1

INTRODUCTION

1.1 WHY THIS BOOK?

The motivation to find an efficient and economical way of obtaining energy from renewable sources, such as from biomass materials, is vital for the present and future generations of this world. There is an increasing demand for energy and an urgent need to protect the world's climate and environment, as a whole. Governments around the world are positively encouraging research and application in this field. There has been a degree of competition in recent years among participating countries, and among international power generating companies, in an attempt to be the first to find a more economical source of energy, mainly from renewable sources. Local and national government laws and emerging international regulations give the same indication, that is, the urgent need for a new type of energy, mainly for the reasons mentioned above. As a result, power generating companies, particularly those in Europe, are facing increasing demands from their local and central governments to reduce their dependency on fossil fuels.* In consequence, these power generating companies, alongside their own internal research, now allocate external

* There are two issues facing power generating companies. The first issue is how to reduce emission at a lower cost. The second issue is how to increase the plant efficiency, that is, during electricity generation, distribution, and up to the end-user applications.

The Selection Process of Biomass Materials for the Production of Bio-fuels and Co-firing, First Edition. Najib Altawell.

budgets to sponsored projects in this field at various educational and research institutes across the globe.

Regarding this book, the message is very clear, stating that biomass materials are a good source of energy and are relatively economical. Furthermore, as natural materials, biomass should not affect the environment and/or increase the emission of CO_2 in the atmosphere. In fact, using energy crops as a source for sustainable energy is the only practical renewable energy system that can actually decrease CO_2 in the atmosphere over a long period of time. Biomass energy is the only source of renewable energy that can be produced in three different states, that is, solid, liquid and gas, similar to the fuel production obtained from fossil fuels. This means that there is no need to reinvent the combustion engine or even to replace it with an electric motor. However, despite a large number of past and present research projects, no economically affordable (at lower cost than fossil fuel) and efficient biomass fuel has yet been found. In other words, a fuel produced without affecting the market in relation to the price of biomass materials used, such as energy crops. This means that the prices of energy crops are kept low even when some of these resources are diverted toward the production of biofuels. For this reason, the main part of this work is to achieve what has not been achieved so far within the field of renewable energy. Fortunately, all the indications and results suggest there is a method that can be used to obtain and harness the chosen biomass materials for the purpose of generating electricity, as well as for use as a fuel for transportation and heating/cooling systems.

The emphasis in this work is given to four/five biomass samples. These samples carry with them the main research justification, as they are the makeup of the fuel which will turn the turbines to generate electricity in the not too distant future. Therefore, the aim of this book is to apply a systematic approach to biomass materials for the purpose of finding the most economical and efficient type, capable of producing sufficient energy on a commercial scale. This should help in reducing harmful gasses and stabilize CO_2 in the atmosphere.

1.2 THE BOOK STRUCTURE

1.2.1 Introduction

This book begins with a literature review and basic revision in areas related to renewable energy in general and biomass energy in particular.

A period of 7 months was spent in the preparation and examination of various projects and research within the above field of energy, that is, biomass energy. The literature review produced a vast amount of material with multiple answers to different types of questions. This in turn produced a number of new ideas on how to proceed with the work during the following steps and stages.

At the beginning of the second stage of writing this book, for example, Chapters 2–4, the laboratory work for selected samples began and lasted for about 8 months. The data obtained from the laboratory tests produced interesting results in that certain biomass samples have similar amount of energy as those obtained from fossil fuels, such as coal. These results were the input for the methodology system REA1.

When the first part of the research approached the final stages, the principal idea of the book was about how to design and implement a new methodology in dealing with the selection of biomass materials. This new methodology should be able to examine various selected samples from different aspects related to commercial, legal, and business to scientific and technical factors. As the research progressed, it was decided that the work itself should be divided into four different parts. “Part 1” deals with investigation of the samples. “Part 2” deals with the building of the methodology. “Part 3” deals with the implementation of the methodology. “Part 4” deals with the biomass commercial aspects scenario during the initial period for the introduction of a new type of bio-fuel, together with an economic analysis report. The fact that the methodology was researched, compiled, and written within a reasonably short period of time indicates the huge amount of effort and time spent in achieving initially unexpected goals. The aim was in part to investigate aspects of this new technology and its commercial use in the early part of the twenty-first century. Biomass in general, among other renewable sources of energy, is the science and technology for a new type of energy, which many predicted would be the challenge facing this century. However, biomass energy, as we know it today, is both engineering and a branch of science. Here we research and investigate various biomass samples for long-term commercial use. This kind of investigation will help in producing new materials and technology to replace the fossil fuels being used at the present time.

1.2.2 Structure

There are four different subjects (Fig. 1.1), which are, nevertheless, integrated into each other, as all of them work in order to achieve certain function(s) for the purpose of obtaining certain result(s). In “Part 1,” investigations took place into the characteristics, composition, and suitability of biomass materials in general, and energy crops in particular, for the production of bio-fuels. “Part 2” builds a new methodology specifically to deal with biomass samples and their final selection. The two main factors on which the methodology relies, that is, scientific and technical (S&T) and business factors (BF) are divided into other factors, such as systems, approach, business viability, applicability, biomass supply, emission, technical and technical risks, commercial and commercial risks, and environmental and human health risks. These factors themselves are then divided into further subfactors. REA1 methodology, therefore, looks at various factors and possibilities in the field of technology and science,

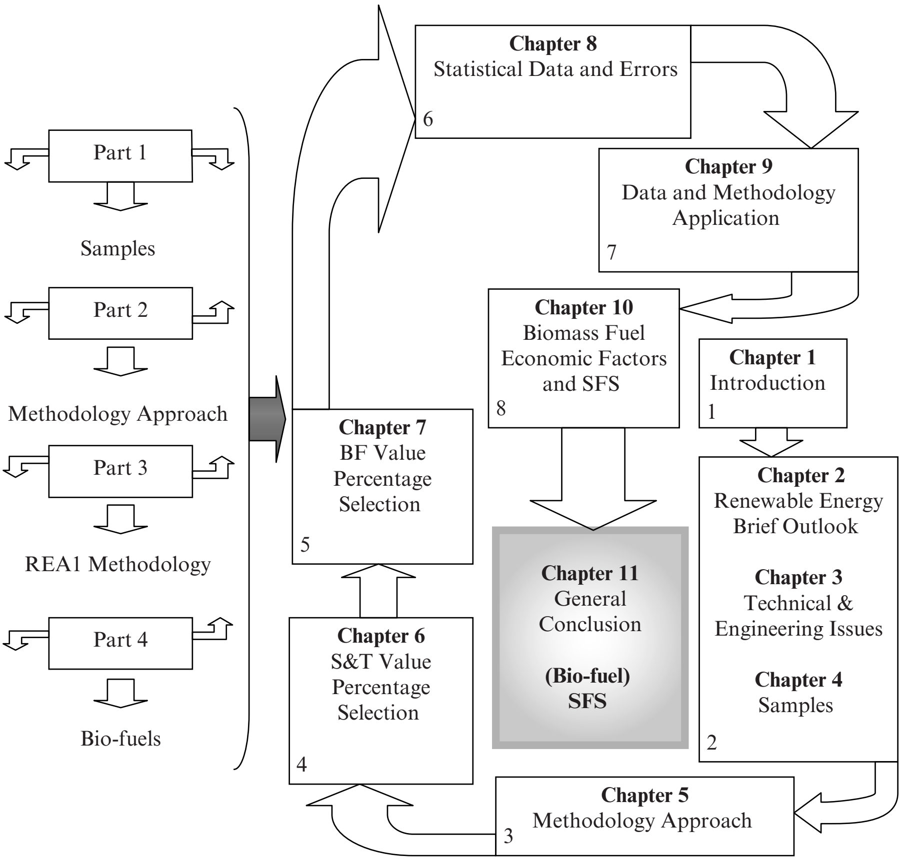

Figure 1.1 Four-part research strategy (concluded with the prospect of a new bio-fuel. *Source*: Author.

in the field of business, and commerce, as well as at government regulations, together with local and international laws.

In "Part 3," a deciding factor was made as to how to proceed to fast and accurate calculation in applying the principles of "Part Two" on each sample. The methodology, as it stands, can be used to do the proposed calculations for each sample. The completion of REA1 methodology for biomass selection, and other possible future applications and development leads to "Part 4."

Finally, "Part 4" is mainly concerned with the scenario of a final biomass sample creation to be used on a commercial scale, as well as the economic analysis for what has been achieved so far. To briefly explain the idea behind this, it would be better to look at the point where each stage during the research itself formed the next part of the work, starting with the four/five final selected samples. These four/five final samples have already been checked from the market point of view and their business viability, in general. The removal (or addition) of any unwanted elements in a single sample (or samples) would be applied commercially on a large-scale plantation. The economic cost can easily be known in advance, depending on the market fluctuations and stability, by using the actual data that "energy businesses" already have (for both BF and S&T factors). The new sample would be ready to produce from the chosen four or five samples. However, this stage would take the book beyond its present scope. The new sample should be higher in quality but cost almost the same (if not less) in comparison to any of the original four or five samples used before the final production.

1.3 ENERGY UTILIZATION

The aim for all types of renewable sources of energy is very similar, in that they all aim for the same target. This target can be summarized as the production of energy that is affordable/economical, sustainable, and environmentally friendly. In comparison with other types of renewable sources of energy, biomass research, development, and applications have been historically the dominant source of energy for thousands of years. The present development within the biomass energy commercial sector is also a market leader in a number of countries across the globe.

Figures related to the percentage usage of energy indicate that around 15% of the world's primary energy is from plant materials. Developing countries use around 38% from the same source as a fuel, while for Sub-Saharan African and as well as a number of Asian countries, plant materials provide between 60% and 90%. In rural areas within the developing countries, the use of biomass accounts for more than 90% of total daily use (EIA, 2013; IPCC, 2012). When biomass energy, as well as other sources of renewable energy, is discussed in the media, daily conversation, or within projects and schemes, together they create a strong momentum that contributes to the creation of new and useful ideas, which in turn implement the use of environmentally friendly energy, anywhere in the world.

In addition to this, the momentum highlights the local, national, and international stage concerning environmental and energy issues and, therefore, can help to provide resources urgently needed for positive actions concerning the environment and safer and more sustainable sources of energy.

When it comes to sources of energy from fossil fuels, sustainability and environmental aspects have been ignored for decades by the majority of policy makers and international commercial energy companies across the globe. In 1949, M. King Hubbert predicted that fossil fuel would be short lived, and in 1956, he predicted that peak oil production in the United States would occur during the year of 1970 (Hubbert's peak). These predictions only recently started to make sense to politicians and world leaders. Consequently, the action taken so far is too late and too little. For this reason, a book such as this can play an important role, regardless of the size of contribution it may provide

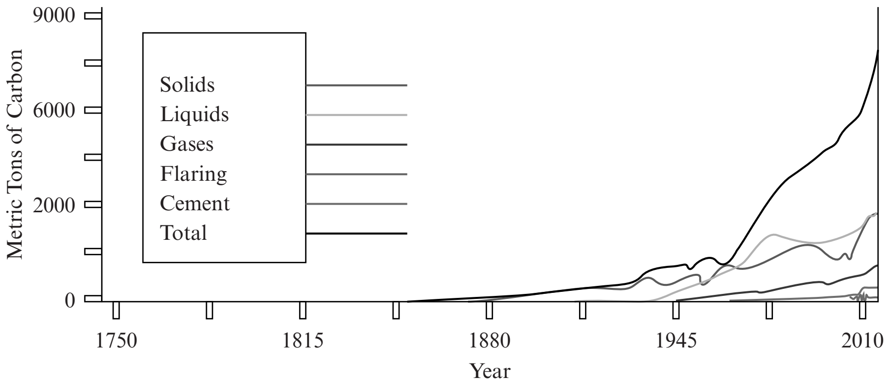

Figure 1.2 Global carbon emissions since 1880. *Source*: Adapted from U.S. Department of Energy.

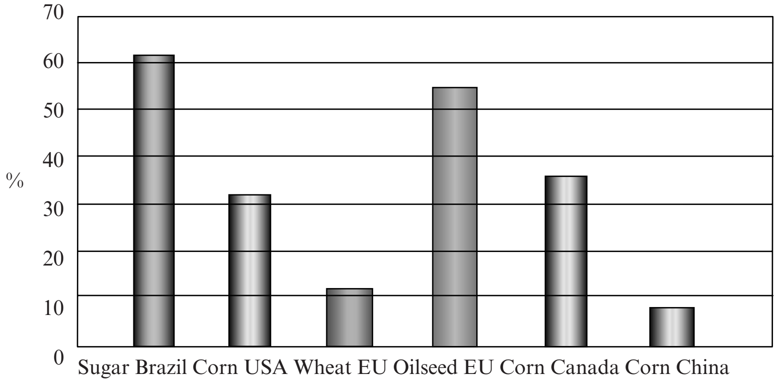

Figure 1.3 Projection for the year 2016 of percentage of crops that will be used for bio-fuel production in various countries. *Source*: Data from OECD (2013).

later on. Supporting and publicizing projects about renewable sources of energy can result in solutions for some of the problems facing everyone on this planet, with regard to environmental issues and energy needs. Increasing global emissions of CO_2 (Fig. 1.2) and the rise of energy crops prices, as a result of their usage in the bio-fuel sector (Fig. 1.3), all make an urgent case for further research, as do new ideas and different approaches in the usage and application of energy sources. As mentioned previously and repeated once more here, the need for energy can be summarized as *sustainable, environmentally friendly, economical, efficient, and adaptable*. The question is if biomass energy can fulfill these criteria.

1.4 THE NEED FOR EFFECTIVE BIOMASS UTILIZATION

The need for an alternative source of energy rises with each passing day. When environmental issues, long-term supply/availability, and economic reasons are taken into account, the design and implementation of a new biomass energy system can provide benefits in many ways. The following points are examples of why the need for a new energy system exists:

a. Developing systems to economically produce fuels and chemicals from biomass will help power generating companies to create their own resources, while simultaneously helping rural economic development.
b. Adding value to agricultural products will economically enhance many local industries.
c. Demonstrating full-scale biomass conversion systems promotes increased adoption of these technologies.
d. Biomass materials for energy stimulate the development of new products and technologies, as well as create a new market (with new jobs) that has export potential.
e. Development of a new biomass fuel (e.g., SFS—see Chapters 9 and 10).
f. Implementing technological and behavioral intervention can stop or reduce GHG before it is too late "Without technological and/or behavioral intervention, atmospheric concentration of GHGs will continue to increase . . ." (DTI Project Report, 2005).

1.5 RENEWABLE ENERGY IMPACT ON BIOMASS ECONOMY

There are several barriers to the adoption of renewable energy technologies; however, opportunities do exist to overcome them. These barriers include:

- Financial constraints, which limit greater deployment of renewable technologies. This barrier lies in the perceived risk associated with investing in this field, which is generally higher than competing in conventional technologies, and the effects of this higher perceived risk on the market.
- The RE technologies are relatively new to the capital markets and as such there is more risk than in using established technologies. The higher the perceived risk, the higher the required rate of return demanded on capital.
- The perceived length and difficulty of permitting process in this field is an additional determinant of risk.
- The high financing requirements of many renewable energy technologies often present additional cost-recovery risks for which capital markets demand a premium.

Possible recommendations could be the following:

- Low interest loans or loan guarantees might serve to reduce perceived investor risk.
- Tax credits for renewable energy technologies production through the early high-risk years of a project may provide another mechanism for further development.
- Regulatory cost recovery mechanisms, which today often favor low initial cost fuel-based technologies, can be modified to recognize life-cycle cost as an appropriate determinant of cost effectiveness.
- Effective redistribution of government spending on research and development that directly reflects the potential of RE technologies.

In the United Kingdom, the government has set up a renewable obligations certificate (ROC) (Biomass Task Force, 2005) in relation to the use of energy. This certificate details:

A. 15% of electricity should be generated from renewable sources by 2015.
B. 20 p/l tax rebate for biodiesel.
C. Direct support for renewable energy.
D. 20% GHG reduction target by 2020.
E. Climate change levy/Carbon Trust.
F. Emissions Trading Scheme (2002).
G. Set aside payments for nonfood crop production.

According to Ofgem (Ofgem, 2009): "A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated." The ROC became law in 2005 when the government issued the Renewable Obligation Order 2005.* The ROC obliged the power generating providers to obtain a percentage of their electricity produced from renewable sources. According to previous government legislation as early as 2002, every year the percentage of electricity from renewable sources should be increased, for example, 2006, 6% and 2007, 7%, reaching 14% by 2014. Power generating companies, who cannot provide proof (certificates) related to the above, can be fined. As a digital certificate, the ROC holds information concerning the production of renewable electricity per unit. The certificates can be traded as they are guaranteed by the government (Box 1.1).

* In the United Kingdom, "The Renewable Obligation Order 2005" that updated the previous orders of 2002 and 2004, obliged power generating companies to supply their customers with 6.7% of its energy derived from renewable sources.

Box 1.1

UK RENEWABLE ENERGY SUPPORT SCHEMES

Renewable Obligation Certificates (ROCs)
Each MWh of green electricity produced 1 ROC is delivered.

An option to use the generated electricity either for the energy business or fed into the grid. By fulfilling ROC quota obligation, an option is available for the ROC to be sold to energy suppliers.

The ROC selling price is between £30 and £50, that is, 0.034–0.056 €/kWh.

Tax: VAT reduced to 5%.

Government Grants: Under Phase I and II Low Carbon Buildings Programme—residential buildings: 50% of project cost or €2276/kW (€2841 maximum). The public sector as well as nonprofit organizations buildings: 50% of project cost or €2841 maximum.

EPIA (2009)

1.6 SUMMARY

Two important topics related to energy supply and climate issues were discussed in the DTI white paper "Meeting the Energy Challenge" (2007):

> The International Energy Agency (IEA) forecasts that $20 trillion of investment will be needed to meet these challenges by 2030. The investment decisions that will be taken over the next two decades will be critical in determining the world's climate and the security of its energy supplies. At home it is likely that the UK will need around 30–35 GW of new electricity generation capacity over the next two decades and around two thirds of this capacity by 2020. This is because many of our coal and most of our existing nuclear power stations are set to close. And energy demand will grow over time, despite increased energy efficiency, as the economy expands.

The IEA figure of $20 trillion of investment may or may not result in what the IEA is forecasting for the next two decades. This kind of forecasting, even if it is built on solid and accurate data, is unreliable. The reason(s) for this usually lie within various constantly changing factors. These factors can range from the degree in which our climate is changing and/or the increase in the earth's population, to a change in politics worldwide, in particular when individual countries are concerned with their own interests rather than the world as a whole. This can contribute to a very difficult situation and can produce disunity, rather than the unity which is very much needed to solve the global warming and energy crises. In the case of internationally vital decisions (concerning everyone on this planet), no country should consider its own interests alone, but rather how its decisions and laws/regulations may influence the present and future global environment.

Box 1.2

BIOMASS MATERIALS

Writing a book to investigate the best way to produce energy from biomass materials can be a long process, especially if creativity prompts new ideas which were not considered seriously at the beginning.

Biomass materials will be one of the main sources of energy in the twenty-first century and beyond it, just as they were in ancient times seen as the main source of energy since man discovered how to make fire from these materials.

Regarding the United Kingdom's future energy need, there will certainly be an increase in demand in this sector, and possibly higher than the figure of 30–35 GW mentioned in the white paper. The reason for this is simply because the UK population is increasing at a higher rate than at any other time in history, according to the latest population survey and home office prediction. One of the reasons attributed to this is the number of East European countries that have joined the European Union. The possibility is that (for the next three decades) the United Kingdom will import most of its energy needs at a higher rate than ever before. Of course, this will depend mostly on the developments taking place in the energy field within the United Kingdom.

As mentioned previously, this book is divided into four different stages in order to allow each stage its own productive environment within that particular field, keeping in mind the connection with the other parts and the final outcome for the book, as a whole. The question about energy and a new system are important issues that should be taken into consideration, that is, relevant issues in the field of energy and viability can be fitted into and lead to the aims and objectives of the book.

Looking at basic factors such as climate change, economic, and political factors to unlock the main discussion, as well as understanding public views and concerns, will open the door in examining more closely the situation of all renewable energies and their possible future impacts. Particular attention is given to the economic and social aspects, which apart from the environmental factor, can affect everyone, both directly and indirectly (Box 1.2).

REFERENCES

Biomass Task Force (2005) Biomass task force report to the government. Department of environment, food and rural affairs (Defra) publications, London. http://archive.defra.gov.uk/foodfarm/growing/crops/industrial/energy/biomass-taskforce/pdf/btf-final-execsumm.pdf (last accessed December 3, 2013).

DTI (2007) Meeting the energy challenge. A White Paper on energy presented to Parliament by the Secretary of State for Trade and Industry, May 2007. http://www.berr.gov.uk/files/file39387.pdf (last accessed December 3, 2013).

DTI Project Report (2005) Best practice brochure: co-firing of biomass (main report). Report No. COAL R287 DTI/PUB URN. http://www.berr.gov.uk/files/file20737.pdf (last accessed December 3, 2013).

EIA (2013) World energy demand and economic outlook. International Energy Outlook 2013. http://www.eia.gov/forecasts/ieo/world.cfm (last accessed December 3, 2013).

EPIA (2009) Overview of European PV support schemes (last update on 8/05/2009). http://www.epia.org/index.php?id=463 (last accessed July 7, 2009).

IFPRI (International Food Policy Research Institute) (2008) Testimony biofuels and grain prices impacts and policy responses. Rosegrant M. W., testimony before the U.S. Senate Committee on Homeland Security and Governmental Affairs http://www.ifpri.org/pubs/testimony/rosegrant20080507.asp (last accessed December 3, 2013).

IPCC (Intergovernmental Panel on Climate Change) (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. http://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf (last accessed December 3, 2013).

OECD (2013) Biofuels and agriculture: projections to 2016. http://www.oecd.org/agriculture/biofuelsandagricultureprojectionsto2016.htm (last accessed December 3, 2013).

Ofgem (2009) Renewables obligation—what is the renewables obligation (RO)? Sustainability, environment. http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx (last accessed December 3, 2013).

U.S. Department of Energy (2006) Biomass energy data book. Energy Efficiency and Renewable Energy, USA.