

Chapter 1

Introduction Overview: World Energy Resources and the Need for Biomass for Energy and Lower Fossil Carbon Dioxide Emissions

Charles E. Wyman

1.1 Introduction

Recently, we have witnessed major swings in petroleum prices, ranging from the highest ever to the lowest in decades within months of each other, with such factors as politics, commodities trading schemes, limits in production capacity, bad weather, rapid increases in world demand, and oil cartels credited with responsibility for these huge price shifts. Regardless of the reasons, such energy price instability damages economies and has been a major contributor to the financial crises now gripping the world. The key is to find new sources of energy to get us out of this recurring dilemma, but little progress has been made in spite of several past episodes of high oil prices leading to economic recession.

Part of the problem is that we take energy supplies for granted as an inherent right that receives attention only when supplies are threatened. Maslow ranked human needs in the following hierarchy of increasing sophistication: physiological, security, loving and belonging, self esteem, and self actualization (Maslow 1943). He further stated that as each level of need is filled, we tend to take that need for granted and focus on fulfilling the next higher level need, which is more difficult to satisfy. Thus, a person without food or water is concerned only with addressing this pressing need for survival and not likely to be overly concerned with self actualization. In a similar way, we generally take energy for granted in our day-to-day lives and give it attention only when supply limitations cause inconveniences or high prices result in economic pain. Unfortunately, a long time is needed to change our energy infrastructure, and failure to devote sufficient attention in advance to assuring a long term and sustainable energy supply will lead to substantial economic, environmental, and societal disruptions that cannot be rapidly fixed.

C.E. Wyman

Ford Motor Company Chair in Environmental Engineering, Center for Environmental Research and Technology and Professor of Chemical and Environmental Engineering, Bourns College of Engineering, University of California, Riverside, California 92507, USA
e-mail: charles.wyman@ucr.edu

In this chapter, an overview of the current energy picture provides a perspective on why new, and in particular sustainable, fuels are needed. The role that cellulosic biomass can play in meeting this important need is then outlined, followed by a summary of options available to convert biomass into fuels that can substitute for petroleum-based products. Based on this background, a picture is provided of how much cellulosic biomass would be needed to make an impact on petroleum use. The chapter concludes with some aspects of the key attributes for cellulosic biomass that could enhance the impact to provide some thoughts on research and development opportunities to support the emergence of a meaningful biomass fuels industry.

1.2 World Dependence on Petroleum

Petroleum prices have a tremendous impact on our economy because of the dominant role oil plays in providing our energy. Overall, petroleum is the source of about 170 quadrillion (10^{15}) British thermal units (BTUs), or quads of energy, of the total of more than 460 quads the world uses, with coal, natural gas, hydroelectric power, nuclear energy, and geothermal and other sources providing the remaining roughly 122, 105, 29, 27, and 7 quads, respectively (US Department of Energy 2008). Figure 1.1 outlines the relative contributions of major energy sources to world uses. Over half of petroleum in this world total is now used for transportation, and demand by this sector is projected to grow rapidly as vehicle traffic increases throughout the world and even accelerates in Asia.

Similarly, the United States obtains more energy from petroleum than from any other resource, with about 40 quads of the 100 total being from this one source. However, as illustrated in Fig. 1.2, the US uses a higher portion for transportation, amounting to about 70% of the petroleum used, and the transportation system is almost totally dependent on this one resource for energy. On top of that, we must add in more than 25% more petroleum to account for that consumed in processing petroleum to fuels, with the result that production and consumption of transportation fuels accounts for about 88% of the petroleum used in the US (US Department of Energy 2008).

Petroleum is favored for transportation because of the convenience of using liquid fuels and their particular suitability for transportation. However, despite having only about 4.6% of the world's population, the United States currently consumes about 7.5 billion barrels of the close to 31 billion barrels of oil used each year around the world, i.e., nearly one-quarter (US Department of Energy 2008). In contrast to our abundant domestic supplies of coal or reserves of natural gas, which are adequate in the short term, US production of petroleum has declined steadily since 1970 and now amounts to only about one-quarter of the total we consume. Despite recent cries to drill our way out of this dilemma, proved US petroleum reserves only amount to less than 25 billion barrels in total, and the relatively large reserves in Alaska, Texas, the Gulf of Mexico, and California would only last the country about half a year each if we tried to satisfy all of our large oil

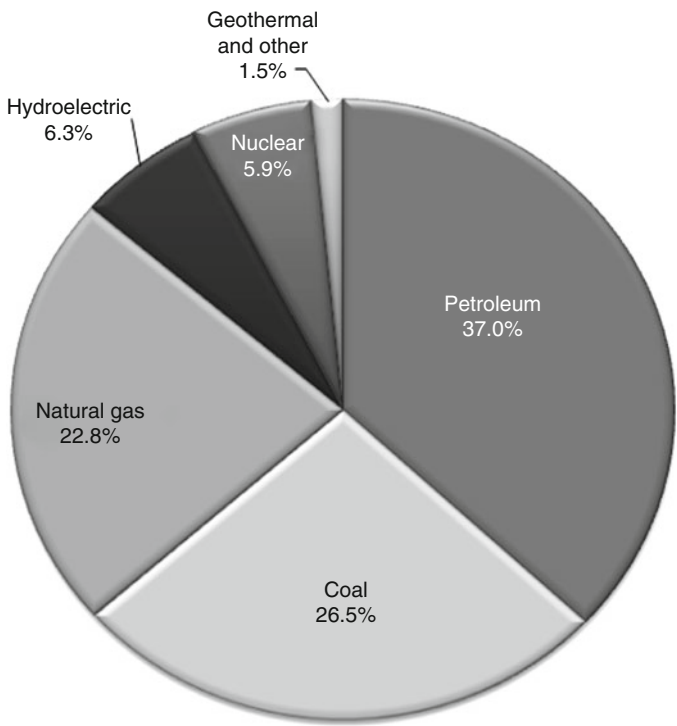


Fig. 1.1 The World is far more dependent on petroleum than any other source for total primary energy production, and non fossil energy sources provide less than 15% of the total energy consumed. Over half of the petroleum consumed is for transportation (US Department of Energy 2008)

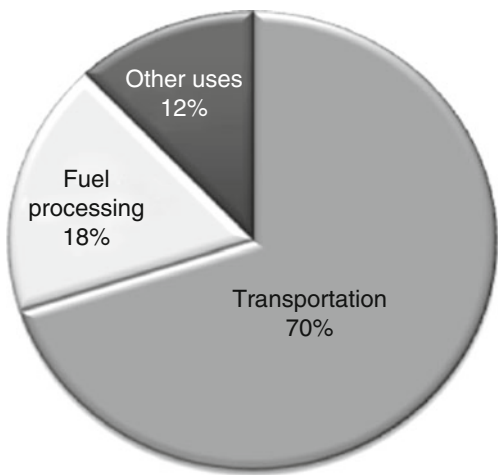


Fig. 1.2 The United States uses a larger share of petroleum directly for transportation than most other countries, with another 18% of petroleum supplying energy for converting crude oil to fuels (US Department of Energy 2008)

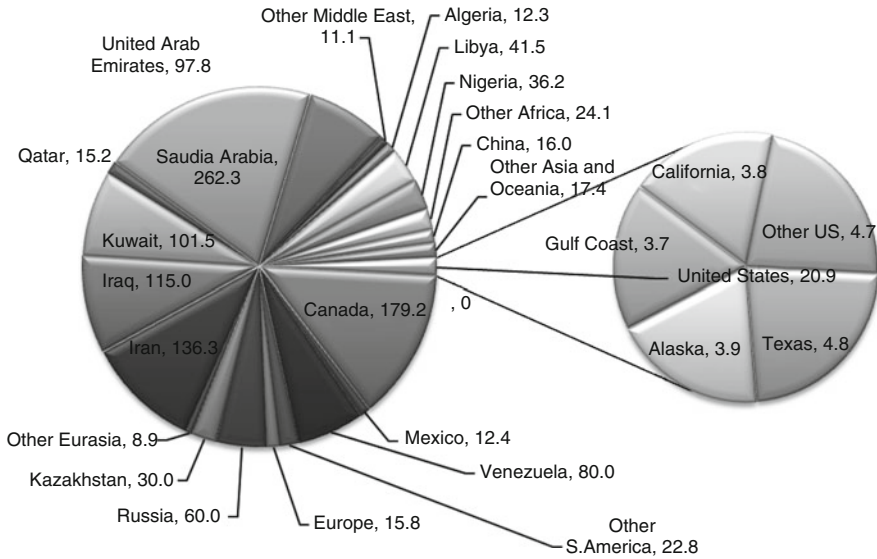


Fig. 1.3 Petroleum reserves. Known petroleum reserves in the United States are only about 2% of total world reserves and much smaller than for many other countries (amounts given in units of billions of barrels of oil). Clearly, domestic reserves are not nearly adequate to satisfy the current US demand of about 7.5 billion barrels/year for more than a few years (US Department of Energy 2008)

appetite from domestic sources. Although claims by critics that new discoveries of oil will extend supplies beyond the proved reserves are no doubt true, the rate of discovery is clearly dropping, with the result that total US production has declined from a high of 3.5 billion barrels in 1970 to about half that level now, and continues to drop. In contrast, as shown in Fig. 1.3, out of total world reserves of somewhat more than 1 trillion barrels of oil, more than 700 billion barrels are said to be located in Saudi Arabia, Iran, Iraq, Kuwait, the United Arab Emirates, and other countries of the Middle East; another 114 billion in Africa; about 100 billion in Eurasia; about 80 billion in Venezuela; and about 35 billion barrels in Asia and Oceania plus about another 180 billion barrels as tar sands in Canada. Thus, continued petroleum use will depend heavily on sources in unstable regions of the world and, although new discoveries will no doubt extend the supply, all of current world petroleum reserves would be depleted in about 30 years at current international consumption rates. Furthermore, we have now consumed about as much oil as are known to be in reserves, and a point of maximum petroleum production could be near due to declining supplies — a point known as Hubbert's peak in oil production — and political impediments to accessibility in many countries. And we should not lose sight of the fact that imported petroleum contributes more to the annual US trade deficit than any other source, with an annual cost of between US \$200 and \$800 billion dollars, depending on the price of oil.

1.3 Oil and Global Climate Change

In addition to concerns such as a high dependence on oil should raise about balance of trade, energy security, and energy supply, burning petroleum is a major source of the carbon dioxide accumulation that leads to global climate change. Carbon dioxide concentrations have increased from about 315 ppm to about 390 ppm (US Department of Energy 2008) over the last 50 years, and this build up is predicted to cause many changes in our climate, with consequences including melting of the polar ice caps, flooding, drought, extinction of species, and disruptions in food supply. The United States and China, with almost five times as many people, each now release about 6 billion metric tons of carbon dioxide annually, more than any other country. Although clearing forests and other human activities also contribute greenhouse gases, about 85% of the US contribution comes from energy consumption, with petroleum amounting to about 43% of the amount from energy. Because of its heavy dependence on oil, transportation has become the leading emitter of carbon dioxide from energy use.

1.4 What are our Options to Reduce Petroleum Use?

The so-called “energy crises” of the 1970s and 1980s were really due to embargoes of petroleum by Organization of the Petroleum Exporting Countries (OPEC) that resulted in reduced supplies and dramatic price run ups. Electric utilities learned from this experience and virtually phased out petroleum use. Similarly, the industrial, commercial, and residential sectors have taken advantage of more abundant reserves of coal and natural gas to limit petroleum consumption. Each of these sectors can also choose among many non-fossil energy sources in the future, including geothermal, hydropower, nuclear power, photovoltaic electricity, solar thermal heat and power, and wind energy. But such sources tend to be more suitable for stationary applications, and alternatives to petroleum for mobility are not so simple to implement. As a result, the near total dependence of transportation on oil has grown substantially following the energy crises, with the result we use a much larger amount of petroleum than ever and import an even larger fraction now than at any time in the past (US Department of Energy 2008).

Serious analysis of the situation shows that the options to reduce both petroleum consumption and greenhouse gas (GHG) emissions by transportation are limited. First, we could rely much more on public transportation and drive less miles — important opportunities but ones that are counter to historic trends. In addition, many fear that reduced travel would hurt the economy. The second choice is to drive more efficient vehicles such as hybrid and lighter, more fuel efficient, cars. This path presents low hanging fruit that has not been taken advantage of sufficiently, and is synergistic with introducing new fuels as well as reducing petroleum use. The third option is to use a source other than petroleum to fuel our vehicles, but we must keep in mind that only a sustainable option will avoid GHG emissions.

Plant Biotechnology for Sustainable Production of
Energy and Co-products

Mascia, P.N.; Scheffran, J.; Widholm, J.M. (Eds.)

2010, XVIII, 458 p. 74 illus., 37 illus. in color., Hardcover

ISBN: 978-3-642-13439-5