SAHYOG Project Grant Agreement no: 289615

Deliverable report

D2.3: Strategic Advice on Biobased Research

Month 19, July 2013

Responsible Beneficiary: NL Agency

Project Co-ordinator: ENEA

Authors:

Kees Kwant, Rebecca van Leeuwen

Project co-funded by the European Commission within the 7th Framework Programme		
Dissemination level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential only for members of the consortium (including the Commission Services)	

TABLE OF CONTENTS

1 Introduction

The objective of the project SAHYOG (Strengthening Networking on Biomass Research and Biowaste Conversion – Biotechnology for Europe India Integration) is to actively and effectively link research activities implemented within EU research programmes and related programmes by Indian national institutions [1].

Targeted research areas concern biotechnological approaches for biomaterials and bioenergy production and sustainable conversion of bio-wastes, the Bio-based Economy.

Main activities of the SAHYOG project include inventories for biomass and biowaste resources, research projects and programmes, project twinning, short-term exchanges of researchers, summer schools, stakeholder workshops, as well as the development of roadmaps defining key RTD priorities and a Strategic Research Agenda (SRA) to facilitate concerted planning of future EU-India research initiatives in the area of biomass and biowaste.

In Task 2.2: Inventories on Research Programmes and Projects (Task leader NL Agency) the objective is to create an overview of existing programmes and research projects within the EU and India. Such programmes and projects exist on a state level and on the Indian or European level.

The information was gathered through an intensive consultation of existing databases in Europe and India.

In Europe the information can be obtained through the relevant ERA-NET networks on Bioenergy, Industrial Biotechnology, Plant Genomics etc, as well as the EC Cordis database and the relevant European projects like Star-Colibri, Bioref etc. that have generated overviews of projects in the area of sustainable biomass production and biotechnological conversion of waste.

In India TERI coordinated building up the information through an intensive consultation with the funding agencies DBT, CSIR.

A classification of research programmes and projects was developed by both the European and Indian project members and applied to the obtained information

The result - an inventory of ongoing programmes and projects in India and the EC and the drivers and expected outputs from these programmes and projects.

With this existing information a Strategy for Biobased Research was developed.

2 Biobased Strategy

Both Europe and India are at the crossroads to develop and implement a more sustainable and prosperous biobased economy in their regions. Research is crucial to achieve this biobased economy and so the goal of this report to develop some strategic ideas based on the present situation and inventories in Europe and India.

Goal of this report is to provide advice on how research results and biomass can be valorised in the biobased economy.

Our society asks for sustainable economic development, jobs, but also conservation of nature and biodiversity for a growing population with increased demand for sustainable resources. The question, is how can we achieve improved welfare for our society, by using less of the precious global resources. In the cooperation within the Sahyog projects European and Indian scientists, jointly developed an inventory on existing research in the biobased economy. Based on these inventories the following recommendations have been prepared.

2.1 Biobased Economy Definition

Biobased economy and bioeconomy are often intertwined used terms and there is a need to formulate a clear definition to be able to locate the borders of the research-scope for this paper (Fig.1).

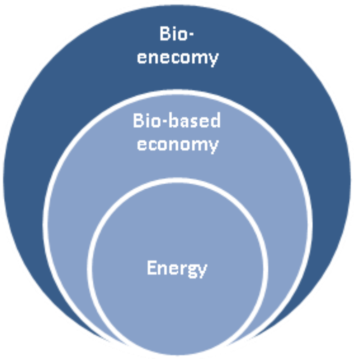


Figure 1 – How the bio-based economy relates to the bioeconomy

Definition Biobased Economy:

Activities related to the biobased economy are those activities where natural and renewable resources are used as a substitution for fossil resources. It composes a wide range of technologies and sectors through the production chain, with the aim of creating added value out of these natural and renewable resources.

2.2 Need for a biobased economy

There are a number of reasons why Europe and India have an interest in developing the biobased economy. These drivers can be classified based on the People, Planet, Profit principle, that was laid out by the Cramer Committee for biofuels[1].

Table 1: Sustainable Development in the Biobased Economy

Sustainability	**Parameters**
People	Food security, jobs, welfare, education
Planet	Environmental clean, climate change, biodiversity
Profit	increased agriculture production, independency from fossil resources, closing the cycle

2.3 Food and Climate Change[2]:

Food security – the availability of and access to sufficient and healthy foods and good nutrition at all times- is central for the wellbeing of people and nations. Until recently, it was expected that despite climate change and increasing world population, there would be several decades with food surplus - and low prices - ahead. Nevertheless, food insecurity has increased in the context of the inter-linked food and economic crisis since 2008. Actions taken so far are not sufficient to overcome the crisis, let alone reduce the chronic food and nutrition security problems.

A key challenge is to sustainably increase the global food supply to accommodate a world growing to 9 billion or more people by 2050 while preserving a safe operating space for humanity by avoiding dangerous environmental change (16). Climate change is already negatively impacting food production, while the agriculture, land use and forestry sectors contribute almost one third of total greenhouse gas emissions and have a high potential for mitigation. A number of recent studies have indicated the need for increasing research efforts in the area of agriculture, food security and climate change.

The Biobased Economy is part of the bioeconomy where simultaneously an improved food supply is integrated with the production of renewable resources for the biobased economy. This will often happen in a cascading approach, where high value products and food are served first and energy is produced from the residues.

[1] See: http://www.agentschapnl.nl/en/programmas-regelingen/sustainability-biofuels
[2] See: http://www.faccejpi.com

3 Recommendations based on the Research Inventory

The Research inventory resulted in an overview of data on research projects and programs in Europe and India[3].

3.1 Drivers for Biobased Research

Drivers for most projects in the inventory for research in Europe could be identified. About 50% of the projects are driven by innovation and economic development, for about 1/5 it is sustainability driven research on biodiversity conservation and green house gas reduction but also rural development and resource security are mentioned as drivers for research projects. (fig 2.)

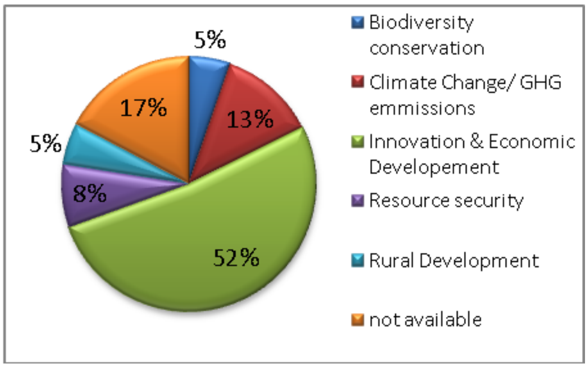


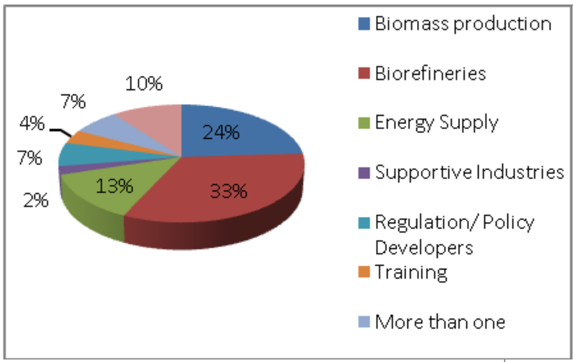
Figure 2. Drivers for Bio-based Research in Europe

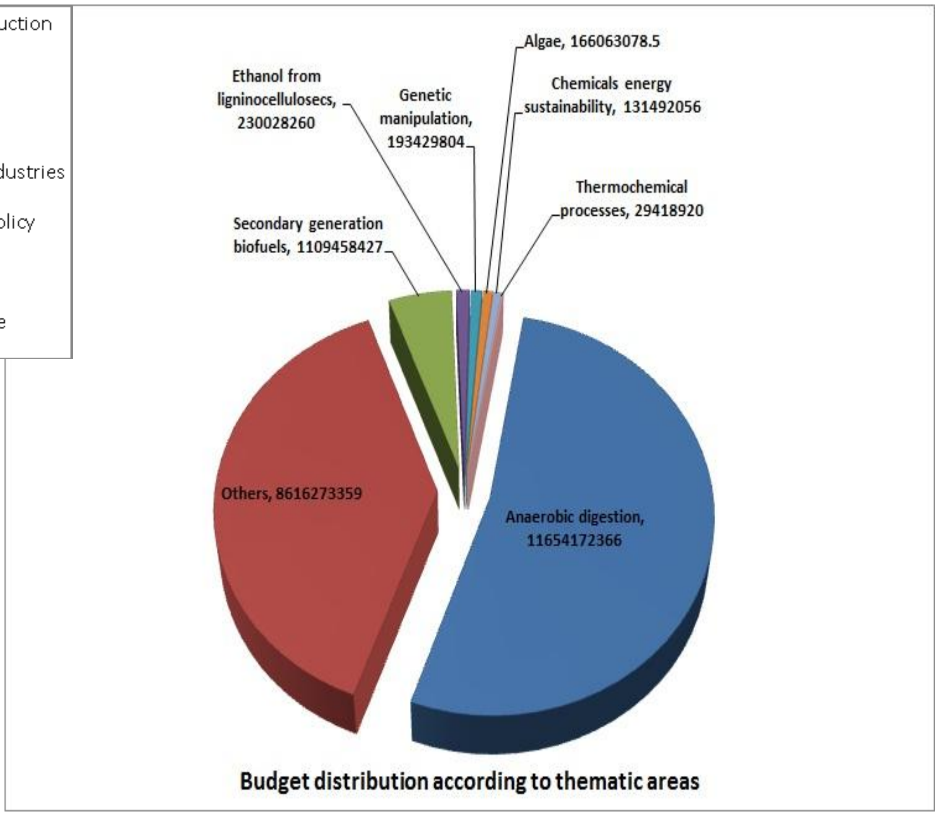
In India the drivers are more geared towards realisation of bioenergy and energy security. In general it can be concluded that drivers for biobased research have a strong economic driver, but also have the opportunity to enhance ecological and economic conditions. In developing a research agenda this should be taken into account.

Strategy Recommendation: Develop the biobased economy, based on economic opportunities, but within sustainable boundaries.

[3] http://www.sahyog-europa-india.eu/inventories

Figure 3. Research Themes in Europe and India





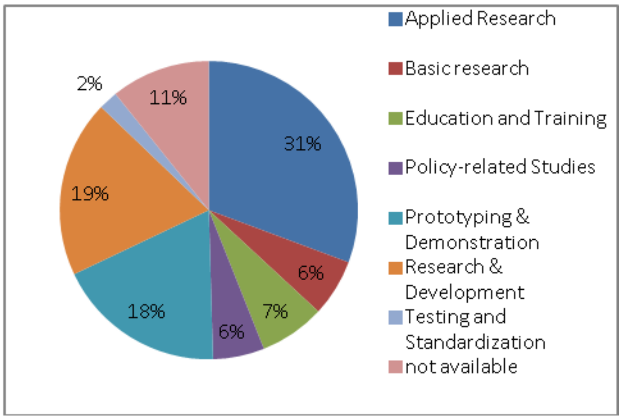
3.2 Research Themes

In Europe most research is done on biomass production and biorefineries, whereas in India the focus is on anaerobic digestion. In general there is a trend in Europe to move with biomass from the Energy sector to the Chemical and Material Sector. With this approach it is expected to increase the economic value from biotechnological processes.

Strategy Recommendation: Try to harvest the highest value from biomass in a cascading approach and align the research in this way.

3.3 Type of Research

The inventories of research activities in India and Europe revealed that in Europe the focus is on applied and basic research, and Research and Innovation, whereas in India most budget is going to pilots/demonstrations and others.



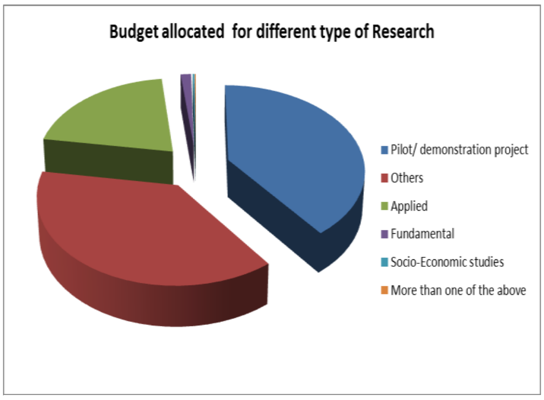


Figure Budget allocated for research themes

Figure 4. Type of Research in Europe and India

Comparing the European and Indian approach leads to suggestions about research approach and collaborations.

Strategic recommendations:

- In the reporting period of the inventory (2007 – 2012) a large budget has been spent in Europe on applied and basic research and research and innovation. It is recommended that in the years ahead in the Horizon 2020 programme more focus will be on piloting and demonstration, however with the continuation of building up new knowledge on new biobased systems.
- In India there has been focus on piloting and the existing piloting facilities could be of interest for cooperation with European researchers and companies. This could have a substantial benefit by lowering the overall costs of research because piloting in India is obviously cheaper than in Europe, and also enables knowhow transfer. However this requires an open approach from both sides, with respect to the Intellectual Property Rights, and a will to make fair business contracts.

4 Strategic Research Advice

This strategic research advice combines a long term future view and practical actions now:

Now: -> Utilise unused waste and agricultural residue streams

Future:**->** Develop Smart Sustainable Agriculture

➔ Develop Biorefineries for the Circular Economy

These suggestions are further elaborated below.

4.1 Climate Smart Agriculture and Forestry for Food and Products

Expected adaptation in agriculture and forestry will require a large coordinated research effort to develop both seeds and breeds adapted to the unchartered climatic conditions of the end of this century. In addition resilient and eco-efficient crop and livestock systems will need to be designed to ensure dynamic conservation of soil, water and generic resources, and socio-economic aspects of adaptation to climate change will need to be accounted for.

More productive and resilient systems may also lead to beneficial side effects in terms of carbon sequestration and reduction of greenhouse gas emissions per unit product and area. In this respect, adaptive interventions will also have mitigating effects, meeting the true challenge of climate smart agriculture and forestry. Such a smart agro/forestry system should supply food, products and chemicals in a sustainable and integrated way where the biorefinery approach will enable the harvesting of all required components. In such an approach there will be no food versus fuel debate, but an optimised resource supply for food and fuel[4].

Agro-ecological engineering through the increased use of genetic and species diversity on field and landscape scales and eco-technologies to adapt water management by improved water harvesting, increased water use efficiency and efficient fertilization practices, to monitor and reduce greenhouse gas, to increase and verify soil and biomass carbon stocks will play a key role. A critical research question would be the balance and interactions between genotype, environment, products, local biorefineries and management to achieve climate smart agriculture[5].

To reach these goals, research should be integrated on a large scale[6]:

• A systemic understanding should be gained, by developing and integrating a large range of disciplines from climatology, to ecology, agronomy, forestry and socio-economy, through plant, soil, microbial and animal sciences, that must be strongly connected to a foundation of agro-ecological and socio-economic modeling.

---

[4] See the FAO approach: http://www.fao.org/energy/befs/en
[5] See: http://www.climatesmartagriculture.org/en
[6] See JPI Facce: http://www.faccejpi.com

• Research Infrastructures need to be assembled in order to integrate scenarios, observations, experiments and models so as to develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties.

• Economics of short- and long-term adaptation/mitigation strategies should be analysed also aiming at improving current food security while taking into account: i) uncertainties in the projections of climate change and impacts, ii) the valuation of ecosystem functions and services and their resilience and integration with material supply

• Developing and implementing specific solutions at the ecosystems and policy levels based on detailed information on regional impacts and meaningful assessment of the adaptive options and their feasibility at local and farm levels. Workable adaptation options will be developed in close collaboration with decision-makers and stakeholders involved in the research and development process.

• A roadmap of breakthrough innovations (technologies and methods) in the areas of crop, livestock, fuel and fibre production, of land, water and genetic resource management and of biodiversity conservation and use should be developed. Social innovation (change of behaviour), organisational (changes in management), and know-how innovation (knowledge around methods and practices) will also be considered. When mature, these innovations will be considered for integration in production systems and in policy measures.

Such an integrated research agenda has been envisioned to deliver impact of research by contributing:

i) to raising the biological efficiency of European agriculture

ii) to responding to a globally increased food demand

iii) to operating agriculture within environmental limits (e.g., greenhouse gas, energy, biodiversity and contaminants)

iv) to building resilience in agricultural and food systems

4.2 Rural Development

The Changes in spatial processes triggered by urban development (about half of the world population is living in urban areas) point to an urgent need of analysis at the global scale which addresses a set of challenges influencing future development of rural areas. The current economic crisis puts our societies and rural areas under additional, severe strain and increases the urgency with which these issues need to be confronted. Based on this understanding of rural potential the following three cross cutting issues can be identified:

- *Diversity.* Rural areas are highly socially, culturally, environmentally and economically diverse. Accepting that rural areas are highly diverse demands that long established, simplistic approaches and viewpoints have to be overcome in order to understand the nature of rural development and to address place-specific challenges and potentials.
- *Rural-urban relationships.* Strengthening linkages between urban and rural areas is key to enhance territorial cohesion. The complex nature and role of linkages in supporting sustainable agricultural and rural development can only be fully understood by considering these within their wider spatial / regional perspective and integrated into networks or circuits of capital, knowledge, material flows and social development.

- *Governance.* Innovations in governance are considered to be crucial to enable current and future transition of rural areas in order to achieve balanced regional development.

Strategic Advice:
Successfully combining the cross cutting themes with the perspective of spatial differentiation outlined above will require trans-disciplinary research that clearly demonstrate a capacity tackling one or more of the research questions.

4.3 Waste is a resource in the Circular Economy

Each year in the EU alone, 3 billion tonnes of waste are thrown away. That is a waste of resources. Other types of waste, such as sulphur dioxide from stacks, damage delicate ecosystems if released in excessive quantities.

The challenge is to transform the supply chains into supply circles that loop used materials back into production. Where this is not possible, resources should be used efficiently.

Such an approach should as well be used for the material resource supply, as well the energy supply.

In essence, this is what also energy transformation is about; a more efficient use of energy and more renewable energy which, by definition, is a closed loop. But thinking about supply circles in energy production also means starting to explore ways to reuse the energy production technology itself.

The **circular economy** is a generic term for an industrial economy that is, by design or intention, restorative and in which materials flows are of two types, biological nutrients, designed to reenter the biosphere safely, and technical nutrients, which are designed to circulate at high quality without entering the biosphere.

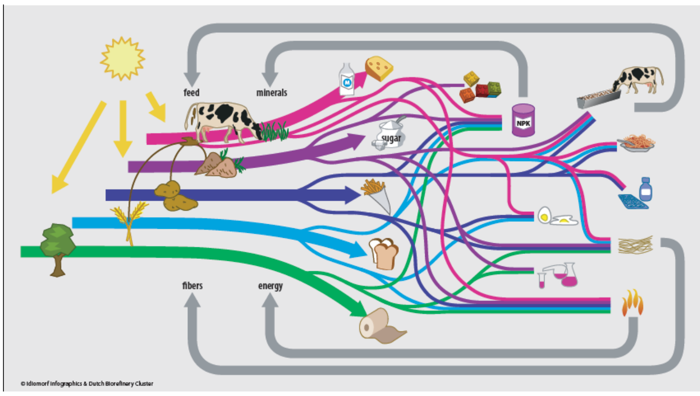
A major outcome of this is the notion of optimising systems rather than components, or the notion of ‘design for fit’. As a generic notion it draws from a number of more specific approaches including cradle to cradle, industrial ecology and waste management.

Strategic Advice:

1. Research in the circular economy is research in the biobased economy, where the economic output of the biomass is maximised by cascading and refining the resource.
2. At present large quantities of unused waste streams are available as agricultural residues or municipal wastes and are the first priority to be used for the biobased economy.

4.4 Biorefineries

Biorefineries have been defined as:
Biorefining ist he sustainable processing of biomass into a spectrum of marketable bio-based products (food/feed ingredients, chemicals, materials) and bioenergy (biofuels, power and/or heat)[7].
Within Europe a strategic research agenda was developed for biorefineries by the Star-Colibri project8. To achieve the Biobased Economy biorefining; being the sustainable processing of biomass into a spectrum of marketable products and energy is a crucial element. Biorefineries will use a wider range of feedstocks and will produce a great variety of end-products. This approach will result simultaneously in high value products (fine chemicals) and residues that can be used for bulk applications and energy.
Achieving this will require future biorefineries to be better integrated, more flexible and operating more sustainably. This will only be possible if crucial bottlenecks along the entire value-chain can be removed. To address these challenges, several strategic research areas must be developed.



Thermochemical Conversion:
For thermo-chemical processes, research should focus on scaling-up and integrating them into existing production units, together with end-product quality improvement (e.g. syngas purification for catalytic conversion and pyrolysis oil upgrading and fractionation).
For chemical catalysis, the main R&D need is for the development of new catalysts tailored for biomass feedstock components and able to work in aqueous media. Use of high throughput screening technology would give a considerable advantage.

Biological Conversion:
The key issue for biochemical processes is to develop new biocatalysts (microorganisms and enzymes) based on a better understanding of microbiology in an industrial context and on the use of industrial performance criteria in the early stages of the selection process.
It is also recommended that research should be focused on downstream processes (separation and purification) and optimisation of water management.
As water will be the usual reaction media for catalytic processes in future biorefineries, it is recommended that a new area of science combining both chemical and biochemical catalysis should be developed.

Integration on molecule and process scale:

Synthetic biology is an emerging and promising research area with the potential to have a strong impact on innovation and technological progress that is beneficial for the economy and for society as a whole. It is an area at the intersection of engineering, bioscience, chemistry, and information technology.
The key conversion processes should be developed in an integrated approach. Future

[7] IEA: http://www.iea-bioenergy.task42-biorefineries.com
[8] http://www.star-colibri.eu/publications/projectresults

solutions will need process integration modelling, taking into account recycling and waste management.

5 Conclusions

Valorisation in the agricultural sector can be achieved in the short term by utilisation of the residues, a proper rural development and realising additional income from local processing of the biomass. In the longer term a smart agriculture needs to be developed with an integrated food and sustainable resources supply.

Valorisation of the biomass can be achieved by a biorefinery and/or cascading approach where the optimal value is realised along the chain from the agricultural field, through the agro/forestry industry to the final consumer.

Valorisation of research results can be obtained by good cooperation between farmers/industry and researchers. Over the last years massive research has been carried out and needs to be realised in the field or in the factory by piloting, scaling up and building plants.

Valorisation of the cooperation between EU and India can be achieved by combining the research results from Europe and set up joint piloting to demonstrate the feasibility and realise implementation in both continents.