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Bio-coal market study: Macro and micro-environment of the bio-coal business in Finland

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ABSTRACT

The general purpose of this paper is to determine the current situation of the Finnish bio-coal sector, and outline a comprehensive picture of the macro and micro-environment related to bio-coal in Finland, as well as to propose, with the help of a SWOT analysis, guidelines and hypotheses regarding how the Finnish market should improve the bio-coal business for the future. The major findings of the study are: 1) the major strength of the Finnish bio-coal sector is its secured biomass supply, higher environmental credentials, and supportive policies. The clear implication here is that the entrance requirement for the bio-coal business is relatively low, “early birds” with foresight will win out; 2) the current weakness of Finnish bio-coal development is undeniable. As an entirely new business, bio-coal does not have a clear development model, which can be attributed to the little market information available, non-viable economic structure, and distribution channels which are not yet available. We would like to advise Finnish companies to work out the cost structure, profit feasibility of the bio-coal business and construct a practicable and sustainable biomass supply system; 3) the opportunities of the Finnish bio-coal sector come along with the national sustainability development policies and construction of a bio-economy. We would suggest that they focus on decentralised local economic sales, biomass supply and energy end use; 4) the crucial threat to the bio-coal sector industry comes from competition with fossil coal and other wood-based biofuels. Improving its competitiveness requires cooperation and integration along the whole supply chain.

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1. Background

Nowadays, there is a pressing need for renewable/sustainable energy solutions to deal with the extreme challenges humanity faces, such as pressure of population expansion, a

dwindling stock of fossil fuels and other non-renewable resources, deterioration of environmental health and ecological balance, and a globally intensive process of industrialization which make heavy demands on energy resources. In line with the concept of sustainable development, sustainable energy solutions should embody economic, social and environmental

Abbreviations: SWOT, strength, weakness, opportunity, threat; HTC, hydrothermal carbonization; PVO, Pohjolan Voima; CHP, combined heating and power; ISO, International Organization for Standardization; RES, renewable energy strategy; GDP, gross domestic product; R&D, research and development; GHG, greenhouse gas; PAH, polycyclic aromatic hydrocarbons.

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issues, and meet the present energy needs without compromising the ability of future generations to meet their own energy needs [1]. Its renewability and higher environmental credentials has meant that bioenergy has been strongly promoted by scientific institutes and governments as a crucial solution, because substituting bioenergy for fossil fuels can reduce carbon dioxide emissions, mitigate the greenhouse effect, alleviate oil dependence, improve energy security, and conserve non-renewable resources [1,2].

Wood-based bioenergy has a significant role in the renewable energy sector in Finland, because of its substantial forest resources, developed forest industry and the well-established forest infrastructure. Finland is one of the leading countries in the production and utilisation of wood-based bioenergy. About one-fifth (85 TWh) of Finnish energy consumption is currently based on wood-based bioenergy, and Finland plans to extend this to 30% of total energy consumption (99 TWh) by 2020 [3].

There are many academic papers focused on Finnish wood-based energy in general; for example, Hakkila [4] outlined the forces driving this industry. Ericsson et al. [5] studied the related policy and its market development, and compared the Swedish market. Heinimö [6] discussed the trade in solid and liquid wood-based biofuels in Finland, While Heinimö and Alakangas [7] explored the Finnish wood-based biofuel market. There are also many studies focused on specific products such as wood pellets [8–11], wood chips [12,13], wood biomass [14–16], and firewood [17–19].

However, little attention has been paid to the Finnish wood-based bio-coal product and market. Bio-coal is new and has only partially emerged from the research stage [20]. Until very recently, the commercial production of bio-coal for industrial applications had only been launched in a small number of countries such as The Netherlands, Belgium, France and the US [21]. In Finland, there is no industrial market for bio-coal as yet. Some Finnish institutions and companies have engaged in product development and business launching programmes. At the beginning of this year, a proposal was announced to build the first large-scale torrefied pellet factory in Ristiina with an annual production capacity of 200,000 t [21]. Hence, a pioneer study on the Finnish bio-coal sector is urgent and important.

This study is intended to enhance the understanding of the challenges and opportunities of the bio-coal business in Finland. Its general purpose is to identify the current situation of the Finnish bio-coal sector, and outline a comprehensive picture of the macro and micro-environment related to bio-coal in Finland, as well as use a SWOT analysis to suggest guidelines and hypotheses regarding what the Finnish bio-coal business market should improve for future. The research questions are as follows:

- 1) What is the current state of the bio-coal business in Finland?
- 2) What are the current drivers and expected changes in the macro and micro-environment of the bio-coal business in Finland?
- 3) What are the strength, weakness, opportunities, and threats in the bio-coal macro and micro-environment in Finland?

The next part defines the terminologies associated with bio-coal and introduces the theoretical framework for the study.

The third part examines the macro and micro-environment related to the bio-coal sector in Finland. The fourth part summarizes all the important factors and analyses them using a SWOT matrix. Finally, this article will provide some future perspectives and suggestions about bio-coal development in Finland.

2. Theoretical background

2.1. Definition of bio-coal

The definition of bio-coal is rather imprecise at the moment, there being no generally accepted definition. Many interrelated terms have been used, such as charcoal, bio-char, char, torrefied wood, torrefied pellets, green coal, black chips, black pellets, and so on. There is also a variety of terms in Finnish, including *puuhiili*, *grillihiili*, *TOPpelletti*, *torefointi/paahdettubiomassa*, *biohiilipelletti*, and *biocarbon*.

Rautiainen et al. [22] defined bio-coal as a solid fuel made from biomass in a pyrolysis process (by heating in an inert atmosphere). Depending on the process conditions, the resultant solid product is either charcoal (process temperature above 320 °C) or torrefied wood (if the process temperature is between 200 and 300 °C). Both of these products are bio-coals. Tremel et al. [23] and Erlach et al. [24] interpreted bio-coal as a coal-like substance which been converted from raw biomass in an artificial coalification process called hydrothermal carbonization (HTC). Borison et al. [20] claim that “Bio-coal is a fuel produced from biomass, whose physical and chemical properties have been changed so it looks and acts to a large degree like coal.”

According to Agar and Wihersaari [25], bio-coal (or green coal) is a fossil coal substitute which is produced from renewable biomass resources in the process of torrefaction. They describe the three major properties of bio-coal as it being 1) a fossil coal substitute with high heating value; 2) having high bulk energy density, and being easy to transport, store and process; 3) having handling properties like fossil coal, such as being easy to grind. Another similar definition is that bio-coal is a dried and enhanced biomass product produced by torrefaction [26]. The Finnish consulting company Pöyry considers that bio-coal is a name for charcoal which is created by pyrolysis of biomass [27]. Fageräs et al. [28] illustrated the compositions of bio-coal produced in the slow pyrolysis process, including the primary solid product – char or charcoal, and by-products – distillates and gases.

In summary, the term bio-coal has been defined as an umbrella concept which covers all solid thermally degraded biomass products produced in the process of pyrolysis, including torrefaction and hydrothermal carbonization with different features and applications. In the context of this paper, we accepted the umbrella view of the term, but with a focus on the solid product and medium and large-scale industrial applications such as replacing fossil coal in coal-fired power plants.

2.2. The macro and micro-environment

The theoretical framework to guide the market information environment analysis is modified on the basis of Hansen and Juslin's information environment model [29], and it includes

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