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ScienceDirect

Energy Procedia 123 (2017) 30–35

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Sustainable Energy and Resource Use in Food Chains, ICSEF 2017, 19-20 April 2017, Berkshire, UK

# The impact of the UK's emissions reduction initiative on the national food industry

Baboo L. Gowreesunker, Sam Mudie, Savvas A. Tassou*

*Brunel University London, Institute of Energy Futures, Center for Sustainable Energy Use in Food Chains, Uxbridge, Middlesex UB8 3PH, UK*

**Abstract**

This study aims at determining the technology combination that provides the lowest emissions and energy cost for the food-industrial sector. Using a linear optimization objective function in determining the least-cost pathway, data from various sources were compiled to perform simulations on two scenarios; a business as usual (BAU) case and an 80% greenhouse gas (GHG) emissions reduction. Even in the base case, the emission level reaches 21% of 1990 levels; a reduction of 39% over the simulation period. This indicates that even without the imposition of GHG constraints on the food sector, it is economically more beneficial for the industry to migrate from fossil fuels. This migration takes place by replacing energy from LPG, LFO, Kerosene, HFO, Coal and Natural gas with biomass, biogas and CHP electricity. Economic benefits arise from the fact that biogas and biomass are produced from wastes which are generated onsite within food factories, hence the avoidance of purchasing energy feedstock from the market. The change in energy consumption between the two scenarios is similar due to the prevalence of least-cost solutions and similar energy and food demand requirements. However, the reduction in emissions are greater in the 80%-GHG case than the BAU case; 52% compared to 39% for the BAU case, for 2050 relative to 2010. This is largely owing to decarbonization of grid electricity. This study finds that the food-industrial sector has the potential to exceed this 80% reduction target to a value of 92%, due to the availability of onsite feedstocks to generate biogas. In this simulation, of all waste produced, 92% of waste feedstock is consumed in AD and CHPs, whilst the remaining 8% is dried and processed to be burned in biomass boilers.


Peer-review under responsibility of the scientific committee of the 1st International Conference on Sustainable Energy and Resource Use in Food Chains.

*Keywords:* Food indutrial sector; Energy consumption; Emissions

* Corresponding author. Tel.: +44 (0) 1895267040.
*E-mail address:* Savvas.Tassou@brunel.ac.uk

1876-6102 
Peer-review under responsibility of the scientific committee of the 1st International Conference on Sustainable Energy and Resource Use in Food Chains.
10.1016/j.egypro.2017.07.281

## 1. Introduction

The UK food sector accounts for 18% of the national energy consumption [1]. Of this, the food industrial sector (manufacturing and processing) contributes 15% [2] and employs 10% of the UK work force [2]. The food industrial sector refers to the processes undergone by food products whereby raw materials are cleaned, sorted, combined and altered/processed to produce finished products which are easier and more convenient to consume. This makes the sector a crucial segment of the food chain and pillar of the UK economy. These processes are generally energy intensive and some facets may require significant energy efficiency enhancement or energy shifts in order to abide by the UK's energy and greenhouse gas (GHG) emission reduction initiatives.

This study focuses on the technology improvements/alterations required by the UK food industrial sector in order to reduce their GHG emissions. The UK is committed to reducing GHG emissions by 80% in 2050, compared to 1990 levels [3], despite Brexit economic and political tensions [3]. Divided into carbon budgets, the phases for emissions reduction are 57% by 2030 and 80% by 2050 [3]. Current policies are however expected to only deliver half of these emission reductions [4], and significant policy improvements are required to re-align the economy to these targets. These include keeping effective policies such as: vehicle fuel efficiency standards, F-gas regulations, Courtauld waste commitments and energy efficient product labelling. On the other hand, technological energy efficiency improvement policies, agricultural policies (such as the Common Agricultural Policy) and energy trade policies would require reinforcements, particularly as the UK dissociates itself from the EU [4].

In this analysis, we investigate the most cost effective manner to attain the UK's emission reduction targets by employing a national and collaboratively developed linear programming tool known as the UK TIMES model (UKTM). The model aims at identifying energy and technology hotspots within the UK food industrial sector in order to understand which sectors and what technologies to strategically fund in order to have the maximum potential impact and contribution to GHG emission reductions. The model encapsulates all sectors of the economy and hence provides a broad analysis of the UK economy and food industrial sector, as opposed to studying the food industrial sector in isolation.

## 2. Methodology

As mentioned, this work feeds into a wider national model known as the UKTM (UK TIMES Model), which consists of various academic, industry and governmental departments, which aim to optimize the technology mix for all sectors across the UK. This study employs the linear programming technique to analyze the applicability of technologies the UK food processing sector. Linear programming techniques have been widely used in modelling technology applicability for difference sectors [5-8], where the objective function - total costs or net profit margins - can either be minimized or maximized, subject to technical, economic, environmental and resource constraints. The IEA-ETSAP TIMES (The Integrated MARKAL-EFOM System) model generator is used here to link the technologies, energy and cost structures in a partial equilibrium model, and together with a technology-rich foundation, it allows the estimation of energy dynamics over a long-term horizon [9]. TIMES uses a linear optimization objective function which determines the least-cost pathway by minimizing the total discounted system costs in order to satisfy the farm's energy demands, subject to technical, economic, environmental and resource constraints. Through the use of a partial equilibrium solution strategy, the model does not provide feedback on other sector changes, and assumes perfect foresight as decisions are made with full knowledge of future policy, technical, economic developments and available resources [10].

Data were obtained from various sources, and has been presented and debated by leading food manufacturers and food federations. The food industrial sector was divided according to the SIC2007 classifications, which segments the food sector into different food categories, such as meat/meat products and fish, fruits and vegetables etc. The technology cluster studied consists of systems for space heating, hot water, drying, direct fire and Combined Heat and Power (CHP).The simulations were performed by considering two scenarios, a 'Business As Usual' (BAU) case (where there are no imposed GHG emissions constraints), and the scenario whereby the 80% GHG emissions reduction is imposed on the model. The model disaggregation and technology mix studied in this paper are illustrated in Fig. 1, whereby the energy parameters (costs and availability) are obtained from the wider UKTM model, analyzing the energy generation sector, which then feeds into the Food Industry (IFD) module developed in this paper. Note that