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Research paper

New biomass products, small-scale plants and vertical integration as opportunities for rural development

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ABSTRACT

The study surveyed eight small-scale operations designed to produce wood pellets and microchips, the latter intended as a low-price pellet surrogate. Surveyed operations were equally spread between the two product types, and they all targeted residential users. They were all run by forest owners or forest contractors, driven to the new business by the need to increase the value of low quality wood and to fill the gap created by a dwindling firewood demand. Production cost averaged 228 € t^{-1} for pellets (9% water mass fraction) and 134 € t^{-1} for microchips (water mass fraction between 11 and 18%). For each process type, three entrepreneurs out of four accrued meaningful profits, estimated at 10% and 6% for pellets and microchips, respectively. However, profitability differences between the two production chains were deprived of statistical significance. Raw material cost accounted for 28% and 50% of total cost respectively for pellets and microchips, and it was significantly lower for forest owners. Product drying was always obtained with renewable energy sources, such as wood or solar radiation. The most important success factor reported by all entrepreneurs was direct sale to final users, without intermediation. Additional success factors were: self-construction, use of unutilized resources at marginal cost, control of raw material supply and capture of opportunity wood. Entrepreneurs who ceased operation attributed their decision to the lower cost of imports, the absence of a receptive market and the higher profitability of alternative products.

1. Introduction

The consumption of wood pellets has increased very rapidly in recent years, exceeding 18 million t in 2014 [1], and scholars predict further dramatic growth by year 2020 [2]. That is the consequence of a resolute EU bioenergy policy, aimed at curbing on greenhouse gas (GHG) emissions [3]. In order to decrease GHG emissions, both the EU as a whole and the individual member states support bioenergy through a mix of subsidies, tax exemptions and mandatory targets [4].

The growing unbalance between supply and demand has generated a lively global trade, where biomass is shipped to Europe from wherever it is available at competitive cost and quality [5,6]. Pellets are especially suitable for long-distance transport, due to their high energy density and market price, and it is estimated that 50% of the global pellet production is the object of cross-border trading [7]. That includes a substantial flow of pellets from outside the EU and into her borders, since the EU represents 85% of the global pellet consumption, but only 60% of production [8]. Canada and the US are currently the main suppliers [9], also because long-distance sea transportation seems more efficient than road transportation between European countries [10].

Compared with other solid biofuels, pellets offer a number of advantages, and especially homogeneity and high energy density. These qualities make pellets the ideal fuel for small-scale boilers, as those used in residential heating. For the same power output, pellet plants are simpler, cheaper and smaller than chip-fed plants, while more convenient than firewood installations that cannot be automated. It is not by chance that Italy is the largest global consumer of pellets in residential heating applications, with an annual demand estimated at 1.4 million tons. This large demand is matched only in part by national production, quantified at 0.8 million t and largely supplemented by imports [11].

Three main factors contribute to the extraordinary success of pellet plants on the Italian market. First and foremost, the very large population of Italy makes residential heating a mass market, which magnifies the effect of any trends, including the current shift towards bioenergy. Second, the Italian gas prices are among the highest in Europe [12], which explains the search for alternatives. Third, the mild climate of Southern Europe limits heating hours below the threshold required

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for the effective depreciation of capital-intensive solutions, such as those offered by chip-fed plants and district-heating systems [13]. Furthermore, any radical changes of the household heating system are best effected within the scope of new building projects [14], but the housing industry has been the worst hit by the recent economic crisis with the consequent slump in new construction projects.

At present, most Italian households are heated through individual boilers fired with natural gas, which is distributed by a dense pipeline network. Until now, the main alternative has been traditional firewood, which is still immensely popular and reaches an estimated annual consumption above 18 million t [15]. Firewood logs are burned in simple stoves and boilers, that are relatively inexpensive but offer little convenience. In contrast, pellet heating systems offer the convenience of automated operation, while remaining still cheaper than natural gas systems. That is especially significant against the background of an aging population, with an increasing aversion towards heavy tasks, such as the management - and often the harvesting - of firewood. In short, wood pellet systems offer the ideal combination of low capital investment, affordable fuel and convenience that best suits the Italian market for residential heating and explains their overwhelming success.

This success is gained at the expenses of traditional firewood, and that may not be a negative thing for itself, since traditional firewood installations are flawed with low energy efficiency and high emission levels [16,17], and pellet plants offer a marked improvement in that regard [18]. However, firewood is generally sourced in the immediate vicinities, supporting local entrepreneurs and forest owners [19], which is seldom the case of pellets. One of the goals of the European bioenergy strategy is to support rural development within the EU [20], and the rapid shift from firewood to pellet seems to defy it. In fact, the decreasing demand for firewood represents a challenge for an already fragile forest economy. Rapidly decreasing profits have favoured irregular operators, who cut corners by evading taxes and hiring illegals. While the presence of irregular operators is endemic in many rural economies [21], the crisis of firewood has exacerbated the issue until it has become a main challenge for most regular operators, who are being forced to leave the firewood business [22].

Therefore, the question is whether small-scale forest entrepreneurs must only incur damage from the expanding pellet sector, or if they can still obtain some benefits from it. One of the ways in which they can obtain some advantage is if they can offer viable fuel for the growing number of pellet stoves and boilers operated in the country. The goal of this study is to explore such opportunities, and in particular: the production of viable pellets in small-scale plants or the production of microchips, as a low-cost surrogate for quality pellets. The focus of the study is on initiatives launched by forest enterprises, alone or in partnership with some other parties. For this reason, the study excludes projects managed by other company types that have no direct connection with raw material production, but are managed by industrial or capital concerns and buy the wood raw material on the market.

2. Materials and methods

2.1. Pellet manufacturing plants

In the years between 2005 and 2010, when the market for pellets first started expanding in Italy, many companies considered installing a pellet manufacturing facility fed with the primary wood resource rather than sawmill residues. A number of feasibility studies were performed in order to gauge the potential of such endeavor. Most studies returned a negative forecast, further confirmed by the premature closure of a few plants commissioned in those years. Shortly afterwards, few small-scale local forest entrepreneurs cautiously started experimenting with the same concept, but on an even smaller scale. Today, an increasing number of small-scale pellet manufacturing plants fed with log material is operating successfully, and this study surveyed four such plants spread over much of Northern and Central Italy (Fig. 1).

All the plants in this study have a capacity below 1 t pellets h^{-1} and are fed with forest products or by-products, not sawdust or shavings. The sample covers a relatively wide range in plant size, capital investment and annual production (Table 1). All pellet plants in this sample deliver a standard product, matching the quality specifications set for commercial pellet (6 or 8 mm diameter, 9% moisture content). As customary for any commercial pellet plant, the plants in this study are equipped with one or more refining mills and with a dryer, which is fired with chips, pellets or firewood - never with gas or other fossil fuels (Fig. 2). The availability of refining mills, makes screening unnecessary. No debarking facility is included, because most operations use thin-barked hardwood logs, and those that also use conifer logs keep them in storage for at least one year in order to reduce moisture content and favor the loosening of bark, which is easily shed during handling.

2.2. Microchip plants

The term “Microchip” describes a very small (7 mm target length) homogeneous wood chip product that can be used to feed conventional pellet stoves and boilers, usually after minor modifications of the feeding system and a resetting of the combustion controls. Microchip production matches the need for replacing industrial pellets with a new product that can be manufactured by small enterprises, using locally available raw materials and low-investment technology.

Microchips cannot match the quality of pellets in terms of high energy density, extremely low moisture content and regular piece size: however, microchips are still dry, dense and homogeneous enough for feeding stoves and boilers that were originally designed for pellet fuel, and that are much cheaper to purchase than an equally powerful plant designed for accepting conventional wood chips. In fact, some manufacturers have developed new pellet plant models specifically adapted to feeding with microchips, which feature innovative moving grates (e.g. CS Thermos) and/or new and wider feeding ducts, often designed for feeding the fuel from below the grate (e.g. DielleItalia, Nemec Srl etc.). In fact, microchip operators 1, 3 and 4 (as well as pellet operator 1) offer their customers the full package, inclusive of fuel and adapted heating plant. In particular, operator Microchip 3 is a joint-venture between a logging company and a heating plant dealer, where the heating plant dealer took the initiative with the intent of producing their own microchips as part of a farseeing strategy aimed at selling their microchip plants with a guaranteed supply of fuel at competitive price.

While pellets are a standardized product, there are no standards defining microchips, although when they are quality certified (operators Microchip 3 and 4) the certificate makes reference to chip quality Class A1 +, according to standard UNI EN ISO 17225–1: 2015 (Table 2).

The microchip operations in this study are even more diversified than the pellet operations, representing a very large variety in capital investment (from 1500 to 345000 €), production capacity and technical characteristics. Yet, they are all harnessed to manufacture the same general product type, and for the same use. Since no refining mills are deployed, all plants include screening as a crucial stage in the process (Fig. 2). The drying of chips is obtained in different ways, often exploiting solar energy and only in one case through a chip-fired boiler. That also explains the large variety recorded for the moisture content of microchips. The most advanced microchip production systems also perform dust removal at some stage along the process, which is not the case for the simplest operations.

Regardless of product type, all operations present the following common characteristics: they all use low-grade hardwood material, especially sweet chestnut (Castanea sativa L.), which is the dominant feedstock in all cases except for Pellet 2; chipping is always performed with a mobile forestry chipper, owned by the operator or contracted for the purpose, and used for a number of other jobs besides processing feedstock for the pellet or microchip production plant. Concerning chipping, it is worth noting that all chippers used for microchip