

# The Bioeconomy and Glycoscience

*Global Challenges Science Week  
Université de Grenoble Alpes*

*Rodney Townsend  
6th June 2019*


# Purposes of this talk

- ❑ To suggest that this is a **uniquely opportune time** to be working on glycoscience and glycotechnology in Europe.
- ❑ To outline how the EU and in particular Horizon Europe is presently thinking about the Bioeconomy as a solution to many **current Global Challenges**.
- ❑ To describe some ways we can increase the profile of new glycoscience and glycotechnology with **the general public and Governments** within Europe.
- ❑ To inform on how we can raise **Research and Innovation funding** for glycoscience and glycotechnology in the next decade within Europe.
- ❑ To discuss some already identified '**R&I**' **challenges** we must overcome in glycoscience and glycotechnology.

1. The role of 'Bioeconomy Europe' and the core concept of "Sustainable Growth".
2. What is "Innovating for Sustainable Growth"? – the concept explained.
3. Glycoscience and the glycotecnologies are essential to deliver the Bioeconomy Europe vision – how do we obtain the funding required? – *SusChem* and *Horizon Europe*.
4. Raising the profile of glycoscience and glycotecnologies in the EU, academe and industry – the mission of *CarboMet*.
5. Some examples of Research and Innovation ['R&I'] priorities and challenges for glycoscience.
6. Conclusions – some actions we all need to take.



# 1: The role of 'Bioeconomy Europe' and the core concept of "Sustainable Growth", as advocated by the EU.....



These are principles and concepts we need to understand and then use to demonstrate to the EC , EU government and Member State governments generally that the comparative current neglect of glycoscience and glycotechnology must not continue....

# An Important Declaration of Principle by the EU on the Bioeconomy in 2012....



EUROPEAN COMMISSION

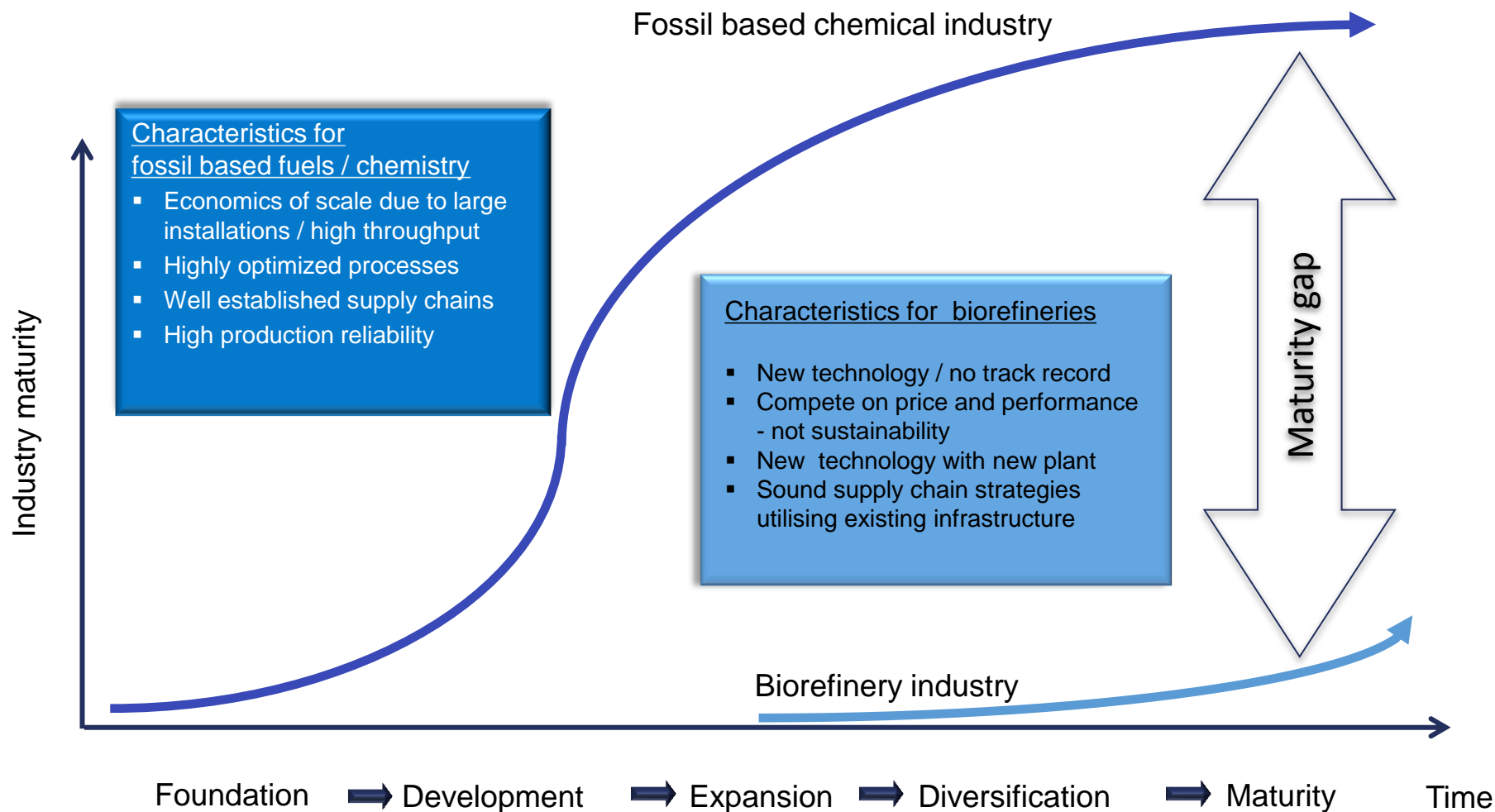
Brussels, 13.2.2012  
COM(2012) 60 final

**COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN  
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL  
COMMITTEE AND THE COMMITTEE OF THE REGIONS**



**Innovating for Sustainable Growth: A Bioeconomy for Europe**

# An assessment by the EU on the Relative Maturity of the Fossil Feedstock Economy *vis à vis* the Bioeconomy in 2012 - not a complete replacement but a major rebalancing....



## Briefing

January 2017



## Bioeconomy Challenges and opportunities

### SUMMARY

The bioeconomy refers to the production and extraction of renewable biological resources and their conversion into food and feed, bio-based products and bioenergy. Although primarily based on activities carried out, in some form, for centuries or millennia (such as farming, fisheries or forestry), the bioeconomy emerged in the past decade as a knowledge-driven concept aimed at meeting a number of today's challenges. In the European Union (EU), the bioeconomy sectors have an annual turnover of about €2 trillion and employ between 17 and 19 million people. They use almost three quarters of the EU land area.

A stronger bioeconomy could trigger growth and jobs, and reduce dependency on imports. It could contribute to optimising the use of biological resources, which remain finite although they are renewable. However, it could also create competition between uses and technologies at various levels. Besides, the amount of available biomass remains disputed. A bioeconomy could contribute to reducing greenhouse gas emissions and improving public health. However, it could also trigger new greenhouse gas emissions and induce adverse impacts on the environment.



# Bioeconomy

## Challenges and opportunities

### SUMMARY

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The EU policy framework for the bioeconomy is spread across a number of policies (agriculture, forestry, fisheries, climate, circular economy and research). Although a bioeconomy strategy from 2012 aims to ensure policy coherence, inconsistencies remain. The EU provides funding to innovative bioeconomy activities through the framework programme for research (Horizon 2020) and a range of other instruments.

The European Parliament has been supportive of the bioeconomy strategy, while highlighting the need for sustainability and policy coherence.



The EU Bioeconomy continues to be a high priority within the currently developing Horizon Europe plans (2021 to 2027). For example, see its recently published 'Missions':

- ❑ Adaptation to Climate Change including Societal Transformation;
- ❑ Cancer in all its forms;
- ❑ Healthy Oceans and Natural Waters;
- ❑ Carbon Neutral and Smart Cities;
- ❑ Soil Health for Sustainable Food.

.....We will return to some of these topics in greater detail later when we consider the contributions that glycoscience can make to building the EU Bioeconomy;

.....Innovative glycotechnology, and the new glycoscience backing it, is needed to provide solutions to the problems and challenges inherent in all five Missions..

# An Important Declaration of Principle - Innovating for Sustainable Growth .....



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**Innovating for Sustainable Growth: A Bioeconomy for Europe**

## 2: What is “Innovating for Sustainable Growth”?

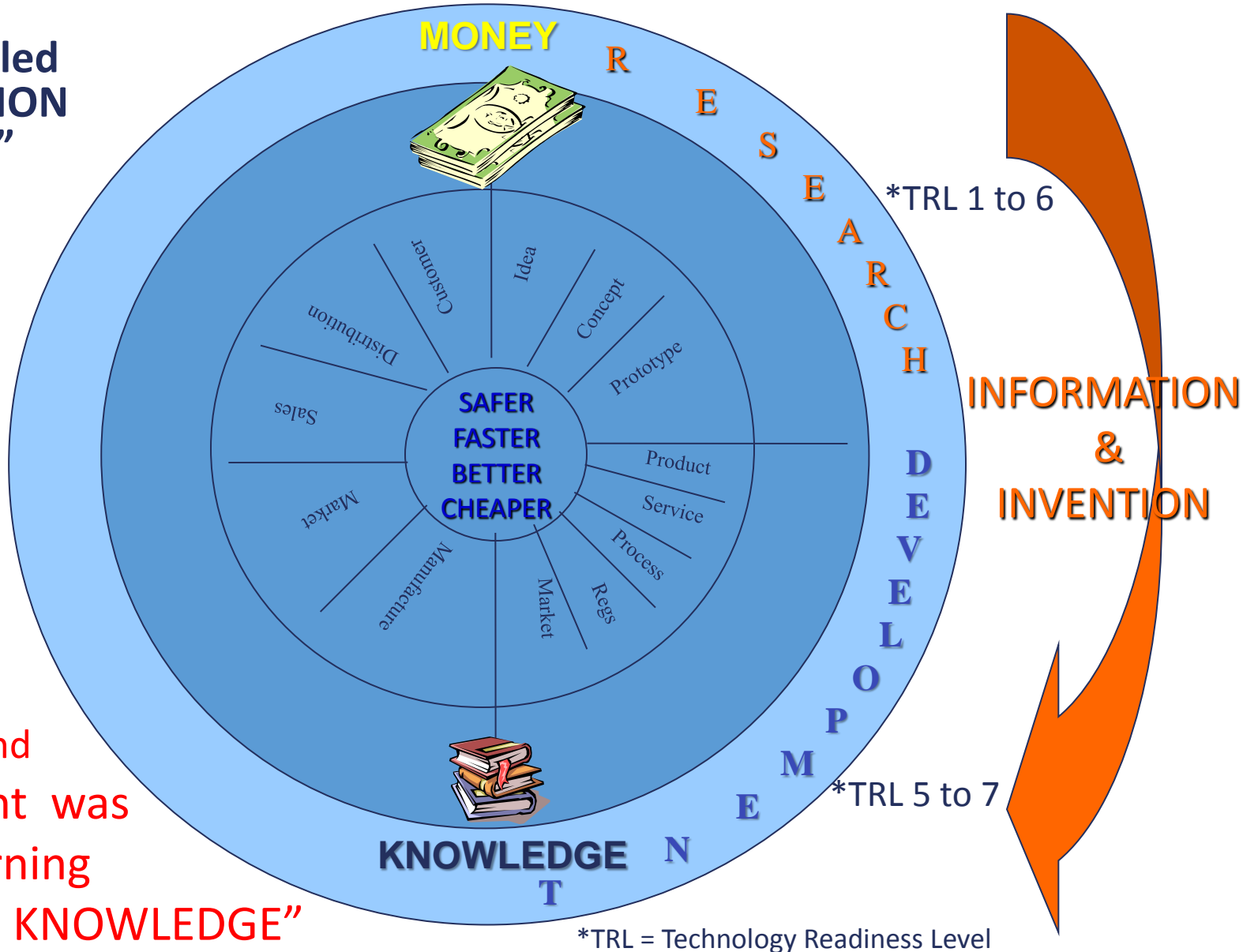


We must comprehend what this phrase means to our stakeholders if we are to be successful in our mission to increase financial support for glycoscience from the European Government, the Commission, Member State Governments and European industry.....

suschem

The so-called  
“INNOVATION  
WHEEL”

“Innovation”: the situation summarised 10 years ago

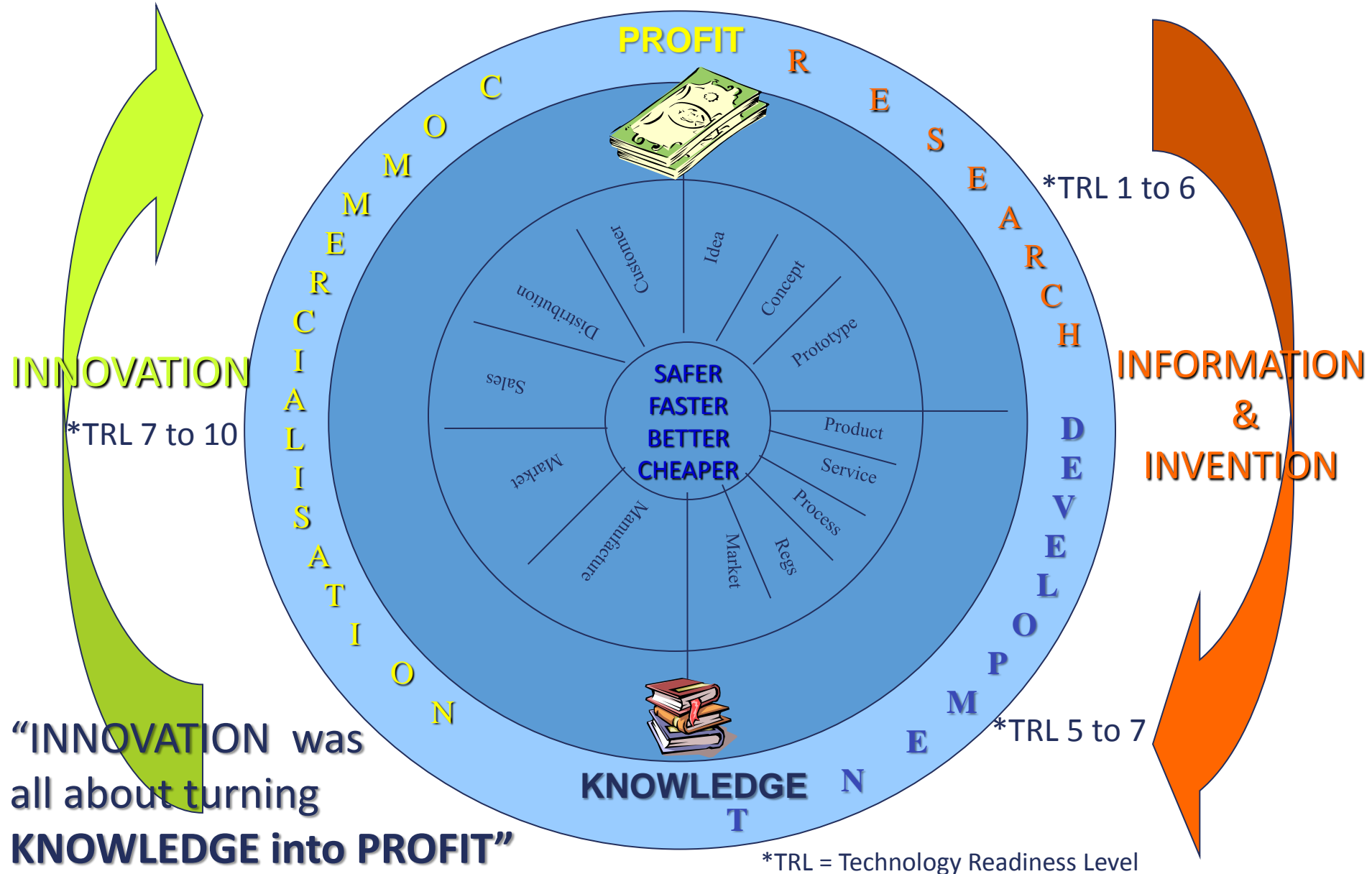


“Research and  
Development was  
all about turning  
**MONEY** into **KNOWLEDGE**”



“Innovation”: the situation summarised 10 years ago

SUSCHEM



A limited definition of Innovation which puts very strong emphasis on profitability as the main, if not only, criterion....

So R & D is (apparently!) just about turning money into knowledge ....

.....and Innovation is (apparently?) just about turning knowledge into nett profit as soon as possible ....

The logic behind this is that the prime justification to invest in (*e.g.*) glycoscience must be whether it makes a profit soon....

....with environmental friendliness being a good extra 'selling point' but "not our problem" primarily.

A limited definition of Innovation which puts very strong emphasis on profitability as the main, if not only, criterion....

The “Innovation Wheel” is a myopic, one-dimensional view ....

.....it is NEITHER the view of most of industry today either (especially those that have signed up to a responsible care commitment) NOR is it the view of the European Parliament/European Commission....

....instead, the target must be “Sustainable Growth” with innovations defined as products and concepts that change the world we live in, by not only being financially viable but also beneficial to the health and wellbeing of the of the whole ecosystem and fair to all sectors of society.

(Quote) - “the target must be ‘Sustainable Growth’ with innovations defined as products and concepts that change the world we live in, by not only by being financially viable but also beneficial to the health and wellbeing of the of the whole ecosystem and fair to all sectors of society.....”

This is a definition of “Innovation” very different from the previous one!  
The issue now is how best to bring about innovation that grows sustainably. ....

**The view of the EU is that to invest in a Bioeconomy is one major way to achieve this.....**

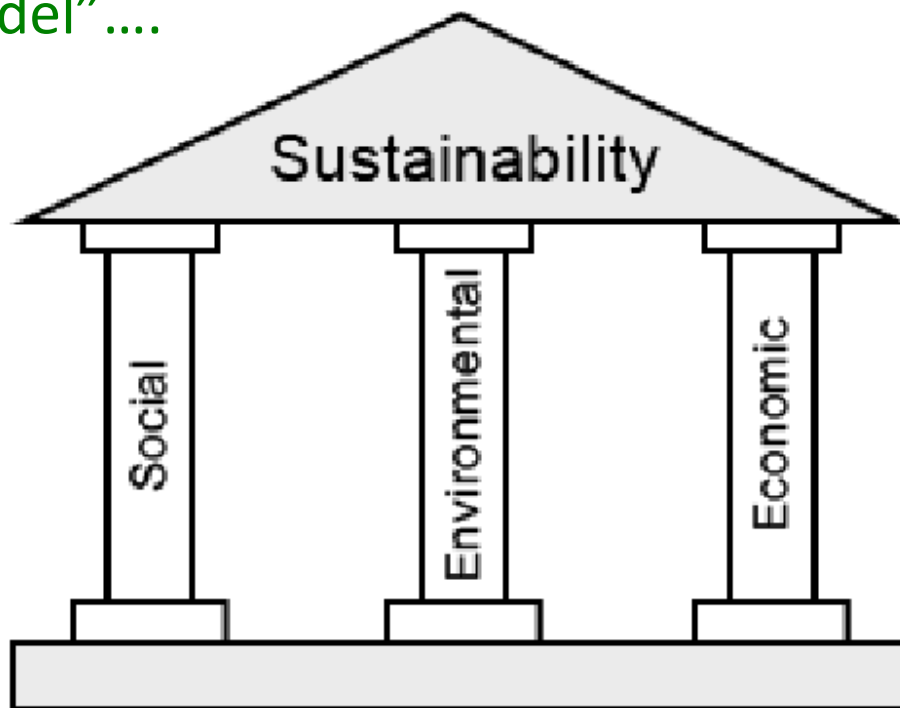
**THE JOB FOR US IS TO CONVINCe THEM THAT EUROPE NEEDS US  
TO HELP ACHIEVE THEIR BIOECONOMY OBJECTIVES**



# suschem A well-known model of Sustainable Growth ...

The famous “Three Pillar Model” ....

....simple but arguably a bit simplistic?....

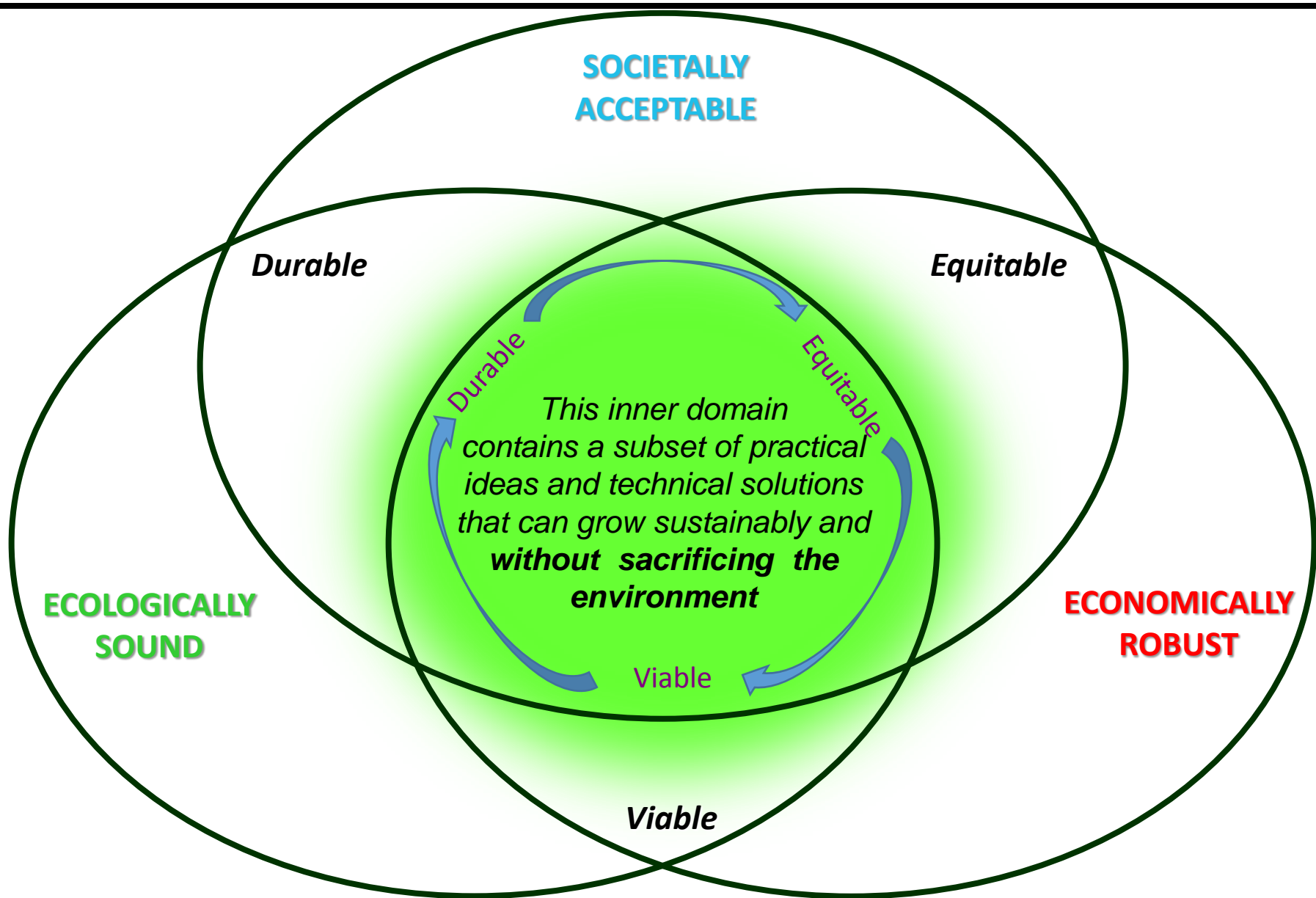


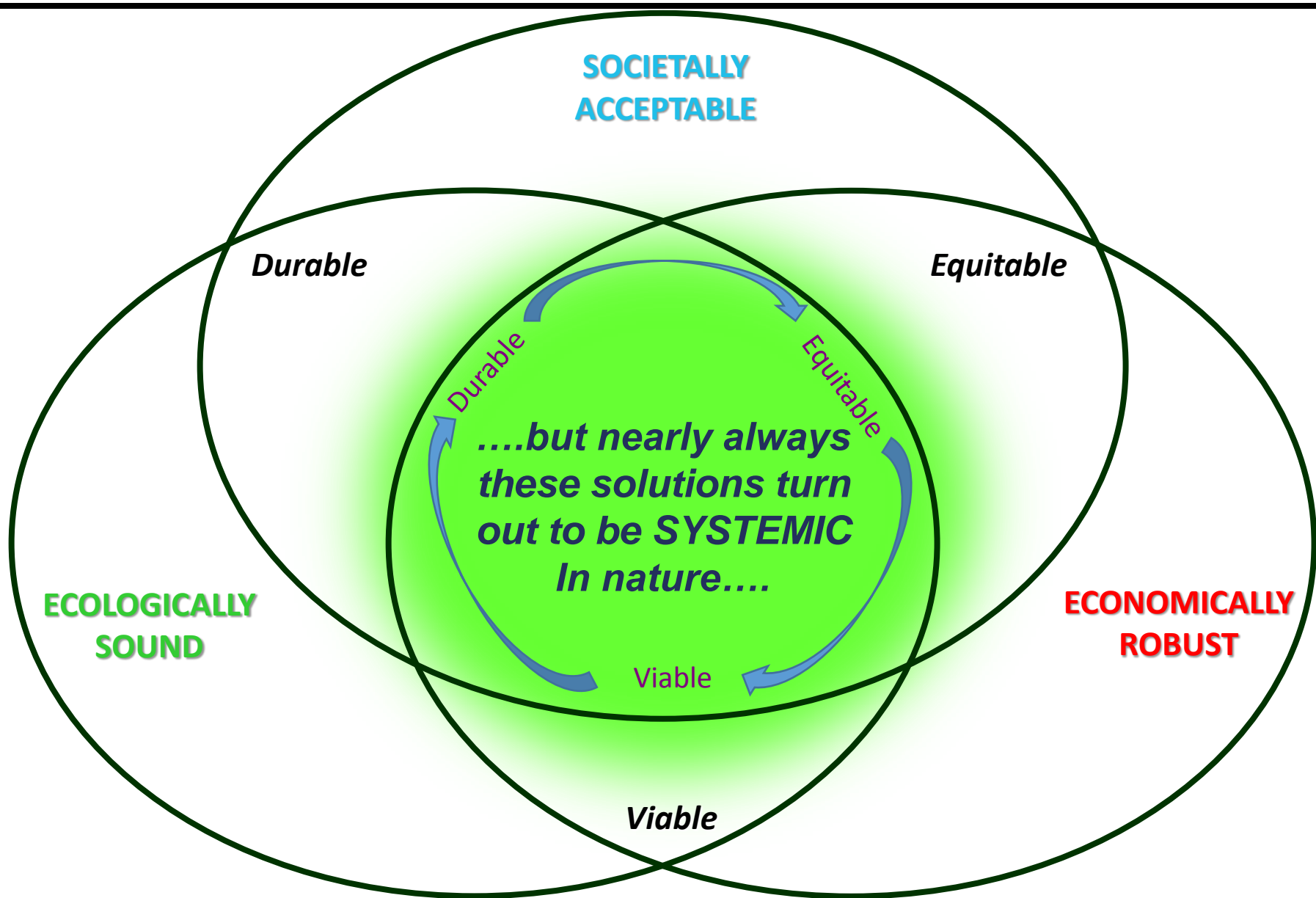
Better to regard the “three pillars” as concentric circles of operation which may mutually conflict....



Conflict resolution may involve difficult choices but then the priorities **MUST** be:  
**Environment** > **Society** > **Economy**

# Innovating for Sustainable Growth







# Innovating for Sustainable Growth: the technical solutions are SYSTEMIC – “The Circular Economy”

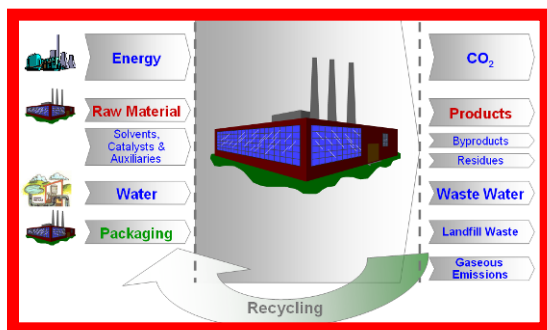
## The Value Chain(s)

### Processing Industries

### Customer Side of the Value Chain

### Societal Needs

Raw Material Supplier Industries



### Downstream Industries

- Automotive
- Transport
- Construction
- Furniture
- Consumer Goods (P&G)

### End-Customers

- Pharma
- Crop Protection
- Consumer Goods

- Quality of Life
- Clean Environment
- Low Carbon Society
- Economic Prosperity

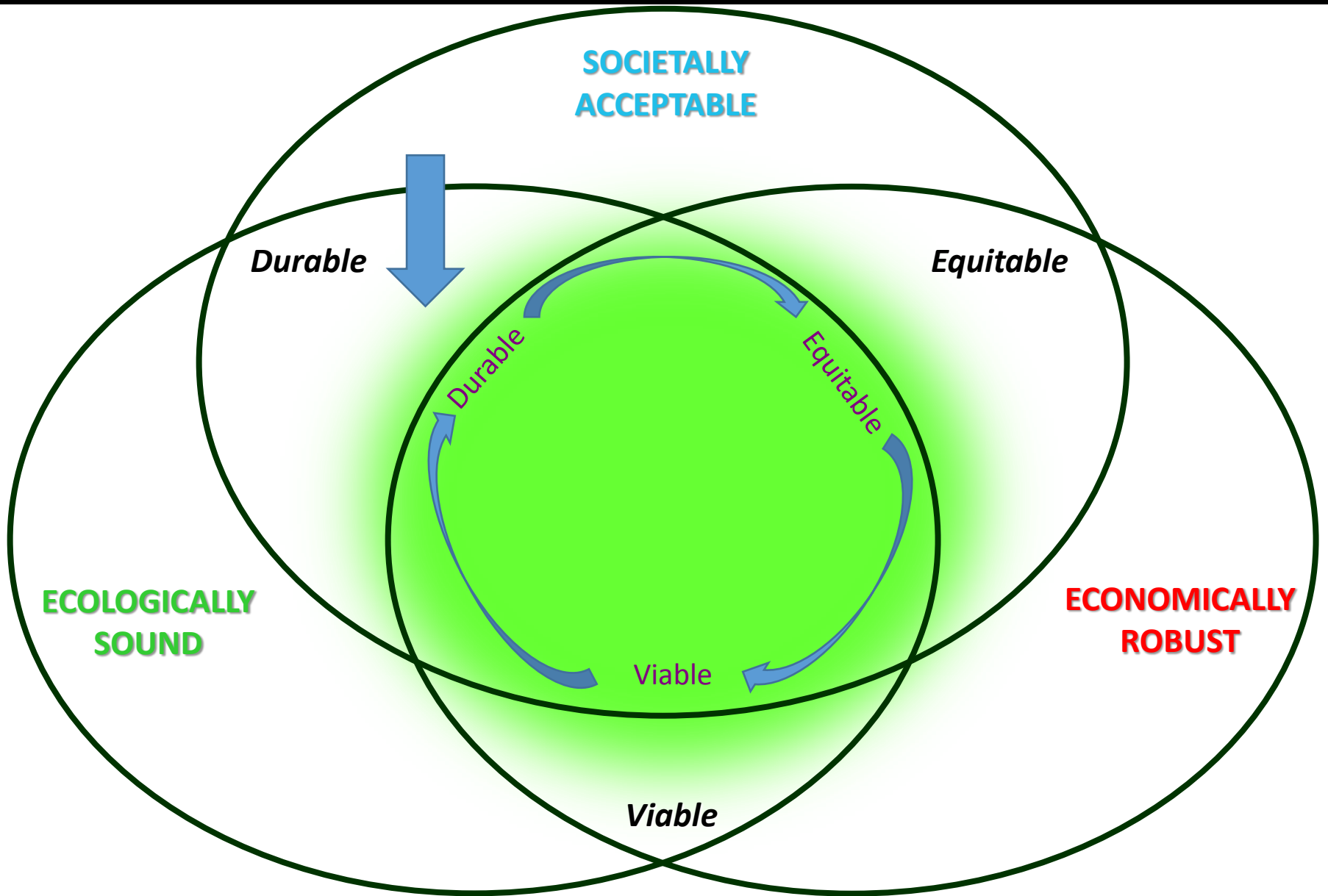
- Biotech
- Pulp and Paper
- Food ?
- Mining ?

“THE CIRCULAR ECONOMY”

Big challenges, requiring systemic, bold solutions...

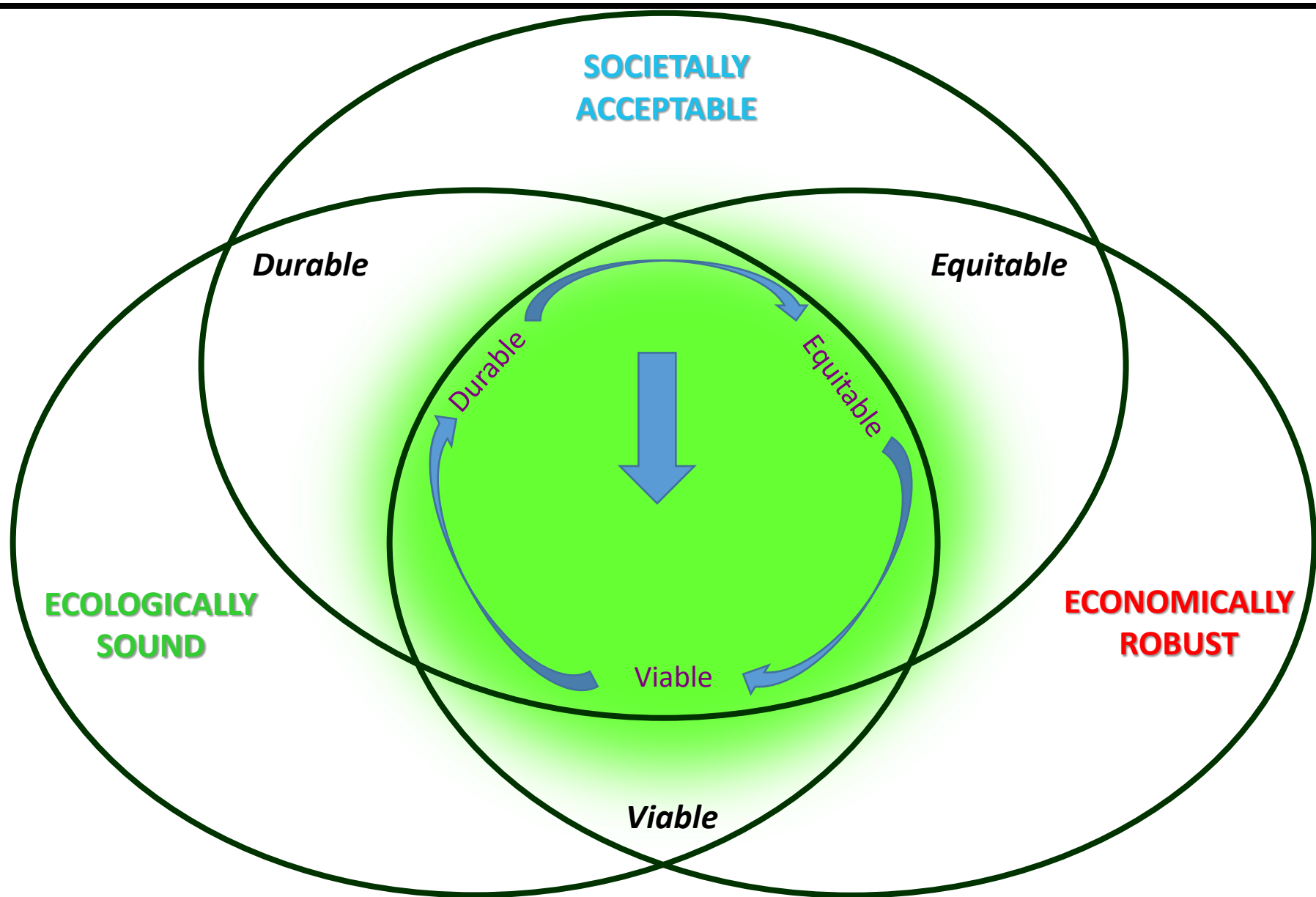
Suppose the best we can do is this?....

suschem



suschem

Then we change the goalposts and level the playing field!....



Moving the goal posts – this is **REGULATION**

Levelling the playing field – these are likely to be **FISCAL MEASURES**

...both these require **LEGISLATION**


.....i.e., the EC acting as **PARTNERS WITH INDUSTRY, OURSELVES  
and OTHER INTERESTED PARTIES.....**

....because the problems are **SYSTEMIC** and indeed **INTERNATIONAL**

**....SO LONG TERM COMMITMENT IS THE ONLY SOLUTION**



### 3: Both glycoscience and glycotechnologies are essential to deliver the Bioeconomy Europe vision – but how do we raise the funding required?



We believe that new glycoscience and glycotechnology are essential to develop the EU Bioeconomy –but do the funders? It is they who will provide the means to realise our vision. **Belief is not the issue!** – we must prove our proposition with hard, evidence-based data and scientific logic...

# Glycoscience research: how do we obtain the funding required within the EU Bioeconomy?

**3.1:** We must show that our glycotecnology advocacy coincides with those of **key industries that influence EU Bioeconomy funding priorities** for the years 2021 to 2027. A key body which is empowered to do this is **“SusChem”**.....

- “SusChem ETP” stands for the “European Technology Platform for Sustainable Chemistry and Biotechnology”, supported financially and in-kind by Cefic and EuropaBio;
- It was set up by the European Commission in 2004-5 using start-up money from the EC of ~€2 million to recommend research and innovation funding priorities in sustainable chemistry and biotechnology research (TRL1 to 6);
- It is led by industry (European SMEs to large corporations) in concert with *academia* and meets regularly with key Commission officials & the European Parliament. It also operates in parallel at the national level in many European Member States as well as affiliated countries;
- **THROUGH SUSCHEM’S SUCCESSFUL ADVOCACY SUSTAINABLE CHEMISTRY AND BIOTECHNOLOGY HAS OBTAINED BILLIONS OF EUROS R&I SUPPORT SINCE ITS INCEPTION.**

SusChem obtained at least € 6 billion for sustainable chemistry and biotechnology research through Framework Programme 7 with substantial additional funding from industry [2007 to 2014]

As well as continuing this level of support through Horizon 2020 SusChem helped to shape the EC’s funding programme (Horizon 2020) from as early as 2010 to form “SPIRE” and “BBI” Public-Private Partnerships [‘PPSS’]

SPIRE [“Sustainable Processing In Resource Efficiency” ] has formed a backbone Public-Private-Partnership throughout Horizon 2020 (worth ~€1 billion) alongside another partnership called BBI [“Bio-Based Industries”]. also worth ~€1billion.

SusChem is now preparing a new Strategic Innovation and Research Agenda as a bid to the Commission with an increased emphasis on the Bioeconomy and Health, Food and Agriculture.....

## Some examples where SusChem considers where more investment could benefit the EU Bioeconomy over the next decade.....

- Biomaterials and Biopolymers
- The Circular Economy in the Bioeconomy
- Bio-based Feedstocks
- “Industry 4.0” for Stratified Medicine Production
- Bio-informatics and Data Analytics in Manufacture
- New Metrology Requirements
- Soft Sensor Technology
- Novel Biologics for Medical care and Wellbeing
- Novel Vaccine Technology
- Human Skin and Gut Microbiome
- Sustainable Food Packaging
- Healthy Eating, Foods and Prebiotics
- Soil Remediation, Engineering and Metagenomics
- Harvesting Sustainably Novel Biomolecules from the Sea
- Synthetic Biology and the Biocatalysis/Chemocatalysis Interface

# Glycoscience research: how do we obtain the funding required within the EU Bioeconomy?

SusChem is therefore preparing a new Strategic Innovation and Research Agenda as a bid to the Commission with an increased emphasis on the Bioeconomy in Health, Food and Agriculture in particular....

Currently considering advocacy in the following areas relevant to us:

- Biomaterials and Biopolymers
- The Circular Economy
- Bio-based Chemicals and Feedstocks
- The Digital Economy
- New Metrology Requirements in Diagnosis and Manufacture
- The Human Skin and Gut Microbiome
- Sustainable Food Packaging
- Healthy Eating, Foods and Prebiotics
- Soil Remediation, Engineering and Metagenomics
- Synthetic Biology and Biocatalysis



# Glycoscience research: how do we obtain the funding required within the EU Bioeconomy?

**3.2:** We must identify with **key targets laid down within Horizon Europe**, and show how and why a substantial investment in glycoscience and glycotechnology will meet the specified targets....primarily in Pillar 2:

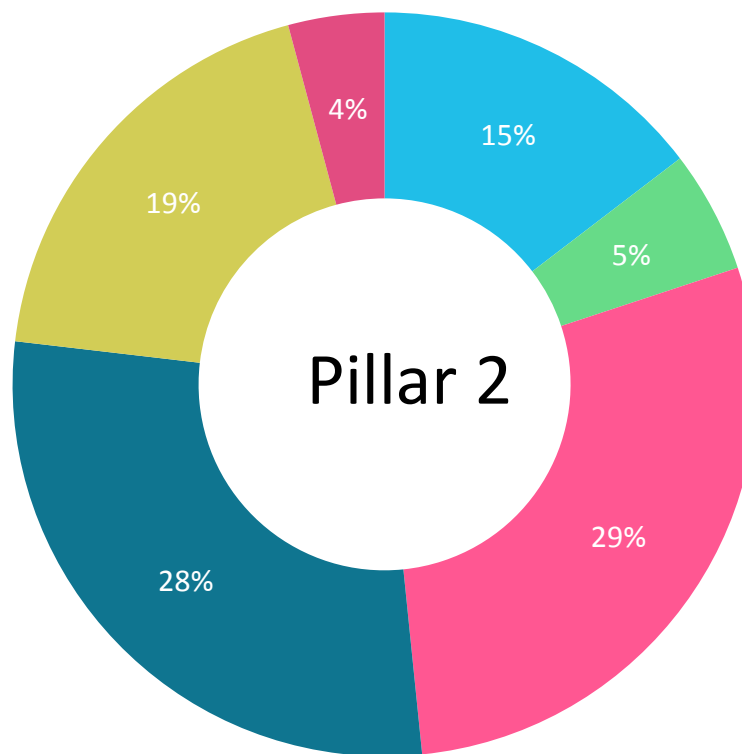


## Answer - Key Targets within Clusters!

2: We must identify with **key targets laid down within Horizon Europe**, and show how and why a substantial investment in glycoscience and glycotechnology will meet the specified targets....



A total of €52,700,000,000 is currently allocated to:  
*“Pillar 2 – Global Challenges & Industrial Competitiveness”*  
 in six tranches or **“Clusters”**.....





Of these five Clusters, we can argue cogently that glycoscience and glycotechnology are directly relevant to **THREE** and indirectly relevant to the **ONE** of the others....

<b>Clusters</b> implemented through usual calls, <b>missions &amp; partnerships</b>	Budget (€ billion)	<b>DIRECTLY RELEVANT?</b>
Health	€ 7.7	<b>YES</b>
Inclusive and Secure Society	€ 2.8	<b>INDIRECTLY</b>
Digital and Industry	€ 15	<b>YES</b>
Climate, Energy and Mobility	€ 15	<b>PARTIALLY</b>
Food and Natural Resources	€ 10	<b>YES</b>
<b>Joint Research Centre</b> supports European policies with independent scientific evidence & technical support throughout the policy cycle	€ 2.2	

Of these five Clusters, we can argue cogently that glycoscience and glycotechnology are directly relevant to **THREE** and indirectly relevant to the **ONE** of the others....

## Clusters in 'Global Challenges and Industrial Competitiveness'

Clusters	Areas of intervention	
<b>Health</b>	<ul style="list-style-type: none"> <li>* Health throughout the life course</li> <li>* Non-communicable and rare diseases</li> <li>* Tools, technologies and digital solutions for health and care</li> </ul>	<ul style="list-style-type: none"> <li>* Environmental and social health determinants</li> <li>* Infectious diseases</li> <li>* Health care systems</li> </ul> <p><b>5/6</b></p>
<b>Inclusive and Secure Societies</b>	<ul style="list-style-type: none"> <li>* Democracy</li> <li>* Social and economic transformations</li> <li>* Protection and Security</li> </ul>	<ul style="list-style-type: none"> <li>* Cultural heritage</li> <li>* Disaster-resilient societies</li> <li>* Cybersecurity</li> </ul> <p><b>0/6</b></p>
<b>Digital and Industry</b>	<ul style="list-style-type: none"> <li>* Manufacturing technologies</li> <li>* Advanced materials</li> <li>* Next generation internet</li> <li>* Circular industries</li> <li>* Space</li> </ul>	<ul style="list-style-type: none"> <li>* Key digital technologies</li> <li>* Artificial intelligence and robotics</li> <li>* Advanced computing and Big Data</li> <li>* Low carbon and clean industry</li> </ul> <p><b>7/9</b></p>
<b>Climate, Energy and Mobility</b>	<ul style="list-style-type: none"> <li>* Climate science and solutions</li> <li>* Energy systems and grids</li> <li>* Communities and cities</li> <li>* Industrial competitiveness in transport</li> <li>* Smart mobility</li> </ul>	<ul style="list-style-type: none"> <li>* Energy supply</li> <li>* Buildings and industrial facilities in energy transition</li> <li>* Clean transport and mobility</li> <li>* Energy storage</li> </ul> <p><b>2/9</b></p>
<b>Food and Natural Resources</b>	<ul style="list-style-type: none"> <li>* Environmental observation</li> <li>* Agriculture, forestry and rural areas</li> <li>* Food systems</li> <li>* Circular systems</li> </ul>	<ul style="list-style-type: none"> <li>* Biodiversity and natural capital</li> <li>* Sea and oceans</li> <li>* Bio-based innovation systems</li> </ul> <p><b>6/7</b></p>

❑ PA1: “Faster development and safer use of health innovations for European patients and global health;

❑ PA2: “Advancing key digital and enabling technologies and their use, including artificial intelligence and quantum computing;

❑ PA3: “European leadership in metrology, including an integrated metrology system;

❑ PA4: “Accelerated competitiveness, safety and environmental performance of EU air traffic, aviation and rail”;

❑ PA5: “Sustainable, inclusive and circular bio-based solutions;

❑ PA6: “Clean hydrogen and sustainable energy storage, technologies with low environmental footprint and less energy-intensive production;

❑ PA7: “Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods;

❑ PA8: “Innovative and R&D-intensive SMEs”.

# Glycoscience research: how do we obtain the funding required within the EU Bioeconomy?

**3.3:** We must **involve** interested parties, including the general public, to show them why investment in the glycosciences and glycotecnologies is in their interest and to their benefit. An organisation is in place to do this, called **CarboMet**.....

## CarboMet

**Metrology of Carbohydrates  
for**

**Enabling European BioIndustries**

*Principal Investigator Professor Sabine Flitsch, MIB,  
University of Manchester, UK  
[sabine.flitsch@manchester.ac.uk](mailto:sabine.flitsch@manchester.ac.uk)*

“CarboMet” is a four-year Collaborative Support Action which aims to bring the importance and relevance of glycometrology to the attention of the European Community for the improvement of medical care, healthy eating and the manufacture of precision medicines. It is funded under Horizon 2020 (FET) and is led from the Manchester Institute of Biotechnology at Manchester University..... we are building a Roadmap of topics and actions and welcome anyone to join our network and get involved in our activities. **The aim of the Roadmap is to get the subject of novel glycoscience squarely to the forefront of Horizon Europe thinking by mobilizing the glycoscience community Europe-wide.**



CarboMet facilitates engagement between key players and stakeholders to ensure full engagement of the glycoscience community across Europe.....

<div> <div>Examples of Key Outputs</div> <div>Key Enabling Technologies</div> </div>		BioIndustry Sector (BIS)			
		Biopharmaceuticals including vaccines, antimicrobials, antibodies and hormones	Diagnosis of disease for development of Precision Medicines	Healthy Living: Food & Personal Care	Carbohydrates as Sustainable Materials
Enabling Technology Area (ETA)	Analytics , Soft Sensors and Measurements				
	Synthesis of Standards				
	Bioinformatics & Databases				



# CarboMet facilitates engagement between key players and stakeholders to ensure full engagement of the glycoscience Community across Europe.....PLEASE JOIN US!



CarboMet

## Scoping workshops:


- ❑ EuroCarb 2017 conference, *Barcelona, July 2017*
- ❑ Three glycotecnology topics were chosen as a start:
  - Polysaccharide based vaccines;
  - Precision diagnosis of disease;
  - The role of dietary carbohydrates in maintaining a healthy gut microbiome.

## Follow up workshops then followed:

- ❑ Polysaccharide Based Vaccines, *Milan, March 2018* - Positioning paper published – contact [syed.ahmed-3@manchester.ac.uk](mailto:syed.ahmed-3@manchester.ac.uk) )
- ❑ The Role of Dietary Carbohydrates in the Gut Microbiome, *Brussels, 7-8 June 2018*  
Positioning paper published – contact [syed.ahmed-3@manchester.ac.uk](mailto:syed.ahmed-3@manchester.ac.uk) )
- ❑ Glycoinformatics Masterclass, *15 July 2018, ICS 2018, Lisbon*
- ❑ 'Carbohydrate – Tools for Synthesis & Analysis', *28 Aug 2018, EuChemS , Liverpool*
- ❑ Carbohydrate-based Materials Workshop, *Grenoble, 24-25 January 2019* (Positioning paper in preparation)
- ❑ 'Frontiers in Glycoscience', ESBOC meeting, *Gregynog, 17-19 May, 2019*



## 4. An example of Research and Innovation [‘R&I] priorities and challenges involving the glycosciences....



**CarboMet** is about metrology *per se*: CarboMet is examining in particular the challenges involved, and the supporting IT support systems required (the ‘Digital Economy’ in Horizon Europe terms). We are proposing possible research programmes that will be needed to meet these challenges.

# CarboMet facilitates engagement between key players and stakeholders to ensure full engagement of the glycoscience community across Europe.....

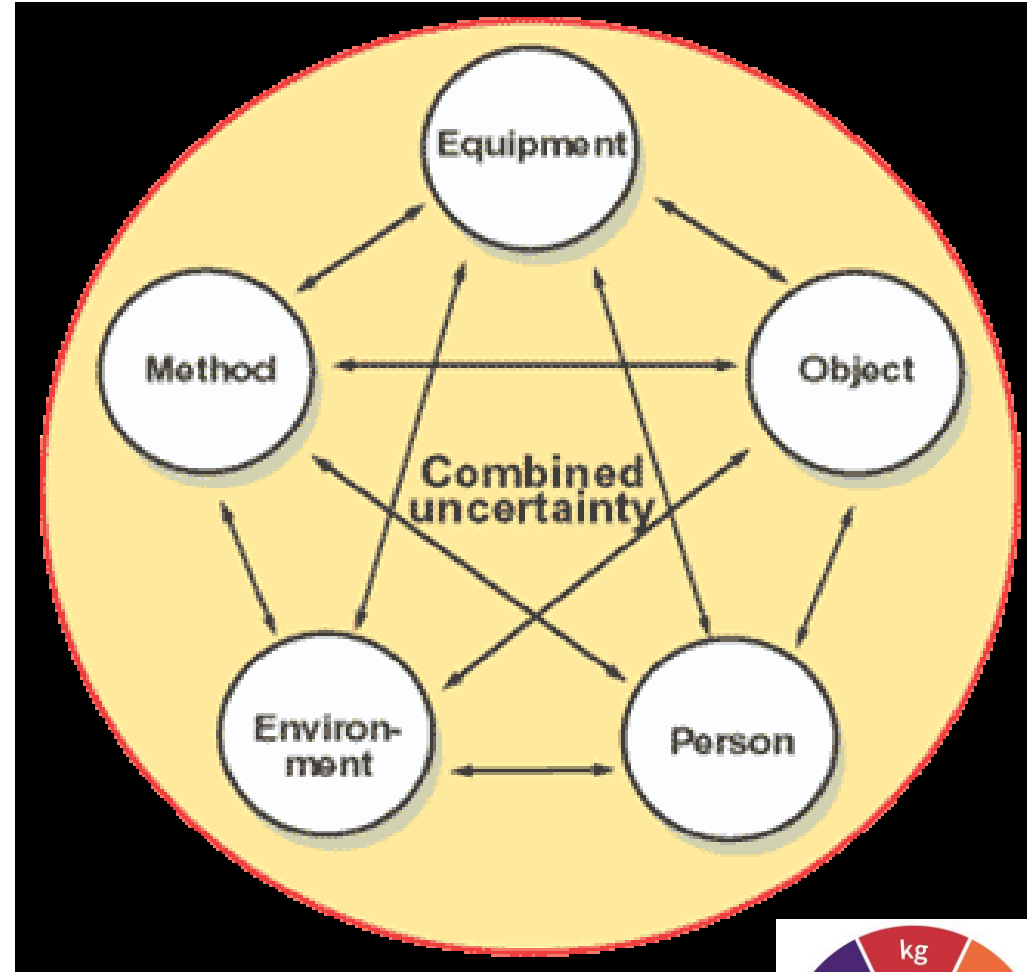
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Enabling Technology Area (ETA)	Analytics , Soft Sensors and Measurements				
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	Bioinformatics & Databases				



# Metrology – what is it?



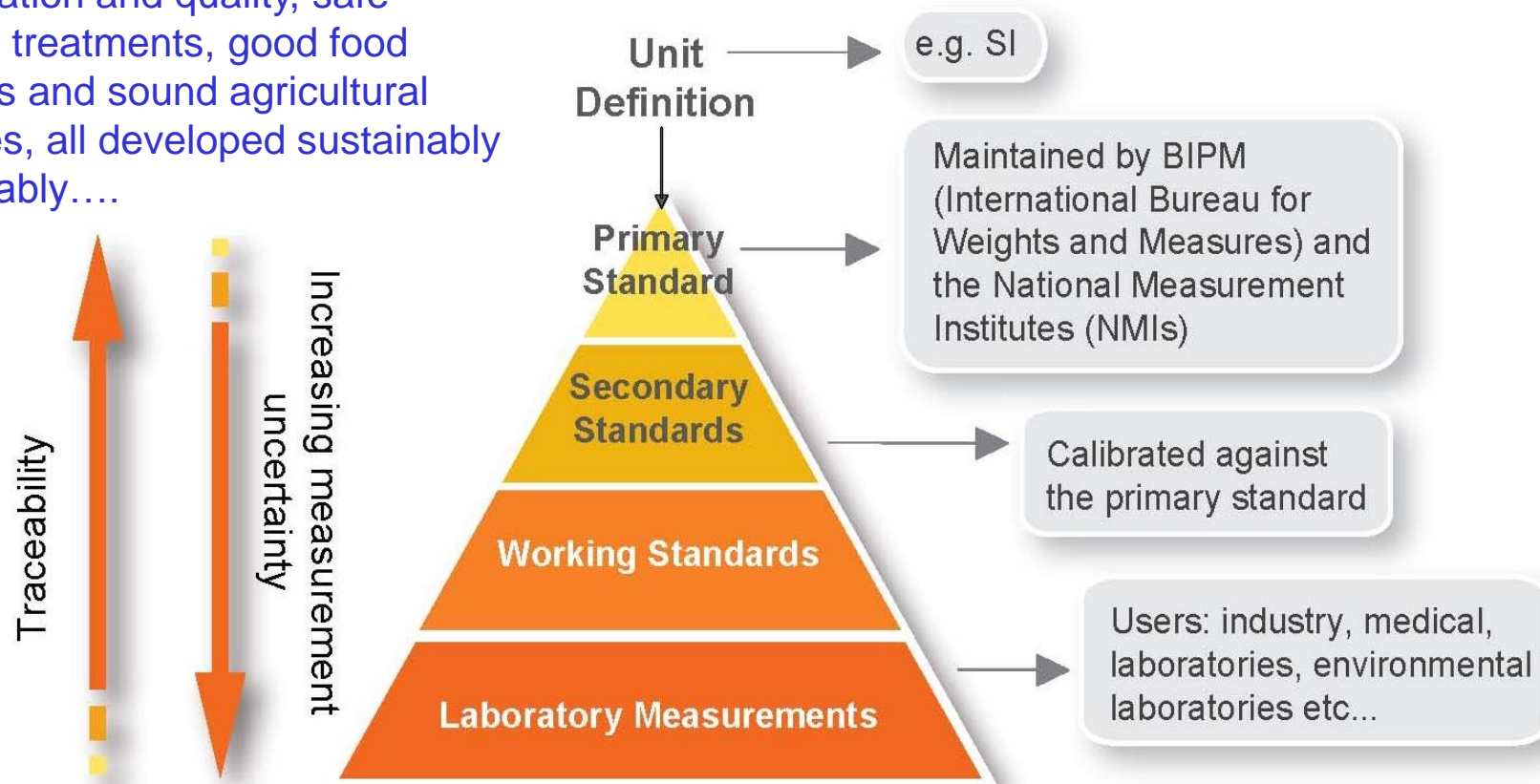
- ❑ Metrology is **NOT** the same as new measurement techniques!...
- ❑ It is about the **scientific study of measurement**. It includes conformance to international specifications and/or technical requirements and the concomitant development of **standards**....
- ❑ ...because to achieve comparability of results over space and time, it is essential to link all measurement results to a common, stable reference or **measurement standard**.
- ❑ Results can then be compared through the **quantified relationship** to that measurement standard.
- ❑ The linking of results in this manner is termed **traceability**.



# ....but why should metrological standards matter to us?



...because they are critical for product specification and quality, safe medical treatments, good food products and sound agricultural practices, all developed sustainably and reliably....



A measurement in (e.g.) Japan should give the same result as one in Europe on the same sample. This is KEY to QUALITY CONTROL in MANUFACTURING (i.e., safety, consistent and guaranteed performance, the genuine article, no contamination, etc. ) – key to safe medicines, foods, etc. .

We aim to build a bio-informatics database of real utility to those who work on glycoscience and glycotechnology and better metrology and sound theory to enable this....

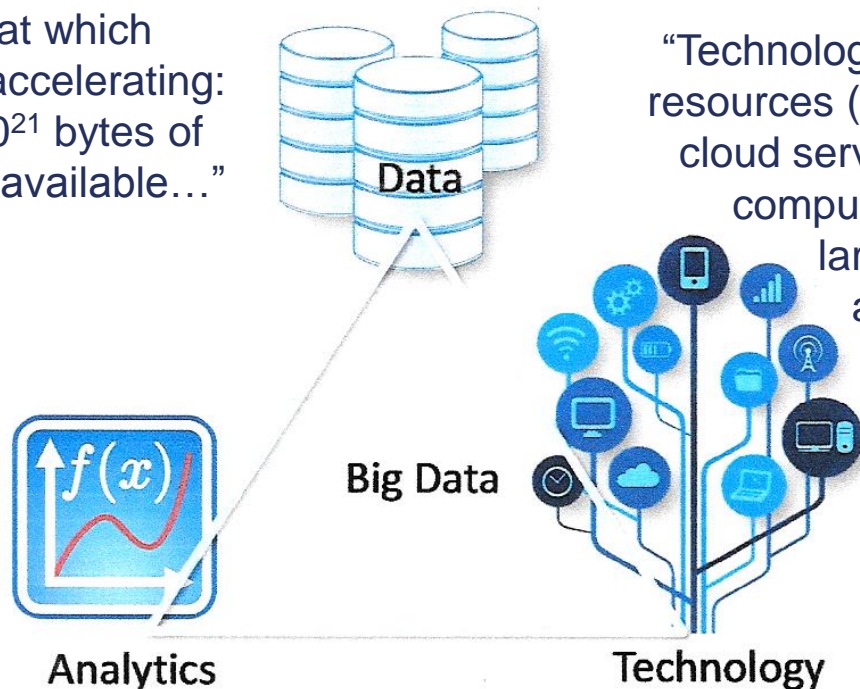
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Enabling Technology Area (ETA)	Analytics , Soft Sensors and Measurements				
	Synthesis of Standards				
	Bioinformatics & Databases				





# Question: has the rise of “big data” meant that we no longer need to understand chemical structure elucidation and reaction mechanisms?

“Data abound now more than ever and the speed at which they accumulate is accelerating: according to IBM,  $10^{21}$  bytes of digital data are now available...”



“Technology provides the computational resources (high performance computing, cloud services, distributed and parallel computing, *etc.*) required to process large amounts of data by using advanced analytics platforms (the third enabler) by turning them into actionable Information in useful time...”

The answer to the question posed above is an emphatic “**NO**”!

“**Big data need big theory too**”

Isn't this all we need?

[From “Industrial Process Monitoring in the Big Data/Industry 4.0 Era: From Detection, to Diagnosis, to Prognosis”,  
M.S.Reis & G.Gins, *Processes* 2017, 5, 35]



# “Big data” are not a magic shortcut!


## Big data need big theory too

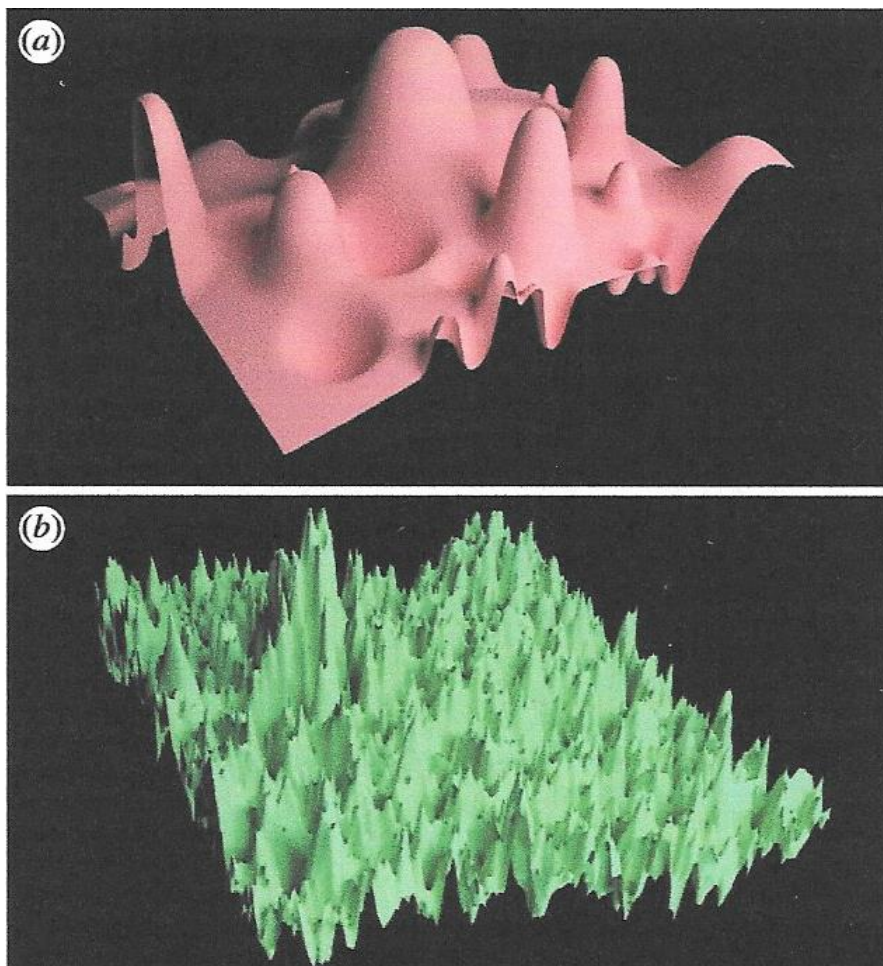
Peter V. Coveney<sup>1</sup>, Edward R. Dougherty<sup>2</sup> and Roger R. Highfield<sup>3</sup>

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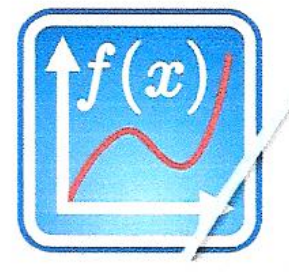


The current interest in big data, machine learning and data analytics has generated the widespread impression that such methods are capable of solving most problems without the need for conventional scientific methods of inquiry. Interest in these methods is intensifying, accelerated by the ease with which digitized data can be acquired in virtually all fields of endeavour, from science, healthcare and cybersecurity to economics, social sciences and the humanities. In multiscale modelling, machine learning appears to provide a shortcut to reveal correlations of arbitrary complexity between processes at the atomic, molecular, meso- and macroscales. Here, we point out the weaknesses of pure big data approaches with particular focus on biology and medicine, which fail to provide conceptual accounts for the processes to which they are applied. No matter their ‘depth’ and the sophistication of data-driven methods, such as artificial neural nets, in the end they merely fit curves to existing data. Not only do these methods invariably require far larger quantities of data than anticipated by big data aficionados in order to produce statistically reliable results, but they can also fail in circumstances beyond the range of the data used to train them because they are not designed to model the structural characteristics of the underlying system.

Coveney PV, Dougherty ER and Highfield RR, *Phil.Trans.R.Soc.A374*: 20160153.

Lots of data are not a substitute for understanding – we need information on the chemical mechanisms underpinning glycan behaviour to interpret the data....

That is, we need rigorous data analytics....

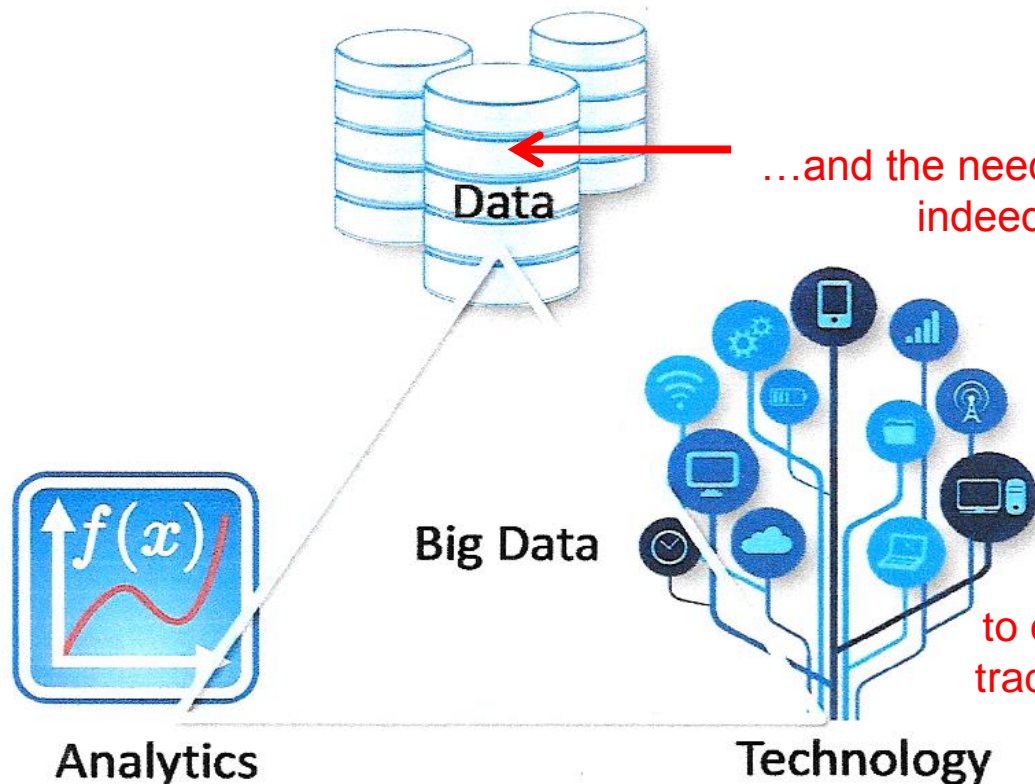


**Analytics**

- ❑ We need to define relationships based on structural and rigorous mechanistic understanding [*i.e.*,  $x = f(T, p, t)$ ], describing how one property varies when other properties change in value;
- ❑ We need to define how extensive properties (such as  $m, V, q, A$ ) and intensive properties (such as  $T, p, \mu, V$ ) can be used most effectively and accurately in the design of novel sensors;
- ❑ We need to design built-in self-learning algorithms that evolve and refine in a cognitive manner (so-called “AI”)....

...this requires detailed knowledge of glycoscience structure and reactivity based on sound theory, which in turn must be based **ON ACCURATE METROLOGY**.

So let's not over-promise. Many other disciplines are facing similar challenges.....



...and the need for good metrology and the measurement indeed lies in the “big data”...the data banks, the computations and the analytics are only as good as the accuracy of the measurement and metrology used. Perhaps an obvious point! - but one that needs to be emphasised as we press for greater funding support from Horizon Europe. We need more than ever to operate across many industry sectors and traditional disciplinary boundaries to succeed!

[From “Industrial Process Monitoring in the Big Data/Industry 4.0 Era: From Detection, to Diagnosis, to Prognosis”,  
M.S.Reis & G.Gins, *Processes* 2017, 5, 35]



- ❑ We have considered why the emphasis on an expanding EU Bioeconomy makes this a uniquely opportune time to be working on glycoscience and glycotechnologies in Europe.
- ❑ We have outlined how the EU and in particular Horizon Europe is presently thinking about the Bioeconomy as a solution to many current Global Challenges.
- ❑ We have described some ways that we can use to increase the profile of new glycoscience and glycotechnologies with the general public and governments within Europe. ....
- ❑ ...and specified ways we can raise Research and Innovation funding for glycoscience and glycotechnologies in the next decade within Europe. To help realize the aims of the EU Bioeconomy.
- ❑ Finally, we have discussed some already identified 'R&I' cross-sector and multidisciplinary challenges we must overcome in glycoscience and glycotechnologies which need us to work across traditional boundaries.

# The Bioeconomy and Glycoscience

*Global Challenges Science Week  
Université de Grenoble Alpes*

*Rodney Townsend  
6th June 2019*