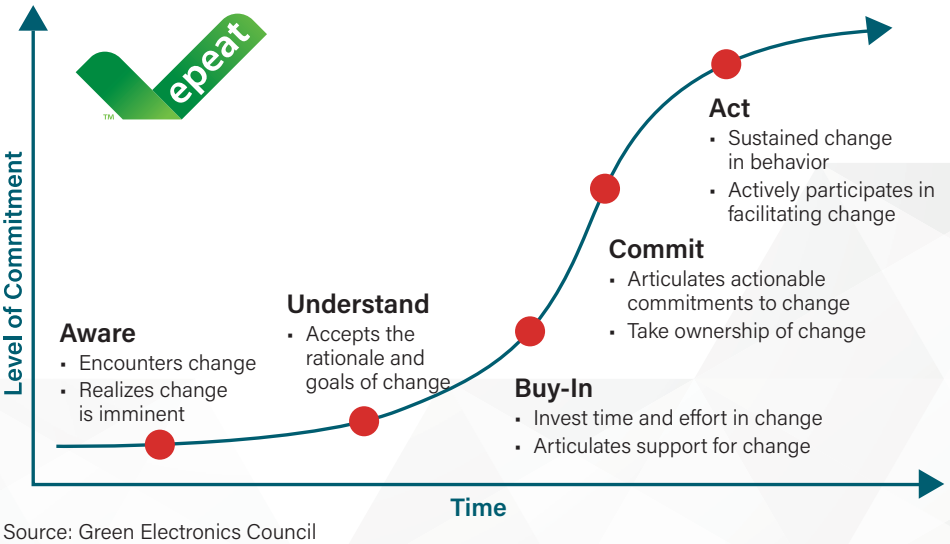
For the electronics industry overall, one of the greatest DfR and DfE success stories in the electronics industry has been the development and rise of the Electronic Product Environmental Assessment Tool (EPEAT). The Green Electronics Council (GEC), a non-profit established in 2006 with the backing of the U.S. Environmental Protection Agency, was initially focused on managing EPEAT, the leading rating system for promoting and expanding greener electronics by collaborating with industry manufacturers and purchasers, particularly large-scale producers and government and other institutional purchasers of electronics. GEC is now working to collaboratively improve the sustainability of electronics in the way they are designed, manufactured, purchased, operated, and recycled.

Key to GEC's efforts is getting the entire electronics supply and users chain aligned in understanding the need for more sustainable product design and manufacturing of electronics and the challenge for developing them. By securing commitments to participate and meet the challenges, GEC spurs action that shifts operational, manufacturing and procurement behaviors.

GEC's collaboration and education within manufacturing and procurement activities is outlined in their S-Curve for Sustainable Electronics:

Chart 4

GEC S-Curve for Sustainable Electronics



Source: Green Electronics Council

Central to GEC's efforts is the EPEAT method for electronics consumers (governments, institutions, consumers, etc.) to measure the effect of a product on the environment by measuring a product's lifecycle by ranking it as a Gold, Silver or Bronze product based upon established environmental performance criteria.

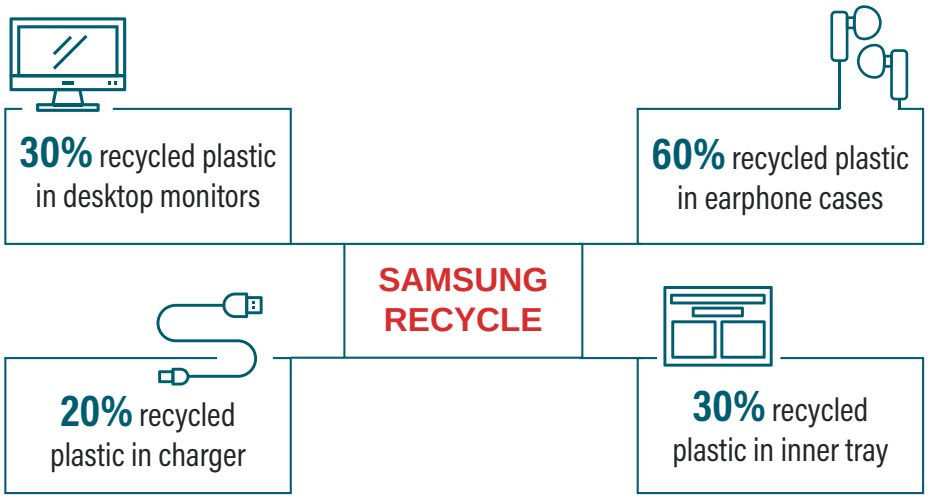
Manufacturers work with Conformity Assurance Bodies that provide third-party assurances that products meet Institute of Electrical and Electronics Engineers (IEEE) 1680 green electronics standards. The IEEE 1680 family of standards are extensive; for example, the personal computer evaluation has 52 different environmental criteria (23 required/28 optional) on the PC's attributes and efficiency, one of which is use of post-consumer recycled (PCR) content plastics. In fact, the growth of the e-plastics recycling infrastructure can be directly attributed to the incentives to use PCR in the EPEAT standard.

The kinds of products in the EPEAT registry include PCs and displays (including tablets, laptops and monitors), imaging equipment (printers, copiers, scanners), and televisions; future categories will include mobile phones and servers. Currently, more than 4,400 products from 60 different manufacturers from 43 countries have been evaluated.

In 2016, Sarah O'Brien, director of global stakeholder engagement for the GEC, told Environmental Leader, "It's interesting to know that there is a continuing need to alert purchasers to the environmental impacts of electronics—and to see that once their awareness is raised, many are eager to find effective ways to act to reduce their impacts. Organizations often want to reduce the environmental impacts of their purchasing but are unsure how to proceed. By reaching out to offer guidance, we in the sustainable electronics community can empower purchasers to adopt EPEAT and reduce the impact of their IT operations."

Chart 5

Recycled Plastic in Samsung



Source: Greenbiz

Procuring Electronics

With an annual contract budget in the hundreds of billions—and information technology equipment and related services budget approaching $100 billion—the federal government is uniquely positioned to influence the procurement process in the public and private sectors. President George W. Bush was instrumental in expanding the "environmentally preferable purchasing" (EPP) process. In its broadest definition, EPP are products that "have a lesser or reduced adverse impact on human health and the environment than competing products that serve the same purpose." While not new, the impact of the policy has accelerated the development of green products in the marketplace.

The Bush Administration's efforts also supported design for recycling (DfR) efforts, increasing the capacity for safe management of e-waste, and promoting the use of certified recyclers.

To help the plastics supply chain fully understand the breadth of opportunities available to support e-procurement, PLASTICS will be publishing a Guide to Environmental Preferable Purchasing (EPP) Policies in early 2017 to support the industry's commitment to promoting the benefits of recycling and encouraging the use of recycled content in manufacturing when possible. This guide explores how EPP Policies can be leveraged to drive preference for products containing recycled content—particularly for plastic products, how this information might be used to incentivize increased use of recycled content and, perhaps, even find new uses for recycled content that will create competitive advantages.

"It is important that we continue to underscore the value propositions for choosing to use recycled content, which are not just related to cost savings," notes Kim Holmes, vice president of sustainability for PLASTICS. "Incentives like preferential purchasing and ecolabel recognition will be key in continuing to drive demand for recycled plastics, particularly when cost advantages for recycled materials disappear."

Wire and Cable Standards

One area the IoT is poised to transform is the home—and plastics will be found throughout that future house from appliances and consumer electronics to floors and windows. Plastics will also be found in the wiring and cables that are responsible for powering these electronics and transmitting the data; even in a wireless or Wi-Fi environment, plastic wires and cables will be present.

"The last yard to the Internet of Things home will be wireless," said PLASTICS' Peters, "but along with that will be an enormous, sophisticated structure behind the wall where wire and cable will providing power and data."

The National Fire Protection Association® recently published the 2020 edition of the *National Electrical Code*®. Thanks to efforts spearheaded by PLASTICS, this *Code* addresses an emerging safety issue concerning the use of communications and data cables carrying power.

Local area network (LAN) cables, which were designed for high speed data transmission between equipment, are now also powering the equipment, eliminating the need for a power outlet. Eliminating the need for a power outlet is a tremendous savings, making this type of application very popular. Until recently, applications utilizing LAN cables for both communicating (data transmission) and powering were very low power.

Not surprisingly, the power carried by this attractive technology has been increasing as new applications are addressed, including LED lighting and television monitors. Higher power leads to higher heat dissipation in the cables. In some applications and cable configurations, the cables will exceed their temperature rating, which leads to an unsafe installation, not to mention a *Code* violation.

PLASTICS introduced the change proposals to address the hazard of overheating LAN cables. The changes adopted into the Code are based on research sponsored by PLASTICS at Underwriters Laboratories. UL published their study in a ***Fact Finding Report on Power over Local Area Network Type Cables (4-Pair Data/ Communications Cables)***. A copy of the report is available on the PLASTICS website.

Based on the UL data, the NEC® now has an ampacity table for LAN cables which considers the wire gauge in the cable, the temperature rating of the cable and the number of cables in a bundle. The ampacity table shows the maximum current the conductors in the cable can carry without exceeding the temperature rating of the cable.

The *Code* also provides a simple alternative to using the ampacity table, "Limited Power" cables. Limited Power cables are listed as being able to carry up to a maximum current level on each conductor regardless of the size of the cable grouping. The maximum current level is marked on the cable.

Category 6A LAN cable is beginning to be widely deployed. Many cable manufacturers are offering CAT 6A cable with the "Limited Power" feature as a standard feature. This will facilitate the adoption of "Limited Power" cables as the preferred, and simple, method of complying with the new provisions of the *Code* and thereby avoiding overheating of the LAN cables.

Newlight Brings New Technology to Plastics For High Tech Companies—And Others

Technology is a two way street and innovation is not limited to Silicon Valley; all companies must be innovative in their manufacturing and product development or they will slowly (or rapidly in some cases) fail. The plastics industry demonstrates this point by developing new polymers and plastics, improving recycling capabilities, utilizing bio-based products, and even capturing carbon from the atmosphere and turning it into plastic.

Newlight, based in Costa Mesa, California, was a finalist for PLASTICS' 2014 Innovation in Bioplastics Award for its AirCarbon technology that is derived from greenhouse gases. Today, Newlight is providing its plastics to all business sectors, including giants in consumer electronics like Dell and Sprint which have strong environmental supply-chain boxes that Newlight checks for the company.

Sprint, which uses the Newlight plastic for its wireless phone safety cases told GreenBizit sees the plastic accessory as a way to accelerate sustainability "by leveraging its role as a large purchaser and supplier" and influence consumers to shift to market-disrupting products.

Dell is using Newlight plastics to package its notebook computers with the hope to expand the plastic to other packaging and products usage.

Newlight uses carbon dioxide or methane from farms, landfills, wastewater treatment and anaerobic digester plants to manufacture its plastics. Newlight's patented AirCarbon plastic is approximately 40 percent oxygen from air and 60 percent carbon and hydrogen from captured carbon emissions. The company focuses primarily on methane sequestration because its heat trapping performance is higher than carbon dioxide; according to the company 20 carbon dioxide capture plants would be needed to match the impact of one methane capture plant).

Newlight combines the greenhouse gas with air in its 9X biocatalyst—the key technology to the company's manufacturing process. Unlike earlier generations conversion systems that required 1 kg of biocatalyst to make 1 kg of polymer, the company's technology generates a polymer conversion yield that is nine times higher at 1:9. The increased yield rate significantly shifts the cost structure of converting greenhouse gas into plastics.

The company moved its AirCarbon production capability to commercial scale in 2013—after 10 years of pilot and demonstration scale operations.

"AirCarbon offers a new paradigm in which products we use every day, like cellphone cases, become part of the environmental solution," said Mark Herrema, Newlight's CEO and co-founder, in a statement. "Newlight's mission is to replace petroleum-based plastics with greenhouse gas-based plastics on a commodity scale by out-competing on price and performance."

Newlight can use AirCarbon to manufacture office hairs, food storage containers, bags and films.

Conclusion

Conclusion

> How to make that connection seamless and useful for the consumer is the new frontier of innovation for consumer electronics…
>
> —*Joe Born, CEO Aiwa*

The evolution of technology and consumer technology is at an incredible point in history according to Gary Shapiro, president and CEO Consumer Technology Association; he points to the revolution that the internet and wireless technology have delivered to consumers and businesses and the pending development of the Internet of Things. As some consumer technology devices hit their ceiling in terms of utilization or penetration, new products are introduced to meet demand. Robotics, sensing technology, nanotechnology and self-driving cars are at their very beginning, but will change our lives for the better.

But in developing these new technologies, plastics will continue to play a role, whether in the design of a new product or in delivering power and data that connects the product to other electronics and shares information.

Interconnectivity and consumer interfaces will be key for the next wave of consumer electronics to take hold. As described by Aiwa CEO Joe Born, "How to make that connection seamless and useful for the consumer is the new frontier of innovation for consumer electronics. As IoT takes off, it's likely that this approach will go from a source of competitive advantage to an existential necessity—regardless of whether your company makes watches, phones, dishwashers or speakers. Instead of every brand vying to be the platform or 'master of masters,' we need to recognize that it needs to be seamlessly useful in context."

Plastics will provide a significant amount of the infrastructure required for these IoT-enabled technologies and greater interconnectivity. An example of how plastics will likely facilitate the future growth of IoT devices is plastic printed electronics using 3D printing technology; researchers are already using inkjet printing technology to output a transistor logic board which has almost 3,400 circuits.

But plastics are already critical in all categories of consumer electronics products—wearables, home technology, VR/AR, drones, etc. In particular, plastics will enable further connectivity between consumers, their devices and clothing and their modes of transportation and homes. Looking a little further into the future as far as clothing, what if your clothes could actually power your devices?

The scientists from Georgia Tech and Chongqing University were able to create textiles that generate power from both sunlight and movement, interweaving plastic fiber solar cells and fiber-based generators that create electricity when rubbed against each other. They were able to make the solar component by making light-sensitive zinc oxide nanowires on manganese and copper-coated plastic wires. Additionally, they took advantage of something called the triboelectric effect for motion harvesting. Their textile uses thin flat strips of copper coated with a Teflon-like polymer act as triboelectric generators. This energy generating cloth is also able to harvest energy from motion and pressure. Since the study's initial release in 2001, advancements have been made with decreasing weight, breathability, and types of fabrics the integrated technology can accommodate; we are looking at the very real possibility that we can in fact power our own IoT devices.

Janna Robinson, an interior designer and lifestyle technology expert known as "The Techorator," says that today's connected home gadgets—smart thermostats, smart security systems, smart locks and other household devices that can be automated and remotely controlled—are just the basic "building blocks" of what will eventually be more of a full-scale home ecosystem. "This learning ecosystem will be built on a self-aware network that will lead to increased safety, comfort and energy savings," she predicts. "It will have interoperability, it will know our habits and movements… and it will use information from our wearables and other connected sensors to make things happen seamlessly without any effort from the consumer."

BMW recently announced plans to introduce software in its vehicles in the United Kingdom that will connect their cars to owners' smart home devices. The German auto manufacturer will use Smart Home Control to enable drivers to control smart home devices from behind the wheel.

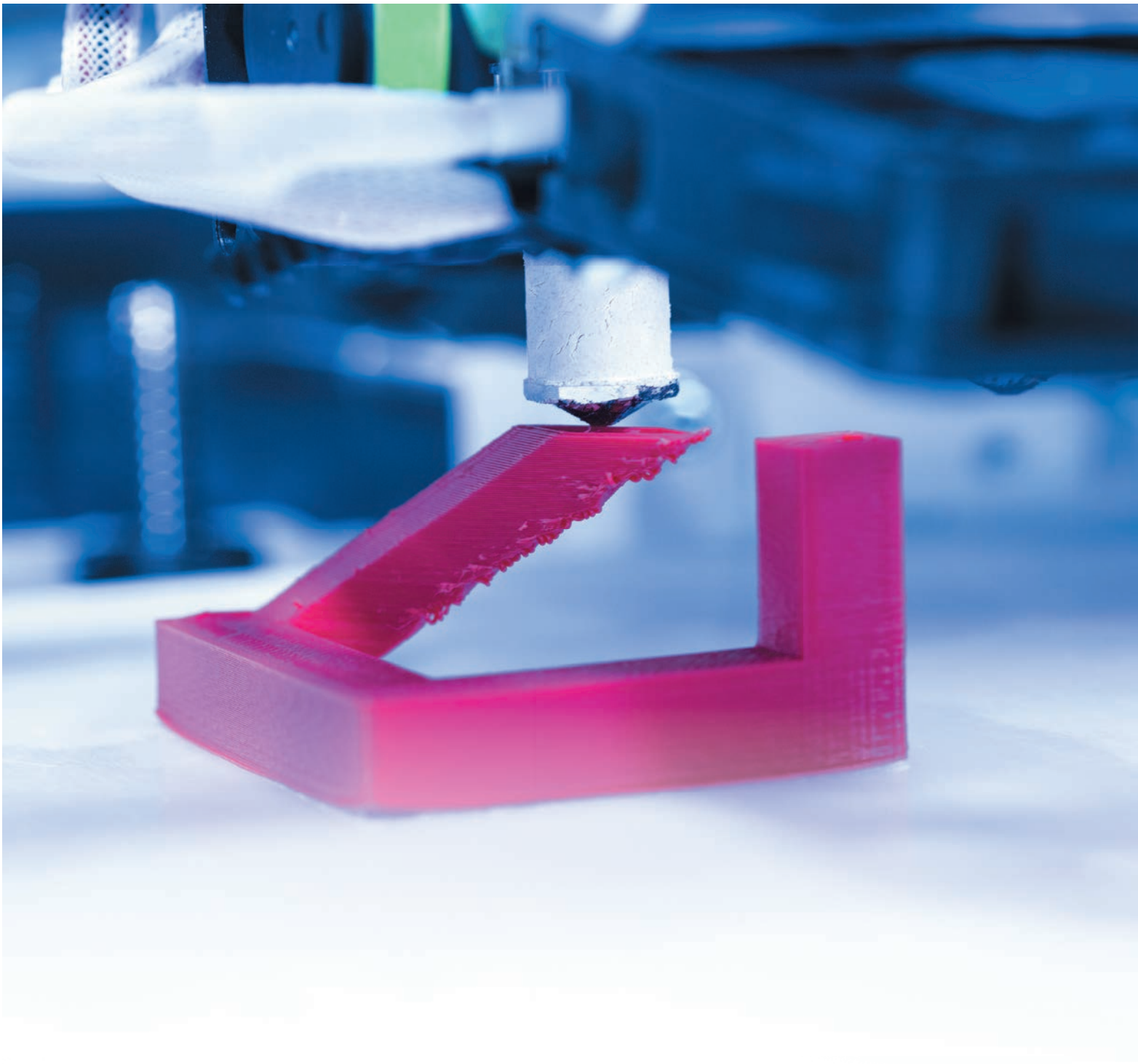
Currently, all new BMW vehicles are equipped with an embedded connection that powers Connected Drive, BMW's connectivity platform for infotainment and remote software updates. The company plans to transmit the new smart home control updates to cars already on the road through Connected Drive, said BMW UK Product Manager Andrew Furse. He explains that BMW wants to be central to its drivers' digital lives by enabling a seamless digital connection between cars and homes.

BMW joins several automakers in the race to build more capabilities for connected cars. LG recently announced a partnership with Volkswagen to develop a connected car platform for in-vehicle entertainment systems and smart home controls. BMW itself has been seeking to partner with Microsoft and Amazon for cloud services to store and analyze data from connected and self-driving vehicles.

Over the next five to 10 years, this internet integration is expected to change the car ownership model, create a new platform for consumers to access content, lead to fully autonomous vehicles, and revolutionize the auto industry. Technology is becoming the marketing highpoint for a number of industries and products; while cars used to compete on horsepower and performance, they are now emphasizing connectivity and safety technology. Some are going so far as to suggest that automakers are now in the software business.

The futuristic innovations coming within a generation may be difficult at times to comprehend and conceptualize; but very real and understandable factors will impact consumer electronics in the coming year. While the rate of growth in electronics production has stalled in recent years, it is poised for moderately faster growth in the coming months. First, the 10-year Treasury rate dropped consistently over 2016; and the Federal Reserve Bank seems to hope falling interest rates will further spending. And consumers, do in fact, have more disposable income for products like consumer electronics.

One thing is for certain, wherever the IoT and this latest wave of innovation takes consumer technology, the plastics industry and its products will serve as a vital enabling material.



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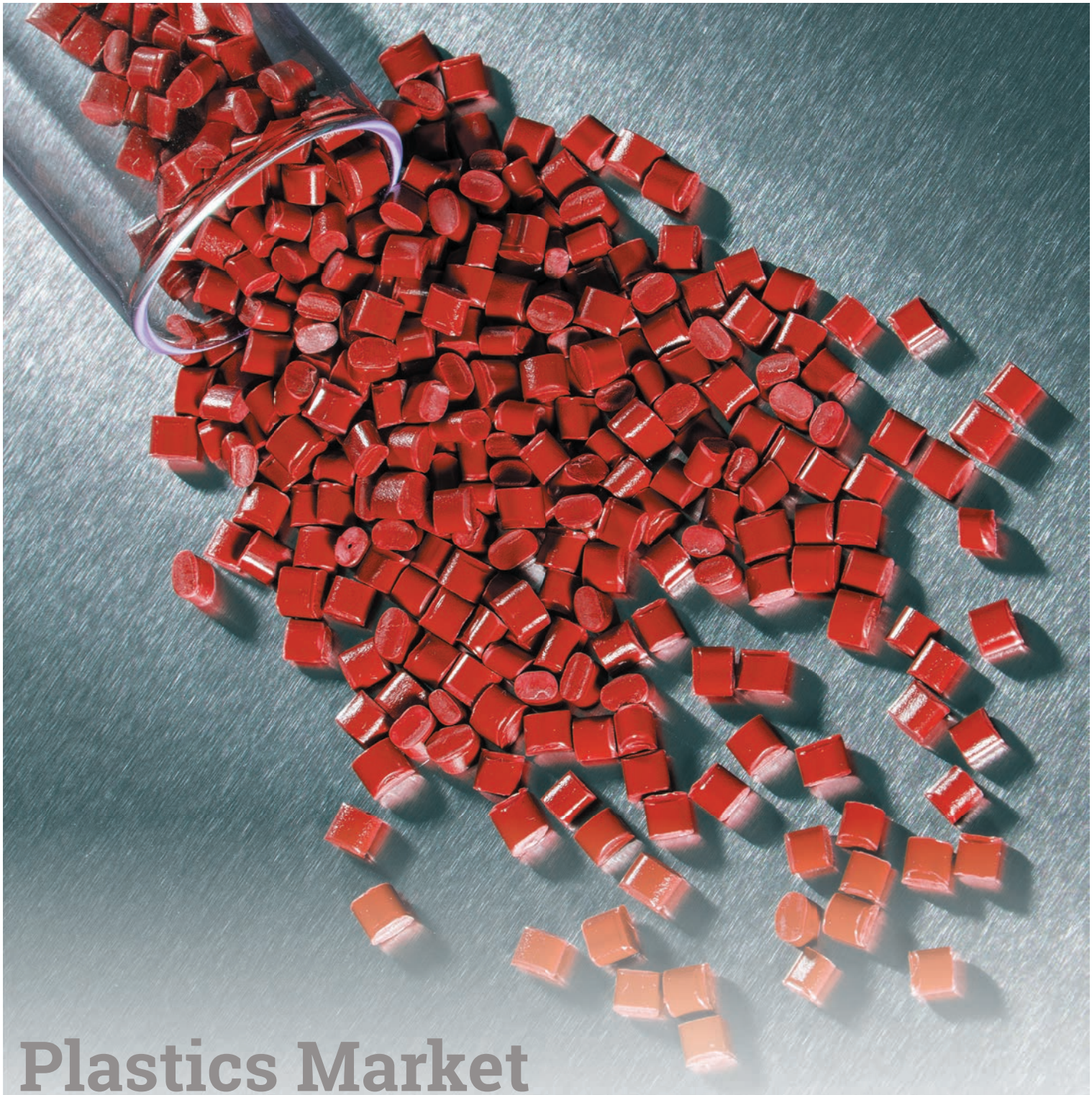

Plastics Market Watch Snapshot

Plastics Market Watch Snapshot

UTILITY OF PLASTICS

Plastic is essential to the engineering, design, function, features and performance of cutting-edge consumer electronics technologies

The products falling under the consumer electronics umbrella are wide-ranging, spanning everything from automotive components to health and fitness applications

Computers, mobile telephones, televisions and game consoles depend upon plastics for structure, circuit boards, wiring and next-generation developments

TECHNOLOGY & INNOVATION

Plastics provide the consumer electronics sector with a unique combination of performance properties that inspire innovation on two fronts: the development of new and better products and the more efficient use of resources

Consumer electronics is a rapidly innovative industry where next-generation applications are rolled out on a nearly annual schedule, providing a wealth of opportunities for the plastics supply chain

While it is expected that IoT will take hold in the U.S., not every application will be a slam-dunk with wide consumer acceptance

ELECTRONICS SECTOR ECONOMICS

Consumer technology (and business technology) is a major economic force around the world with the pace of innovation outmatching nearly every other sector

Within 5 years, homebuyers will expect Smart Home technology and it will become the "new norm," particularly as millennials purchase homes

New categories of technology comprise a significant portion of industry growth. And the economic and social impact consumer technology has had around the world is hard to overestimate

While revenues for dominant technologies (smartphones, tablets, LCD TVs, computers) in the consumer sector have been flat or declining, there continues to be strong promise and optimism among companies and savvy-tech consumers

DEMOGRAPHICS

Currently, nearly half of millennials own smart home devices, and 81 percent indicated they would be more likely to buy a home that had interconnected home technology capabilities than one without it

Major citable reasons for the exponential growth of consumer technology are increasing disposable incomes, expanding middle class population and growing internet penetration rate

People don't see plastics in consumer electronics initially, but once people recognize that there are items in their life that would be impossible without plastics, people's opinions change about their importance

Consumer technology companies will operate with some uncertainty in the coming years as consumer dollars shift among product categories and emerging technologies take hold

SUSTAINABILITY

Industry has worked to develop proper recycling best practices and standards, in the U.S. and abroad, designed to mitigate any risk to human health and the environment during e-scrap dismantling and reclamation

Design for Environment (DfE) / Design for Recycling (DfR) has been an equally important priority for many consumer electronics OEMs

Environmental Preferable Purchasing (EPP) Policies are accelerating industry's commitment to promoting the benefits of recycling and encouraging the use of recycled content in manufacturing

OEMs continue to be challenged—by NGOs, regulators and consumers—to consider the management of their products at end-of-life as part of their broader business model

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1425 K Street, NW, Suite 500
Washington, DC 20005

Phone:202.974.5200

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