Resources, Conservation and Recycling 104 (2015) 239–253

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Waste-to-fuel opportunities for British quick service restaurants: A case study

Anthony Velazquez Abad[a,*], Tom Cherrett[a], Peter Holdsworth[b]

[a] Transportation Research Group, Engineering and the Environment, University of Southampton, Southampton SO17 1BJ, United Kingdom
[b] Martin Brower UK Ltd., Hemel Hempstead HP2 7EQ, United Kingdom

ARTICLE INFO

Article history:
Received 11 April 2015
Received in revised form 19 June 2015
Accepted 3 August 2015
Available online 26 September 2015

Keywords:
Biomass
Fuel
Energy
GHG
Restaurant
Waste

ABSTRACT

The fast food supply chain is facing increasing operating costs due to volatile food and energy prices. Based on a case study of a major fast food logistics operator, this paper quantifies the potential for fuel generation from the waste generated by quick-service restaurants in Britain. Several fuel pathways and supply chains were mapped to understand the carbon intensity of the various waste-to-fuel opportunities, the number of heavy goods vehicles that might be powered and the key factors that could help companies make better informed decisions related to fuel generation from waste.

The research suggested that depending on the scenarios considered, between 13.9 and 17.2 million GJ of energy could be obtained from fuels made from the waste arisings of British quick service restaurants and their distribution centres (DCs), representing between 4.4 and 5.8% of the national energy consumption from heavy goods vehicles (HGVs) and well-to-wheel (WTW) greenhouse gases (GHG) savings of between 652 and 898 thousand tonnes of CO_2 equivalent annually.

Used cooking oil and burger fat arising from British quick-service restaurants could generate enough energy to power up to 3891 HGVs with FAME diesel (B100), 1622 with HVO diesel (B100) or 1943 with biomethane annually. The paper and card generated by these same establishments could also power an additional 4623 biomethane vehicles, wood pallets could power an additional 73 bioethanol trucks and plastics could also power 341 vehicles running with synthetic diesel.

The results showed that collections of separate waste fractions by logistics operators could make a relevant contribution towards the decarbonisation of the supply chain while reducing disposal fees and fuel costs. The carbon emissions resulting from this approach depend greatly on the footprint of the collection and transportation systems used to move waste from the restaurants to the processing plants and return the converted fuel back to the distribution centres where the vehicles are refuelled. Logistics firms are in a privileged position to manage these flows as they can use empty back-haul trips to collect and consolidate waste in distribution centres.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

The economic recession has forced supply chain operators across the EU to reassess their operations in order to remain competitive. Customers are also becoming more sensitive towards issues of sustainability, and organisations must reconcile these concerns with their triple bottom line (people, planet and profit) as a way to improve stakeholders' loyalty (Elkington, 1998). Rising food prices coupled to volatile energy prices and concerns related to environmental sustainability and energy security have led to increased interest in how to maximise the use of existing resources, particularly the waste-to-fuel opportunities arising from the food supply chain. According to Hollins (2013), UK hospitality and food service outlets only recycle, send to anaerobic digestion (AD) or compost 46% of the 2.87 million tonnes of waste generated each year. Designing products for a circular economy could allow UK supply chains to become virtually waste free whilst generating an income stream of $1.5 billion (equivalent to approx. £0.9 bn. as of 31/12/2013) per year or around $172 (£104 as of 31/12/2013) profit per tonne of food waste (Ellen MacArthur Foundation, 2013). This paper uses a detailed investigation of a British fast food supply chain (FFSC) to understand the nature of the co-products and by-products produced, how these are currently treated, and the scope for their secondary utilisation in the operation of logistics fleets.

* Corresponding author.
E-mail addresses: A.Velazquez@soton.ac.uk (A. Velazquez Abad), t.j.cherrett@soton.ac.uk (T. Cherrett), pholdsworth@martinbrower.com (P. Holdsworth).

http://dx.doi.org/10.1016/j.resconrec.2015.08.004
0921-3449/© 2015 Elsevier B.V. All rights reserved.

1.1. The British fast food supply chain

Quick service restaurants (QSRs) account for 12.1% of hospitality sector outlets in the United Kingdom (UK) (WRAP, 2011) and generate annual revenues in the region of £5.5 bn (IBISWorld, 2013). They are responsible for generating 246,000 tonnes of waste annually with less than 57% of this being recycled, reused or composted (WRAP, 2011). Hollins (2013) estimated the total food waste of UK QSRs in 76,000 tonnes (including fast food, take-aways, fish and chip shops and sandwich bars), representing £277 million per year (at £3500/tonne) from which just 17,000 tonnes were unavoidable. With retail diesel costs having increased by almost 40% from 2004 to 2014 (DECC, 2015), there is growing interest in whether waste arisings can be used as a supplementary fuel, given that biofuels have been shown to deliver substantial greenhouse gas (GHG) emissions savings, avoiding negative indirect land use changes and relieving pressures on food prices. The whole UK food chain emitted around 115 million tonnes of CO_2eq. in 2009[1] (Defra, 2011) with the commercial transportation of food for UK consumption representing around 9% of these GHGs emissions (Defra, 2011) and between 1.8% (FRPERC, 2010; Smith et al., 2005) and 2.5% (Garnett, 2003) of total UK carbon emissions.

1.2. Waste streams

QSRs typically operate separate waste collections for paper and card, plastics, used cooking oil (UCO) and grease trap waste (GTW), kitchen food waste, glass and wood among other fractions. Waste arisings at QSRs also result from damage to products during handling, storage and transportation as well as from products discarded by customers. A survey conducted by WRAP (2011) reported that mixed waste from UK QSRs generally consisted of kitchen food waste (51%), paper (15.1%), card (8.6%), dense plastics (4.8%), plastic film (6%) and glass (3%). It was estimated that UK QSRs produced around 16,300 tonnes of paper and 9200 tonnes of card as mixed waste in 2009 (WRAP, 2011). Thermoplastics are widely used in the FFSC as packaging, and UK QSRs produced around 5200 tonnes of dense plastic and 6300 tonnes of plastic film in 2009 (WRAP, 2011).

In 2009, the UK food chain produced 15 million tonnes of drink and food waste, almost half coming from households, 3.2 million from manufacturing and 0.6 million linked to the UK hotel and catering sectors (Defra, 2011). From the 54,700 tonnes of food waste produced by QSRs (0.3% of the total) 15,500 tonnes were avoidable (WRAP, 2011). To put this into perspective, Tesco generated 28,500 tonnes of food waste in the first two quarters of 2013, mainly from bakery products and fruit and vegetables (Houses of Parliament, 2013).

In Europe, an estimated 14.6% of meat and 19% of fish are wasted between distribution and point of consumption (Gustavsson et al., 2011); Defra's estimate for the UK is considerably lower and suggested that 13% of edible meat and fish are wasted (Defra, 2013a). The UK produces around 14 billion litres of milk annually (C-Tech Innovation Ltd, 2004) and over 1 billion litres (7%) are estimated to be wasted along with 26.5% of cereals, 23% of potatoes and 27% of fruit and vegetables between distribution and consumption (Gustavsson et al., 2011).

In Europe, the main oil crops are sunflower and rape seed (C-Tech Innovation Ltd, 2004) which are the main ingredients in the vegetable cooking oils used by one of the leading UK fast food supply chains. British QSRs generate significant amounts of UCO with Kentucky Fried Chicken (KFC) collecting 7.75 m litres annually (KFC, 2012) and McDonald's over 3.6 m litres (McDonald's, 2012), not including GTW from wastewater interceptors or separately collected burger fat. More efficient cooking technologies such as air fryers and healthier meal options may reduce the availability of UCO in the future, with Burger King and McCain having already introduced fries with 40% less fat in 2013 (Burger King, 2013).

1.3. Waste-to-fuel opportunities for British QSRs

Biogas is typically obtained from AD or landfill gas recovery from organic waste feedstocks such as fish, meat, fruit, vegetables, dairy products, wasted oil, fat, paper and cardboard. In August 2011, there were 66 plants in the UK treating around 1 million wet tonnes of food and agricultural waste (Houses of Parliament, 2011); this increased to 78 plants by June 2012 (NNFCC, 2012). To convert this biofuel into biomethane compatible with compressed natural gas (CNG) trucks, the biogas needs to be upgraded to 95% methane, venting or capturing the CO_2 by-product. Biomethane as a fuel for transportation is gaining popularity, with three of the 23 liquid natural gas (LNG) and three of the eight CNG dedicated refuelling facilities currently registered in the UK using biogenic content (Gas Vehicle Hub, 2014). Alternatively, energy producers can use biomethane in combined heat and power plants (CHP) to reduce their energy costs and GHG emissions. When the fuel is generated through AD, the residue of the process (digestate) can also be used as a biological fertilizer reducing the need for synthetic fertilizers (Banks et al., 2011; Heaven et al., 2011). If the digestate complies with the requirements of the Publicly Available Specification BSI (PAS) 110, it is no longer considered a waste and does not attract disposal costs.

The paper industry generates pulpwood waste, black liquor and coke from the paper Kraft process and there is potential for producing methane from these wastes (Lin et al., 2011; Magnusson and Alvfors, 2012; Rintala and Puhakka, 1994) with some large paper manufacturing companies installing CHP plants to use the biogas obtained from their recycling processes (Saica Natur, 2012). Besides AD, energy efficient recovery pathways for paper, cardboard and wood waste (pallets) include combustion and incineration with heat recovery and at a smaller scale, gasification and pyrolysis of ligno-cellulosic waste. Gasification is more appropriate in applications where there is a use for heat while pyrolysis is typically used to transform biomass into liquid fuels (Panwar et al., 2012). The char produced during pyrolysis can also be gasified to produce syngas which is energy-rich in hydrogen, methane, monoxide of carbon and other compounds. GHG savings of 98% have been reported by using black liquor from waste wood as feedstock from the paper industry (Edwards et al., 2014). The Conservation of Clean Air and Water in Europe (CONCAWE) report estimates that synthetic diesel can yield GHG savings of 97% by using the Fischer–Tropsch approach (Edwards et al., 2014). This gas-to-liquids chemical process converts a mix of gases (monoxide of carbon and hydrogen) into liquid hydrocarbons (Damartzis and Zabaniotou, 2011). Currently, the only Biomass-to-Liquid (BTL) initiative in the UK is a pilot plant producing biobutanol (Bioenergy2020+, 2013), a fuel that can be blended with petrol. As the majority of the HGV fleet in the UK runs on diesel, there is very little scope for making any impact on this specific market in the short term.

UCO from the food industry is widely recycled in the UK and constitutes one-third of all fatty acid methyl-ester (FAME) biodiesel feedstock (DfT, 2013a). In the UK, there are 30 registered medium and large UCO collectors and biodiesel producers (organisations with more than 50 employees) with the capacity to process 250 million litres of UCO per year (Environmental Audit Committee, 2012). First generation biodiesel converts UCO into FAME biodiesel through transesterification; however, current commercial second generation biodiesels convert UCO into hydrogenated vegetable oils biodiesel (HVO), obtaining bio propane as a co-product (DECC,

[1] Excluding overseas production, food packaging, food waste and land use change.

Download English Version:

https://daneshyari.com/en/article/1062826

Download Persian Version:

https://daneshyari.com/article/1062826

Daneshyari.com