Effects of Industrial Symbiosis on Company’s Energy Efficiency and Renewable Energy Use

Slavica Tomić*, Dragana Delić**

*University of Novi Sad/Faculty of Economics, Subotica, Serbia
**University of Novi Sad/Faculty of Economics, Subotica, Serbia
tomics@ef.uns.ac.rs, delicd@ef.uns.ac.rs

Abstract - Manufacturing activities account for around one-third of the world’s total final energy consumption. When energy prices are low and relatively stable, and energy costs represent only a small part of total production costs, energy as an input factor within the industrial production process had low or even zero priority for corporate management. This is about to change. A number of environmental megatrends are likely to converge and to transform manufacturing activities in the future. These trends will lead to economic and environmental efficiency and sustainability becoming central to company’s resilience and competitiveness. Increased competition for raw materials and energy put pressure on the natural resources (which resulted in price increase) and has potentially significant effects on future company’s growth and success. Improvement of resource productivity and energy efficiency through industrial symbiosis (by-products and waste become energy resources) could yield significant economic and environmental benefits for company.

Keywords: industrial symbiosis, energy efficiency, renewable energy

I. INTRODUCTION

Continued economic growth and development and technological progress put significant pressure on environment and have negative consequences on global supplies of resources. A number of environmental megatrends in the form of climate change, population growth, urbanization, accumulation of waste, increased competition for energy, demand for land, water, and materials, will require major shifts in the way business (industry) operate [1, pp.19]. The challenges (for industry) are huge and complex: they involve a multitude of concepts and disciplines, ranging from resource efficiency to innovative business models. In the face of these challenges, the reactive trends (possible responses) by business (industry) could be: the increasing use of mechanisms to “price” the impact of production on the environment, higher sustainability standards around the impact and efficiency of production, zero waste strategy (concept), closed loop or circular (business) model, industrial symbiosis, eco-industrial parks, and etc. The one of main ideas behind those concepts is that companies should use waste and/or by-product as inputs in order to maximize resource (material and energy) efficiency and minimize pressure on virgin resources.

II. CIRCULARITY AND RESOURCE EFFICIENCY

Efficiency means the relationship between the results achieved and the resources employed. The need for even more efficient utilization of resources is coming more and more sharply into focus in business, in research and in politics. A crucial question is what options do companies have to reduce not only costs but also the use of resources and emissions, by exploiting more efficient technologies, solutions, practices. There is a need to reduce the quantity of resources used whilst increasing production output, and therefore to improve the productivity of resources. This means manufacturing as much as possible from the use of a given quantity of raw materials and energy. Instead of “maximum profit (gain) from the minimum of capital there is a need to achieve maximum profit from the minimum of resources” [2, pp.4].

Manufacturing is directly related to natural resources and immediately affected by their diminishment. Therefore, the future of production will need a reduction of the environmental impacts associated with resource use and reduction of the associated economic costs and risks to business. Production systems which create products-output, while using less material and energy inputs represents sustainable manufacturing systems. The objective of resource efficient manufacturing is to improve manufacturing productivity whilst inputting less raw material, water and energy. Greater resource efficiency has been pursued broadly in industry and advances have been made, largely because efficient use of resources has significant financial benefits which in competitive markets have always been a priority. Though often framed as a “green” objective, this can equally be understood as a significant increase in multi-factor productivity. According to McKinsey Global Institute report [3] “there is an opportunity to achieve a resource productivity revolution comparable with the progress made on labour productivity during the 20th century”. According to the report, resource productivity could meet up to 30 percent of the global demand for natural resources until 2030. Market forces alone are unlikely to generate sufficient progress in material and energy productivity within a critical mass of manufacturing activities, at least until scarcity of those inputs reaches a stage which is disruptive to the economy as a whole, and resource-intensive industries in particular.
Industrial sustainability or sustainable industrial systems imply circularity (circular, closed-loop model), which keeps materials within the system of production and use, rather than discarding them, i.e.:

- reuse, remanufacturing, refurbishment and recycling;
- synergetic business relationships for better use (utilization) of by-products and waste (industrial symbiosis);
- industrial clustering for decarbonization, etc.

Circularity (or circular, closed-loop, cradle-to-cradle strategy) is an approach which stands in contrast to the "linear", traditional production and consumption (take-make-dispose) pattern, and involves the joining up of the value chain so that end-of-life products are reused as inputs, and waste is utilized as a resource wherever possible. By associating both ends of a linear value chain, the chain can be joined up either with other value chains, forming networks of industrial symbiosis, or with itself, meaning that whatever waste, by-products or heat there is in a process must be exploited rationally in a different manufacturing process. Within circular industrial (eco) systems, organizations (companies) utilize each other's material and energy flows including wastes and by-products to reduce the systems virgin material and energy input as well as the waste emission output from the system as a whole. In addition to the improvements achieved to date in the sphere of recycling, it is increasingly a matter of integrating resource cycles within process chains and within production generally. The use of recycling materials from production waste makes a significant contribution to improving energy efficiency. This contribution results predominantly from the distinctly lower use of energy required for the production of secondary material. In the ideal situation, recyclable material from production can be utilized further without, for example, energy-intensive melting processes or similar, thus further improving energy efficiency. There is a large potential in metal processing, especially in the area of sheet metal and stamping waste. For example, up to 60 % of metal sheets used in automobile production end up as production waste [4, pp.12]. Also, according to the research [5], chemical and metallurgical companies intensively reuse by-products in their internal processes - the chemical companies are able to capture their by-products and find economical means to convert them into marketable products or they were used in another step of the production process.

Although companies have clear incentives to be efficient within their own core processes, by-products, waste, surplus energy frequently occur. This raises the possibility of synergetic collaborations to make use of these resources as inputs in a different processes (within the same or among different companies), through concepts such as industrial symbiosis. Industrial symbiosis represents an association between two or more industrial facilities or companies in which waste or by-products of one become the raw materials (inputs) for another with the aim to manage the flow of resources through socio-economic systems with a view to optimizing their use. Hence, industrial symbiosis involves identification and development of relationships that would not "naturally" occur. This can result in economic benefits such as the generation of new revenue (additional sales of by-products or waste), saving on waste treatment expenses or landfill taxes (cost savings) and the more efficient use of resources. Additionally, industrial symbiosis collaborations can generate positive externalities which the system as a whole benefits from. These include not only the benefits of greater material efficiency, such as resilience against resource insecurity and environmental benefits (landfill diversion, CO$_2$ reduction, raw material saved...), but also high levels of (cross-sectoral) innovation and knowledge spillovers [6, pp. 99].

National Industrial Symbiosis Programme (NISP) in UK, example of industrial symbiosis best practice, generated a good return on public investment of £5-£9 of value for every £1 put in. Calculations of reductions in water and material use, CO$_2$ emissions and waste going to landfill show that this occurred at a cost of less than £1 per tonne. The results achieved through NISP provide a robust evidence base to support the role of industrial symbiosis in helping businesses improve efficiency and profitability, competitiveness and better environmental performances. Between April 2005 and March 2013, due to collaboration in form of industrial symbiosis (supported by NISP), 45 million tonnes of materials were recovered and reused, industrial carbon emissions was reduced by 39 million tonnes, 71 million tonnes of industrial water was saved, £1.1 billion cost savings achieved, £1.4 billion generated in additional sales[7].

Industrial clustering for decarbonisation is the integration between industrial sites to deliver energy savings. It can reduce emissions by optimizing the use of resources (waste or by-products) - such as CO$_2$ from one process to be used beneficially by another process, while costs are shared, heat is used wisely and other benefits increase [8]. Waste heat recovery can bring further energy efficiency benefits through re-use of low grade heat by other heat users outside of the sector producing that waste heat. Clustering is a long-term, gradual option that requires new or replacement plants to be encouraged to locate where clustering benefits can be realized, and existing plants to maximize local opportunities. The barriers to clustering are generally related to organizational collaboration and include the perceived risk of becoming reliant on a partner who may not be present in the long term.

III. INDUSTRIAL SYMBIOSIS, ENERGY EFFICIENCY AND RENEWABLE ENERGY USE

Resource efficiency, particularly energy efficiency is very important in manufacturing activities, since manufacturing accounts for around one-third of the world’s total final energy consumption [9]. Better industrial energy efficiency, first and foremost the efficiency of the manufacturing processes at the core of industry is the most effective lever available to curb industrial energy consumption. Growing numbers of companies are seeing energy efficiency as a key part of their efforts to promote sustainability and promoting energy efficiency in their supply chains to meet their own sustainability commitments.

When energy prices are low and relatively stable, and energy costs represent only a small part of total production costs, energy as an input factor within the industrial production process had low or even zero priority for corporate management. In those conditions, energy costs are in most cases only treated as overhead rather than as a
cost category for which managers were directly accountable for. This situation has changed with the considerably rising of energy sourcing prices within the last decade. As a result, the number of companies addressing energy-related issues has risen in recent years and increasing activity concerning energy management can be determined in business practice. Industrial companies have seemed to realize that energy management can be an effective lever for enhancing their production systems and operations towards improved energy efficiency and thereby reducing energy use and related costs. One of the ways to improve energy efficiency and renewable energy use in manufacturing is through industrial symbiosis, which can contribute to less final energy consumption and better economic and environmental performances of companies. Selected examples of internal and external industrial symbiosis in food and beverage production companies (Nestle, Strauss Adriatic, Carlsberg, and British Sugar) will illustrate how by-products and production waste (leftovers) could be turn into energy (resources).

A. Nestlé

Anaerobic digestion system at Nestlé’s factory (Fawdon, the North East of England) is turning chocolate and sugar confectionery waste from the site’s manufacturing processes into renewable energy. Rejected chocolates and sweets which are not suitable for sale or reprocessing (and which would otherwise be disposed of externally), along with waste residues such as starch and sugar are broken down in to small pieces. This mixture is then partially dissolved using the waste liquids from the site’s cleaning processes to create a ‘chocolate soup’ which is then fed into an airtight tank where anaerobic digestion occurs. Almost 10% of the site’s overall energy needs (heat and power) is met by burning the biogas which is the primary by-product of anaerobic digestion. As a result of the heat and power generated from the biogas, factory’s greenhouse gas emissions are expected to fall by about 10%. Set up at a cost of CHF 4.7 million, the anaerobic digestion system isn’t cheap; but due to the cost savings it has generated, the investment is expected to take around four years to pay off. The factory’s anaerobic digestion converts about four tonnes of solid waste and 200,000 liters of liquid waste a day, making the site that have now achieved zero waste for disposal status. Also, in 22 Nescafé factories, the spent coffee grounds and discarded coconut shells resulting from the manufacturing process are used as a source of renewable energy (fuel) [9, 10, and 11].

B. Strauss Adriatic

Company Strauss Adriatic uses coffee chaff (which has always been treated as a waste) as fuel (biomass) to heat complete production and administrative facilities of its plant in Serbia. The plant in Serbia annually produces 140 tonnes of coffee chaff briquettes, which is enough for 3 months of heating. The boiler room is designed to burn other kinds of biomass as well, so that the rest of the heating fuel can always be chosen in accordance with the market trends. The total value of the investment is EUR 120, 000, but annual savings are estimated at between 65,000 and 90,000 Euros thanks to huge financial savings (the use of coffee chaff cuts heating costs)1. Aside from being cost efficient, the use of coffee chaff briquettes as a fuel is also eco-efficient because it solves the problem of waste disposal since the coffee chaff is a by-product of the coffee processing process, and as such it used to represent a waste. One kilogram of coffee chaff briquettes has the energy value of 13,500-14,000 KJ, while the energy value of wood briquettes amounts to 17-18,000 per kilogram (classical energy value of biomass ranges from 11,000 to 20,000 KJ per kilogram and is considered a usable source of energy). Analyses focused on gases released during the combustion process, showed that the emission of harmful gases is no bigger than when any other form of biomass is combusted. What remains after the coffee chaff combustion is ash which can be used as an additive in the cement industry.

C. Carlsberg

Circularity is becoming a more integrated part of brewing operations, too. Waste and by-products from the brewing process provide excellent opportunities for reuse. Many of Carlsberg’s breweries are re-using and recycling close to 100 percent of their total solid waste and by-products. Examples include brewer’s grains sold as animal feed and the recovery of methane from the anaerobic digestion of wastewater to produce renewable energy for use at brewerries. Carlsberg often applies anaerobic treatment technologies that recover organic carbon to produce biogas, which is a source of renewable and clean energy. In total, 5.2% of heating energy comes from renewable energy sources. Company currently operates 15 biogas-recovery wastewater plants, which produce and use over 9.5 million cubic meters of biogas - energy enough to heat 11,000 European homes [13, 14].

D. British Sugar

The core product of the company British Sugar is sugar. But, company employs a number of methods and uses by-products and production waste to minimize energy consumption, maximize (energy) efficiency and diversify business. British Sugar factory in Wessington developed and installed system to capture biogas from the effluent treatment plant and use it as a supplementary renewable fuel. The project increases energy efficiency, reduces fossil fuel consumption and provides CO₂ emissions savings of around 2,000 tonnes per annum. Thereafter, fermentation/distillation plant producing up to 55,000 tonnes of bioethanol per year. This is used as a renewable fuel to blend with petrol.

Company also uses combustion gases (which traditionally go to the chimney) and recovered heat from CHP plant to grow tomatoes in glasshouse (over 140 million tomatoes annually). This provides heating and CO₂ which is essential to promote plant growth. More than two hundred and forty miles of piping carries hot water from the factory’s Combined Heat and Power (CHP) plant around the glasshouse, to maintain the temperatures which suit tomato plants. This hot water would otherwise be destined for cooling towers, so the scheme ensures that the heat is used productively. Another benefit is the productive use of waste carbon dioxide from the factory, which tomatoes use during photosynthesis. At Corner ways,

1http://www.aurea.rs/article_aurea.php?id=542002_en
carbon dioxide (a by-product from the CHP boiler) is pumped into the enormous glasshouse to be absorbed by the plants, rather than vented into the atmosphere as waste emissions².

IV. CONCLUSION

The long-term environmental constraints on the world’s ecosystem pose specific challenges for the industry (manufacturing sector). The circumstances in which manufacturers will have to operate in future will be very different. The closed energy and material loops was believed to entail a promising way in which future industrial systems could be designed so that the negative environmental impact from industrial operations could be close to zero. Uncertain supply of resources and worries over the environmental and social effects of greenhouse gases emissions, have lead companies to focus on how the use of by-products and waste as energy, through industrial symbiosis, can be optimized. While also serving environmental objectives, focus on productivity gains through energy and resource efficiency should equally be regarded as an economic priority.

REFERENCES


