Readers of this article are strongly encouraged to learn more about SusChem from its website www.suschem.org and for them and their organisations to actively join in with SusChem's activities as it advocates the key importance of sustainable chemistry for delivering the objectives of Europe 2020.

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Building a

Sustainable Chemistry Future in an Uncertain Europe

■ **A key word for today's chemistry community is that of sustainability. It is here that new chemical technologies can really make a tangible difference by creating distinctive added value.**

Rodney P. Townsend

Nobody needs reminding about the problems that Europe is facing at the moment. The financial debt crisis is the first thing that comes to mind, but in reality the malaise goes much deeper than this: the key issue is how to ensure the future prosperity of Europe in an increasingly competitive global economic situation.

This makes it necessary to identify where Europe can add distinctive value as economies in the developing world in particular grow ever stronger. To do this the European Commission set up a recovery plan some two or three years ago and as part of this initiative, President **José Barroso** launched Europe 2020, which is the EU's strategy for growth for the coming decade.

Towards a smart, sustainable and inclusive economy

Three words encompass the overall aim, which is to make Europe a smart, sustainable and inclusive economy. To help achieve this aim, within Horizon 2020, the funding programme that will succeed Framework Programme 7, the Commission is ring-fencing substantial amounts of funding for particular initiatives, called European Innovation Partnerships, as part of the so-called Innovation Union.

The proposed budget for Horizon 2020, which will run from the beginning of 2014 to 2020, is currently projected to exceed EUR 80 billion. It is most important for the chemical community—both academia and industry—that it should gain access to a substantial proportion of these funds. It is also important for the success of Europe 2020 that the innovative chemical community should be well funded, as we shall see.

Throughout FP7, the European Technology Platform for Sustainable Chemistry—SusChem for short—has been successful in obtaining funding from industry and the European Commission (more than EUR 1 billion to date) which represents about 3% of the total available FP7 budget.

SusChem is determined that chemistry and its associated European chemical industries, which arguably contribute in some manner to about 20% of total European GDP when added value along supply chains is taken into account, should continue to be recognised and funded under Horizon 2020.

Of the three words which together encompass Europe's 2020 strategic aim, a key one for the chemistry community is that of sustainability. It is here that new chemical technologies can really make a tangible difference by creating that distinctive added value. It is therefore necessary first of all to examine in a little more depth what is meant by the term sustainability.

Economical criteria must be satisfied

When developing the technologies which are required to ensure that a new process or product is genuinely sustainable, a common mistake can be to focus on satisfying environmental criteria only. In fact, a fully sustainable innovation must also satisfy rigorous economical and societal criteria.

Citizens within a society need to believe that a product or process confers real benefits to people as well as being ecologically friendly. Also, the market price of the product must be one that is not only acceptable to the consumer but also provides an acceptable profit margin for the producer. This means that ideally a truly sustainable innovation must meet three sets of criteria:

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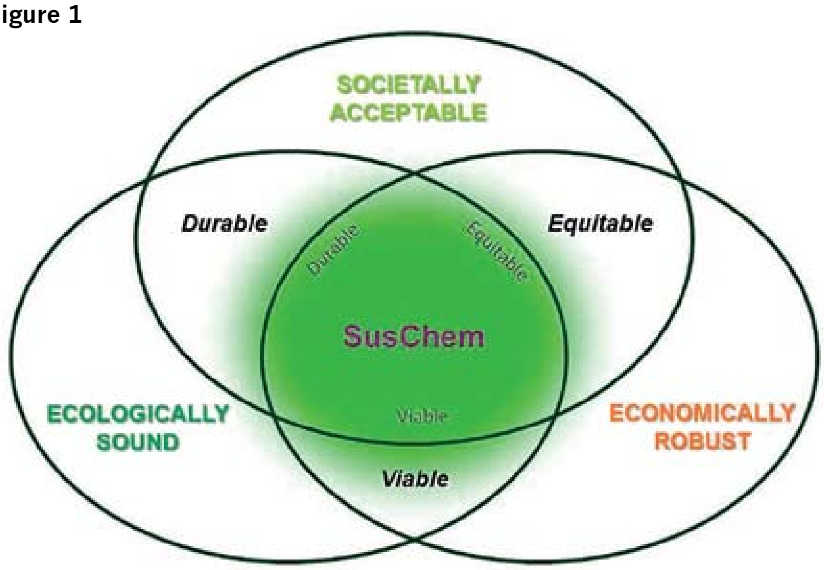
Figure 1



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Applying tests that meet these three criteria together should ensure that technical solutions are truly sustainable, that is, giving solutions that are simultaneously viable, equitable and durable. Therefore, SusChem aims to set its operations to sit squarely in the central region of this Venn schematic (Figure 1).

Sustainable experimental design should be a first consideration always, not just for the research scientist but also for the process engineer, the manufacturer and retailer—wherever one sits in the value chain.

Waste figures truly shocking

In addition, the issue of waste must be addressed. It was estimated in a recent UK report that currently 93% of production materials do not end up in saleable products, 80% of products are discarded after a single use and no less than 99% of materials used in the production of goods, or finally contained within them, are discarded within six weeks of manufacture.

These figures are truly shocking and clearly demonstrate an unsustainable situation. Therefore a truly holistic design model must extend the value chain to include recycling (a "cradle to cradle" approach):

It is hard to identify any process or product group shown in Figure 2 where the development of innovative sustainable solutions would not involve the chemical sciences or chemical engineering.

Yet if Figure 2 is thought of as a supply rather than value chain, with successive contributions to GDP from different industrial sectors being analysed sequentially, then the contribution that the chemicals industry makes would be limited to only parts of the diagram, simply because many of the processing and manufacturing activities further across the chains are defined in terms of other industrial sectors.

Sadly, this is often the manner in which the contribution of the chemical industry is recognised, thus substantially understating the importance of chemistry for wealth creation.

A continuing challenge for chemistry

The involvement of chemistry at all stages along the value chain shown in Figure 2, and in recycling, shows that the chemical sciences must be encouraged, and seen, to play a ubiquitous role in helping the Europe 2020 Strategy to succeed.

Throughout FP7, SusChem has pressed this case with considerable success and it intends to continue its strong advocacy on behalf of the chemical sciences, chemical engineering and the chemical industries within Europe.

Another recognition challenge for chemistry needs to be highlighted at this point. Although it is one of many interfaces between sectors and disciplines, the chemistry/bioscience interface is critically important.

Whilst it is a matter of common knowledge that chemistry and chemical technology is quintessentially about molecular synthesis, reactions and mechanism, it is not so generally understood in the popular mind that these phenomena also completely underpin many of the biosciences and biotechnology itself.

This can be amply demonstrated by examining a typical supply chain which starts with biomass and ends with familiar materials and other products, as depicted in Figure 3.

At every point along the value chain, chemistry, chemical engineering, biochemistry and bioengineering overlap in a near-seamless manner. It is therefore misleading, if not even inimical to future sustainable innovation, to contrapose chemistry and biotechnology as though the output of the former is, for example, purely concerned with "artificial" molecules whereas biotechnology produces new options from "natural" molecular processes. Unfortunately, this false perception is commonly held by the general public and indeed is often encouraged by the media and in advertising.

Chemistry and biotechnology are linked together

It is customary to classify different biotechnology clusters using a colour coding convention; this convention is convenient for showing the intimate connections that exist between chemistry and biotechnology.

The five most relevant biotechnology clusters are shown in Figure 4, where the intimate relationships between chemistry, chemical engineering, the biosciences and all the industrial technologies which

Figure 2

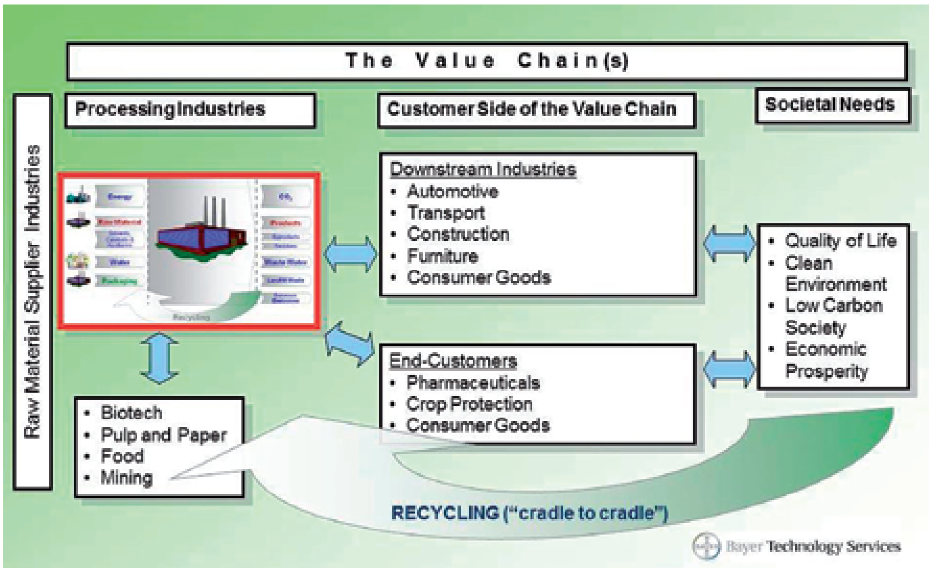

Figure 3

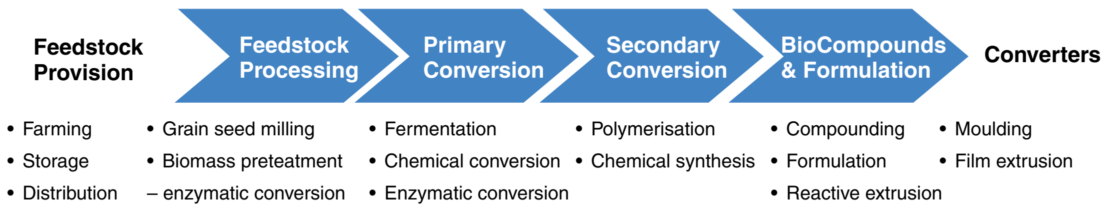

Figure 4

Biotechnology Classification	Fields of Operation (Examples)	Horizon 2020 EIPs of High Relevance	Horizon 2010 EIPs of SomeRrelevance	Examples of Some Key Scientific Frontiers	Examples of Opportunities for Chemistry and Chemical Engineering	Current Priority for SusChem
"White"	Raw Materials, Bio- and Chemical Processing, Sustainable Product Design, Life Cycle Assessment, Novel Recycling Solutions	• Raw Materials • Water Efficiency	• Bioeconomy • Smart Cities	• Biomass feedstock conversion • Biorefineries • Enzymatic catalysis • Use of micro-organisms and fermentation • Biomaterials • Water purification and re-use • Energy economy	• Industrial biotechnology for design, feedstock derivation and processing of raw materials • Industrial technology for onward processing and manufacture of novel sustainable materials and other products • Use of biotechnology and chemistry for re-use and recycling at all stages in manufacture, use and disposal	High
"Red"	Medical Diagnostics, Pharmacology, Antibiotic Resistance, Cancer and Ageing, Gene and Stem Cell Technologies	• Healty Ageing	• Bioeconomy • Raw Materials	• Discovery and use of novel drugs, synthetic vaccines and new clinical technologies • Cell apoptosis mechanisms • Gene therapeutics • Stem cell applications and organ restoration	• Atom economy in novel synthesis and biosynthesis • Epigenetic interventions using novel chemistry and biochemistry • Applications of metagenomics • Development of non-animal testing protocols	Medium to low
"Green"	Land Utilisation, Crop Science (Food and non-Food), Forestry and Agricultural Biotechnologies	• Agricultural Sustainability • Bioeconomy • Water Efficiency	• Raw Materials • Healthy Ageing • Smart Cities	• Discovery and use of novel genes, molecules and materials in land plants, crops and forestry • Genetically modified non-food crops • Energy from biomass	• New chemical transformation processes for biomass feedstock refining • Eco-friendly fertilizers and pesticides • Soil remediation technologies • New measurement methods to detect trace contaminants (GMOs)	Medium
"Yellow"	Food Production (Land and Sea), New Crop Technologies, Food Processing and Preservation	• Agricultural Sustainability • Bioeconomy • Water Efficiency	• Healthy Ageing • Smart Cities	• New wild-type selection and epigenetic technologies • Novel food bioprocessing technologies • Combined ecological and economic studies on land availability and food/non-food crop balance • Food waste recycling and energy production	• New measurement methods to detect trace contaminants (GMOs) • Combined bio- and physical engineering for novel processed food manufacture • Novel "nutraceuticals", prebiotic and probiotic foods	Medium to low
"Blue"	Marine and Freshwater Management, Harvesting and Farming	• Agricultural Sustainability • Bioeconomy • Water Efficiency	• Raw Materials • Smart Cities	• Discovery and use of novel genes, processes and materials in freshwater and marine organisms • Hydrogen production from algae • Novel water purification processes	• More sensitive measurement methods to detect trace contaminants (e.g. Hg, radionuclides) in both fresh water and marine environments	Low

depend on these disciplines is instanced with various examples. Alongside these examples is also a description of where SusChem is currently setting its priorities.

Understanding the close relationships between these disciplines is even more important now that "the bioeconomy" has been generally recognised as a key player in helping to deliver the Europe 2020 Strategy.

The current size of the bioeconomy sector is indeed large: in the EU as a whole it is estimated that its annual turnover is EUR 2 trillion and that it employs some 22 million people, 9% of total employment in the EU.

Finland has a thriving bioeconomy

Finland itself is notable in this respect; it has a thriving bioeconomy and alongside this, a relatively large chemicals industry. It is not surprising therefore that the European Commission has recorded its strong recognition of the importance of the bioeconomy by launching a major initiative in the form of a bioeconomy strategy and action plan.

SusChem is strongly supportive of this new initiative from the European Commission. In fact, close links between chemistry and biotechnology have been a core part of its strategy and structure since the inception of SusChem in 2005.

It benefitted throughout FP7 from the commitment and direct support of two European trade associations that have together played the role of key shareholders in SusChem, namely, the European Chemical Industry Council (Cefic) and the European Association for Bioindustries (EuropaBio).

This alliance was proclaimed through a joint declaration in 2005, signed by the Presidents of Cefic and EuropaBio, where they affirmed that both organisations were "confident that… (SusChem)… provides solid guidance in setting the strategy for sustainable chemistry research and in creating a supportive framework for chemistry and biotechnology innovation in Europe"; the fruits of this alliance has been manifested in the strong support that SusChem initiatives and activities have received from the FP7 NMP and KBBE themes.

As part of its ongoing move into the years of Horizon 2020, SusChem remains strongly committed to combat negative perceptions of chemistry wherever they arise and to take a leading role in EU innovation projects, including ones that operate at the chemistry/biosciences interface, within Horizon 2020.

SusChem looking forward to future cooperation

SusChem is looking forward very positively to continuing to work with others in research, innovation and education partnerships when Horizon 2020 is finally launched in 2014 and has already taken action to enable this to happen, by linking into already existing European Innovation Partnerships.

It is aiming to operate at an even higher level compared to that attained in the FP7 years, partly through a higher commitment to innovation instanced by collaborations in major Public-Private Partnerships, but also by continuing to facilitate and obtain funding support for a variety of projects that will enhance partnerships with other academic disciplines and industry sectors. ❐

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