FELLOWSHIP SUMMARY REPORT

Name of research fellow:
Takahiro Yoshida

Affiliation of the fellow:
Forestry and Forest Products Research Institute (FFPRI),
Forest Research and Management Organization, Japan

Subject title:
Establishment of value-adding products from woody biomass toward low carbon emission

Theme number:
Theme 3, Transformational Technologies and Innovation

Host institution:
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Leipzig, Germany
(German Biomass Research Center)

Host of collaborator:
Dr. Volker Lenz, Head of Thermochemical Division

Dates of your fellowship:
21 July to 7 December, 2019 (20 weeks)

Consent:
I consent this report being posted on the Co-operative Research Programme's website.

1. What were the objectives of the research project? Why is the research project important?

The mitigation of the fossil fuel industry following the beneficiation of renewable resources is important to achieve low carbon emissions. Biomass consists of the organic matter within renewable resources and has the advantages of storage, control, and reproduction. Woody biomass offers the advantage of stable supply owing to the absence of conflict with food utilization. To establish the local forestry economically and sustainably while achieving energy independence toward low carbon emission, we must obtain high-value products from woody biomass and efficiently utilize the energy from its processing residue. Effective use of ash obtained from biomass fuel as fertilizer provides an advantage to decrease fertilizer cost and improve agricultural production and incomes. Thus, bioproducts, bioprocessing, and the supply chain can be established in the region and sustainability in forestry and bio-economy can be achieved. However, the use of wood for material and energy has some disadvantages because of its sensitivity to biodegradation and lower energy content compared with fossil fuels.

Wood energy from fuelwood and charcoal that is mainly used for cooking and heating emits 1.0-2.4 Gt of CO_{2eq}/y, which is 2-7 % of the total manmade GHG emissions. However, the efficiency of traditional charcoal kiln is 10-22 % at most (FAO, 2017). Increasing charcoal yield is one of the possible mechanisms to improve the situation. Torrefaction is the mild carbonization of biomass at 250-300^{o}C that improves hydrophobicity and durability without causing severe decomposition. This method has been used to provide better fuel quality for large scale power generation, but the use of high-value products in small scale applications would present better economic opportunities.

The objective of this project was to establish a new bio-economy model to lower carbon emissions and examine the use of novel bioproducts and smart energy utilization systems in the industry by introducing torrefaction.

1. Sophistication of converting value-added bioproducts via the torrefaction process

   To create high-value products from forest resources in the local community, methods of obtaining high-value products by torrefaction in combination with other procedures were studied.

2. Efficient usage wood processing residue for ultra-microsmart energy utilization

   To mitigate the carbon emission in households, the feasibility of the ultra-small smart bioenergy utilization system using non-torrefied and torrefied wood fuel was investigated.

3. Design of bio-economy model to promote woody biomass in local community

   Together with the knowledge obtained from the laboratory experiments and on-site survey for the commercial bioproduct and small bioenergy plant, integration of the value chains of production using different sources of woody biomass, including wood residue from forestry, and establishment of wood processing was conducted. Using this information a new bio-economy model aiming at lowering carbon emissions was designed.

2. Were the objectives of the fellowship achieved?

Objectives are being achieved. First, the role of torrefaction in making charcoal and upgrading the value added by products in a laboratory-scale experiment was conducted. Some of the data was already presented at a conference. Also, the fundamental properties of non-torrefied wood fuel during the gasification process prior to the usage of micro CHP (Combined Heat and Power) operation were examined. The gasification demonstration experiment using torrefied fuel will be conducted by DBFZ in early 2020 because enough preparation of wood fuels could not be achieved within a shorter period.

3. What were the major achievements of the fellowship? (up to three)

1. Sophistication of converting value-added bioproducts via the torrefaction process

The torrefaction method was used to enhance the efficiency of the charcoal making process. Through the combination of torrefaction and subsequent heating control, shorting of carbonization period without severe mass loss compared to conventional charcoal making was achieved. The biochar obtained from using these methods showed some advantages in usage such as activated carbon. In addition, by omitting the charcoal making process, torrefied material showed advantages in material usage, such as for pavement and heat insulation purposes.

2. Efficient usage wood processing residue for ultra-microsmart energy utilization

From the thermogravimetric and chemical analysis, the differences in reactivity of the gasification process were found between Japanese wood and German wood fuels. These findings were quite useful for the design and operation of the micro CHP unit.

3. Design of bioeconomy model to promote woody biomass in local community.

The value added to the chains of production via torrefaction of different sources of woody biomass, including wood residue from forestry, was simulated and used to propose a wood processing and new bio-economy model, named "ToMoECO," aimed toward lowering carbon emission. The model would be economically feasible with some policy incentives and it could not only improve the economy in the local community, but it would also use biofuel in the global agricultural supply chain, promote green growth from the efficient use of renewable bioenergy resources, and allow the sustainable use of forest production. Torrefaction is a traditional method but it could be used as a novel technology to convert value-add products from biomass in the local community.

4. Will there be any follow-up work?

・Is a publication envisaged? Will this be in a journal or a publication? When will it appear?

Part of the results was already presented at the conference (Takahiro Yoshida, Jasmin Boße, Volker Lenz, "Novel Torrefaction Technology for value-adding products from woody biomass toward low carbon emission," Status Konferenz, September 16-17, 2019, Leipzig, Germany). A manuscript will be submitted to a journal after finishing some additional analysis.

・Is your fellowship likely to be the start of collaboration between your home institution and your host?

This fellowship enhanced the collaboration between FFPRI and DBFZ.
We are planning to apply for additional funds for future co-operative research.

・Is your research likely to result in protected intellectual property, novel products or processes?

The objective of this study is to effectively promote the use of woody biomass in the local community. Thus, our results might not result in protected intellectual property, novel products or processes.

5. How might the results of your research be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

This study will advance the scientific knowledge of bioproducts and bioenergy in combination with the torrefaction process. With this process, the bio-economy model for the conversion of local woody biomass into valuable bioproducts and efficient use of this energy is established. This model will affect future policies regarding biofuel in the global agricultural supply chain, promote green growth from the efficient use of renewable bioenergy resources, and increase the sustainable use of forest production.

6. How was this research relevant to the objectives of the CRP and the research theme?

This study will create a pathway to obtain more valuable bioproducts from torrefied wood, use micro-CHP technologies (SmartBiomassHeat) from torrefied wood residue fuels, and establish the economical utilization model. In doing so, this research will provide the basis for understanding that torrefaction allows wood to be converted more easily into value-adding products and it will provide more efficient energy utilization by using the micro-CHP system. Thus, the results of this study will contribute to the understanding of the biological process involved in the development of the effective production chain of bioproducts and the bio-economy.

7. Satisfaction

・Did your fellowship conform to your expectations?

Yes. This fellowship exceeded my expectations. I had a very fruitful experience studying in an excellent environment in DBFZ. I would like to thank the host and all my colleagues in DBFZ for their sincere support during my research and my stay. It also gave me an excellent opportunity to strengthen existing collaborations and expand my network not only with DBFZ researchers but also with other researchers and engineers in Germany though joining conferences and participating in site tours of the commercial CHP plant and exhibition.

・Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities?

Yes. I am in my late forties and work in a chief position in the laboratory at my institute. No limitation of age in this fellowship program is one of the reasons I wanted to apply to the program. I gained a deeper understanding of the thermochemical properties of woody biomass from the fundamental and practical viewpoints during the stay in DBFZ. The fellowship experience was also very valuable in terms of making future research strategies and frameworks while working in a chief position at my institute. I think the OECD Co-operative Research Programme fellowship increased my carrier opportunities.

・Did you encounter any practical problems?

No.

・Please suggest any improvements in the Fellowship Programme.

It would be more useful to summarize the main features of this program on the top page of the website (no limitation of age, sincere support on the application and so on.).

8. Advertising the Co-operative Research Programme

・How did you learn about the Co-operative Research Programme?

I learned about this fellowship from FFPRI and the details from past fellows in FFPRI and NARO, Japan.

・What would you suggest to make it more "visible"?

As mentioned in Chapter 7, it would be more useful to summarize the main features of this program on the top page of the website (no limitation of age, sincere support on the application and so on).

・Are there any issues you would like to record?

I am greatly appreciative of the advisory body and secretary of the OECD Co-operative Research Programme for giving me the opportunity to expand my knowledge and to collaborate with FFPRI and DBFZ throughout this Fellowship program.