Final Project Report

(2011-2015)

Strengthening networking on biomAssresearcH and biowaste conversion – biotechnologY for EurOpe India integration

(SAHYOG)

Funded By

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Project Information

Title of the project: Strengthening networking on Biomass research and biowaste conversion – biotechnology for Europe India integration (SAYHOG)

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Executive Summary

1. Introduction

The SAHYOG project was established as a partnering initiative to map out what the European Union and its Member States could do together with India to find solutions to challenges/needs in order to coordinate research activities carried out in both regions on biomass production and biowaste conversion through biotechnological approaches. The integrated project activities were carried out by a partnership of stakeholders from EU and India involving public and private organizations that conceive and fund research programs as well as representatives from the scientific community. Strong EU-India linkage was created between on-going and future research and innovation projects with the aim to exploit cooperation synergies for sustainable development.

2. Approved Objectives of the Project

The broad objectives of the study are:

First year

- To bring together leading organizations in the field of biomass production and bio-waste conversion research carried out within EU research programmes and related programmes by Indian national institutions.
- Inventorization of biomass and biowaste potentials and research projects to be elaborated and analyzed within SAHYOG.

Second year

- These inventories will be the basis for the joint Strategic Research Agenda (SRA) finally leading to a Roadmap for policymakers and researchers.

Third year

- Wide-range networking of relevant industries and scientific communities and establish linkages between ongoing research and innovation projects from EU and India.

Scientific and Technical Progress

1. Progress made against the Approved Objectives, Targets & Timelines during the Reporting Period

1.1 Project Management

TERI as the Indian project coordinator was actively involved in coordination among Indian Partners and EU partners for smooth running of the project. During the first year there were four internal meetings held among Indian project partners, three of which were organized by TERI [23rd April,2012 (Kick off meeting), 17th July 2012 and 22nd-24th August 2012] and one was organized by JNU (12th October 2012), These meetings were held to ensure in resolving the problems faced during inventorization for timely completion of work packages. Teri has also organized a project meeting from 5th - 6th of November, 2012 and a stakeholders meeting on 7th November, 2012 at TERI, IHC, Delhi, which was attended by all SAHYOG partners and resource persons from EU and India. During other two years there were several video and tele-conferencing organized by TERI, in order for the Indian partners to coordinated with the EU partners, during project meetings. TERIactively coordinated with all Indian partners for drafting the final project and inventory report, organizing short term exchange of EU researchers, preparing Strategic Research Agenda (SRA) and Road map/ Policy Recommendations from Indian side.

2. Inventories

2.1IndianBiomass and Bio-waste Inventories Report

2.1.1 Biomass Inventories-India

The present report focuses on Inventorisation of Biomass and Biowaste sources from the coordinating countries for biomass, its availability for use/consumption and the surplus availability for energy production. To achieve this objective, the study for India has been carried out in two approaches based on the availably of the existing data sources. Initially based on the existing data source for the entire country, an inventory on pan India basis was developed. Further based on the availability of few data sources that categorized the information from various Indian states, an attempt was made to prepare an inventory for 23

states. For which, the project partners were assigned the states according to their geographical locations, for example, CSIR-IICT was associated with inventorizing for south India states (Andhra Pradesh, Karnataka, Tamil Nadu, Kerala), JNU (Haryana, Himachal Pradesh and Rajasthan), Tezpur University for North eastern states of India (Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Tripura, Nagaland and Sikkim), GBPUA&T (Uttar Pradesh, Uttarakhand and Gujarat), ARTI (Maharashtra, Chhattisgarh, Madhya Pradesh and Goa) and TERI (Delhi, Punjab, Pan India forest data and Municipal solid waste data) However, considering the availability of complete information for the inventory, this report will focus on the information sourced through the pan India data only.

2.1.1.1Sources of Information

One of the major limitations for developing the Indian inventory was the non-availability of central databases for biomass resources in India. The information was available in various formats and focused mostly on the production and yield of various agricultural and plant product. The information required to meet the objectives of the project where the focus on availability of surplus biomass or bio-waste for its valorisation was not available in any central database. Information available was limited to academic reports and publications but it was specific to the objective of the study or limited to local or regional levels. Considering these limitations, the inventory had to be prepared by considering certain extrapolations on the available data from the sources mentioned below.

2.1.2Biomass from Forestry

Even after an exhaustive data search, information on biomass availability and its source from forestry did not yield any significant outcome. It was apparent from survey of the sources mentioned below, as well as discussion with various stakeholders, that in India forest and forest products are very difficult to be considered as a resource for any biomass conversion applications. Thus in the biomass inventory prepared for India,the details of the forest biomass is missing and not considered.

1. Biomass Resource Atlas of India, Indian Institute of Science, India 2004
2. Annual report of Indian States of Forest 2011
3. Annual report and publications from several state and central forest research Institute

2.1.3Biomass from Agriculture and Fishery

Though there were no direct data sources to ascertain the availability of biomass and bio-waste in India that can be utilized for valorization through various biotechnological interventions, information on total production or yield was available in different sources. Thus for developing the inventory, the primary source of information on production and yield was taken from the following major source. This primary source information was then subjected to extrapolation as per the methods described below for deriving the available biomass and bio-waste in the country.

1. Statistical Year Book, Government of India, 2012
2. Directorate of Economics and Statistics, Government of India (http://eands.dacnet.nic.in) , 2012
3. Reserve Bank of India, Data base, Ministry of Agriculture, Government of India , 2012
4. TIFAC Biomass resources Report (Technology Information, Forecasting and Assessment Council), 2009

Apart from these, there are annual reports published in India by authenticated Government sources, which clearly define the annual production of the country for several agricultural commodities. These data sources reveal the production data for agricultural crops in most recent year 2010-2012. Few of the documents are mentioned below. The individual data sources like academic publications also have a mentioned in the Biomass inventory attached along with this report.

1. Several states Directorate of Land Record, India
2. Several states Commissioners of Agriculture, India
3. Several states Directorate of Horticulture, India
4. Several States Directorate of Economics and Statistics websites
5. Several States Directorate of Agriculture websites
6. Several States Forest Department
7. Biomass Assessment Report 2011, RRECL Rajasthan

2.1.4 Biomass from Waste

Though there was no central data base available for this category, the inventory was prepared by extrapolating the data available from the following two sources.

1. Central Pollution Control Board report (CPCB,2012)
2. Report on Sustainable Solid Waste Management in India by RanjithKharvelAnnepu, Columbia University in the City of New York, 2012.

It was a major challenge to document the inventory for biomass and bio-waste availability in India. There was no information available in central databases from where the initial inferences could be drawn. Further for few resources like Biomass from forestry, information was limited, as forest is conserved and legal issues for usage of forest biomass is applicable by Government of India. The information on TOF (Trees outside forest) is very limited and no recent information is present in any secondary sources available to the investigators. Likewise, there is no record of residues from sawmilling, woodworking, furniture industry, by-products of the pulp and paper industry (black liquor, tall oil), processed wood-fuel, post-consumer recycled wood, in Indian Biomass inventory. Similarly the data for food, fruit processing and fishery biowaste is missing in Indian biomass inventory as no authenticated secondary source for these were present in India. As the information is either limited to local sources or to the small or medium scale industries under which these wastes are generated, a proper documentation through secondary data was not possible.

2.2 Categorization of Indian Biomass and Bio-waste Inventories

Biomass categories used in the SAHYOG database in India was mainly similar as used by EU partners and divided in to three main broad categories. All these categories were already discussed above in detail. The SAHYOG database provides the following information for each biomass resource category:

1. Total available biomass (it corresponds to the biomass potential, i.e. the fraction of the theoretical potential which is available under the regarded techno-structural framework conditions with the current technological possibilities such as harvesting techniques, infrastructure and accessibility, processing techniques)
2. Used biomass (biomass utilized by farmers and others for fodder, energy and lively hood and material production)
3. Net biomass potential (Total available biomass – Used biomass)
4. Energy content of Net biomass (Surplus)
5. Conversion processes (processes used for biomass transformation)
6. Geographical location (main geographical locations where biomass was produced/collected)

7. Source/link (data source)
8. Reference year (year of biomass production/collection)
9. Notes or any additional information

Database or the inventory has been set up using MS Excel program.

2.2.1 Methodology used for constructing Biomass and Bio-waste Inventories

As described earlier, due to non-availability and limited information on biomass availability in the country, a set of extrapolation had to be carried out to prepare the Indian inventory. As agreed by all investigators, data in the Indian database refer to the domestic availability of biomass and bio wastes, which can be used for the production of energy, materials, and chemicals. The secondary data source considered for the inventory was collected from the time frame of 2010-2012. From India side there was no biomass reports from forest as it is marked conserved and legal implications for usage of forest biomass is there by Government of India, while data on TOF (Trees outside forest) is very limited and no recent information is present in any secondary sources available. Whereas to assess the availability of agricultural biomass, the crop production statistics were taken into consideration since the data on consumption and waste is not reported in any relevant reports. For agricultural data, the total amount of residues (actual biomass) was calculated using Crop Residue Ratio (CRR) but the data for used and surplus residues (net biomass) were not available. The reference used to calculate CRR ratio was from Hiloidhar et al., (2012) and Chauhan(2011) Biomass and Bioenergy. 37,pp. 205-212. The CRR value was used for the extrapolation of the biomass residue data using the production data from these three authenticated sources. The comparative analysis of all the three sources (Statistical Year Book, India 2012, Directorate of Economics and Statistics, Department of Agri. Coop. India) was carried out for Pan India biomass estimation (Production, Biomass residue generation, Biomass surplus, Power potential). Net biomass potential is determined by multiplying the available biomass with the residue availability factor. The value of availability factor for rice straw, husk and other remaining crop residues is taken as 50%, 75% and 80%, respectively.

Net biomass potential = Total available biomass × residue availability factor
(Source: Hiloidhari et al. Renewable and Sustainable Energy Reviews (2011) 15: 1885–1892, and thus used biomass was calculated)

The Energy Content was calculated as the total energy content of the biomass = Net Biomass Potential of the specific biomass × lower heating value of the biomass (The energy content is obtained for the whole year for the specific biomass)

In the inventory sheet, energy content is calculated as,

Energy content (TJ/year) = [Net biomass potential (MMT) × Lower Heating Value (MJ/Kg)] ×1000

(Where 1000 is the factor to convert MJ to TJ)

(Source: Hiloidhari et al. Renewable and Sustainable Energy Reviews (2011) 15: 1885–1892)

The Pan India biodegradable fraction of municipal solid waste was calculated to be 25542726.84 TPY, as mentioned in the thesis entitled "Sustainable Solid Waste Management in India" by RanjithKharvelAnnepu, Columbia University in the City of New York, Sponsored by the Waste-to-Energy Research and Technology Council (WTERT) and taken the reference of latest CPCB, India survey. Since the amount of MSW generated is not available, extrapolations were done on the population basis, in order to calculate the actual amount of waste generated and the power generation potential that can be derived from it. The total sludge generated was calculated as 70mg/L, based on the information provided by ETP treating sewage waste water by activated sludge process. The calorific value of dried sewage sludge is 13.8 MJ/kg. Hence, the energy content was calculated by multiplying the total sewage generated with the calorific value in the present inventory sheet. In case of municipal waste the bio-waste is not separated from hazardous waste.

2.3 Results of Indian Biomass Inventory data and Bio-waste Inventories

From first category i.e. Biomass from forest, as already mentioned in India there was no information available from authenticated sources about Biomass from forestry, therefore Indian Biomass inventory sheets were kept blank for this category and moreover data on TOF (Trees outside forest) is very limited and no recent information is present in any secondary sources available. The second and most important category from Indian side is Biomass from Agriculture and Fisheries, the majority of the biomass generated in India comes from this category this could be inferred from the data collected that most of the information presented in Indian Biomass inventory is available on Agricultural crops, Oil crops, Agricultural by-products (Husk, Straw, Stover). The major biomass sources which

comes direct from agricultural land consist of Sugar crops (117.42 MMT) followed by Oil crops (97.3 MMT) and Starch crops (29.74 MMT) (Fig.1).

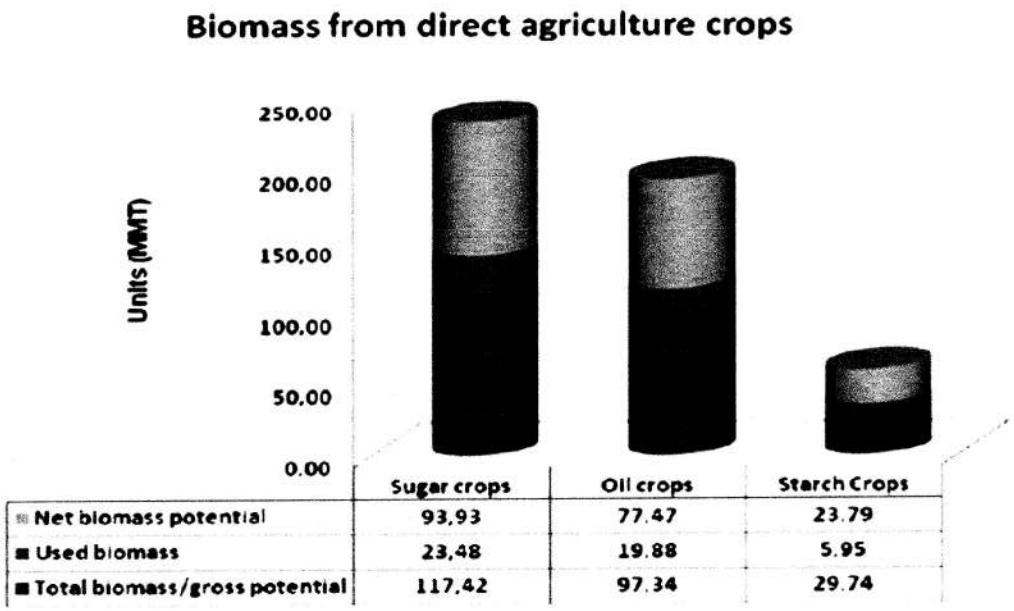


Fig 2.1: Biomass from direct agriculture crops

The by-products obtained from agricultural were considered as the major source of the biomass in India. The crops that mainly constitutes for high biomass were Rice (158.89 MMT), Wheat (148.52 MMT) and several Cash crops (156.44 MMT) apart from other sources like Maize, Pulses, Bajra and Jowarthat also contributes significantly (Fig. 2).

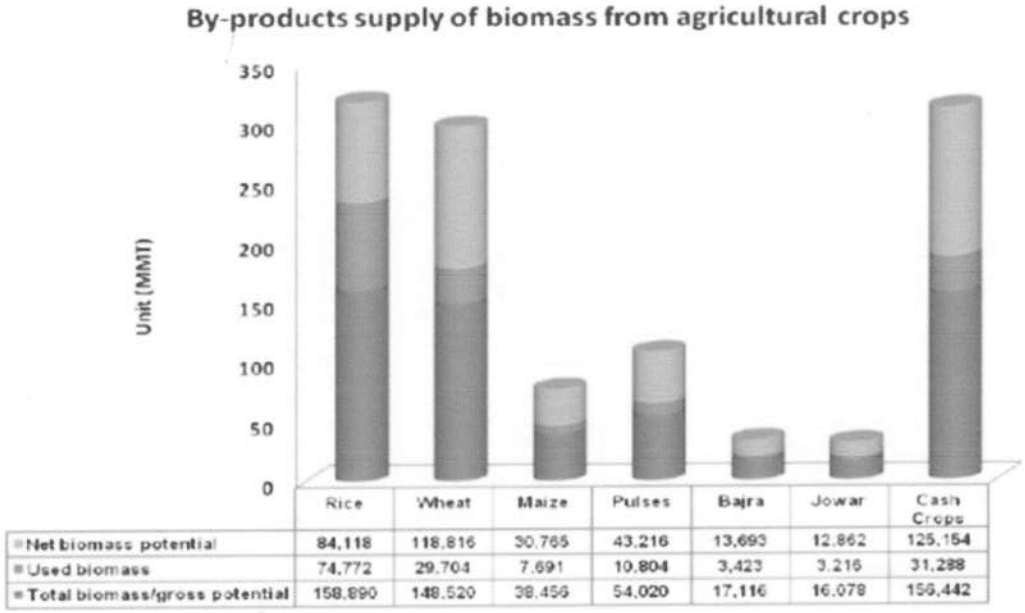


Fig 2.2: By-products supply of biomass from agricultural crops

The type of conversion processed used for conversion of the biomass to energy as identified in India were mainly Pyrolysis (57%), Gasification (29%) and Combustion / Anaerobic digestion (14%) (Fig. 3)

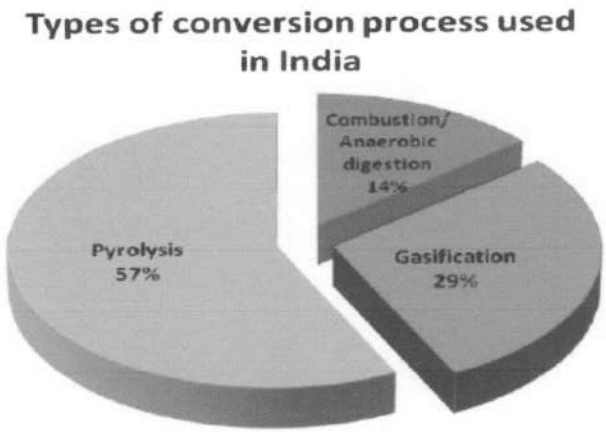


Fig 2.3: Types of conversion process used in India

Regarding the Category biomass from wastes, there was no consolidated information on availability of biomass from wastes from India. There are couple of academic reports but limited to specific geographical area or study making it difficult for any extrapolation to have an idea at the national context. However one report published by Central Pollution Control Board (CPCB), Ministry of Environment and Forests, Government of India, with the

assistance of National Environmental Engineering Research Institute (NEERI) indicated a survey of solid waste management in 59 cities (35 metro cities and 24 state Capitals of the country. As the data was specifically based on urban cities, the data did not reflect a representative scenario for the entire.

Another report published as "Sustainable Solid Waste Management in India" by RanjithKharvelAnnepu, Columbia University in the City of New York, sponsored by the Waste-to- Energy Research and Technology Council (WTERT) and which have taken the reference from updated of "Status of Cities and State Capitals in Implementation of MSW (Management and Handling) Rules, 2000", jointly published by the Central Pollution Control Board (CPCB) and the National Environmental Engineering Research Institute (NEERI), was taken into consideration. According to the report among the four geographical regions in India, Northern India generates the highest amount of MSW (40,500 TPD or 14.8 million TPY) constituting around 30% of all MSW generated in India. Among the states, Maharashtra (22,200 TPD or 8.1 million TPY) tops the list.

However for any waste valorisation, only the biodegradable fraction of the MSW needs to be considered. It was observed in reports that the biodegradable (organic) fraction present in the MSW is varied. Thus to consider a figure of waste availability from municipal solid waste of the country, an average figure of 54% was taken into consideration. It was estimated that the total available biodegradable fraction of waste that can be generated from the country would be estimated at 25542726.84 TPY (Table 1).

Table 2.1: Total MSW generated and Energy potential in Indian states

Type of Biomass	Biowastes (biodegradable fraction) in TPD	Energy generated out of waste (MW)
Andhra Pradesh (A.P.)	1676	19.274
Arunachal Pradesh	18	0.207
Assam	246	2.829
Chhattisgarh	725.4	8.3421
Goa	36.45	0.419175
Gujarat	1592.722	18.316303
Haryana	1367.28	15.72372
Himachal Pradesh	31.89	0.366735
Karnataka	865.2	9.9498
Kerala	229.36	2.63764
Madhya Pradesh (M.P.)	1027.8	11.8197
Maharashtra	10002.15	115.024725
Manipur	72	0.828
Meghalaya	137	1.5755
Mizoram	86	0.989
Nagaland	20	0.23
Punjab	1010.88	11.62512
Rajasthan	2234.7	25.69905
Sikkim	19	0.2185
Tamil Nadu	1862	21.413
Tripura	114	1.311
Uttar Pradesh (U.P.)	1691.13	19.447995
Uttarakhand	67.29	0.773835

Source: Sustainable Solid Waste Management in India" by RanjithKharvelAnnepu, Columbia University in the City of New York (2012) and Energy recovery from municipal solid waste (urbanindia.nic.in/publicinfo/swm/chap15.pdf)

Likewise, there was no central data base available for sewage sludge. The reports of CPCB indicated the total sludge generated from several major cities and towns of India but still unable to provide the complete picture of the sewage generated. Thus an extrapolation was carried out for sewage sludge generated for the country. For this a sum of sewage generated in class-I and class-II cities of India was taken from the report published by Central Pollution Control Board (CPCB) "Control of Urban Pollution Series: CUPS/70/2009–10". The calorific value of dried sewage sludge is 13.8 MJ/kg. Hence, the energy content was calculated by multiplying the total sewage generated with the calorific value. The power potential was calculated by converting the energy content from MJPD to MJ/s. Since,

1MJ/s= 1MW. Thus the total sewage sludge generated in Indian came to be 1420.8126 TPD and its expected Power potential estimated was 226.94 MW (Table 2).

Table 2.2: Total sewage sludge generated and Power potential in Indian states

State	Total sewage generated (MLD)	Total sludge generated (TPD)	Power Potential (MW)
Andhra Pradesh	1978.19	98.91	15.80
Assam	386.60	19.33	3.09
Chhatisgarh	391.29	19.56	3.12
Goa	23.68	1.18	0.19
Gujarat	1908.47	95.42	15.24
Haryana	670.21	33.51	5.35
Himachal Pradesh	28.94	1.45	0.23
Karnataka	2023.77	101.19	16.16
Kerala	806.49	40.32	6.44
Madhya Pradesh	1379.62	68.98	11.02
Maharashtra	10200.02	510.00	81.46
Manipur	26.74	1.34	0.21
Meghalaya	32.09	1.60	0.26
Mizoram	5.71	0.29	0.05
Nagaland	14.98	0.75	0.12
Punjab	1685.66	84.28	13.46
Rajasthan	1530.16	76.51	12.22
Tamil Nadu	1261.88	63.09	10.08
Tripura	24.00	1.20	0.19
Uttar Pradesh	3851.71	192.59	30.76
Uttarakhand	186.04	9.30	1.49

Source: CPCB report "Control of Urban Pollution Series: CUPS/70/2009–10"

It can be summarized that in India, the direct biomass which comes from field mainly included the sugar and oil crops. As India produces nearly 370 million tonnes of biomass (Chauhan 2010). Being an agriculture-based country, one of the non- conventional sources of energy in India, is bio residue or biomass that is available mainly as a by-product of crop production and agro-industries. The proper utilization of agriculture residue for power generation has been shown by the states of Karnataka, Andhra Pradesh, Maharashtra and Uttar Pradesh in-spite of the fact that the state of Punjab and Haryana are amongst the highest crop producing states. It has been observed that there is an increasing trend of burning the crop residue (husk and straw) by the farmers in Haryana and Punjab. This leads

to the reduction in the surplus availability of biomass. Therefore, there is a pressing need to channelize maximum surplus biomass for power generation. The conversion process which is utilized in the country for biomass into energy conversion is mainly through pyrolysis. There is vast potential for energy generation from waste in India as municipal waste generated in the country comes from varying sources and disposed in a local landfill site. Moreover, there were not proper record from authenticated sources from textiles, leather, food and fruit processing industries which may also account for the significant amount of bio wasted generated in the country, which are not included in the inventory sheet due to lack of authenticated source for waste from these sources. The sewage generated in India was accountable but the further treatment to form sewage sludge was again missing in the reports from authenticated sources, thus extrapolation was carried out for estimating it. Likewise, in India the biomass from forest was not taken into consideration as forest in the country comes under resource security policies, thus considered as conserved. The tree outside forest (TOF) data was also not compiled in any national reports which can provide us the overall figure of the biomass available from this source thus missing in Indian inventory sheets. Although, some information was collected at state level survey, but that also have high consumption demand as a fuel wood in India, thus not available as surplus.

Note: The inventory datasheets (Excel sheets) prepared for Pan India Biomass and Biomass project inventories are provided as a softcopy with this report

2.4 Inventory of Research Programmes and Projects in India

2.4.1 Projects Inventory in India

One of the major challenges for documenting an inventory for projects funded under the theme of SAHYOG from Indian side was the lack of existing databases as was available in EU. Projects for biotechnological interventions for biomass and bio-waste valorisation are funded by various government departments under different ministries but a central database was missing. Thus the exercise of documenting the project inventory had to be initiated from scratch.

TERI had initially identified a set of sources of information where most Indian projects and programmes can be found. Ministry of Science and Technology, Government of India maintains a project inventory though its National Science & Technology Management

Information System (NSTMIS) website. This is the only central database available in the country but only very basic information is updated in this website. Apart from this source, the information was collected though correspondence and visits to nodal persons of different central and state ministries, state science and technology websites, state and central forest and agricultural department research institutes and other semi government and industrial funding sources.Thus, the work of documenting the project inventory was divided among all the Indian partners and information was documented either by personally visiting the major funding agencies and research institutes falling under the geographical area distributed among the Indian partners as done in the case of biomass inventorization.

The criteria for considering the projects:

- Minimum funding: 1 million INR (~ Euro16600 as per current conversion rate)
- Time period: The projects for year 2007 onwards (completed and on-going)

Based on these selection criteria, a total of 280 projects were taken up in this inventory, the details of the same are provided in the inventory sheet.

The Indian project inventory had to rely basically on the NSTMIS website that updates the completed projects and the databases for on-going projects are not available at public domain. Thus access to the details of the project as expected to complete the inventory was limited and projects that are sanctioned in the recent years are limited and not reflected adequately. Further the detailed project overview could not be retrieved adequately thus categorization of the projects was done based on the general understanding of the project title. Information on projects from ministries other than science and technology is limited though we are aware that there are projects sanctioned by other ministries.

2.4.2 Categorization based on thematic areas

The inventory sheet indicates that the projects can have been broadly classified into ten broad thematic areas of Second generation biofuels, Chemicals energy sustainability, Anaerobic digestion, Genetic manipulation, Agriculture and Forest produce enhancement,Ethanol from lignocellulosic, Algae, Waste Treatment /Utilisation, Thermochemical processes and Microbe assisted treatment. The majority of the projects (56) were found to be running under Second generation Biofuel followed by projects working under Chemicals energy sustainability (41), Anaerobic digestion (35) and Genetic manipulation (35) each.

Thematic Area	No. of Projects
Secondary generation biofuels	56
Chemicals energy sustainability	41
Anaerobic digestion	35
Genetic manipulation	35
Agriculture and Forest produce enhancement	31
Ethanol from lignocellulosics	28
Algae	27
Waste Treatment /Utilisation	12
Thermochemical processes	9
Microbe assisted treatment	6
Grand Total	**280**

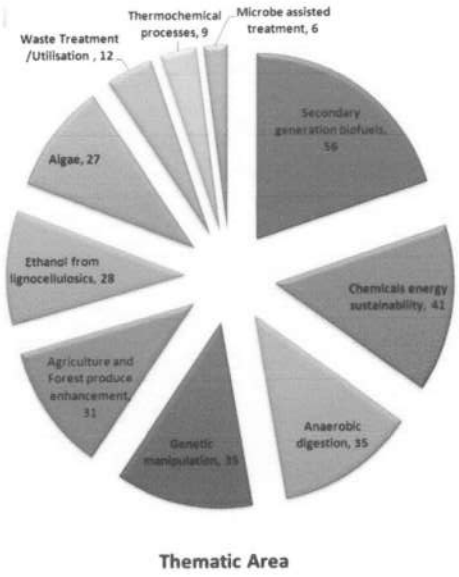


Fig 2.4: Projects based on thematic areas

It could be also inferred that the total amount of funding for the 280 projects in the inventory turns out to be 22130,336,271 INR and that is equivalent to 350 million Euros. When classified into the selected thematic areas, it was observed that a major amount of funds have been accounted for anaerobic digestion. The funding on areas like Agriculture and Forest produce enhancement and second generation biofuels are also significant.

Thematic Area	Budget Distribution according to Thematic Areas
Algae	166063079
Anaerobic digestion	11654172366
Chemicals energy sustainability	131492056
Ethanol from lignocellulosics	230028260
Genetic manipulation	193429804
Secondary generation biofuels	1109458427
Thermochemical processes	29418920
Agriculture and Forest produce enhancement	8568340094
Waste Treatment /Utilisation	22316301

Microbe assisted treatment	25616964
Grand Total	**22130336271**

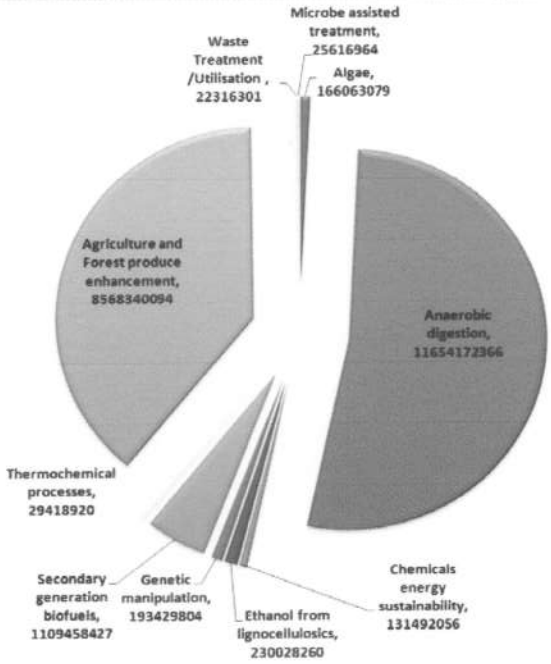


Fig 2.5: Budget distribution based on thematic areas

2.4.3Categorization based on generic processes

The projects sanctioned in India related to the current themes can be put into categories based on three processes of Upstream, Downstream or Whole chain. There are majority of projects sponsored for downstream processes (128) as compared to upstream processes (115) and only 37 projects on whole chain processes was observed. Though the number of projects is higher for downstream processes, the budget of the projects sanctioned under the category of upstream is on the higher side. The inventory indicates that almost 86% of thetotal funds are sanctioned for the upstream processes. Though the total number of projects sanctioned for whole chain processing is around 10%, only 4% of the total budget is contributed for downstream processes. This indicates that major focus in terms of funding is for developing processes and thus can be implied that most of the research on the selected themes are on bench stage or in development stage.

Processes	No of projects
Downstream (D)	128
Upstream (U)	115
Whole chain (C)	37
Grand Total	**280**

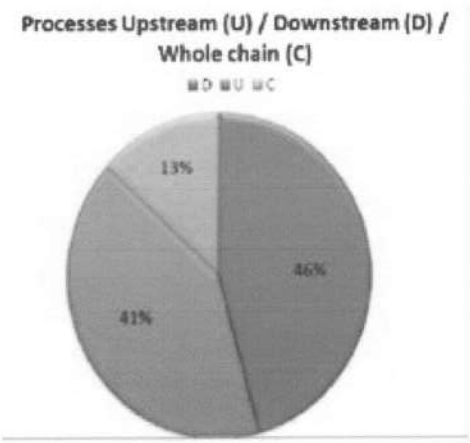


Fig 2.6: Projects based on processes

Processes	Budget Allocated in INR
Upstream	18908324800
Whole chain	2304560014
Downstream	917451457
Total Budget	22130336271

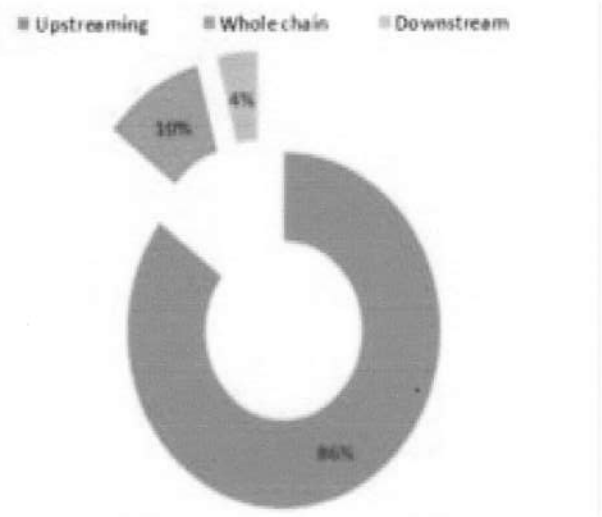


Fig 2.7: Funding based on theme processes

2.4.4Categorization by type of biomass

A total of 280 projects constitute the current inventory. Though there was some ambiguity in understanding the project objectives, the projects can be classified in terms of biomass resource. The majority of the projects identified from Indian side fall in the category of using Waste and residues (88), which was then followed by the Agricultural biomass source (80). The inventory also indicates that the almost half of the total amount sanctioned for the total projects by various funding agencies are utilized in projects that utilize waste and residues.

Types of Biomass	Number of Projects
Waste and residues	88
Agricultural	80
Aquatic	50
Not specified	39
Several of the above	14
Forestry	9
Grand Total	**280**

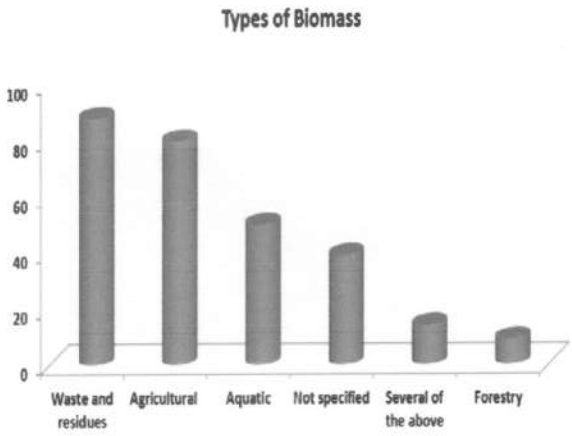


Fig 2.8: Projects based on types of biomass

Biomass sources	Budget Allocation for different Biomass sources
Waste and residues	11917015507
Agricultural	408951896
Aquatic	255695945
Not specified	9333586063
Several of the above	76538300
Forestry	138548560
Grand Total	**22130336271**

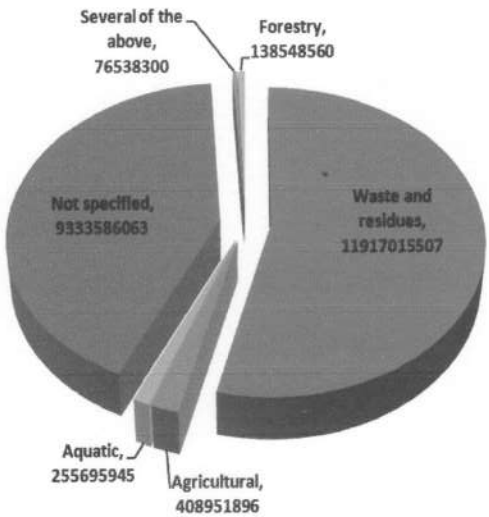


Fig 2.9: Fund allocation in various sources

2.4.5Categorization based on final outcome or product

It was quite difficult to categorize the projects based on its final product or outcome of the project as this information was not clear either due to lack of full project overview or due to the fact that the achieved objectives/milestones were also not clearly mentioned on the project or source information. Therefore the most identified final product after others (135) category were identified project have end product as the liquid fuel (97).

Row Labels	Count of Categorisation D: Products
Liquid Fuels	97
New Technology Development	45
Resource Generation / Sustainable development	43
Biomass / Biofuel	29
Gas	23
Data / Information	19
More than one of the above	9
Chemicals	9
Electrical Power	2
Heat	2
Feed	2
Grand Total	**280**

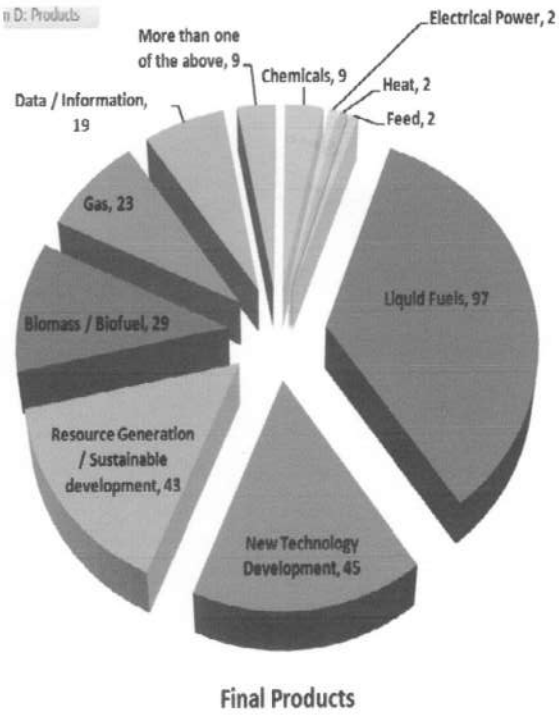
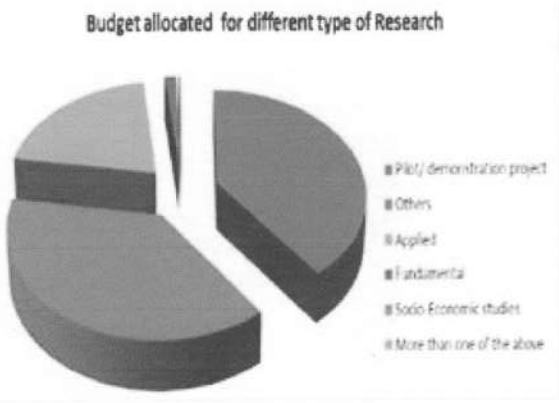


Fig 2.10: Projects based on final products

2.4.6Categorization based on the research focus

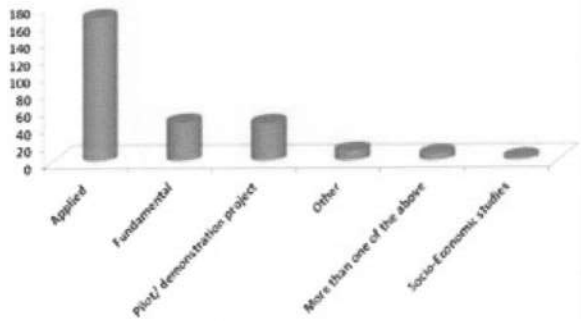
Upon investigating the budget allocated for these 280 projects, a majority of the projects are funded for development of process and products. The second category falls under the projects that fall into the category of demonstration projects. It is also observed that significantly low percentage of the total budget was sanctioned for basic and fundamental research. This section of the inventory deals with the type of research which was carried out

by the Organization or researchers, i.e. fundamental, applied, pilot/ demonstrated or socio-economics studies, etc. The majority of the project taken up indicates that most of them are working on applied research (167) as compared to research projects working on the fundamental concepts (45).



Type of Research	Budget allocated (in INR)	Euros (in million)
Pilot/ demonstration project	8805039650	135.46215
Others	8347727547	128.42658
Applied	4581116616	70.478717
Fundamental	309464326	4.7609896
Socio-Economic studies	53840212	0.828311
More than one of the above	33147920	0.509968
		0
Total Budget	22130336271	340.46671

Fig 2.11: Budget allocated for research themes



Type of Research	No. of Projects
Applied	167
Fundamental	45
Pilot/ demonstration project	44
Other	12
More than one of the above	8
Socio-Economic studies	4
Grand Total	**280**

Fig 2.12: Projects based on research areas/themes

2.4.7Projects for Collaboration

Based on the selection criteria mention above, a total of 90 projects identified for collaboration from India. Apart from the criteria mentioned above, the basis of selection of these projects mainly depends on the project objective and their role on Biomass enhancement and Biowaste utilization and conversion using biotechnological interventions. These projects also fall into the category of higher reliability. On the reliability scale of 1-5, there were a total of 106 projects which were falling in reliability criteria "4" followed by 58 projects which were identified falling in reliability criteria "3". The selected projects were also falling into the "IN'category. Based on the selection criteria, a total of 108 projects were considered in "IN" criteria, which shows that these projects are mostly related to the topic of Biomass/Biowaste research

SAHYOG Project Database available online:

Project Database: http://www.sahyog-projects-database.eu/

Biomass Database: http://intern.ec-elements.com/wip-sahyog-biomass/

3.0 Networking and Exchange

The main objective of WP3 is to initiate, facilitate and execute a programme of networking and exchange between Indian and European R&D programme managers, scientists, funding organizations, industry and other stake holders. This will be done both at the project level by twining on-going EU and India R&D projects and programmers (Task 3.1), at the institutional level by launching a programme for short time exchange of researchers (Task 3.2) and at the institutional level by organizing a number of Stakeholder Workshops both in EU and India (Task 3.3).

3.1 Details of the training programme/workshop organized

SAHYOG Stakeholder Workshop in Copenhagen, Denmark, 6 June 2013

The aim of this SAHYOG workshop was to involve international experts and specialists from research, industry, and Governments in the elaboration of the Strategic Research Agenda (SRA) and the R&D Roadmap developed in the framework of the SAHYOG project.The SAHYOG Stakeholder Workshop "EU – India Cooperation on Biomass and Bio-waste Research and Development" was organised by WIP on 6 June 2013, on the occasion of the 21stEuropean Biomass Conference and Exhibition, 3-7 June 2013 in Copenhagen.In this workshop activities and findings of the SAHYOG project were discussed with international stakeholders. Furthermore, project participants from India presented an overview of current research and development initiatives in the field of biomass and bio-waste in India.

Photo 3.1: SAHYOG Stakeholder Workshop in Copenhagen, Denmark

3.2SAHYOG Mini-Symposium and Twinning Workshop, Utrecht, Netherlands, 28-29 October 2013

The main objective of the SAHYOG Project Twinning workshop was thus to bring together project- and programme leaders for increased networking and matchmaking, by reviewing a large set of on-going projects and (industry) initiatives from EU and India. In addition, workshop participants has identified major areas for collaboration through interaction and engaging in project twinning. The following activities are possible under SAHYOG project twinning: research cooperation and exchange of researchers, organization of joint workshops/meetings; development of common trainings; common literature reviews; exchange of tools, analytical methods and databases; exchange of data, information, knowledge and material. This coordination activity is of large importance to systematically bridge the on-going respective activities from India and Europe that help providing the basis for novel applications in a sustainable bio-economy of the future – the so-called knowledge based bio-economy (KBBE).

Photo 3.2: SAHYOG Mini-Symposium and Twinning Workshop, Utrecht, Netherlands

3.3 Short Term Exchange Program European Union Researchers to India, 19th-27thNovember, 2013, India

The STE tour programme is one of the objectives of the SAHYOG project. The first exchange programme was organized from 18th - 28th November, 2013 for EU researchers to visit Indian Institutes and University, working in the field of Biomass and Biowaste valorization. The objective of the project is to organize short-term exchanges (STE) programme to enhance the networking and exchange of young talents and to establish a sustainable cooperation between the EU and India. The total of seven researches was selected from Europe to visit India,where they visited TERI, IICT, GBPUA&T and JNU as a part of their exchange tour programme. The exchange of EU researchers to India was organized by CSIR-IICT. During the STE tour the researchers were able to visit several labs and have discussion with the resource persons, scientists and professors working in the field of biomass and biowaste from several Universities and institutes in India.

Proposed different research themes for the STE

- Anaerobic digestion technologies (biogas, biomethane, hydrogen)
- Bioethanol production from lignocellulosic biomass
- Feedstock production and genetic improvement of plants
- Algae production and conversion systems
- Biomass to chemicals- the biorefinery approach
- Thermochemical conversion technologies (pyrolysis, gasification)

Further, a proposal for STE from the Indian side was prepared and the leaflet containing the information about the program was prepared and sent to the respective Indian SAHYOG partners. An invitation letter was sent to various institutions in India to confirm their willingness to host European researchers. A letter of interest (LoI) was also prepared and sent to the respective SAHYOG partners. In response to the LoI, acceptance from TERI, GBPUA&T, JNU and CSIR-IICT to host the European researchers was received and sent to the European STE coordinator.

SAHYOG Short-Term Exchange of Researchers

The increasing global demand for energy has led to scarcity of resources, climate change, environmental problems and a reduction in biodiversity. The Europe 2020 strategy tackles these problems by turning them into the challenge of implementing smart, inclusive and sustainable growth. As biomass and biowaste are the most efficient and abundant renewable resources forming the basis for such an economy, biotechnology in the broad sense is one of the key technologies in this context. India is also recognizing this key point with its National Action Plan for Greenhouse gas Mitigation focusing on solar energy and renewable biomass. This lays the foundation for an EU-India partnership in a key area of interest of both the regions.

SAHYOG Project

The main aim of the project is to actively link leading organisations in the field of biomass production and bio-waste conversion research carried out within EU research programmes and related programmes by Indian national institutions. All activities conducted within SAHYOG have the objective to contribute to a joint Strategic Research Agenda (SRA) finally leading to a Roadmap for Indian and European policymakers and researchers, paving the way for a sustainable European Indian cooperation in the field of biomass production and bio-waste conversion.

Short-Term-Exchange

Connecting young researchers is an important pillar for a sustainable and long-term cooperation. To enhance the networking and exchange of young talents in Europe and India in the field of biomass and biowaste a **call for proposal addressing junior experts is published in March 2013**. The winners are awarded for their outstanding academic records and their innovative and creative ideas in a relevant field of research. With this component SAHYOG seeks to **increase international cooperation** in order to jointly contribute to the development of innovative ideas and solutions in the field biomass production and biowaste conversion.

Young European and Indian researchers will be invited to visit renowned research facilities of their respective field of research. The objective is to strengthen the inter-regional exchange: Indian researchers will be invited to visit European institutions, European researchers will visit India. The exchange is envisaged for one week and is fully financed by SAHYOG. Therewith young talents will have the unique opportunity to gain first hand **insights of the respective research landscape, make contacts and build new networks.**

Requirements

Proven excellent command of the **English language**

A **graduate degree** with above-average grades

Age: **up to 35 years**

Working in one of the following **fields of research**:

- Bioethanol production from lignocellulosic biomass
- Thermochemical conversion technologies (pyrolysis, gasification)
- Anaerobic digestion technologies (biogas, biomethane, hydrogen)
- Algae production and conversion systems
- Biomass to chemicals – the biorefinery approach
- Feedstock production and genetic improvement of plants
- Sustainability and life cycle assessment

Please find all relevant information for your application on:
www.sahyog-europa-india.eu

SAHYOG

Strengthening Networking on Biomass Research and Bio-waste Conversion - Biotechnology for Europe India Integration

Contact for SAHYOG Short-Term Exchange:

Wageningen UR, The Netherlands
Dr. Robert Bakker
robert.bakker@wur.nl

DLR - Deutsches Zentrum für Luft - und Raumfahrt e.V., Germany
International Bureau of the Federal Ministry of Education and Research at the Project Management Agency c/o German Aerospace Center (DLR)
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Website: www.sahyog-europa-india.eu

SAHYOG is supported by the European Commission within the 7th Framework Programme (FP7-289816) and by the Department of Biotechnology (DBT) of the Indian Ministry of Science and Technology

Figure 3.1: A model of STE program Leaflet

A brief profile of the STE hosting Institutes in India (TERI, GB Pant and JNU) was collected, compiled and sent to European STE coordinator. A common format for CV was prepared to maintain uniformity in the application process and schedule of the STE was prepared and circulated among all the partners.The detailed program for the STE that was held in India was designed and circulated to the EU researchers. Itinerary of each visiting institute was circulated among the EU researchers.

Table 3.1: List of EU researchers selected for STE

S.No.	Name of the candidate	Country	Institute
1.	Carla Ferreira	Portugal	National Laboratory of Energy and Geology
2.	GianpaoloSabia	Italy	ENEA Research Center Bologna
3.	Axel Funke	Germany	Karlsruhe Institute of Technology
4.	Sebastian Riedel	Germany	IPK Fraunhofer
5.	Joe Bennett	UK	University of York
6.	ZsoltBarta	Hungary	Budapest University of Technology
7.	Dario Prando#	Italy	Free University of Bozen-Bolzano

Dario Prando visited Indian Institute of Sciences (IISc) and did not participatd in tour programme

Photo 3.3: Short Term Exchange (STE) for EU researchers in India

Photo 3.4: Visit of EU researchersto different facilities under Short Term Exchange (STE) programme in India

3.4Short Term Exchange Program for Indian researchers to European Union, 30th March - 11th April, 2014.

A short term exchange program of Indian researchers to Europe was held during 30th March 2014 to 11th April 2014 for which DLR was the responsible coordinator. A guided tour to various institutions in Germany, Belgium and The Netherlands was organized. CV's and SOP's of Indian applicants were collected by CSIR-IICT and sent to EU coordinators. Eight Indian researchers have been nominated and selected by EU, participated in the program (Table 3.2).

Table 3.2: List of Indian researchers selected for STE

S.No.	Name of the candidate	Institute
1.	Dr. Piyush Joshi	The Energy and Resources Institute (TERI)
2.	Mr.Rahul Singh Chutia	Tezpur University
3.	Dr. Nisha Kant Pandey	Jawaharlal Nehru University (JNU)
4.	Ms.PunamKumari	Jawaharlal Nehru University (JNU)
5.	Ms.AmulyaKotamraju	CSIR-Indian Institute of Chemical Technology (CSIR-IICT)
6.	Ms.J.AnnieModestra	CSIR-Indian Institute of Chemical Technology (CSIR-IICT)
7.	Ms.HarshitaNegiRawat	G.B.P.U.A.&T. Pantnagar
8.	Ms. RuprekhaSaikia	Tezpur University

The program was mainly focused on visit to various EU institutions and industries working in the field of utilization of waste towards bio-energy. The exchange of knowledge was mainly through active interaction sessions and lab visits held during the program. The objective of the project SAHYOG is to actively link research activities implemented within EU research programmes and related programmes by Indian national institutions. One effective element is to enhance the networking and exchange of young talents and by this to pave the way for a sustainable cooperation between Europe and India. Therefore focus of the Short Term Exchange Programme was to create conditions for mutual learning as well as to involve young scientist in the decisions about future EU-India science and technology

cooperation (STC). Furthermore the awardees had the chance to present their ideas (e.g. in context of discussion sessions within the hosting institutions) and the possibility to strengthen their networks.

Photo 3.5: Short Term Exchange Program for Indian researchers to European Union

The tour from India to Europe comprised eight participants and took place from 30 March 2014 to 10 April 2014. The researchers could gain deep insights into different research institutions in the regions they visited. Linkages among the institutes, thematic foci, available infrastructures and current research topics were addressed, thus laying a solid foundation for possible mid- or long-term collaboration. Due to the small size of the groups each participant was given the opportunity to present his or her home institution and their personal research on several occasions during the trip. Furthermore, the tour provided ample opportunities for individual conversations among the researchers as well as extensive Q&A sessions after the presentations from the hosting institutions.

Photo 3.6: Mini congress at Wageningen University, Netherlands

For most of the participants, the STE tour was their first chance to visit Europe, thus getting a first impression of the regional customs, culture and research landscape. With the participants being at an early stage in their research career, this first experiences abroad will make it easier to seize similar chances in the future.

3.5 SAHYOG Final Meeting and Brokerage Event, Brussels, Belgium (November, 18-19, 2014)

The SAHYOG project final meeting was held during November 18-19th 2014 at Brussels, Belgium. The meeting was chaired by Project coordinator along with delegation for European commission, Mr. Carlo Terella (Project Officer), DG R&I European Commission and Mr.Florent Bernard, DG R&I India Desk, European commission. There were series of presentations for each work packages and the achievements from both the sides (India and EU) partners, and discussion on the similar project and their achievements around the world. There were discussions on the possibilities of future collaboration with the same consortium. DG R&I from European Commission provides the information on the Horizon 20-20, its opened calls, the budget and the countries included under the call under several different aspects, he suggested that the consortium can again work together in future if India will participate in Horizon 20-20.

Photo 3.7: SAHYOG Final Meeting and Brokerage Event, Brussels, Belgium

3.6 SAHYOG Indian partners interactive meeting at ENEA and lab visit at Italy (November, 20-23, 2014)

The SAHYOG Indian partners visited ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development), headquartered at LungotevereThaon di Revel, Rome from November, 20-23, 2014. There were lab visits, lecture and partners join meeting held on 21-23 Nov. 2014, which was organized to delineate the future course of action of SAHYOG project. It includes the visits to ENEA headquarters and research facilities,like visit to fully equipped glass house facility demonstrating the hybrid plants under different conditions, demonstration of anaerobic fermentation unit, where canteen waste was used to produce methane, demonstration of waste water treatment unit and bio-hydrogen production facility, Biotechnology and Microbiology lab visit and discussion with facility in-charge and their staff. There was a lecture by Prof. NeeraBhallaSarin (JNU) on the JNU activities and Biomass potential of India, followed by the interaction session with the scientists and researchers of ENEA

Photo 3.8: SAHYOG Indian partners interactive meeting and lab visit at ENEA, Italy

3.7 SAHYOG Interactive meeting was held at GBPAUT, Pantnagar, Uttarakhand from December 10-13, 2014.

A meeting of was held with Dr. Aziz Qureshi, Governor, Uttarakhand and Vice-chancellor Dr. HS Dhami regarding SRA and roadmap. Further, deliberations were also made regarding future INDO-EU collaborations.

Following research centres were visited by Dr. Neeta Sharma (SAHYOG Project Coordinator) and Prof.NeeraBhallaSarin (JNU).

- Norman E. Borlaug Crop Research Centre
- Vegetable Research Centre
- Dairy and Poultry Farm, Nagla
- Floriculture Research Centre

Dr. Neeta Sharma, ENEA, Project coordinator, visited Kumaun University, Nainital, Uttarakhand to explore future research probabilities.

Photo 3.9: SAHYOG Interactive meeting was held at GBPUA&T, Pantnagar, India

4.0 Strategic Research Agenda

This Strategic Research Agenda compiles the shared vision for the EU and India on the latest developments in the bio-based economy, and the research needs in this context. It defines specific needs and possible ways, scientific expertise research tools needed the size of demonstration and pilot plants etc. to enhance the bio-based economy. The inventory of the biomass and bio-waste potentials and existing research projects elaborated and analyses within the WP1 of SAHYOG form a basis for the joint Strategic Research Agenda (SRA) finally leading to a Roadmap for policymakers and researchers. Based on the state of the art technology and inventory available biomass and biomass production potential, a road map will be produced paving the way for a Biobased industry and economy in Europe and India, taking into accountsthe comments and concerns of different stakeholders. A strategic research agenda will indicate the needs and gaps in the field of RTD that need to be developed to support the implementation of the road map.

The structure of the SRA is depicted below. It consists of three main chapters, each describing the present status and strategic research needs for collaboration between Europe and India in specific domains. Chapter 3 focuses on feedstock including biomass and waste production, Chapter 4 on bio-refineries (or alternatively biomass/waste valorization and technologies), and Chapter 5 on products, markets and policies (but with a focus on the research needs related to these topics). Each chapter deals with the description of the vision relevant to the Chapter, the current status (state of the art & problems & challenges), description of the strategy and the recommendations for R&D. A lead author and a team of co-authors were assigned to each Chapter from both India and Europe. The Chapter covered under SRA were broadly includes following fields and their recommendations (a) Biomass and Biowaste Feedstocks, (b) Bio-refineries and (c) Markets, Products and Policies A number of brainstorm sessions followed by telephone conferences and regular collaboration between the authors were necessary in order to come to a coherent, comprehensive strategic research agenda.

The contents of the chapter mainly include the following:

- Introduction
- Vision
- Current Status
- Future recommendations

The conclusions drawn from the Strategic Research Agenda document are listed below from three different chapters:

4.1 Biomass Production and availability

Biomass becomes available as a renewable resource from agriculture and forestry, or is available as waste. Only first estimations of quantities could be achieved and it is recommended to carry out further research to get better and more region specific data available for the present status and expectations for the future. Large amounts of untapped resources are available in India and Europe from agricultural, industrial and municipal residues and waste. Land surface for forestry and agriculture in Europe and India is limited as well as constraints in water, soil quality, fertilization, bio-diversity and pesticide. Applications require a smart approach to increase production in a sustainable way. Historically and climate given, Europe is more forestry oriented and India is more small scale agriculture oriented. A number of opportunities have been identified
and require further research and exploration, with a focus on specific crops as well aquatic cultures and improved practices. Change in policy regimes is also required for optimal utilization of currently untapped resources.
Valorization of these residues might yield a huge potential for the Bio-economy, increasing the value of the product and improved environmental practice.

Research Recommendations for collaboration between Europe and India on biomass production

- Development of uniform databases at the State level for potential available biomass resources
- Biomass production intensification with minimum and sustainable inputs of biofertilizers, biopesticides, water and selection of crops adapted to specific soil and climatic conditions
- Supply chain management (logistics, reduction of losses, storage)
- Improved waste collection, treatment, valorisation to products and energy
- Improved characterisation and administration of biomass and waste resource flows

4.2 Bio-refineries

Bio-refineries are the crucial technology to valorize the biomass and waste by producing a spectrum of products and energy. It brings together the different sectors: Agriculture, Forestry, Waste, Chemicals, Fuels and Energy. Bio-refineries can be categorized and have been developed in Europe and India in the paper and pulp and sugar industry, but will now be expanded to the production of integrated food, products, chemicals and energy with a variety of incoming feedstock.

Research Recommendations for collaboration between Europe and India on bio-refineries

- Development of smart enzyme systems at lower cost price
- Development of smart microorganisms for conversion of residues and waste;
- Development of smart processing equipment
- Improved thermal conversion by gasification and pyrolysis for simultaneous production of chemicals and energy
- Improved anaerobic digestion by bacteria selection, pre-treatment, post treatment to fertilizer
- Development of bio-based value chains (from crop to chemical and energy)
- Analysis and optimization of geographical locations for bio-based production and products.

4.3 Markets, Products and Policies

The analysis of the present situation and drivers in both continents leads to the conclusion that biomass is seen as a renewable resource, but its sustainability needs continuous attention. Markets exist in Europe under the Renewable Energy Directive, and new markets are foreseen in the bio-based economy for bio-based chemicals. India has a huge energy need and the utilization of biomass for energy has the first priority. Both continents acknowledge the need for valorization and the bio-refinery approach in the future. Priority markets exist for Energy from waste and residues, as large volumes from agriculture and municipalities are at present unused in India and Europe (mainly Eastern Europe). The societal need for waste treatment creates business opportunities. In the long- term a strong bio-economy supports rural development and local livelihood, creates jobs and local employment and reduces Greenhouse gas emissions. Industries are interested to develop this, but need a policy environment that enables these sustainable businesses.

Research Recommendations for collaboration between Europe and India on Markets, Products and Policies

- Develop agreement on sustainable production and use of biomass;
- Develop a common political framework stimulating the bio-based economy approach (level playing field);
- Develop standards for residues and declassify them as waste;

- Develop standards for performance criteria of bio-based products;
- Develop Public Procurement of bio-based products;
- Stimulate Zero Waste communities and production system (circular economy);
- Develop awareness programmes and education on as sustainable bio-economy with proper waste management;
- Develop Training and Education for researchers and engineers in the bio-economy (Human Capital).

This strategic research agenda has been based on the work planned and conducted under the SAHYOG project, taking into account results from other related Work Packages.

4.4 Surveyfor R&D Recommendation

The survey was carried out among the Industrial, Academic and Governments stakeholders, and active of the various sectors of the bioeconomy. In total 207 complete responses were received both from Europe and India. Stakeholders from industry, academia as well as governmental institutes responded, as displayed in Figure 4.1. More or less equal responses were obtained from universities, research institutes and industry. For EU-28, the industrial participants were from large enterprises, SME and consultancy firms. In India, mostly large enterprises participated and less participation was noted for SMEs and consultancy firms. In addition, also stakeholders from the various sectors were addressed. For India, the responses were mostly from the energy, environmental and agricultural sector in almost equal amounts. For Europe, on the hand, a higher contribution from the chemistry/material sector and less from the environmental sector were collected. The other category mostly comprises stakeholders active in biotechnology with a cross-sectorial domain.

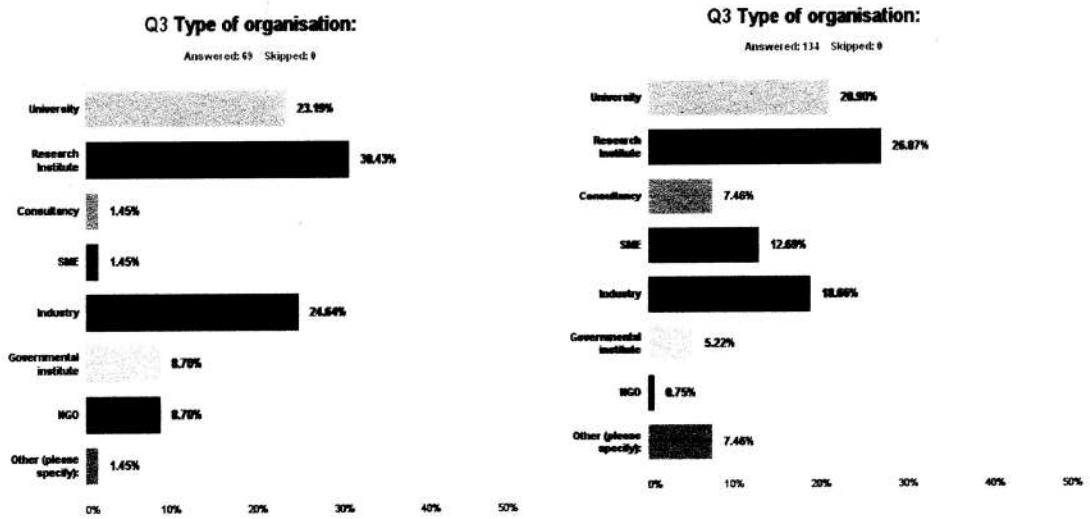

Fig 4.1: Type of organization of the respondents (left: India, right: EU-27)

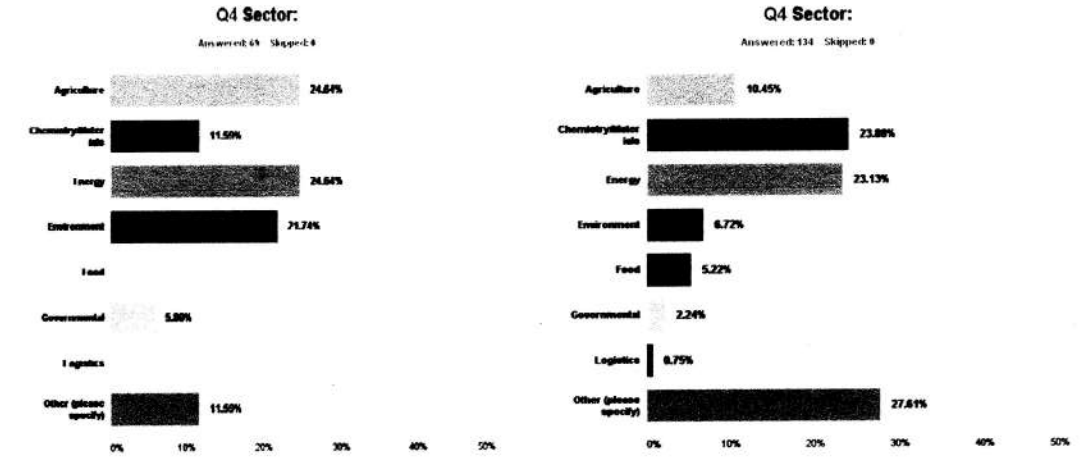

Fig 4.2 : Sector wise distribution of the respondents (left: India, right: EU-27)

For each of the three categories (+ a fourth related to policy and markets), the respondents had (maximum) three votes that could be given to the R&D recommendations that were considered to be the most important for the EU-India collaboration. The total results (cross-sectorial, and considering all organizations) are given below according to themain areas of interest:

Feedstock:

- Optimization of agricultural practices through breeding, modelling, monitoring. Providing regionalized solutions. Development of accurate biomass mapping methodology.
- Development of new (energy) crops, including phenotyping, suitable for marginal and abandoned lands and/or low nutrient/water supply and allowing agricultural intensification.
- Research and development on micro- and macro algae as future biomass source.

Waste and By-products:

- Set up of surveys to monitor the amounts and compositions of the different types of residues and wastes (municipal, agricultural and process residues and waste). Proper databases on the available biomass potential allowing future predictions considering climate change. Improving the collection of municipal waste (segregation) and sustainable agricultural residues harvesting.
- Development of new technologies to convert the different types of solid wastes and residues (agro-forestry, municipal and industrial).

Bio-refineries:

- Development of biorefinery based on lignocellulosic biomass towards fuel and chemicals.
- Linked to waste: further development of anaerobic digestion to convert organic wastes into biogas (and in a later stage chemical of biofuels).

5.0 WP5: Communication and Training

The main objective of WP5 is to widely communicate and disseminate SAHYOG project activities and results among European and Indian scientists and R&D programme managers. Thereby, this work package will actively promote knowledge exchange between R&D experts, stake holders and key actors. It has furthermore strengthened EU India linkages within on-going and future research and innovation projects for contribution in joint collaboration.

5.1 SAHYOG First Summer School in Athens, 9-16 June 2013

The SAHYOG first summer school took place at the National Technical University of Athens (NTUA), Zografou Campus, Athens, Greece, during the period 9-16 June 2013. A total of 20 Young Researchers was selected to attend the summer school, half of them from India and the other half from European teams. The programme consisted of 20 (4 per day) 2-hour class units taught by distinguished experts who presented the latest developments in their respective fields coming from a total of 10 countries, with a good balance of geographical distribution. The teaching programme besides classroom work included a laboratory visit, a computational exercise, a welcome reception and a farewell party, an excursion in the city and the region, and a questionnaire-based evaluation. Each student was also required to develop a research project in a student paper. The students evaluated the Summer School very positively, especially the quality of content and lectures and offered suggestions for its further improvements.

Photo 5.1: SAHYOG First Summer School in Athens, Greece

5.2 SAHYOG Second Summer School in Tezpur University, Assam, India (20-26 July 2014)

The 2nd SAHYOG Summer School was held during 20-26 July 2014 at Tezpur University, Assam, India.Professor MK Chaudhuri, Vice-Chancellor of Tezpur University, inaugurated the event. During his speech, Prof. Chaudhuri focused on the growing need of sustainable, affordable and quality source of power and heat from biomass and other renewables for 21st century. Further presentations were made by Dr. Rupam Kataki, Professor D Deka, Professor YS Yadav, and Dr. PM Sarma during the inaugural session. The key-note lecture was delivered by Professor Ashok Pandey, Head of the DBT Centre for Biofuel and Biotechnology Division, CSIR-National Institute of Interdisciplinary Science & Technology, on "Advances in Biomass and Bioenergy research and vision for future". During his lecture, he reviewed the international and national energy scenario and presented an in-depth analysis of all possible options for a biobased energy supply scenario in India.

In the following four technical sessions, participants were deeply introduced in the various biomass, bioenergy and biotechnology fields:

- Biomass Assessment, Characterization, Production and Improvement
- Biomass Conversion: Science, Technology and Biotechnology
- Sustainability and LCA of biomass;
- Biomass, Society and Rural Development

The presentations were given by total of eighteen speakers from Europe and India. Furthermore, field visits to renewable energy installations, to a tea garden and to local sight-seeing destinations were included. Participants also worked on biofuel based problems in groups and presented case studies. 21 young Indian researchers, mostly undergoing doctoral training representing Indian Institute of Technology (IIT), National Institute of Technology (NIT), Central and State University and CSIR Laboratories, participated in the summer school. In the closure session participants mentioned that it was a significant learning and sharing experience for them. The 2nd SAHYOG summer school was concluded with vote of thanks offered by the coordinator, Dr. Rupam Kataki to all the participants and speakers for making the event a vibrant one through their interaction during presentations by various speakers. He also thanked all those who helped in organization of the 2nd SAHYOG summer at Tezpur University

Photo 5.2: SAHYOG Second Summer School held at Tezpur University, Assam, India

5.3 SAHYOG Conference and Brokerage Event on Bio-economy was organized in New Delhi, India, on 3-4 February 2014

The final SAHYOG Conference and Brokerage Event on Bio-economy was organized in New Delhi, India, on 3-4 February 2014. The conference was organized by SAHYOG in cooperation with TERI and the European Commission. It took place on the occasion of the Delhi Sustainable Development Summit (DSDS) on 6-8 February 2014. The DSDS, convened annually by the Energy and Resources Institute (TERI), is an international gathering that facilitates a vital exchange of the ideas, knowledge, lessons and awareness needed for the sustainable development of India and the world. The event was inaugurated by Dr. Philippe de Taxis du Poet from DG Research and Innovation, European Commission, Dr. Shailja Gupta and Dr.RenuSwarup from DBT. It also witnessed participation from senior management of industry, active researchers from national and international institutes, representatives from embassies, stakeholders from small and medium enterprises, NGO's, financing institutions, business schools, and most importantly farmer organizations, both

from EU member states and India. The deliberations were focused on understanding the importance of transition towards the bio-based economy with the perspective from both EU and India. The highlight of the event was the overwhelmed response from the industry through participation of their senior management and dialogue on opportunities as well as technology and policy gaps in this emerging field.

Another major highlight of the event was the presentations on the Strategic Research Agenda that is being developed under the project SAHYOG to facilitate concerted planning of future joint EU-India research initiatives. The discussion lead to a clear road map of activities leading to identifying pathways in promoting technologies and policies that might drive Europe and India to an increased exploration of biotechnology for biomass production and biowaste conversion.

While inaugurating the programme Dr. Philippe Du Poet, Minister Counselor, Delegation of European Union to India, said, "This joint initiative will effectively link research activities implemented within European Union's research programmes and related activities of Indian national institutions to provide a policy framework for future research initiatives in areas of bio-economy," Dr. R. K. Pachauri, Director General, TERI, complimented the on-going effort of this Indo-European consortium, emphasizing the importance of a radical change required in the area of biomass technologies for a sustainable bio based economy.

This event was the first comprehensive deliberation on Bio-economy that aimed at strengthening EU-India collaboration in the field of bio-based economy by facilitating linkages between existing projects and triggering new collaborations particularly with the industries.

Photo 5.3: SAHYOG Brokerage event and Stakeholders meet, New Delhi, India

5.4 SAHYOG Workshop on Biomass Production, Conversion and Utilization 22nd - 23rd May 2014, Pune (India)

The main objective of the workshop was to bring together stakeholders from the leading organizations, in particular from Maharashtra, Rajasthan, Odisha and Andra Pradesh States (Central India), to present the results of SAHYOG project and to discuss on the current bio-based research and technologies, in the interest of future co-operation and exchange of India-Europe-Maharashtra Collaborative Program. The workshop on Biomass Production, Conversation and Utilization was organized by Appropriate Rural Technology Institute (ARTI), Pune, India under the aegis of FP7 project SAHYOG. About 41 participants, including stakeholders from Academia, Industry, NGOs and senior level research students, actively participated in the two day workshop. In total, seven sessions were conducted during the two days program.

The sessions were arranged under five main topics:

- Key note address
- SAHYOG – Overview, Objectives and achievements: Europe and India
- Biomass Research and Development in Academic Context
- Biomass conversion: Industrial Context
- Biomass for sustainable Development and Environment

Photo 5.4: SAHYOG Workshop on Biomass Production, Conversion and Utilizationheld at ARTI, Pune, India

All sessions were chaired by experienced, academic, researchers, and representatives from companies and NGO Sectors. In total 20 speakers presented their work and the research results related to the different topics defined under the workshop program. All the participants actively participated in panel and group discussion after each session. The main objective of the workshop was to bring together stakeholders from the leading organizations, in particular, the stakeholders from Maharashtra, Rajasthan, Odisha, Andhra Pradesh, Uttar Pradesh, New Delhi and Italy to deeply discuss the biomass based technologies that might be an excellent support for the future India-Europe-Maharashtra Collaborative Program.

6.0 Summary and Conclusions

6.1 Specific Outcome from Biomass Inventory studies

- SAHYOG biomass inventories contain the updated information on the availability of biomass in Europe and India. However, setting up both EU and Indian inventories revealed that because of lack of relevant data in various databases consulted for this purpose, it is really a challenging task to achieve a complete and reliable picture of biomass availability. Indeed, datasets in official statistical reports are not always complete or contain mainly highly aggregated data. For example, in the case of biomass from forestry in India, the information is very limited due to the fact that forests come under resource security policies and are considered as conserved.

- An analysis of the EU and Indian inventories demonstrates similarities as well as differences in the availability and usage of renewable biomass for energy, chemicals and materials. Being an agriculture-based country, India derives most part of its potential biomass from agriculture by-products, whereas in the EU a huge quantity of biomass originates from forestry. A common feature is that in both EU and India, a great part of the available biomass from forestry, agriculture, and biowastes remains unexploited. In addition, due to data heterogeneity, it is not always possible to directly compare biomass availability in EU and in India for specific subcategories. However, under the framework of SAHYOG project, the work on the on-going research for new data will be continued to fill in the gaps in the inventories. An accurate analysis of the results for both SAHYOG inventories will finally outline the EU and Indian priorities in biomass utilization and technology implementation.

- Based on the results of inventories, specific research cooperation activities between stakeholders from EU and India will be implemented. The information provided in the SAHYOG biomass inventories will help to define common fields of interest to maximize EU-India collaboration and will constitute an important instrument to develop the joint Strategic Research agenda and the future R & D Roadmap in the field of bio-based industries.

6.2Specific outcome from project Inventory

- A total of about 700 projects in the EU and 280 in India have been identified in an inventory of biobased projects in the EU and India, based on existing databases in the EU and a thorough survey in India.
- The total funding of these projects is more than 1.5 billion Euro in the EU and 35 million Euro in India during the period 2007 – 2012.
- A categorization method was developed to find areas of research and the underlying projects could be identified.
- These overviews should be made available to researchers and programme managers to allow for the identification of twinning opportunities.

6.3 Research recommendations for Europe & Member States and India

- Development of uniform databases for potential available biomass resources
- Biomass production intensification with minimum and sustainable inputs of biofertilizers, biopesticides, water and selection of crops adapted to specific soil and climatic conditions
- Optimization of crop harvesting and collection of agricultural wastes to reduce losses
- Reduction of MSW land filling through recycling of wastes
- Development of efficient methodologies for waste collection, separation and treatment
- Research and development of sustainable algae production systems for the production of renewable energy, wastewater treatment and for other uses

The outcome of Strategic Research Agenda (SRA), Roadmap and press release are available in public domain and can be accessed at "http://www.sahyog-europa-india.eu/".

7.0 Details of New Leads Obtained, if any:

The proposed SRA will lead to a Roadmap for policymakers and researchers. There is the possibility of extension of the SAHYOG collaboration for the future Biobased economy or Bioeconomy.

8.0 Details of Publications & Patents, if any:

Research outcome

Publications, Short communications/Abstracts and communicated papers = 3 Abstracts, 6 Publishedand 4 Papers (communicated)

Abstracts:

1. Neeta Sharma, PriyangshuManabSarma, Silvia Tabacchioni, Piyush Joshi and Luigi Chiarini. (2013). An assessment of the available Biomass Resources in the EU27 and India for synergistic development of Bio-based economy. Presented and published in European Federation forInformation Technology in Agriculture, Food and the Environment (EFITA), Turine, Italy
2. Piyush Joshi, KeesKwant, Neeta Sharma and PriyangshuManabSarma. (2013). A related analysis of the Biomass related project funding in India and EU for development of future Bio-based economy. Presented in International Conference on Applied Bioscience and Biotechnology (ICABB-2013), 25-27th Nov. 2013, Pune, India
3. Piyush Joshi, Neeta Sharma and PriyangshuManabSarma. (2013). Study on Biomass potential: A comparative analysis of India and EU leading towards Bio-based economy. Accepted for 4th International Conferenceon Advances in Energy Research (ICAER), 10th- 12th Dec. 2013, IIT Bombay, India

PapersPublished:

1. Ruprekha Saikia, Rahul Singh Chutia, Rupam Kataki, Kamal K. Pant.(2015) Perennial grass (Arundo donaxL.)as a feedstock for thermo-chemical conversion to energy and materials.Bioresource Technology (in press doi: 10.1016/j.biortech.2015.01.089).
2. M.Agarwal, J.Tardio, S.Venkata Mohan. (2015). Pyrolysis biochar from cellulosic municipal solid waste as adsorbent for azo dye removal: Equilibrium isotherms and

kinetics analysis. International Journal of Environmental Science and Development, 6(1), 67-72.

3. J.Annie Modestra and S.Venkata Mohan. (2014). Bio-electrocatalyzed electron efflux in Gram positive and Gram negative bacteria: an insight into disparity in electron transfer kinetics. RSC Advances (4) 34045–34055.
4. M.Agarwal, J.Tardio, S.Venkata Mohan. (2014). Effect of pyrolysis parameters on yield and composition of gaseous products from activated sludge: towards sustainable biorefinery. Biomass Conversion and Biorefinery.DOI: 10.1007/s13399-014-0129-3.
5. K.Chandrasekhar and S.Venkata Mohan (2014). Bio-electrohydrolysis as a pretreatment strategy to catabolize complex food waste in closed circuitry: Function of electron flux to enhance acidogenic biohydrogen production. Int. J. Hydrogen Energy. 39, 11411-11422.
6. M.Agrawal, J.Tardio,S.Venkata Mohan. (2013). Critical analysis of pyrolysis process with cellulosic based municipal waste as renewable source in energy and technical perspective. Bioresource Technology, 147, 361-368.

Papers communicated:

1. Dennis Cardoena, Deepak Pant, Piyush Joshi, Priyangshu M. Sarma, Ludo Diels. (2014) Agriculture Biomass in India: Part 1. Estimation and Characterization. Resource, Conservation & Recycling.(Communicated).
2. Dennis Cardoena, Deepak Pant, Piyush Joshi, Priyangshu M. Sarma, Ludo Diels. (2014) Agriculture Biomass in India: Part 2. Post-harvest losses, cost and environmental impacts. Resource, Conservation & Recycling.(Communicated).
3. Piyush Joshi, Neeta Sharma, PriyangshuManabSarma. (2015) Assessment of Biomass potential and current status of Bio-fuels and Bio-energy production of India.Current Biochemical Engineering (Bentham Science Publishers).(Communicated).
4. K. Amulya, ShikhaDahiya, S. Venkata Mohan. (2015). Building a bio-based economy through waste remediation: Innovation towards a sustainable future. Book Chapter in Bioremediation and Bioeconomy (Elseiver USA) (Communicated).

UTILIZATION CERTIFICATE

(For the Financial year ending 31st March, 2015)

(2014-15)

1. Title of the Project/Scheme :	Strengthening Networking on Biomass Research and biowaste conversion-biotechnology for Europe India Integration (SAHYOG)
2. Name of the Organization :	Tezpur University
3. Principal Investigator :	**Dr Rupam Kataki**
4. Dept. of Biotechnology sanction order No. & date of sanctioning the project/programme	BT/IN/EU/07/PMS/2011, Dtd. 29.12.2011
5. Amount brought forward from the previous financial year quoting DBT letter No. & date in which the authority to carry forward the said amount was given	**Rs. 5,13,615.00,** Vide DBT letter no. BT/IN/EU/07/PMS/2011, Dtd. 26.09.14
6. Amount received from DBT during the financial year (Please give no. & dates of sanction orders showing the amount paid	**Rs. 15,07,000.00** Rs. 13,07,000.00 vide DBT letter no. BT/IN/EU/07/PMS/2011, Dtd. 26.09.14 Rs. 2,00,000 vide DBT letter no. BT/IN/EU/07/PMS/2011, Dtd. 13.11.14
7. Other receipts/interests earned, if any, on DBT grants :	Rs. 15,000.00 as Joining fee towards the SAHYOG Summer School
8. Total amount that was available for expenditure during the financial year (Sl. No. 5, 6 and 7)	**Rs. 20,35,615.00**
9. Actual expenditure (excluding commitments) incurred in the financial year (statement of expenditure is closed)	**Rs. 18,32,769.00**
10. Unspent balance refunded, if any (Please give details of cheque no. etc.)	**Rs. 2,02,846.00**
11. Balance amount available at the end of the financial Year 2014-15	NIL
12. Amount allowed to be carried forward to the next financial year vide letter No. & date	N/A

1. Certified that the amount of Rs 18,32,769.00 mentioned against col. 9 has been utilized on the project/ scheme for the purpose for which it was sanctioned and that the balance of Rs. 2,02,846.00 remaining unutilized at the end of the year has been surrendered to Govt. (vide no.....dated.....)/ ~~will be adjusted towards the grants-in-aid payable during the next year (2015-16)~~.

2. Certified that I/we have satisfied myself that the conditions on which the grants-in-aid was sanctioned have been duly fulfilled / are being fulfilled and that I have

exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercised:

1. Accounts audited by qualified chartered Accountant appointed by this University as Internal Auditor.
2. The C.A.G. will audit the account shortly.
3. All the chemicals, consumables, equipments etc. purchased from the grant are entered in the log book.

13.05.2015

Project Investigator
Tezpur University

Dr. RUPAM KATAKI
Associate Professor
Department of Energy
TEZPUR UNIVERSITY
Tezpur- 784 028, Assam

Finance/Accounts Officer
Tezpur University
Finance Officer
Tezpur University

Registrar
Tezpur University
Registrar
Tezpur University

Statement of Expenditure referred to in para 9 of the Utilization Certificate

Showing grants received from the Department of Biotechnology and the expenditure incurred during the period from **01.04.2014 to 31.03.2015**

Item (1)	Unspent balance carried forward from the previous year (2013-2014) (2)	Grants received from DBT during the year (2014-2015) (3)	Other receipts/Interest earned if any on the grant (2014-2015) (4)	Total of col. (2+3+4) (5)	Expenditure incurred during the period from 01.04.2014 to 31.03.2015 (2014-2015) (6)	Balance (7)= (5-6)
1. Non-recurring						
Equipment	Nil	Nil	Nil	Nil	Nil	Nil
2.Recurring						
i. Human Resource	2,05,965	2,70,000	Nil	4,75,965	4,78,645	(-) 2,680.00
ii.Contingency	321	75000	Nil	75,321	75,318	3.00
iii.Travel-Domestic	37,804	37,000	Nil	74,804	48,202	26,602.00
iv.Travel-International	1,69,525	2,00,000	Nil	3,69,525	3,69,525	0.00
v.Local Hospitality	1,00,000	50,000	Nil	1,50,000	Nil	1,50,000.00
vi.Workshops	-	8,00,000	15,000	8,15,000	7,86,079	28,921.00
vii.Overhead	Nil	75,000	Nil	75,000	75,000	0.00
Total	5,13,615	15,07,000	15,000	20,35,615	**18,32,769.00**	**2,02,846.00**

13.05.2015

Project investigator
Tezpur University

Dr. RUPAM KATAKI
Associate Professor
Department of Energy
TEZPUR UNIVERSITY
Tezpur- 784 028, Assam

22/5/15

Finance/Accounts Officer
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