# Chapter 88
# The Drivers for a Sustainable Chemical Manufacturing Industry

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## ABSTRACT

*This chapter describes the current situation of the chemical manufacturing industry and looks to the future demands on the sector such as: for sustainability, the advent of new bio-based feedstocks for improved energy management and the implications of these demands on the sector. These implications include definitions of sustainability criteria for the chemical manufacturing industry and the need for transparent reporting following the Triple Bottom Line approach. The important role of chemical (or more generally, process) engineers in delivering bio-based sustainable solutions is emphasised, but this also suggests that a new way of thinking about the discipline is required. Indeed, there are arguments that the demand for a sustainable chemical manufacturing sector could bring about the next paradigm shift in the discipline with concomitant education implications.*

## INTRODUCTION

The Chemical Manufacturing Industry (CMI) can be multinational in operation and varied in scale whilst producing the products which underpin other sectors such as: health provision; clothing; housing and shelter; food and nutrition; entertainment and leisure; transport and tourism—the very fabric of human life. The variety of activity in the sector can be said to demand that, "Process Engineering," is a more correct term to encompass industries as widely different as food processing, minerals processing, pharmaceutical manufacture and petroleum refining. However, there is commonality in their activity where heat and mass transfer, transport phenomena, reaction kinetics, modelling and fluid mechanics are all applied in unit operations albeit to widely varying materials

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and situations. For this reason in this chapter we have used the term CMI to cover this spectrum of activity and the general approaches which we describe can be applied equally well to all in our opinion.

The products of the chemical industry are derived from inorganic, synthetic organic and biological sources which have been manipulated by a range of process operations which include classical physico-chemical processes such as synthesis, distillation, precipitation, filtration, solvent extraction and crystallisation techniques which have been supplemented by fermentation processes, the application of industrial enzymes and the genetic manipulation of microorganisms in modern biotechnology. These technologies have made a vast number of products available to promote social development and economic growth and prosperity. At the same time the chemical industry has been accused of overexploitation of natural resources, air, water and land pollution (such as by oil production in the Niger River delta, opencast mining on fragile Pacific islands and the catastrophic Deepwater Horizon oil spill in the Gulf of Mexico) and creating social problems associated with rapid industrialisation and the invasion of vulnerable societies and environments for commercial gain (witness the toxic release from the Union Carbide plant in Bhopal, India, in 1984). When Industrial Revolutions have taken place starting from Europe, North America and then into Latin America, Asia and Africa the ills of industrialisation were ignored initially, as the price to pay for progress although eventually the development of organised labour and government structures have improved the situation in many cases. Whilst accepting this historical context (Coley & Wilmot, 2000) the future development of the CMI must nowadays be viewed in the light of the concept of sustainability (Garcia-Serna, Perez-Barrigon, & Cocero, 2007) which means tackling the issues of the change from fossil fuel to bio-based raw materials and energy conservation and management (Hall & Howe, 2010).

This chapter will describe the criteria by which the CMI is judged and how sustainability is reported by the industry. It will then describe the new technologies impacting on process engineers in a sustainable CMI and finally go on to discuss whether the sustainable approach will demand a new type of process engineer and the educational implications of this demand.

## BACKGROUND

### Defining Sustainability

Sustainability, or Sustainable Development (SD), is a discipline that has long been of interest to scientists, technologists, politicians, and business alike. Thomas Malthus in his, *Essay on the Principle of Population*, of 1798, proposed that the power of population increasing in a geometric ratio would outstrip the power of the earth to sustain mankind increasing in an arithmetic ratio and thus a link was made between population and sustainability. However, the advent of the concept of sustainability can be traced back in modern times to the 1970's but the UN Commission on Environment and Development (the so-called Brundtland Report) in the 1980's was a major point in defining the topic (World Commission on Environment and Development, 1987). The Commission was originally instructed to investigate the issues of global inequality, resource distribution and global population impacts and recommend solutions to these issues. Their oft-quoted report definition of sustainable development is, "Development which meets the needs of the present without compromising the ability of future generations to meet their needs."

The report linked economic development with social and environmental concerns for the first time and a balance of economics, social justice and environmental protection was proposed if sustainable development was to happen - this became known as the Triple Bottom Line. The