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Research paper

Evaluation of wood pellet handling in import terminals

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ABSTRACT

Wood pellet imports are expected to increase in the European Union and Southeast Asia by 2030, considering pellets are the main feedstock used for co-firing in power plants throughout these regions. Due to the material's physical and biological properties, the equipment at an import terminal need to be different than what is used for other bulk material. Thus, most of the common problems associated with handling can be avoided. Dust emission and explosions, degradation in storage, self-heating and ignition are important criteria when designing a wood pellet port terminal, and can greatly affect associated logistics. Despite some availability of data concerning the handling of pellets, there is a lack of insight into the equipment and operations of actual handling facilities. A detailed literature research was performed in order to ascertain the level of the scientific background on the subject. Subsequently, visits in pellet facilities in the Netherlands and in-depth interviews with representatives were conducted and serve as a means of gaining an overview of current industry practices and equipment used for the handling of wood pellets. The main objective of this work is to evaluate the state-of-the-art in wood pellet handling in import terminals. This way, future bottlenecks can be identified and actions needed to overcome them can be determined. The analysis performed shows that while wood pellet terminals might be able to cope with the low amounts being traded currently, a reexamination and redesign of terminal facilities to accommodate the increased volumes will probably be required by 2030.

1. Introduction

Biomass used for energy purposes (bioenergy) is expected to increase in final energy consumption in all the European Union Member States (MS). In 2014, bioenergy consumed in European Union (EU) amounted to 61% of the total renewable energy consumption or 4416 PJ, and 10% of the gross final energy consumption. Use of biomass was concentrated mainly in the heating sector (88% of total renewable heating), but with significant contributions to electricity production and transport fuels [1]. Although this share is expected to decrease by 2020 to a total of 57% [2], due to the development of other renewable sources such as wind and photovoltaics (PV), the actual amount of biomass for heating, electricity and transport is expected to rise to 5860 PJ [1].

The largest part of EU biomass supply is and will be based on domestic sources; currently, 4% of the total biomass used for energy purposes is imported. However by 2030, this amount could substantially increase, taking into account potential supply gaps, especially in the industrial sector (electricity production, closing down of coal power plants) [3,4].

Specifically, wood pellet use in the EU is expected to grow in sectors such as co-firing in coal power plants and residential heating in the short-term future, and possibly in the form of high quality industrial heat in the long-term future [4]. The majority of the wood pellets consumed will be imported, as many of the EU members lack the industrial tradition of wood processing on the one hand, and import of wood pellets from overseas seems to be more economically efficient than road transportation, even from neighboring countries [5]. In the Netherlands, the use of wood pellets in coal-fired power plants will be ramped up to approximately 25 PJ by 2020 [6]. This corresponds to approximately 3.5 Mt of imports, since the country has been relying on them in order to reach the renewable energy target for electricity production [7], and is expected to rely on them for the foreseeable future. Concurrently, Belgium consumed more than 1.5 Mt of wood pellets in 2015, almost exclusively imported. Similarly, Denmark consumed 2.6 Mt of imported wood pellets in 2015 [8]. In total, the 3 countries are expected to consume more than 11 Mt by 2025 [9]. Accordingly, the bulk port terminals in the Amsterdam-Rotterdam-Antwerp (ARA) region will have to accommodate the increased flows of wood pellets.

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List of acronyms

EU	European Union
MS	Member State
PV	Photovoltaic
ARA	Amsterdam-Rotterdam-Antwerp region
RPS	Renewable Portfolio Standard
ISO	International Organization for Standardisation
DEM	Discreet Element Method
CSU	Continuous Ship Unloader
ATEX	Atmosphères Explosibles (Explosive Atmospheres)
RFID	Radio-frequency Identification
UN	United Nations
OECD	Organization for Economic Co-operation and Development
CIF	Cost, Insurance and Freight

Measurement units

J	Joule
t	tonnes
m	metre
kg	kilogram
m^3	cubic metre
^{o}	degree angle
K	degrees Kelvin
s	second

At the same time, Japan and South Korea are set to become two of the largest wood pellet consumers in the world. Japan is looking to shift from a dependency on fossil fuels to renewable energy sources, and aims for biomass to comprise 20% of its renewables generation by 2030 [10]. The Japanese government recently approved regulations that allow major utility companies to benefit from the national feed-in-tariff. Wood pellet imports to Japan reflecting this policy change are expected to start in 2018 [8]. Canada is currently Japan's biggest source of wood pellets, supplying approximately 63% of Japan's imports in 2015 [11]. Similarly, South Korea aims to increase its wood pellet use through the Renewable Portfolio Standard (RPS) [12]. Having Vietnam as a primary supplier of biomass, South Korea could reach more than 8 Mt of wood pellet demand by 2025 [9]. Combined, these two countries could require more than 17 Mt of wood pellets by 2025, most of which will need to be covered by imports [11,13]. Overall, Asia is expected to provide one of the largest future growth opportunities in the medium-to long-term, leading to similar challenges for port facilities as in the EU.

Wood pellets are regarded as a bulk material, as they are mostly transported in large quantities. However, compared to traditional dry bulk materials, such as coal, grain and iron ore, wood pellets have other unique demands for handling, transport and storage, regarding for example prevention of degradation and moisture uptake [14]. Use of unsuitable equipment or careless treatment can damage the product or constitute major health and safety hazards. This constitutes the main issue with wood pellet terminal facilities: in order to optimize the handling procedures, the equipment and techniques at the respective terminals need to cope with the materials' specific properties. This is only realized to a limited extent at the moment; since the volumes currently being moved in the EU are low, they do not necessitate investments in specialized infrastructure.

The notable exception to this is the UK, where utility company Drax consumed 50% of the 2016 global industrial pellet demand of 13.6 Mt [15]. Drax is serviced by four ports, where dedicated biomass equipment and infrastructure is used to handle the incoming wood pellets, mainly from the Southeast US [16,17]. However, this required years of development of an expansive, specialized freight and logistics infrastructure dedicated to the import, storage and delivery of wood pellets (such as their high volume rail wagons [18]), and more than 284 million euros of investments (250 million pounds[1]) [19]. Drax and the UK situation in relation to wood pellets represent an extreme end of the spectrum of pellet imports and it is not representative of the EU or Asian import terminal situation. While some terminals may come close to that range, especially if they function as a hub import terminal like stated in the following paragraph, achieving the scale of Drax's facilities is not going to manifest for the short to medium term future. However, the lessons to be learned by the UK's experience when handling wood pellets can support import terminals around the world in decision making regarding biomass infrastructure setup and investments.

As an example, du Mez [20] states that the Port of Rotterdam aims to handle 8–10 Mt of wood pellets by 2020, and as such assume a hub role for biomass imports to the whole of Northwestern Europe [21]. This could have a range of implications for the receiving bulk terminals; existing infrastructure might have to be adjusted in the short term, while larger scale and elaborate infrastructure will be required in the long term future. Extended periods of development will be needed for most of these actions. Generally, even minor changes in a port terminals' design and operations require considerable investments in numerous elements of its setup. It is therefore crucial to have a comprehensive understanding of wood pellet terminal equipment setup and operations before any substantial commitments are made.

Despite numerous technical reports offering detailed advice on handling and storage of solid biomass in general [22–24], there is little information to be found in scientific literature considering a state-of-the-art approach in a real-world industrial setting. Several researchers have investigated different aspects of the subject: Rossner et al. [25] have researched the CO monitoring of small scale wood pellet storage for residential or small building use, and Proskurina et al. [26] looked into the bulk handling of wood pellets in export and import ports, for which the authors state that specialized equipment is required. The mechanical degradation of wood pellets during indoor and outdoor storage was examined by Graham et al. [27], albeit on a small scale. Graham et al. [28] also performed research on the mechanical properties of wood pellets in a laboratory environment. The most comprehensive and recent account of wood pellet handling and storage comes from Bradley and Carbo et al. [29,30], offering advice on selecting equipment when dealing with pellets, considerations when setting up a project, and future trends. Ilic et al. [31] provide the most recent and complete aggregation of key design parameters for solid biofuels in general, as well as suggestions on how to approach biomass handling systems design. Thus, research so far has examined different aspects of the wood pellet handling and storage infrastructure. However, the conclusions are either based on too small a scale, or they come in the form of general rules of thumb for design and use of equipment and methods. As such, most of the up-to-date scientific literature lacks a perspective of actual large scale, bulk pellet handling. Consequently, informed decisions regarding import terminal developments might be lacking. An in-depth analysis and assessment of receiving terminals has not been performed so far in a scientific article.

The main objective of this article is to assess the state-of-the-art in wood pellet handling in import terminals. After a comprehensive understanding of the current status in the particular research field is gained, the goal of providing advice on import terminal design changes is also explored. Potential future bottlenecks that might hinder wood pellet handling in import terminals are identified and suggestions to overcome these hurdles are provided.

[1] Based on the exchange rate of 1 GBP = 1.13497 EUR on December 5th, 2017.