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Contents

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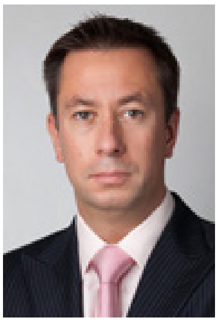


Dmitry Konov
Chief Executive Officer, Sibur, Russian Federation

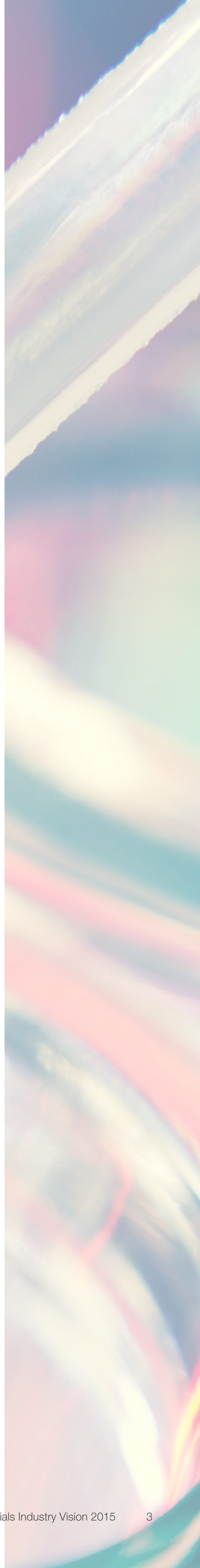
We live in turbulent times: significant shifts in geopolitics and geo-economics, emerging technologies disrupting entire industries, growing needs for sustainability and numerous other dynamic trends are defining a new global context.

The New Global Context is the theme of this year's Annual Meeting – it will shape the ways of the world of tomorrow. To remain competitive in this restructured context, businesses – and especially the chemicals industry – will have to be alert and act with foresight.

Take emerging technologies as an example: the so-called 3D printing of goods is turning established industries upside down, books are digitizing, printed newspapers are slowly vanishing and even traditional industries are moving into the Digital Age. As a provider of solutions to all global and regional industries, our industry has to anticipate the trends and provide the right solutions at the appropriate time. In Davos, discussions concerning our industry and cross-industry issues will provide critical insights that will help us stay abreast of these developments.

Not only are trends outside our industry reshaping it. Trends from within also provide us with many new opportunities. Biotechnology solutions, for instance, enable us to improve both the economy and the sustainability of our products, opening avenues to smarter solutions for our customers. Collaboration along the value chain will be crucial if we are to make the most of these new opportunities, not only for our industry but for society as a whole.

There is no silver bullet that ensures success in the new global context, but we can be sure that in these challenging times we have to be collaborative, informed and provident to be successful. I look forward to our discussions in Davos and to exploring with you the many new, strategic insights that will help us to navigate our companies within the new global context.



Message from the Director of the Chemistry and Advanced Materials Industry

Andrew Hagan
Director,
Chemistry and Advanced Materials Industry,
World Economic Forum

The global business environment and the Chemistry and Advanced Materials Industry

As the world changes, developing its new connected and digital context, there is a clear need to adapt: the teething problems that come with these changes are visible in the tensions between the established order and the past, and the new emerging era. Digital tools are not only enabling the obvious; they are also amplifying other emerging technologies, allowing a major evolution towards “transhumanism”. Deloitte’s Jeffrey Carbeck highlights this in his piece on “Digital and Physical Convergence” on page 6. None of the new trends can be, nor should they be, ignored. Everything keeps moving unless other forces, including friction, prevent it.

Transparency is increasingly crucial: the ability to hide and cover up in such a connected world is much more difficult. The old trading systems and financial markets are worrying examples; for instance, Li Keqiang, China’s Premier, has suggested that his country may not be using the real amounts of deposit reserves that it could relative to its GDP and the reality that it suggests. China’s situation combined with the unwinding of the US Federal Reserve’s large-scale asset purchases (LSAPs, also known as QE) have left some people suspecting that some sort of game is being played with the collateral trading of copper, cotton and iron ore. Add in the corruption investigations so prominent in China and there is potential to inadvertently expose any collateral trading should it exist. This coupled in turn with a vast amount of non-performing financial assets and loans could spark a new global crisis. Falling oil prices and geopolitical insecurities are already giving huge cause for concern, especially to those countries dependent on oil revenues.

At last year's Chemicals Industry Governors Meeting during the World Economic Forum Annual Meeting 2014 in Davos-Klosters, Dennis Snower suggested that the principal reason for not seeing growth was that it has only come from catching up on the destruction of capital, whether a war or a dotcom boom. I argued that it stems principally from demographics, the retirement of the baby boomer generation and ageing. Looking at the above, it may be that these are one and the same issue.

As QE is wound down, as now on a massive scale, any accompanying artificial stimulation engendered by it could also unleash an earthquake – both financially and for society. The chemicals-related industries could suffer from looming overcapacity in private equity, as is illustrated in the piece on “The Impact of Feedstock Prices on the Regional Production of Intermediate Chemicals” by Meredith Annex and Charles Blanchard from Bloomberg New Energy Finance (BNEF) on page 10. Understanding the consumer and markets will be necessary to avoid overproducing a product that lacks demand and thereby pushing down prices and creating a vicious circle.

This comes at a time when the chemicals industry is at a pivotal point: with activist shareholders and the splitting of, or spinning off of, advanced materials companies and with a major focus on biotech. It will be interesting to see whether these new companies can consolidate substantially enough and quickly enough to avoid being acquired themselves in four to five years’ time (and there would be many buyers interested in accessing their technologies, materials and markets). This basically appears to be one player playing the other market players. The value of chemical companies is still seen as high, yet that often comes from the synergies that make the sum of the parts greater than the whole. Taking out a part is sometimes not the same as a division of the whole, which is why it sets up a re-merging at a later date.

The demographic shift continues in many ways and along with it, cultural and public perception. People worry about emerging technologies as they have done for centuries. At the beginning of the 20th century, many were suspicious of new technologies. Yet, if we ask those who benefited and saw life expectancy increase dramatically, few would go back to the old ways. Carbeck highlights the emerging opportunities in materials for the chemicals industry, but it is clear that he is only touching the surface. The secondary implications for new players and business models should be a major area to be wary of to avoid the mistakes of, for example, Eastman Kodak's hiding a new technology or Motorola's lengthy all out gamble on Invidium. Of course, every new solution or technology will bring its own new set of problems. For example, there are social issues related to the replacing of traditional white collar jobs – Deloitte reports suggest that 47% of white collar jobs in the United States can now be replaced by machines, 35% in the United Kingdom.

Labour and resources are always fundamental issues and they remain key focus points in the changing global dynamics. Walter Stahel of the Product-Life Institute in Geneva (page 16) proposes novel and interesting solutions to this through a virtuous circle: the creation of a circular economy of physical goods and human capital, rather than taxing the resources, so as to encourage labour-intensive rather than resource-intensive progress.

It is certainly a transient time in global society and it feels like we could be at the *tipping point*. The Chemistry and Advanced Materials Industry will have to provide some of the solutions in a beneficial, well-considered and transparent way. Thus The New Global Context, the theme of this year's Annual Meeting in Davos-Klosters, is extremely relevant.

The Personal Implications of Digital and Physical Convergence and Opportunities for Materials Providers

Jeffrey Carbeck, Specialist Leader, Advanced Materials and Manufacturing, Deloitte Consulting; Vice-Chairman of the Global Agenda Council for the Future of Chemicals, Advanced Materials and Biotechnology
Kevin Lang, Manager, Deloitte Consulting

Introduction

Over the past several years, the World Economic Forum has developed an annual list of the *Top 10 Emerging Technologies* that will have an impact on society in the coming three to five years. In 2013, the Forum identified 3D printing and remote manufacturing as one of these technologies. Body-adapted wearable electronics was included in the 2014 list.

A distinctive element to both of these emerging technologies is the unique combination of digital and physical components. This digital and physical convergence is what gives these technologies promise and impact, particularly at the level of the individual, as products are unlocking new possibilities in personal choice and benefits for the consumer. These technologies are of particular relevance to the chemicals and materials industry and present new arenas for growth as their physical differentiators are largely the product of advanced materials and manufacturing technologies.

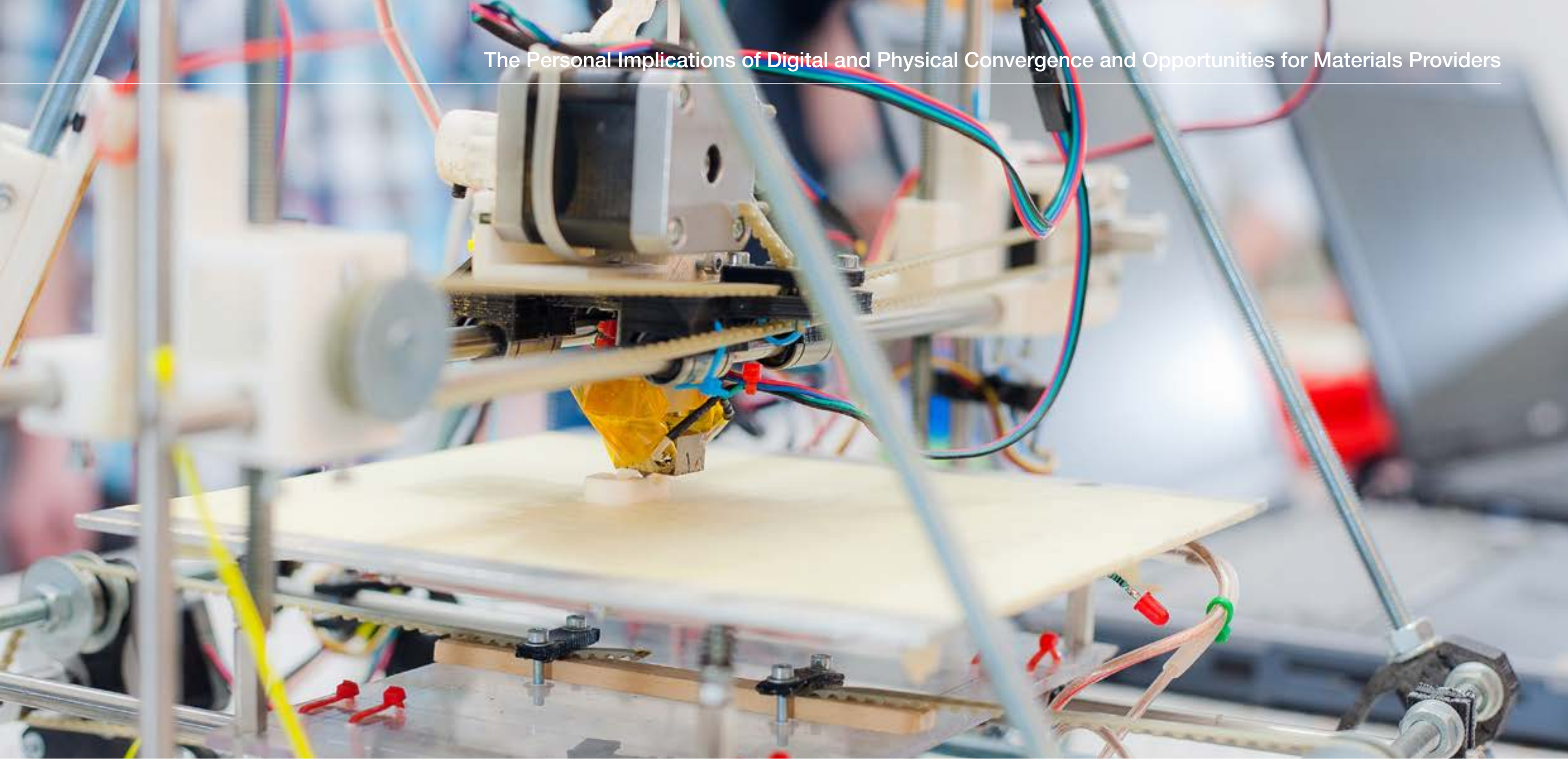
The combination of digital and physical technology elements that creates new product categories and markets is not itself a new development. The recent advent of smart phones, for example, was possible due to a collection of converging technologies and capabilities such as pressure-sensitive displays, mobile processors, increased battery capacity, GPS availability, and fast, reliable cellular network architecture. However, with the exponentially increasing pace of technological discovery, these instances of digital and physical convergence and subsequent new market opportunities will become more common. Thus, it is important for chemicals and materials companies to understand this trend and develop competencies to capitalize on opportunities, potentially altering traditional investment decision-making and business models.

Body-adapted Wearable Electronics and 3D Printing: Digital and Physical Elements

First, to fully understand the opportunities these two technologies present, it is necessary to evaluate the unique combinations of physical and digital elements of each, identify key drivers of technology development, and also highlight the important role of advanced materials.

Body-adapted Wearable Electronics

Body-adapted wearable electronics (or “wearables”) are electronic systems that perform practical or beneficial functions and have been packaged as an accessory or clothing item in a way that is comfortable and in some instances invisible to the wearer. Devices range from familiar fitness trackers from the likes of Fitbit, Jawbone and Nike, to smart eyewear like Google Glass and APX, to more nascent applications such as haptic shoes and bionic implants. Typically, these devices must have a



sufficiently robust, intimate interface with the body to measure the physical, physiological and biological properties and responses of the wearer.

Digital elements of wearables include sensing, computing, analysis, synthesis, communication, aggregation, predictive analytics and user feedback. Physical elements involve sensors, active and passive electronic components, energy storage (batteries), physical, chemical and biological interfaces to the human body, radios and antennas, and output devices such as screens, mechanical transducers, and light-emitting diodes. These systems incorporate software technology that detects, records and enables the communication of the measured data and also, ideally, provides clear, actionable feedback to the individual wearer in real time.

Several key drivers contribute to the recent proliferation of wearable technology. Rapid increases in computing power allow for processing and storage capabilities with a small, lightweight footprint and nominal energy usage. Socially, a more health-conscious population generates consumer demand for devices that can measure body movement and vital signs during regular daily activities, exercise and sports. Additionally, society's growing desire to integrate technology with their daily personal lives (i.e. the quantified-self movement) has led to greater acceptance of mechanisms that track and record behaviours while providing real time feedback. Additionally, the substantial increases in sensor capabilities, particularly accelerometers, gyroscopes and touch sensors that have transpired over the past decade now allow devices to translate body movement into accurate, meaningful data. Finally, the potential contribution wearables offer to reduce health costs by providing access to more accurate data attracts investment and interest from insurance companies and healthcare providers, fuelling commercialization.

Digital technology innovation as an enabler for wearables may seem apparent. However, the important role advanced materials play can be understated. Advanced materials, such as smart fabrics and flexible circuitry, enable electronics to be packaged in a manner that is conformal, comfortable, flexible and ideally imperceptible to the user, yet durable enough to resist moisture, perspiration, dirt, dust, shock and wear. These attributes must offer high performance balanced with affordability.

3D Printing and Remote Manufacturing

3D printing is a fabrication system that converts digital design files directly to finished or near-finished products using additive technologies, typically layer by layer. These systems differ from previous digital fabrication technologies such as computer numerical controlled machining and milling in that they utilize additive rather than subtractive fabrication methods. They also use a broader array of materials, including plastics that can be safely fabricated in "non-industrial" settings, such as schools, libraries and homes. In this way, 3D printing makes the custom and rapid fabrication of physical objects available to the individual at an affordable cost.

Digital elements of 3D printing technology include 3D scanning, computer-aided design, finite element analysis, computational fluid dynamics, and computational materials design and selection. Physical elements involve X-Y-Z motion control, materials deposition technology, controlled environments (controlled heat, moisture or inert atmosphere, depending on the materials used), localized delivery of energy, recovery of unused materials, and environmental and health systems.

It is necessary to note that the recent breakthrough of 3D printing into low-cost consumer applications was driven primarily by exponential increases in computing performance versus price, not advances in materials or deposition technologies. In fact, new developments in materials and deposition technologies dramatically lag behind advances on the digital side.

Advanced materials allow for localized deposition and fusion into solid objects via chemical (e.g. light activated polymerization and crosslinking) or physical (e.g. melting or sintering) mechanisms which often require compounding, formulating or powdering existing materials. It is important to consider that while advanced materials enable the crucial functionality of 3D printing, stereo lithography still uses the same basic materials and deposition technology today as it did when it was first invented in the 1980s, while the computing technology that controls these printers has increased more than one-million-fold in performance and decreased more than one-thousand-fold in cost during the same span.

Personalized Experience and Consumer Choice

With a better understanding of how digital and physical elements are converging to enable advances in these two emerging technology areas, it is next necessary to evaluate the personal implications of these technologies, particularly how they empower consumers by unlocking a bevy of choices and benefits. First, both wearables and 3D printing provide consumers with an opportunity to become more active decision-makers, introducing deeper layers of choice and influencing product form and function, along with the overall user experience.

For wearables, individuals can make customized selections among various form factors and functions, including size, colour and texture. Apple, for instance, announced that the Apple Watch will be offered in three construction styles, two sizes, and six watch bands, yielding 36 different product configurations. The company also boasts "literally millions of different appearances" for the digital face itself. This level of customization is a noticeable deviation for a company that traditionally simplifies the purchasing decision by offering a limited number of product choices per platform – particularly for the first generation of products. It is clear that Apple, like many other wearables manufacturers, understands the importance of satisfying the consumer's preference to choose which product characteristics best fit their body and personal style. Consumers may also choose when it is appropriate to wear the product, whether or not it transmits data to their friends and family via social media or other virtual networks or, in some cases, whether they want to have their data aggregated and analysed with that of other users. Additionally, it is the user's choice whether or not to utilize the data output of the wearable device to change their behaviour, or beyond that, to use the output of the predictive analytics of aggregated data to incite behaviour change.

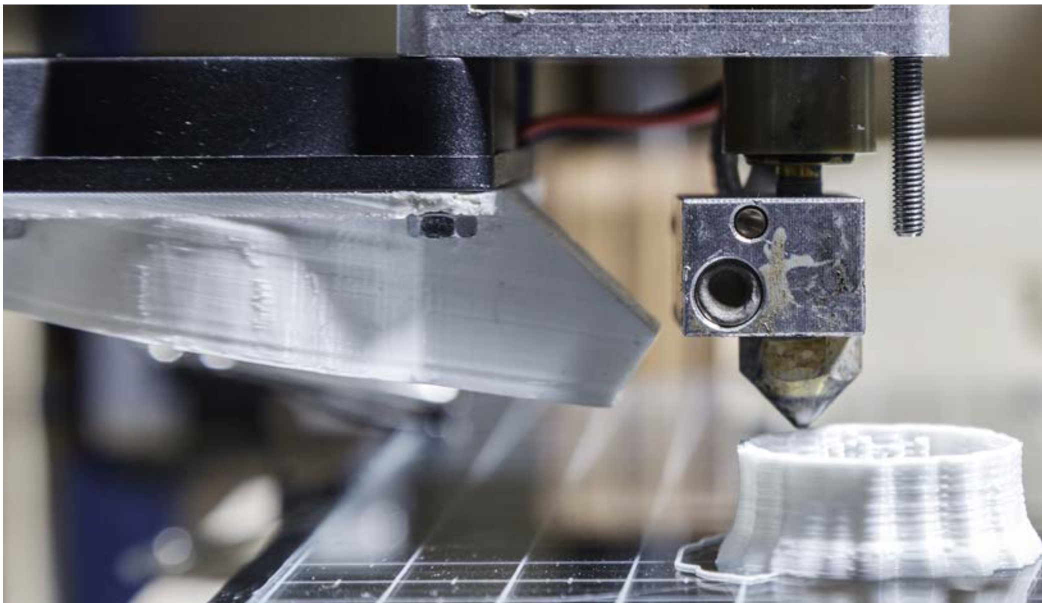
The 3D printing consumer experience is also characterized by significant personal choice. The user is free to choose the object's design, either creating it independently using computer-aided design software or 3D scanning technology, or by selecting it from an online library. Remote manufacturing aspects enable the creation of the part whenever and wherever the user chooses. Just as the internet has made digital information instantly accessible to three billion users over the past two decades, the advent of 3D printing has brought the ability to create customized physical elements to the masses, turning the traditional supply chain on its head. Personal choice also exists regarding material selection, although substantial opportunity for innovation remains on that front.

Second, as consumers are increasingly able to create a product that best fits their needs, wearable technologies and 3D printing unlock benefits for improved health, data aggregation and personalization. Wearables provide real-time, personalized feedback directly to users, along with the ability to identify trends by monitoring wellness and behaviour performance over time. The ability to share data with others through social networks drives motivation, while aggregating data with others provides predictive analytics aimed at shaping behaviour, performance and wellness. For 3D printing, the increased levels of personal choice offer the benefit of widespread customization and the ability for consumers to make what they need when they need it. The sharing of designs in online libraries allows for crowd-sourced design enhancements, eliminating the reliance on traditional in-house research and development (R&D) expense.

However, increased personal choice does not come without risks for consumers and society at large. The proliferation of personal data generated by wearables creates privacy and security concerns for users as hackers prey on this new information source. Financial risk may also occur as biometric payment interfaces such as fingerprint scans enable payment authorization in seconds. Additionally, 3D printers potentially allow consumers to create dangerous items such as guns or medical devices in the absence of typical regulatory safeguards.

Realizing Value: Opportunities for Materials Providers

Products in the wearables and 3D printing space are becoming extremely personable. For wearables, these products are worn on (or applied to) the skin. Some future devices promise applications that are subcutaneous or reside inside the body (like pacemakers today). Such intimate



human contact requires materials that are comfortable, biocompatible, lightweight, durable, visually appealing and even fashionable. For 3D printing, production, traditionally concealed from consumers via centralized subtractive manufacturing processes, is now taking place in homes, offices and classrooms, increasing the need for safe materials, manufacturing processes and end-product functions. While rapid advancements in digital technology have largely driven the ability to deliver wearable and 3D printing products to a broad market, consumers largely consider digital elements as a minimum level of technology and thus are making purchasing decisions based on product characteristics and differentiators that are material-dependent.

Despite this demand, currently no true chemicals companies or materials providers actively are participating in a major way in either the wearables or 3D printing space. This situation is possibly the result of the traditional emphasis chemicals and materials companies place on high-volume opportunities, limiting investment in potentially lower volume, higher margin markets. This opportunity could be a missed chance to capture significant value. If manufacturing players can develop capabilities to gain a better line of sight into individual consumer wants and needs and place their bets in areas where digital technology advancement will open doors for new, high-quality, material-driven markets, converging technology areas such as wearables and 3D printing may present higher margin future business opportunities.

Also, chemical and materials companies do not necessarily have to invest in the development of new molecules and chemistry to provide this level of quality in materials for these applications. They can instead leverage their vast library of existing materials and fabrication technologies (the processes they use to make, shape and integrate materials into final products) to address emerging needs in these new markets. By employing inventive combinations of those materials and cutting-edge fabrication technologies, chemicals companies can develop functional solutions that best satisfy consumer needs (i.e. smoother 3D printed objects, more comfortable wearables). In many cases the quality and value of the technology depends on the quality of the material inputs. Consumers have demonstrated they will pay a premium for products that satisfy their comfort, style and performance demands. Through strong intellectual property protections at the system level (beyond just patenting molecules) and differentiated, defensible business models, materials companies can situate themselves to capitalize on this premium and maximize the value they capture from their materials solutions.

Furthermore, companies that act on this convergence trend can help shape future markets. Some organizations are already taking advantage of the potential at this digital and physical intersection. For example, the not-for-profit Fab Labs, a part of the Fab Foundation and an educational outreach component of the Massachusetts Institute of Technology Center for Bits and Atoms, is meeting artists' and other non-technical individuals' needs for high-performance, customized digital manufacturing (and not just 3D printing). Additionally, some chemical companies (e.g. Eastman Chemicals) are forming new partnerships and developing new business models to capture its vast potential.

Conclusions

The convergence of physical and digital technologies in applications such as wearable electronics and 3D printing offers unprecedented ability for individuals to shape, measure and improve their personal experience and environment. As individual consumers adapt to this level of personalized experience and uncover new ways to utilize these technologies to improve their daily lives, increased expectations around quality, comfort and performance will require a step change in the materials and fabrications technologies currently deployed. Importantly, companies should employ systems-level design and integration to bring together business models, process technologies and advanced materials aimed at addressing unmet market needs.

Moreover, the unique materials requirements of wearable electronics and 3D printing provide an opportunity for the advanced materials industry to gain profitable growth in high-margin applications as consumers have demonstrated a willingness to pay for the comfort and aesthetic qualities that only advanced materials can enable. However, in order to capitalize on these financial rewards, the industry must not fall prey to conventional thinking that neglects potential high-margin opportunities because they are not high volume, asset driven sales. Furthermore, to be successful, materials providers will need to take a more consumer-centric approach to R&D and product development to become closer to the end user and their specific needs. Also, single-sized product approaches are likely to fail as differences in gender, culture and size call for a range of solutions. As such, companies with diverse teams that better understand the nuances in culture and fashion that influence purchasing decisions will have the upper hand. Finally, companies should think beyond mature markets and also consider how these technologies may address challenges in the developing world. Therefore, strategies to identify and value nascent or emerging markets and bring existing materials and fabrication technologies into these areas are needed as well.

Chemistry and Advanced Materials
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The Impact of Feedstock Prices on the Regional Production of Intermediate Chemicals

Meredith Annex, Associate, Bloomberg New Energy Finance
Charles Blanchard, Lead Analyst, Bloomberg New Energy Finance

Cheap shale gas is leading to a boom in North American supply of many of the chemical intermediates that are produced from natural gas or natural gas liquids (NGL) feedstock. These intermediates include olefins, methanol and ammonia. Yet demand for these products is growing faster elsewhere – especially in Asia.

Were long-term oil prices to remain at what we see as their lowest sustainable level – around $70/bbl, just enough to keep US production growing – US olefins producers using ethane and light NGLs would encounter serious competition from heavy liquids like naphtha.

North American methanol and ammonia producers are more sheltered than olefins producers, as the price at the US Henry Hub will act as a "floor price" for liquefied natural gas (LNG) globally, ensuring that natural gas prices in Europe and Asia are more expensive. This could change if the North American "shale miracle" were to be duplicated – certain Asian countries sit atop massive shale and tight gas resources and could see domestic prices drop; Europe would be less affected.

Our analysis examines how the operating economics for intermediate chemical production would change under two feedstock price scenarios:

- Our Back to Black scenario assumes oil prices return to $70/bbl by year's end and $90/bbl in the long run. This is the level needed to ensure production growth from oil sands, ultra-deepwater, and eventually the Arctic. In this scenario, US LNG exports are much cheaper than oil-linked volumes.
- Our Technological Advancement scenario assumes that advances in drilling and completion technology that have made the US a low-cost

oil and gas producer spill over into other geographies. Shale gas and tight oil become global phenomena, leading to lower feedstock prices across the board. This scenario uses a long-term oil price of just $70/bbl, and sees Asian domestic gas prices close to US prices.

Our conclusions seek to answer two simple questions about these price scenarios:

1. Does North America remain the lowest cost region to produce chemicals?
2. What could happen to change that?

Scenario 1: Back to Black

Bloomberg New Energy Finance (BNEF) is a specialist not in global chemical markets, but in global chemical feedstock markets. Therefore, the analysis is underpinned by fundamental views on the price trajectories of those feedstocks. This section first presents our Back to Black scenario for feedstock prices and then constructs a view on what this means for the cost of producing methanol, ammonia and ethylene.

The Back to Black view uses market forwards for coal and assumes that oil prices return to $70/bbl by year's end and $90/bbl in the long term, which is the level necessary to ensure production growth from the oil sands, ultra-deepwater and Arctic.

North America has seen sustained low gas prices for the past few years, yet rising demand and the exhaustion of "core" acreage for drilling means that this cannot last forever. By 2023, prices are projected to rise above $6 per million British Thermal Units (MMBtu) – enough to cause a drop in demand from price-sensitive sectors, including liquefied natural gas (LNG) exports (Figure 1).

A key contributor to rising North American demand will be the introduction of LNG exports. While these exports will increase the price of gas in North America, they will decrease gas prices abroad. This has to do with the structure of US LNG export contracts and the sheer volumes expected to be available.

- Existing LNG supplies (e.g. from Qatar or Australia) tend to come from stranded assets with no access to local markets. In the US, however, overseas exports represent just one of many sources of demand for gas supplies. The presence of a large local market means US LNG can be offered at market (spot) prices and with volume-flexible (i.e. "take it or leave it") shipping terms: if Henry Hub gas prices rise too high, the buyer can refuse the volumes and the gas will remain in the domestic market.
- North American LNG export capacity is forecasted to be in excess of 11 billion cubic feet per day (Bcfd) (80 MMtpa) by 2020 and 18 Bcfd (131 MMtpa) by 2030; this is equivalent to 26% of global LNG demand in 2020, or 35% by 2030.

Because of the flexible shipping terms of US LNG, the cargoes will directly affect spot LNG prices, pushing them down. The addition of new LNG supply (regardless of where it is located) will also affect the larger market, which is underpinned by long-term, oil-linked contracts. This new supply, both from the US and other growing exporters like Australia, will shift the balance of power from sellers to buyers by the end of 2016. This is expected to lead to more favourable contract terms from a buyer's point of view going forward, meaning both lower oil linkages and more flexible shipping terms.

The combination of all of these factors indicates that the future LNG spot price will be set by the price of gas at the Henry Hub. Spot LNG will act as the marginal, price-setting source of European gas markets. The price of gas in Asia will decline alongside both falling spot LNG prices and more favourable long-term contract terms (Figure 2, Figure 3).

Unlike ammonia and methanol production, which can use either coal or gas as a feedstock, olefins are produced either from natural gas liquids (NGLs: ethane, propane and butanes) or heavy liquids (naphtha or vacuum gasoil). Ethylene – the most widely produced olefin – is produced alongside other saleable products in different concentrations, depending on both the choice of feedstock and operating conditions.

Going forward, it is assumed that ethane – currently the preferred cracker feedstock in North America – will retain links to the natural gas price in North America and propane prices elsewhere. Similarly, it is assumed that naphtha and crude oil prices will continue to correlate closely, as they have in the past (Figure 4). Lastly, the analysis implicitly assumes that the prices for other saleable olefins (co-products like propylene, butylene and butadiene) will remain constant.

Scenario 2: Technological Advancement

In the Technological Advancement scenario, the developments in drilling technology that have fostered increased oil and gas production in the US trigger a similar phenomenon abroad.

- Global oil has an effective floor price which is set by the fundamental economics of production in the US and Canada, which together account for 13 MMbpd of crude production. For many US producers, breakeven oil prices hover around $70/barrel (bbl); prices below this point would cause US production to decline, removing supply from the market and ultimately sending prices back up. This scenario uses a long-term oil price of $70/bbl, versus $90/bbl in the Back to Black scenario.
- Since European shale resources are relatively small, European gas prices are projected to remain tied to the lower of the oil-linked price or spot

LNG. Said another way, indigenous European gas resources will not be enough to "back out" imports, i.e. meet demand with local sources. Using an oil link of ~10% (which reflects historic terms with Russia), the low oil price of $70/bbl implies a gas price of $7/MMBtu. With Henry Hub gas around the $6/MMBtu mark even before liquefaction and shipping costs (which add at least another $2), oil-indexed gas would be the cheapest option for Europe under this scenario.

– Asian gas has a greater potential downside. Unlike Europe, Asia could exploit vast, untapped domestic resources which may (albeit are not likely to) back out imports, such that a large swath of consumers in Asia pays about the same as or less than their North American counterparts.
– With gas abroad priced below Henry Hub plus the cost of liquefying and shipping LNG, North American gas would be priced out of the global LNG market (i.e. the US would not fully utilise all of the LNG export terminals it is building). This means that the "call" on North American producers would be lower than in the Back to Black scenario, which would feed back into slightly lower domestic prices (Figure 1).
– Asian coal is unchanged from the Back to Black scenario.
– NGL and naphtha: North American ethane prices remain low, following changes in the North American gas price. Naphtha and LPG prices, meanwhile, fall alongside the oil price.

Conclusions

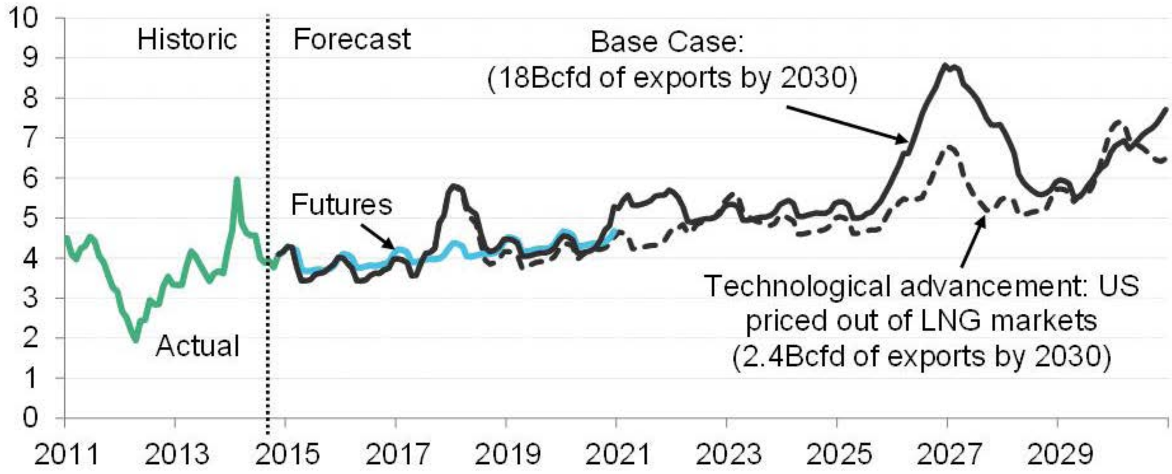
The Back to Black scenario's view on feedstock prices – with North American gas prices rising, oil prices at around $90/ bbl and an LNG market increasingly defined by a mixture of gas- and oil-linked contracts – sees the global dynamics of intermediate chemical production as relatively unchanged from today. For methanol and ammonia, US natural gas remains the most economical option through 2030. The exception is coal gasification in Asia, and this is despite a significant drop in LNG prices, and hence Asian gas costs (Figure 5).

Meanwhile, US olefins units maintain their position as the lowest cost source of ethylene production outside of the Middle East. With oil prices at $90/ bbl, cracking naphtha would only be more profitable than cracking ethane were ethane priced above 90 cents per gallon (cpg) (follow the steps in Figure 6 to track the logic). That ethane price – 90 cpg – is far above the long-term view of 70 cpg.

This could change in a world in which shale and tight oil become a global reality.

– Low oil prices would enhance the economics of cracking heavy liquids like naphtha and eat away at the advantage of North American ethane cracking. At $70/bbl, there is a more diverse landscape for ethylene crackers.
– Asian producers of methanol and ammonia via steam methane reformation stand to gain the most in a world with low oil prices and/or high gas production outside North America. This is especially true for countries with substantial shale reserves and access to pipelines, which could see domestic prices uncouple from those of the global LNG market (for example, China).
– Europe lacks substantial volumes of shale reserves, and therefore stands to gain less.
– In both scenarios, coal gasification in Asia remains the cheapest form of production for ammonia and methanol. It would require a global carbon price above $25 per tonne of CO2 equivalent to push the operating costs of coal gasification above those for North American steam methane reformation.

Figure 1: North American gas prices, historical, BNEF Base Case forecast, and BNEF Technological Advancement forecast ($/MMBtu)



Source: Bloomberg New Energy Finance

Figure 2: European gas price – historical, BNEF forecast, and benchmarks for comparison ($/MMBtu)

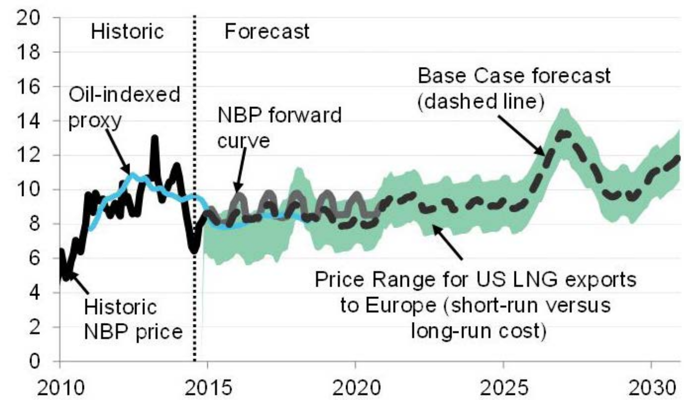
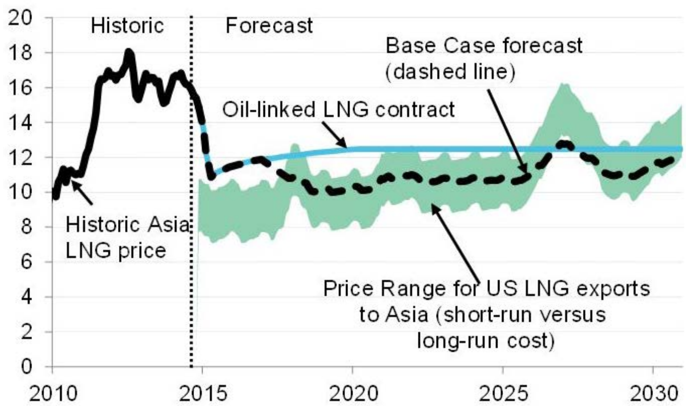
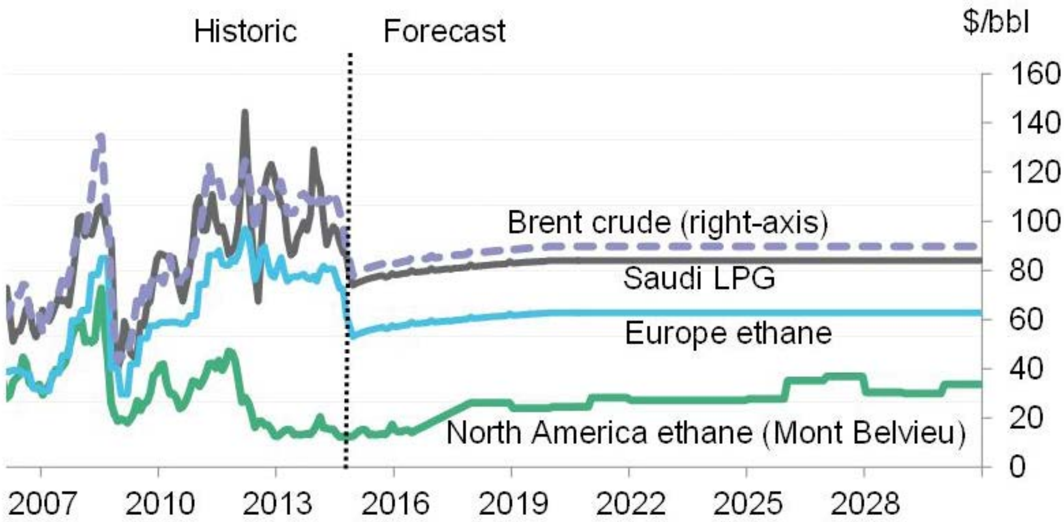


Figure 3: Asia gas price forecast – historical, BNEF forecast, and benchmarks for comparison ($/MMBtu)



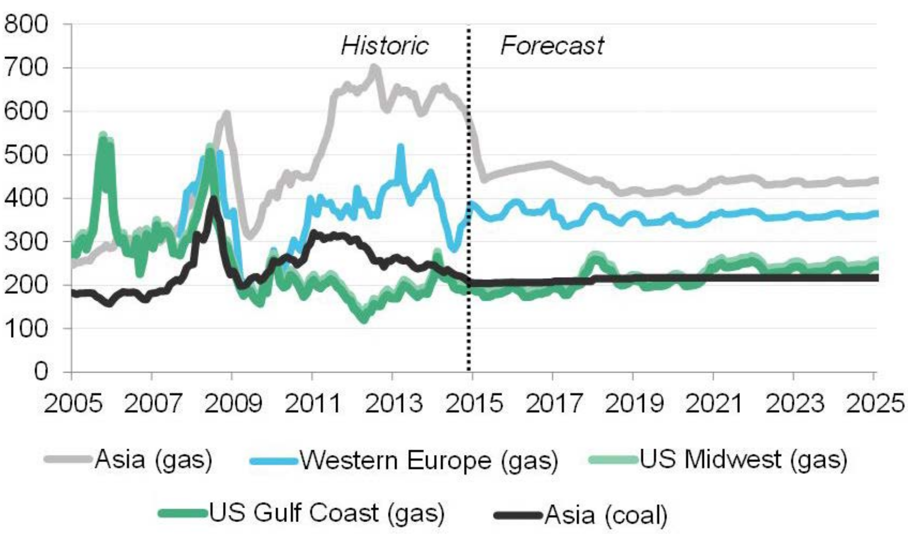
Source: Bloomberg New Energy Finance, Bloomberg Terminal

Figure 4: Ethylene feedstock prices – historical and BNEF forecast ($/gal. and $/bbl)



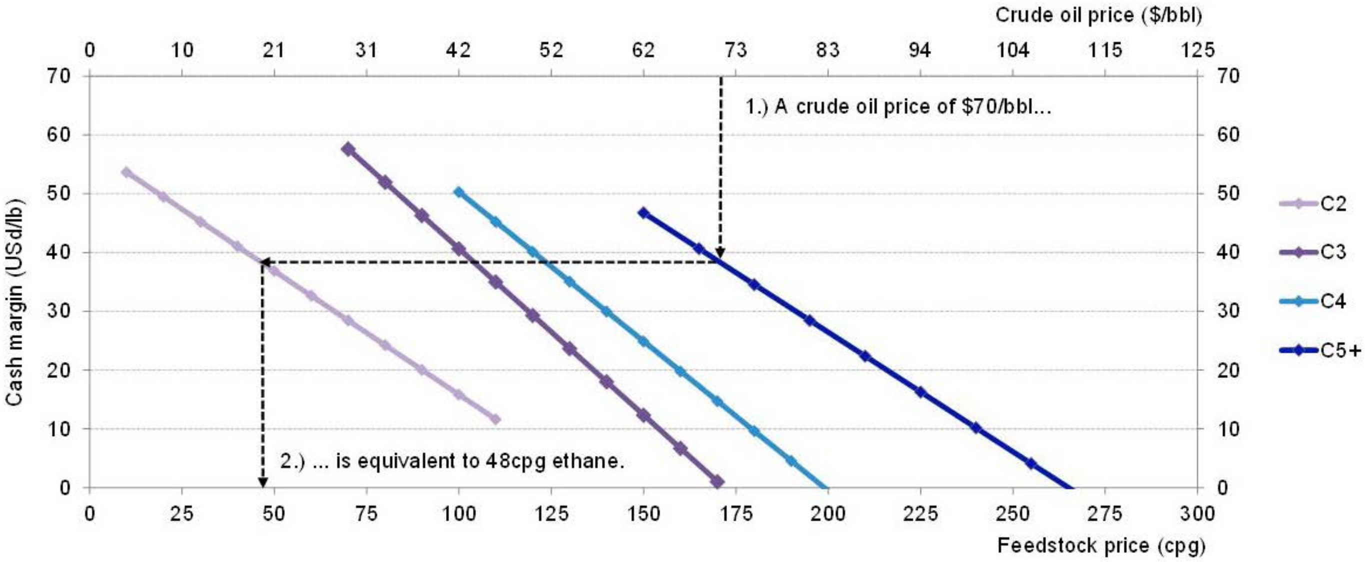
Source: Bloomberg New Energy Finance

Figure 5: Ammonia production costs – historical and BNEF Base Case forecast ($/tonne)



Source: Bloomberg New Energy Finance

Figure 6: Ethylene cash margin by feedstock and sensitivity to primary feedstock prices



Source: Bloomberg New Energy Finance

Chemistry and Advanced Materials
Industry Vision 2015

The Virtuous Circle? Sustainable Economics and Taxation in a Time of Austerity

Walter R. Stahel, Founder-Director of the Product-Life Institute, Switzerland

Introduction

Sustainability is built on economic, ecologic, social and cultural pillars and constitutes a dynamic balancing by society in exploiting the environment, creating economic wealth and fulfilling social needs. Most political actions to increase sustainability in industrial countries have focused on isolated issues linked to health and safety, international development or the environment, such as the prevention of accidents, the conservation of natural capital or the reduction of greenhouse gas emissions.

A different focus would create synergies between the social, economic and environmental pillars of sustainability. The suggested policy change – exempting all renewable resources from taxation – represents a huge lever for a holistic change towards a more sustainable economy. The result would be a circular economy for physical goods and human labour. It is focused on maintaining the performance, value and quality of existing stock, in synergy with manufacturing innovative new systems. It also involves the best use of human labour and of a non-taxation of all renewable resources, including work. The impact will be higher resource efficiencies in producing wealth and welfare.

In reading such ideas, one should avoid mental filters like “we have never done things this way” in favour of a more common sense approach that considers future generations. “Eating people is wrong” is a statement that most people will support and adhere to; “taxing renewable energies is wrong” will sound equally right for most people. However, many governments subsidize renewable resources such as

biomass, solar and wind energy. Yet the efficient use of human labour has traditionally been discouraged through taxation, while its waste has been encouraged through subsidy (such as the welfare state). A policy change towards appropriate sustainable taxation is the logical next step.

The need for a policy change

Taxation should reward the desired developments and discourage the unwanted effects of activities. The principles of sustainable taxation should be simple and convincing, such as the following proposal. In a sustainable economy, taxes on *renewable* resources including work – human labour – are in fact counterproductive and should be rethought. The resulting loss of state revenue could be compensated by taxing the consumption of *non-renewable* resources, in the form of materials and energies, and of undesired wastes and emissions. Such a shift in taxation would promote and reward a circular economy with its local low-carbon and low-resource solutions. These are inherently more labour-intensive than manufacturing because economies of scale in a circular economy are limited.

A circular economy increases employment because less than a quarter of the labour input to produce a physical good is engaged in the fabrication of basic raw materials such as cement, steel, glass and resins, while more than three-quarters are in the manufacturing phase. The reverse is true for energy inputs: three times more energy is used to extract virgin or primary materials as is used to manufacture products from these materials. The reuse of components and goods (through remarketing, repair, remanufacturing, technologic upgrading) instead of manufacturing new ones therefore uses considerably less energy and provides more jobs to fulfil a given need. The new policy needs new metrics, comparing resource consumption, value creation and labour input, to monitor its success: value per weight and labour input per weight.

The result is a circular economy

Changing the tax focus will in itself foster the transition to a more sustainable economy in terms of both energy and materials.

- **Energy:** taxing non-renewable energy consumption instead of labour would promote a circular regional economy over a linear global one. Reuse activity consumes less energy than manufacturing and requires considerably less transport distances.
- **Material:** taxing the consumption of non-renewable materials instead of labour promotes local reuse of goods, components and molecules and reduces end-of-life waste volumes. The competitiveness of material-preserving business models would thus increase automatically.

To summarize, a shift in taxation from labour to non-renewable resources will reinforce the emerging trend towards a circular economy based on stock management instead of throughput. This is especially with regard to the material (physical) part of the economy, without hindering the development of a knowledge economy.

Such a trend is already fuelled by developments in markets, legislation and resource scarcity.

- Market saturation**:** With consumer goods markets such as cars, mobile phones and electronics moving from scarcity to abundance in industrial economies, production and scrapping rates are equalizing. More production no longer increases welfare.
- Re-marketing: The last decade has seen the development of a new industry of re-selling goods through web-based second-hand markets. Some companies have also started doing this; for example, Lufthansa advertises used aircraft seats for sale in its in-flight magazines. “Caring” increasingly influences producer and consumer attitudes in the circular economy, partly replacing “fashion” as the driver of the consumer society.
- Capital goods: Retrofitting (technological updating) of existing plants and infrastructure is cheaper and quicker than building new ones, and promoted by many manufacturers.
- Legislation: The 2008 European waste directive has reconfirmed waste prevention as the first priority, and has defined the re-use and service-life extension of goods (i.e. a circular economy) as the main strategies to achieve waste prevention. China put its Circular Economy Law into force in 2008.
- Material scarcity: Many innovative information technology (IT) and clean energy technologies use rare earth elements (REE) in nanotechnology applications where molecules cannot be recovered economically through recycling. Component reuse may then be the only or most feasible option. Rising energy and material prices enable economic actors to gain a competitive advantage by preserving the embodied resources through reuse.
- **Value preservation** and stock optimization thus become a second economic policy in addition to the industrial economy’s creation of added value through production flow optimization. A circular economy which allows the maintaining of the performance and value of manufactured capital will become the most profitable option for many types of goods.

In a sustainable economy, a better use of existing wealth will become the preferred option for economic reasons; the environmental benefits are a result of, not the driver towards, higher competitiveness. Business models to exploit the potential of locally available resources, both human work and skills and such physical assets as buildings and equipment (manufactured capital) will boost local economic opportunities, many of which are already competitive with global manufacturing activities.

The trend towards a circular economy is further strengthened by business models built on *retained ownership*, such as:

– Operational leasing by manufacturers, selling goods as services (e.g. Xerox selling customer satisfaction).
– Public procurement based on buying services instead of hardware (e.g. NASA buying launch services from Space X instead of owning its own space shuttle).
– Fleet managers such as railways and airlines exploiting hardware to sell (mobility) services.

These functional service economy business models are becoming the preferred option in many fields; witness the rapid rise of operational leasing and private finance initiatives (PFI) for capital goods and infrastructure and sharing schemes for consumer goods, such as rental and car sharing business models (substituting car sales).

Selling the performance of goods instead of the goods themselves involves:

– **Internalization of the costs of waste and of risk** – which in the traditional production-consumption-waste society are externalized to the state (waste) and the customer (risk)
– **Reductions in waste volumes** as well as public expenses and an increase of disposable consumer incomes
– **Maximization of product durability** – a modular system design for goods based on component standardization and ease of maintenance
– **Profit maximization** – the creation of an in-house circular economy by manufacturers and fleet managers to maximize profits

Economic actors selling performance instead of goods will promote sufficiency and prevention for selfish reasons, because it increases their economic profits.

Technological progress accelerates in a circular economy because manufacturing and reuse activities are symbiotic. Marginal progress will be faster and more efficiently integrated into existing goods through technological upgrading services and retrofits. Quantum leaps in technology, however, will continue to be launched in new goods and components, ensuring that society draws the highest profits from innovations. The circular economy is thus complementing manufacturing, not replacing it.

Today's economic policies, which are still based on industrial revolution logic that aims to increase throughput to increase GDP, give neither incentives nor rewards for the *prevention* of waste and emissions and for *sufficiency* solutions (otherwise termed zero options, which are among the most efficient options to achieve greater sustainability). The Kyoto Protocol, for instance, gives rewards to major polluters for greenhouse gas (GHG) emissions reductions in an industrial economy but not for the prevention of the same emissions in a circular economy.

Designing and implementing a tax system which supports and incentivizes sustainable solutions aiming to increase efficiency, sufficiency and prevention may be the biggest challenge of this century for policy-makers. Incentives for prevention have been used in the field of health and safety but not in the field of resource efficiency and emissions into the environment.

The impact of not taxing human labour on resource efficiency

In industrialized countries, taxing the consumption of *non-renewable* resources and the *undesirable* results of an economic activity, such as emissions and waste, instead of labour, will give economic actors clear and powerful incentives to design more sustainable business models. Looking at the different pillars of sustainability shows:

– ***The resource/environment) angle*** – If the public moneys spent in the 2010 cash-for-clunkers initiatives in over 20 countries had been used to remanufacture and technologically upgrade, or replace, the used engines, a similar result for the CO_2 emissions would have been achieved with:
  – Billions of tonnes of new material resources not consumed, and related environmental damage

in the mining industry prevented (the rucksacks, or a measure of the amount of environmental materials consumed to make the product but not used in the product itself)
  - Millions of tonnes of new energy resources and related embodied GHG emissions avoided (by reusing the embodied energy)
  - Millions of tonnes of waste (and related environmental damage in recycling) prevented
  - Billions of tonnes of water consumption in manufacturing avoided (by reusing the embodied water)
  - Thousands of skilled jobs in local and regional workshops maintained

Similar results have been shown in research on the remanufacturing and technological upgrading of the first generations of high-speed trains, the refurbishment of major buildings and the remanufacturing of commercial aircraft.

- ***The social angle*** – Employment is at the heart of the social pillar of sustainability. Human labour is the most versatile and adaptable of all resources, with a strong but perishable qualitative edge.
  - It is the only resource capable of creativity and with the capacity to produce innovative solutions.
  - Human skills deteriorate if unused – continuity of work and continued learning are necessary to maintain and upgrade skills. A person who has been unemployed for a few years risks becoming unemployable.

Governments should give priority to human labour in resource use because a barrel of oil or a tonne of coal left in the soil for another decade will not deteriorate, nor will it demand social welfare. Furthermore, labour is a zero-carbon energy. Human CO_2 emissions are the same for working and unemployed people.

- ***The government angle***: Economic success does not depend on income taxes. Florida and Texas, the new powerhouses of the US economy, do not tax labour income; other nations and states have economic problems despite heavily taxing human labour.

People at work are a desire for nation states. Governments invest on average ten years in education and vocational training to teach young people marketable skills, and unemployment – wasted human resources – represent a high cost to governments and a lost opportunity for the national economy.

Not taxing human labour would also greatly reduce incentives for informal work in the shadow economy, which accounts for a double-digit percentage in the gross national product of many national economies.

- ***The economic angle***: skills, stock, utilization value, productive work. The circular economy is a high-quality world: Stradivari instruments and expensive watches do not live forever by design, but through periodic remanufacturing; retrofitting infrastructure and equipment is best done by workers beyond retirement with the knowledge and know-how of past technologies and the skills necessary to maintain the performance and value of physical assets.

Equally important for the circular economy are stock statistics. The quantity and quality of the existing stock of manufactured capital are largely unknown, input-output models for stock inexistent. Basic statistical tools for stock would greatly improve the overall efficiency of the circular economy.

The utilization value of the circular economy will replace the exchange value as the central notion of economic value. This will necessitate changes in legal structures, such as liability insurance which today is based on depreciated values that are independent of the real goods involved in claims. Replacing depreciated value by replacement value (that is the market value corresponding to the actual quality and use value of the goods) would correspond to the philosophy of a circular economy and promote reuse and repair activities.

Productive work in economic theory is limited to manufacturing and goods that can be resold. In this way, a surgeon operating on a patient's leg is classified as useful work; whereas a violin virtuoso may be neither productive nor useful. In the new circular economy, value-preserving work in a low-carbon, resource-miser context will become the truly productive work.

Conclusion

The industrial economy of the future will have to be more resource efficient, using considerably less non-renewable resources and producing less waste. A circular economy is a big step in this direction as it uses more labour and little material and energy inputs to achieve wealth.

The transition towards a circular economy has started. China has even made the circular economy the centre of its economic policy. But adapting framework conditions, including taxation, to sustainability, such as not taxing renewable resources, lags behind.

The financial services industry needs to accept the challenges of a change in focus to managing stocks instead of production flows and exploit the chances offered by economic actors selling goods as services, internalizing the costs of risk and of waste and retaining the ownership of goods and resources.

In the past, reuse and service-life extension were often strategies in situations of scarcity or poverty and had the image of inferior quality. Today, they are signs of good resource husbandry and smart management.

The change to a circular economy will be accelerated by not taxing labour as a renewable resource and increasing taxes on non-renewable resources instead.

Endnotes

1. Further details on these findings can be found in the associated White Paper published by Bloomberg New Energy Finance (BNEF). Available online at http://about.bnef.com/white-papers/
2. Stahel, Walter R. and Genevieve Reday-Mulvey. *The Potential for Substituting Manpower for Energy.* Report to the Commission of the European Communities. Brussels, 1976.
3. Value per weight (€/kg) and labour input per weight (manhour/kg) are the absolute indicators which Walter R. Stahel proposes in his book *The Performance Economy*.
4. Stahel, Walter R. *The Performance Economy*. London: Palgrave MacMillan, 2010.
5. These ideas have been sketched out in Giarini, Orio and Walter R. Stahel, *The Limits to Certainty: Facing Risks in the New Service Economy*. Springer, 1989.

Calendar of Events 2015

January	World Economic Forum Annual Meeting 2015	Davos-Klosters, Switzerland
TBD April	Innovation & EntrepreneuRing	Cambridge, United Kingdom
21-23 April	World Economic Forum on East Asia	Nusa Dua, Indonesia
6-8 May	World Economic Forum on Latin America	Riviera Maya, Mexico
TBD May	Innovation & EntrepreneuRing	Boston, USA
23 July	Biotechnology Ecosphere	Montreal, Canada
TBD August	Biotechnology Ecosphere	São Paulo, Brazil
9-11 September	Annual Meeting of the New Champions	Dalian, China
30 Sept-01 Oct	Industry Strategy Meeting	Geneva, Switzerland
28-30 October	India Economic Summit, Biotechnology Ecosphere	New Delhi, India
TBD November	Sherpa Meeting	Geneva Switzerland
TBD December	Biotechnology Ecosphere	Beijing, China

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BP

Braskem

CF Industries

Clariant

The Dow Chemical Company

DuPont

Evonik Industries

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Mitsubishi Chemical Holdings Corporation

Mitsubishi Corporation

Novozymes

PhosAgro

Reliance Industries

Royal DSM

Saudi Aramco

Saudi Basic Industries Corporation (SABIC)

Sibur

Sumitomo Chemical

Toray Industries

UPL

Contact Information

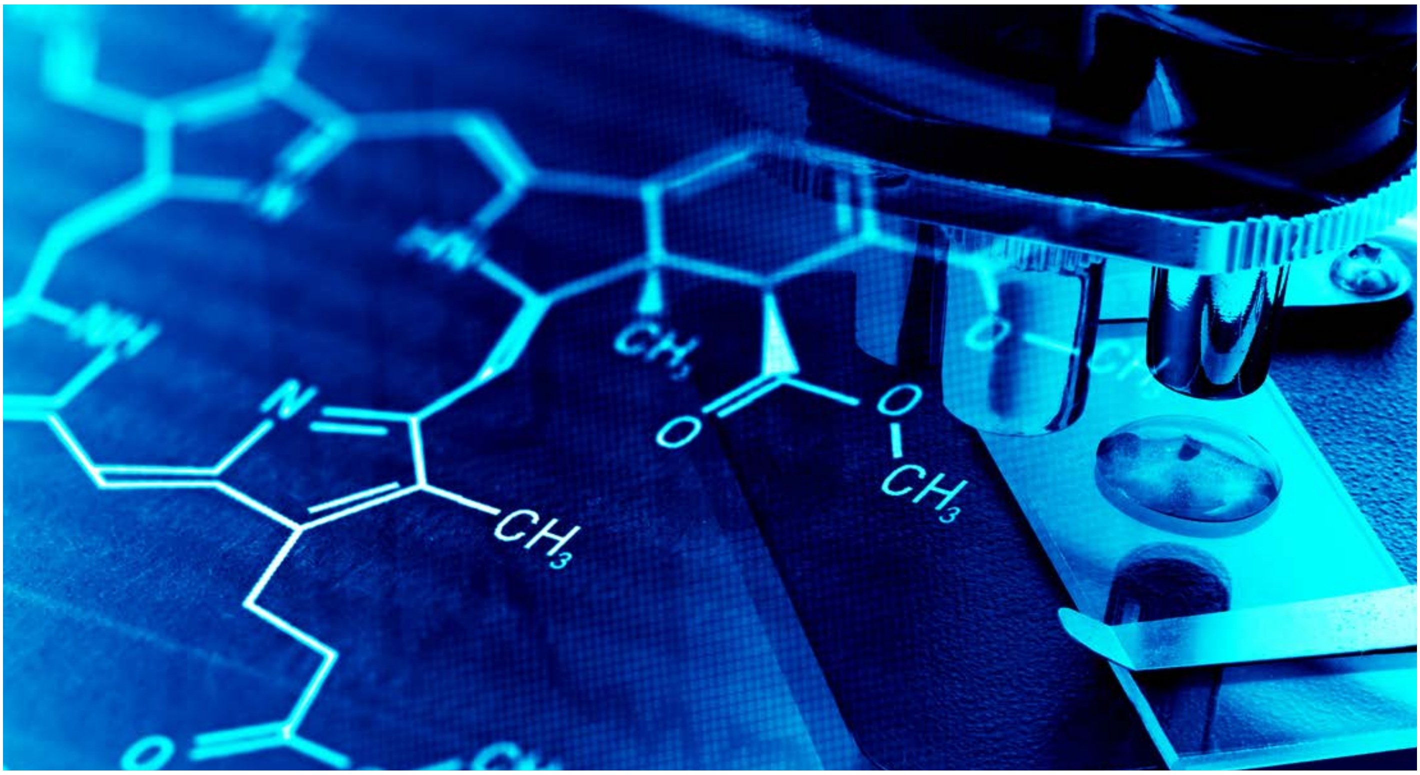
Andrew Hagan
Director, Head of Chemistry and Advanced Materials Industry
World Economic Forum
Tel.: +41 (0)22 869 1488
Email: andrew.hagan@weforum.org

Tatiana Babakina
Associate Director, Chemistry and Advanced Materials Industry
Global Leadership Fellow
World Economic Forum
Tel.: +41 (0)22 869 6554
Email: tatiana.babakina@weforum.org

Oliver Inderwildi
Senior Community Manager, Chemistry and Advanced Materials Industry
Global Leadership Fellow
World Economic Forum
Tel.: +41 (0)22 869 3667
Email: oliver.inderwildi@weforum.org

Alice Cascioli
Team Coordinator, Chemistry and Advanced Materials Industry
World Economic Forum
Tel.: +41 (0)22 869 3507
Email: alice.cascioli@weforum.org

Alex Wong
Senior Director, Head of the Centre for Global Industries and Head of Basic Industries
World Economic Forum
Tel.: +41 (0)22 869 1460
Email: alex.wong@weforum.org



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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org