Human Capital Development for the Evolving 21st Century Bio-based Economy in USA: Assessing Needs for Education Skills and Capabilities by Agribusiness Enterprises.

By

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Introduction

The unique convergence of powerful strategic, environmental and economic imperatives has accelerated research and development as well as business development in sustainable and renewable resources. Among renewable resource options, biomass stands as the most flexible resource for economic development and the production of a broad range of value-added manufactured commodities and products (Tripp et al., 2005). Bio-renewable resources are receiving increasing attention. There are many signs that the bio-economy is becoming a reality.

Economic activity that is fueled by research and innovation in the biological sciences, the "bioeconomy", is a large and rapidly growing segment of the world economy that provides substantial public benefit (NBB, 2012). The bio-based economy focuses on biological tools and products from renewable resources to create wealth and sustainability in the production of medical treatments, diagnostics, more-nutritional foods, energy, chemicals, and materials, while improving the quality of the environment (Pellerin and Taylor, 2008). According to Fischler (2010), bio-based economy is defined as production paradigms that rely on biological processes and, as with natural ecosystems, use natural inputs, expend minimum amounts of energy and do not produce waste as all materials discarded by one process are inputs for another process and are reused in the system. In order to enhance the growth of bio-economy, current US administration recently released its Bioeconomy blueprint, outlining its strategy for U.S. economic revival based on U.S. technological lead in agriculture, biotechnological health science and entrepreneurism. Among the five strategic objectives proposed, one is to update training programs and align academic institution incentives with students training

for national workforce needs. It stated that “opportunities exist to enhance training efforts at all levels to keep pace with changing career pathways.”

The Blueprint focuses on reforms to speed up commercialization and open new markets, strategic R&D investments to accelerate innovation, regulatory reforms to reduce unnecessary burdens on innovators, enhanced workforce training to develop the next generation of scientists and engineers, and the development of public-private partnerships.

US agriculture is transforming as production of bioenergy, biofuel and bio-industrial products augment the existing production of feed, feed and fiber. Also, advances in energy conservation and efficient technologies provide opportunities for on-farm energy savings. This transformation is affecting the economy, social structure, and ecology of US farms, rural communities and rural landscapes in many ways (USDA-CSREES, 2007).

As the U.S. economy diversifies, workers will need to be prepared to build and operate a bio-based economy. A bio-based economy will alter the technology, market, and educational skills necessary to be competitive in business of agriculture and forestry. As bio-economy matures and moves more into the commercialization stage new positions and skills are required. For this reason, it is important the human resource requirements are fully understood and supported. Biotechnology’s fusion by science and business creates unique requirements for occupations in the sector (Bio Talent Canada – Skills Profiles, 2010).

Problem Statement.

The lack of job opportunities in rural areas has caused a significant and long lasting trend of urbanization, and consequent depopulation of rural areas. However, recent technological development and new business trends are creating economic opportunities even for the rural areas. Many new income opportunities are to be found in the distributed bio-based concepts, which are not only contributing to the positive environmental impacts, but are at the same time a powerful engine for economic growth in rural areas (Luoma, et al. 2011). Educated and competent people are needed to operate plants and to design higher value-added products and services. Primary production, cultivation, and harvesting will link closely to the secondary production and the use and recycling of the products. New opportunities rise not only in agriculture, forestry, but in food, chemical, pharmaceutical, and energy industries as well. Knowledge intensive services, such as consulting and legal services in planning, operation, optimization and maintenance are also needed.

The important decisions associated with these rapid developments highlight the need for new bodies of knowledge and expertise in the social, human, engineering, and biophysical sciences (USDA_CSREES, 2007). It has to do with a human capital, or the education, skill levels, and problem-solving abilities that will enable an individual to be a productive worker in the bio-economy of the twenty-first century.

Development of bio-economy creates unique requirements for occupations in the sector. Executives and managers must have technical expertise, while technical staff needs entrepreneurial skill sets. Particularly, occupational descriptions from other sources don’t exactly fit to bio-economy context. In addition to solid technical knowledge and operational experience, Bioeconomy workers need strong communication skills to

manage and motivate interdisciplinary teams of staffs and outside consultants as well as senior company officials and government representatives. They also need to have strong problem solving abilities to ensure that production issues are addressed quickly and efficiently. Furthermore, they need critical thinking skills to identify priority issues from analysis of large volumes of information and to ensure that potential risks are identified and managed effectively.

Finding people with the necessary skills for a specific position can be challenging for employers. If agriculture and agricultural industries are to maintain its competitiveness in a global economy, it must have trained and capable workforce to face new challenges. A team of inadequately trained workforce would jeopardize businesses in their efforts to compete with other industrialized nations. To meet demands of the knowledge economy curriculum must be dynamic and able to adjust to new situations and environments that help to improve on-the-job effectiveness of graduates (Coorts, 1987; Slocombe and Baugher, 1988). The more is known about essential skills and competencies needed for agribusiness careers and incorporated in to curriculum development, the more employable graduates will be in market place.

Due to increase technical competencies, and change in industry, there is need to determine the entry level knowledge, skills and abilities required for new graduates. By incorporating the desired skills in to the curriculum, graduates will be more qualified to adapt to the hi-tech, fast paced jobs of the future.

Objectives:

Therefore, given the needs of the emerging bio-economy, the objectives of the study are to:

1. develop a profile of selected small and medium bio-based enterprises.
2. identify and rank skills, capabilities of human resources needs of employees in US bio-based enterprises.
3. describe perception of employers as to the growth of bio-economy, the human resource needs and skill requirements for employers.

Bio-based Products and their Growing Importance:

A wide variety of biomass resources are available for conversion into bio-products. Bio-products are defined as non-food, non-feed agricultural products that are used in a variety of commercial/industrial applications thereby harnessing the energy of the sun to provide raw materials for the industry and transportation fuels known as bio-fuels such as ethanol and methane. Scientific developments are allowing changes in the relative contributions of agriculture and forestry industries and the chemical industry leading to increased use of renewable inputs.

As the world human population grows and with changing consumer demands, sustained economic development will depend upon a secure supply of raw-materials as inputs for industrial and commercial production. The majority of consumer goods are currently made from hydrocarbons produced by petrochemical industry. Continued depletion of limited global natural resources support the concept of supplying industrial production and energy needs through the use of renewable or bio-based resources. Bio-based products and bio-energy from crops, trees and agricultural, industrial, municipal and forestry wastes-hold great promise as contributors of the future economy. In the

United States biomass resources account for only about 3 percent of our nations total energy consumption. (Bio-based products and Bio-energy Vision, 2001). New revenues from use of bioenergy and bio based products create new income for farmers and rural America but also reduce annual greenhouse gas emissions.

Increasingly, agricultural research and development (AR&D) will take the lead in providing the technology for a bio-based economy in the 21st century. The bio-based industrial products will be a major U.S. economic growth area in the 21st century. The need in this area is not only for investment in AR&D to develop the bio-based industry of the 21st century but also to gather, sort and disseminate information/knowledge concerning the scope and potential of bio-based products to targeted audiences. At the same time it is important that graduates in agribusiness and agriculture in general be knowledgeable in this newly developing system to advance knowledge and marketing of bio-based products in the global economy. The transition to bio-based economy will be technology- and market-driven, and the educations skills and needs of producers will change. Traditional attitudes and expertise may no longer serve producers well. In short, the attitudes, skills and knowledge of farmers and other agricultural professionals must change to take full advantage of bio-based economy (Swisher and Fields, 2000). These changes make it necessary to re-evaluate educational programs in agriculture to specifically address the question: What are the competencies required of graduates of schools/colleges of agriculture as perceived by employers? What is needed to prepare bioenergy workforce?

Human Resource Needs:

A number of studies have found various needs desired by employers. Andelt, Barrett, and Bosshamer (1997), Singh et al (2000) found that the employees with leadership abilities, especially in the areas of problem solving and team work were found desirable by employers. Klein (1990) also found the ability to be a team player was important for employees to possess. Other skills identified by Klein included the ability to listen and carry out instructions, read and understand specific technical information, use general business computer software, interpret and use math and statistical methods, have a positive work attitude, high ethical values, and being self motivated. Litzenberg and Schneider (1980), Radhakrishna and Bruening (1994) found that employers value interpersonal, business, and communication skills. Long, Straquadine, and Campbell (1992) found that employers value knowledge and skills in the computer sciences and oral and written communication. A number of researchers have also advocated the need for practical work experience (Merritt and Hamm, 1994). According to Klein (1990), educating students for a career in agriculture and natural resources demands greater skills plus a more holistic perspective on interaction with society. In this study technical knowledge and other statements to measure specialized knowledge needed or preferred by bio-product manufacturers in their employees were included to provide guidance for curriculum changes.

A company's ability to attract and develop talent is often what makes the difference between survival and failure. For example, more than 35% of Canadian bio-economy firms lack the full set of skills they require. An equivalent number say they can't find appropriately qualified candidates when they go looking, and 55% need to

outsource skills and tasks. Hence, there need to be a comprehensive bio-economy skills profile development to find the skills and competencies required to work in key positions in the bio-economy (BioTalent Canada, 2011).

Procedures:

The data for the study were collected through an online survey similar to the 2004 survey on skills and attribute of agriculture graduates for bio-based industry and economy (see Singh, et al., 2004). The previous survey was designed in identifying and profiling various employers (both in public and private sectors) who hire graduates in agriculture needing training/knowledge in renewable resources (bio-based products) and seek their input for training graduates to work in these businesses. More specifically, the objective was to identify educational and experiential skills needed by employers and to determine preferences of employers in regard to selected skills and attributes that their entry-level employees may possess.

Since there was a rapid development of bio-based economy in USA in recent years, a new set of information is needed to analyze human capital requirements, skills including communication skills, attributes and experience required for the agribusiness enterprises for the evolving bio-economy. Therefore, a new set of survey was conducted for firms engaged in development and production of renewable energy as well as those who are producing other bio-based products in identifying human resource skills, knowledge and experience needed for the industry.

The address and list of biomanufacturers was obtained by the Biomanufacturing Association (BMA). The population of this study thus consisted of employers of entry-level graduates and producing, developing bio-products including research organizations.

A survey instrument (questionnaire) adapted from other studies was used (Klein, 1990, Litzenberg and Schneider, 1988; Singh et. al. 2004). The 2004 survey questionnaire was modified to include statements of skills and abilities identified in the literature and present day needs of employees. A committee comprised of 6 representatives from various agricultural disciplines validated the content of survey questions.

The survey instrument consisted of statements of technical knowledge, skills, abilities needed for bio-products industry and employee experiences regarding source of information and marketing channels used. Knowledge and skills are broken into categories. The questionnaire was divided into three groups of question(s).

Part one of the questionnaire consisted of questions to show the nature and structure of the firm to develop bio-products manufacturing firms. Part two of the questionnaire consisted of questions designed to measure the preparation and importance of knowledge, skills, and ability of entry level employees. The employer rated the knowledge, preparation of entry-level employees on technical knowledge; quantitative, and management information skills; business and economic skills; communication skills; interpersonal characteristics; knowledge about health safety regulations; and types of experiences the graduate has. The last part of the questionnaire dealt with university research in the byproduct area and sources of information used often by industry and how much trust they place in the information provided. Reponses were measured using likert-scale, rank (1-5) to indicate importance of knowledge, skill perceived by the respondent. A rank of 5 being extremely important and 1 least important. In addition, there were open-ended questions pertaining to the issues, barriers that impact on educational training of graduates and development of bio-based products. The survey was administered via

online. At the time of preparation of this manuscript, responses were received from 17 firms/organizations. The mean scores were calculated and responses to experiences and other questions were ranked. The companies that responded were some of the most well known/respected businesses in the field.

Profile of Firms: The 17 companies that responded were some of the most well known/respected businesses in the field located across the United States. Majority of firms (around 47 percent) identified themselves as manufacturing firms. Other firms (12% in each category) identified themselves as processing, service, biotech and energy related business types. Only one firm was involved in Research and Development. Fifty seven percent of the firms identified them as firms producing intermediate products while 7% were end use and 36% were biofuel related products. The intermediate products include liquid industrial sugar, plant oils, car parts, paper coatings, paintings, biolatex, enzymes, pulp etc. Most businesses (47%) were less than 10 years in the business. Twenty nine percent were in operation between 11-20 years while another 29% were in operation between 21-30 years. About 53% of the responding firms claim to engage in exporting goods. In terms of full time employment, 38% of the companies responded were having less than 25 full time employees while 25% of companies were having over 500 employees. The majority of firms (41.2 percent) had annual sales volume of $5 million. Another 35.3% of firms indicated having annual sales volume of less than $250 million. Only 1 firm had sales volume between $250 and $500. About 17.7% of firms had sales volume between $1 and $5 million annually (see table 1 for the details of the profiles of firms).

Employer Educational Needs

The results of respondents' evaluation of skills, knowledge and experience are presented in Tables 2 to 8. Both the rank order within each category and the rank order across the six categories are presented. In general, it should be noted that "skills", communication and interpersonal, (Table 5 and 6), tend to be given a higher rating than knowledge or experience. For example in overall rank ordering out of top ten rankings eight were in Tables 5 and 6. The highest rated characteristics was "use of general computer software", followed by ability to speak clearly, self motivation and ability to work in team environment. These results seem to imply that employers place a higher value on skills and personal attributes than knowledge and experience. Except several deviations in ranking orders, the above results were quite similar to the results of 2004 survey.

When asked to evaluate importance of different types of technical knowledge for employment, the respondents gave a high rating to biotechnology, processing of bio-based products, and knowledge of principles and processing equipment to handle solid feedback as they ranked them as 12, 18 and 23rd respectively in overall ranking (Table 2). Table 2, suggests knowledge of maximization of biomass production, environmental issues and energy fuels is also important.

In Table 3, five computer and quantitative skills are evaluated. Use of "general computer software" was rated as number 1, which was ranked 1st in overall ranking. "Use and interpretation of quantitative and statistical methods" was ranked second while "design and implement management information systems" were ranked third. These rankings indicate that the employers rank knowledge of computers and use of software as important qualities in their employees but they do not necessarily want them to be skilled

in modeling or other more complex uses. In evaluating business and economic skills, respondents gave a high rating to the ability to "solve complex problems" followed by the ability to "identify goals and objectives" for the firm and" knowledge of marketing of (bio-based) products" (see table 4 for details). Employers also rated management of risk and uncertainty and ability to read and use financial statements as important business and economic skills. Knowledge and understanding of food transportation and distribution systems, forecast economic business and agricultural trend, knowledge in international trade are some of the lowest rated skills in this category. These skills were all rated 47 or below in the overall ranking. Surprisingly the selling skills and use of accounting concepts were not rated high with an overall raking of 39 and 37 respectively. Similarly, "knowledge in international trade" was not rated high. Relatively low ratings for knowledge of international trade might simply reflect the views of firms that do not see a role for themselves in the international market place.

Table 5 shows the rank order of communication skills. Ability to speak clearly and write clear technical reports was the highest rated communication skills businesses were looking for. Among the 4 communication skill categories, communication with non-scientists and science related issues was categorized as the lowest rated skill.

Among the interpersonal characteristics businesses were looking for, self motivation, ability to work in a team/team player, and strong people skills were selected as highest rated interpersonal characteristics. Among the knowledge and understanding of health safety and environmental regulations, safety and efficiency of industry products and knowledge regarding impact of environmental regulations were rated high (10^{th} and

16th) respectively in the overall ranking. (Table 7). These findings reflect concerns businesses have about environmental and health regulations and how they affect their operations. It may also reflect that businesses are increasingly recognizing that customers are becoming more health conscious and demanding more safe and healthy environment.

The respondents were also asked to indicate sources used by them to collect information about bio-products and related issues. They also rated these sources in terms of their trustworthiness or how they perceive them to be less or more trust worthy. Mostly used (frequently) source of information was internet followed by "Word of mouth" (other businesses) and "trade magazines". Table 8 shows the percent of respondents indicating their perception of how much trust they place in listed sources of information for bio-products/biotechnology. Industry scientists were trusted highly by the largest percentage of respondents (64.7 percent) followed by university scientists (41.2 percent), farm journalists (35.3 percent), extension professionals (29.4 percent), government scientists (29.4) and health professionals (23.5).

When examining the six categories of knowledge and skills separately, the results of this survey parallel and tend to support the findings of the Litzenberg and Schneider (1988), Klein (1990) and Singh et.al (2000) in several areas. In particular, the results presented also give some of the highest ratings to interpersonal characteristics and not highly specialized skills. The ability to express ideas in writing and verbally, self-motivation, teamwork, leadership ability and strong people skills were rated as very high. In terms of technical knowledge, knowledge about application and process appear to be more important than more theoretical areas. Technical knowledge areas evaluated could

guide in developing curriculum and courses to train graduates to work for firms producing bio-products.

CONCLUSIONS

To prepare students for work place is a two-fold process: 1) providing education (knowledge, skills) and training necessary for a person to function in a competitive workplace, and 2) preparing students to behave in a professional manner. Educational institutions have the responsibility of installing professionalism in a student so they can work well in a real world situation and compete effectively. If the curriculum stresses only the acquisition of technical knowledge, at the expense of teaching students how to act professionally and react in a problem-solving context, institutions may not be preparing them to meet the demand of contemporary agribusinesses. Also, it is important that the technical knowledge needs to be more relevant and up-to-date. In the communication skills area, employers rated written, verbal expression, presentation skills, listening, and understanding instructions as very important. All personal character traits listed were very important to the employers. Heavy emphasis placed by employers on communication, interpersonal characteristics, team work, leadership etc. may raise questions about the way curriculum are structured in general at educational institutions. For example, subject matter specialization, acquisition of technical knowledge may be stressed more at the expense of developing skills to think independently and react in a problem solving context. Based on these findings, it is recommended that faculty/administration examine curriculum and include changes to suit for the newly

developing areas of bio-products. The following activities may assist in developing more relevant curriculum to benefit graduates and employers:

- Develop partnerships with businesses involved in bio-product manufacturing and providing services for inputs in the technical knowledge.
- Explore the adoption of senior projects, colloquia, or other avenues to acquire skills in communication, problem solving, and decision-making.
- Require more writing and presentation as part of the total degree program.
- Incorporate the use of computer skills with more course assignments.
- Incorporate more “hands-on” teaching in the classroom. Organize an interdisciplinary advisory committee (on- campus) to seek on-going input into the technical aspects of the curriculum.

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Table 1 Profile of bio-based products manufacturing firms

Category	Percentage of firms
Type of business	
Manufacturing	47%
Processing, service, biotech and energy	12%
Product type	
Intermediate products	57%
End use	7%
Biofuel related products	36%
Number of years in business	
<10 years	47%
10-20 years	29%
21-30 years	29%
>30 years	11.8%
Engage in exporting goods	53%
Full time employees	
<25 full time employees	38%
>500 employees	25%
Annual sales volumes	
1-5 million	17.7%
5-250 million	35.3%
250-500 million	5.8%
>500 million	41.2%

Table 2. Average Rating and Rank Order of Knowledge, Skills and Experience by Different Categories

Technical Knowledge or Other Related Skills-Category

Knowledge, Skill	Average Rating 2012*	S.D.	Overall Rank	Within Group Rank
Crop Production Systems	2.93	1.53	36	11
Bio based process and products	3.60	1.30	18	2
Food Science and Processing Technology	2.00	1.13	49	15
Knowledge of fermentation technology to improve the rate of fermentation yield and concentration of biobased products	2.79	1.67	41	12
Bio-Materials (such as soybean oils)	2.71	1.27	43	13
Energy fuels (Solid, Liquid, Gaseous)	3.00	1.36	34	6
Biotechnology-Basic Understanding	3.21	1.31	24	8
Livestock production systems	2.93	1.21	35	16
Bio-Science/Biotechnology/Biochemistry	3.81	1.33	12	1
Integrating biology and engineering	3.13	1.41	29	6
Genetics of plants and bacteria that will improve understanding of cellular process	3.21	1.76	26	10
Evaluating sustainability/environmental issues	3.00	1.15	33	5
Bio-chemicals (Agricultural Chemicals)	3.07	1.39	30	7
Protein engineering methods to allow the design of new bio catalysts and novel materials for the biobased industry	2.36	1.39	46	14
Knowledge of principles and processing equipment to handle solid feedback	3.25	1.39	23	3
Physiology and biochemistry of plants and microorganisms directed toward modification of plant metabolism and improved bioconversion process.	3.21	1.42	25	9
Knowledge of maximization of biomass production	3.06	1.12	31	4

*Represents a weighted average of respondent evaluation of attributes on a 1-5 scale with #5 representing highest level of importance and #1 representing least important

Table 3. Average Rating and Rank Order of Computer, Quantitative and Management Information Skills

Skill	Average Rating 2012	S.D.	Overall Rank	Within Group Rank
Use computers in problem solving and decision making	3.31	1.25	20	4
Design and implement Management Info Systems	3.31	1.08	19	3
Use of general computer software	4.63	0.50	1	1
Use and interpretation of quantitative and statistical methods	3.75	0.68	13	2
Computer modeling in Agricultural Projection	2.44	1.59	44	5

Table 4. Average Rating and Rank Order of Business and Economic Skills

Skill	Average Rating 2012	S.D.	Overall Rank	Within Group Rank
Markets and Bio-based products	3.67	1.11	15	3
Knowledge and Understanding of food transportation and distribution systems	2.29	1.33	47	15
Knowledge and understanding of economics of general economy	2.88	0.89	38	7
Understanding U.S. agricultural policy	2.80	1.61	40	
Knowledge and understanding of the business firms	3.20	1.01	27	6
Identify goals and objectives for the firm	3.69	1.14	14	2
Coordinate Human/Physical resources	2.75	1.34	42	9
Read and use financial statements	3.31	1.25	21	5
Solve complex problems	3.81	0.98	11	1
Knowledge in international trade	2.00	1.26	50	13
Evaluate programs and policies	2.43	1.34	45	12
Forecast economic business and agricultural trend	2.20	1.08	48	14
Selling skills	2.87	1.46	39	10
Identify and manage risk uncertainty	3.19	1.22	28	4
Understand and use basic accounting concepts	2.88	0.96	37	8

Table 5. Average Rating and Rank Order of Communication skills

Skill	Average Rating 2012	S.D.	Overall Rank	Within Group Rank
Speak clearly	4.63	0.50	2	1
Communication with non scientists and science related issues	4.00	0.63	8	4
Work without supervision	4.19	0.75	6	3
Write clear technical reports	4.38	0.62	5	1

Table 6. Average Rating and Rank Order of Interpersonal Characteristics

Characteristic	Average Rating 2012	S.D.	Overall Rank	Within Group Rank
Self motivated	4.56	0.51	3	1
Provide leadership	3.88	0.72	9	4
Able to work in team/team player	4.56	0.63	4	2
Experience in multidisciplinary team approaches to research	3.63	1.02	17	5
Strong people skills	4.13	0.96	7	3

Table 7. Average Rating and Rank Order of Health Safety and Environmental Regulations

Knowledge -Understanding of	Average Rating 2012	S.D.	Overall Rank	Within Group Rank
Environmental regulations and how they affect the firm's operation	3.63	0.89	16	2
Safety and efficacy of industry products	3.81	0.83	10	1
Knowledge of biotechnology issues, including ethical, Environmental, sociological and legal	3.31	1.30	22	3
Health ramifications of bio-based agriculture	3.06	1.18	31	4

Table 8. Informational Sources Used by Respondents and Percent of Respondent Indicating Degree of Trust.

Source	Degree of trust as a source of bio-products/ biotechnology information (%)			
	Do not Trust	Low Trust	Moderate Trust	High Trust
Farm Journalists	0	17.7	47.1	35.3
Energy/Biotechnology industry scientists	0	5.9	29.4	64.7
Consultants	5.9	17.6	64.7	11.8
Mill/Processor personnel	0	11.8	52.9	0
Company Sales representative	5.9	58.8	35.3	0
University Scientists	0	5.9	52.9	41.2
Extension Professionals	0	0	64.7	29.4
Government scientists	0	11.8	52.9	29.4
Family/Friends	5.9	41.2	35.3	0
Producer Groups	0	29.4	58.8	17.6
Consumer Groups	0	64.7	35.3	0
Environmental Groups	11.8	52.9	35.3	0
Political Officials	11.8	82.4	5.9	0
Health Professionals	11.8	23.5	41.2	23.5
Regulatory agency officials	5.9	29.4	47.1	17.6
Advertisements	35.3	52.9	5.9	0