Part I

Exploring the Bioenergy Potential
Chapter 1  
How to Realize the Bioenergy Prospects?

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1.1. WHAT IS THE NEWS?

Biomass has been a major source of energy in the world since the beginning of civilization. It has been important in development processes, including early stages of industrialization in several countries. In Sweden, for example, the first concerns about preservation date from the seventeenth and eighteenth centuries, resulting from the recognition of the central role played by forests in energy provision (see also Kaijser, 2001). Biomass was also essential in the initial development of the iron industry in Sweden and, later on, the same happened in Brazil, where charcoal is still largely utilized in iron reduction. Biomass remains a major source of energy in many countries. Ethiopia and Tanzania, for example, derive more than 90 per cent of their energy from biomass. In fact, the African continent as a whole relies heavily on biomass resources for the provision of energy services.

When observing what happened in the past two centuries, we have the impression that the more industrialized a country became, the more dependent it grew on fossil fuels. But there are exceptions. Norway, for example, was able to industrialize without developing the typical dependency on fossil fuels thanks to its hydropower endowments. At a global level, however, the industrialization period has been characterized by an increasing use of fossil fuels as energy carriers. Thus there is a tendency to think that countries with large biomass dependency are poor countries with a low level of industrialization. The generalized view has been that countries climb an energy ladder that leaves biomass behind in favor of more efficient fuels and technologies, which are often based on coal, oil and gas.

In the past decades, the old rule, that the richer and the more industrialized a country is, the more dependent it becomes on fossil fuels, has been broken. Many countries have realized the need to harness local resources to increase the security of energy supply, reverse fossil fuel dependency and improve trade balance. The global environmental agenda, for example in the form of the Agenda 21 and the Climate Convention, has also played a role in this process for more than ten years now. As a result, there is a general trend to search for energy alternatives involving locally
available renewable resources, while simultaneously pursuing increased energy efficiency throughout the economy. Countries have chosen different paths to move towards sustainable energy systems, and the accomplishments vary significantly.

The good news is that the connection often made between biomass utilization and poverty starts fading. All types of energy services can and are being provided today using biomass, with the reliability, safety and efficiency required by the modern economy and society. Moreover, this is not only happening in rich countries, it is also happening in many developing countries. The other good news, and part a corollary of the former, is that industrialization, which is seen as an important step in the development process, can be achieved using sources of energy other than fossil fuels, and this can create jobs and contribute to regional development instead of displacing people, eroding local economies and destroying the natural environment.

There are reasons to believe that the turn of the century has also been a turning point for bioenergy. This results not only from the recognition of the bioenergy potential, but also from the maturity of technologies, the reliability of positive results achieved so far, and the awareness of policy makers about the multiple benefits accrued from bioenergy. To developing countries, this means that the old idea of climbing an energy ladder that gradually goes from biofuels to fossil fuels as a way to access modern energy services should be questioned and reviewed under the light of recent technological development and international opportunities for investing in renewable alternatives.

This may sound almost like a manifesto for bioenergy. Let it be so. Biomass can be used to produce different forms of energy such as heat, electricity and transport fuels, thus providing all the energy services required in modern society. We know that. Some countries have actually come a long way in testing technologies and models that can be replicated. These countries are already realizing their biomass potential. In Sweden, for example, biomass already accounts for 16 per cent of the total energy supply. In Finland, biomass responds to 19 per cent of the country’s total supply. In Brazil, 27 per cent of the energy comes from biomass, almost half the part being sugar-cane based, including an annual production of some 10 million m³ of ethanol which are used in the transport sector. In these countries, biofuels are being used to feed modern and efficient systems, providing essential energy services.

Truly, opportunities come with challenges. We have to face the crude fact that, despite all efforts being made to introduce renewables and despite their rapid percentual growth in many regions, fossil fuel annual additions to the world energy supply are still much larger in absolute terms. A quick look at OECD countries reveals that most of them still depend about eighty per cent or more on fossil fuels for the provision of energy services. Also, developing countries are largely meeting their increasing energy demands with fossil fuels, thus replicating past trends and nonsustainable experiences. Unless very significant and more proactive measures are
taken both nationally and internationally, this situation will persist for many years to come, delaying the shift towards sustainable energy systems.

Bioenergy options are at hand, satisfying technical, commercial, environmental, social and even political requirements. Energy infrastructure is important for social and economic development in modern societies, and bioenergy is attractive at all stages of development due to its potential integration with development strategies in rich and poor countries alike, and in comprehensive ways hardly matched by other alternatives. It is no exaggeration to see bioenergy options amongst the most attractive energy forms that we can harness today, with technologies and system solutions that are already mastered, with strong public and political acceptance, and often also with a commercial appeal.

Certainly, we ought to be realistic about what can be accomplished, and at what speed and range. A sustainable use of biomass requires comprehensive management of natural resources such as land and water. There are a number of factors that need consideration when it comes to achieving a fair balance in the use of scarce resources. For example, it is necessary to guarantee that land competition does not jeopardize food production and security. In addition, there are questions of security of supply, vulnerability of energy systems and the challenging task of designing policies that can address the development of multisector systems. Still, these broad tasks should not keep us away from ambitious targets, particularly in the face of promising multiple rewards in the direction of sustainability.

1.2. THIS BOOK

In this book, we talk about opportunities and challenges when it comes to harnessing the biomass potential. In other words, we consider ways through which bioenergy can contribute to global sustainable energy systems. What types of energy services can be provided and how? What needs to be addressed when implementing bioenergy systems? We do not try to be comprehensive but we do move about in the different realities of Europe and developing countries, where needs and demands can mean different things though the bioenergy benefits can be quite similar. We address resource management, markets, technological and institutional development, and policy issues.

Our major task is to show accomplishments and indicate possible directions. We also provide views of different stakeholders so that we can better understand their concerns and the specific roles they can play in the implementation of solutions. We are not proposing a business plan, but we are perhaps suggesting that we should be working on a strategic plan from which various business plans can be generated. Why do we need a broad framework to move forward? – Because the tasks are many,
and the potential impacts, very significant. There is need for a multisectoral coordination of action, and that requires appropriate plans for timely and speedy moves, which prove effective in both short and long terms.

We are asking questions such as what the main forces enhancing bioenergy utilization are. Where and how are opportunities being sized, and how can ongoing initiatives be enhanced? What policies are being applied to foster biomass technologies, and how can they be improved? How can the environmental and social benefits of bioenergy be better highlighted and valued, in order to increase the bioenergy attractiveness? What are the challenges ahead and how should they be framed towards effective action? Thus, we are now beyond the question of whether biomass is an attractive and effective energy carrier. Our focus is not on the problems, but on the opportunities. We identify demands and questions related to next steps in developing bioenergy systems, and try to answer some of them by indicating possible solutions.

This chapter provides an introduction to the role of bioenergy in perspective and as it stands today, and a discussion of how bioenergy prospects can be realized and framed towards sustainable development. Throughout the book, the demands and prospects are further discussed, the role of accumulated knowledge and experience reviewed, and new tasks identified.

Chapters 2 to 4 explore policies to promote bioenergy utilization. In Chapter 2, Bauen discusses the policy framework in the European Union (EU), and gives examples of how these policies are reflected in national action. Chapter 3 describes the Swedish experience, and ways through which bioenergy utilization can be enhanced in the country in the near future. In Chapter 4, Rakos addresses the issue of public acceptance to the introduction of district heating systems in Austrian villages, providing a concrete case to exemplify the effect of policies and technology dissemination at the local level.

Chapters 5 to 7 are focused on the management of biomass resources and enhancement of biomass production. Rijal addresses relevant issues in the context of Himalayan Mountain Forests while Braunbeck et al. discuss ways to enhance the biomass base of cane production in Brazil. In Chapter 7, Silveira and Andersson discuss the integration of forestry and energy activities in Lithuania where Swedish experiences are providing the know-how basis for helping explore the local bioenergy potential.

Chapters 8 to 11 discuss ways to promote bioenergy utilization. Sandberg and Bernotat assess the potential for new district heating systems in three counties in Sweden. In Chapter 9, Walter et al. discuss how cofiring natural gas and biomass can be an interesting alternative both technically and commercially. Wijayatunga et al. show a feasibility study done for Sri Lanka where biomass is contemplated as an alternative for the provision of electricity. In Chapter 11, Thrän et al. describe
the international work within the EU aimed at standardization of biofuels as a tool to boost markets. These chapters are particularly relevant for the methodologies they present.

Chapters 12 to 16 discuss the Clean Development Mechanism (CDM) to the Kyoto Protocol as a means of promoting bioenergy projects. Economic advantages, development priorities and climate change mitigation are addressed in Chapter 12. The emphasis, however, is given to aspects of project implementation. In Chapter 13, Kossoy discusses the CDM in a business context, particularly from a financial point of view. Chapters 14 to 16 provide examples of CDM projects in Brazil and Ghana.

Chapter 17 closes the book with some final considerations on the trade-offs involved in the choice of energy options, and the need for comprehensive strategies and systems integration to achieve the sustainability goals. Some considerations are also made about the platforms available for enhancing synergies and the ultimate value of energy projects. How can so many opportunities be combined effectively towards the realization of the bioenergy potential and sustainable development? What role can the developing countries play at a global level?

1.3. BIOENERGY AS PART OF THE RENEWABLE BASKET

IEA (2003) estimates that 13.5 per cent of the total 10 038 Mtoe of primary energy supply in the world came from renewable sources in 2001. As much as 79.6 per cent came from fossil fuels, and 6.9 per cent came from nuclear power. Over the last thirty years, the average increase in the utilization of renewables went hand in hand with the increase in energy supply, or around 2 per cent per year (IEA, 2002). Unfortunately, this implies a faster absolute increase in the use of fossil fuels. In fact, the absolute use of fossil fuels increased five times more than the use of renewables in the last three decades.

Since 1990, the primary energy supply in the world grew by 1.4 per cent per year while the growth of renewables was 1.7 per cent per year, indicating not only a slower increase in the use of energy but also a slightly more rapid increase in the use of renewables when compared with other sources. Nevertheless, fossil fuel utilization is still increasing faster in absolute terms as renewable sources are still at low levels. Thus much remains to be done in order to shift world energy systems towards sustainable solutions.

Figure 1.1 illustrates the shares of various renewables in the world energy supply. New renewables such as solar, wind and tide comprise a very small fraction, corresponding to less than 0.1 per cent of the total energy supply of the world and only 0.5 per cent of the renewables. Biomass is by far the most significant renewable source, representing 10.4 per cent of the world total. It is worth pointing out
that while 87 per cent of the biomass resources are used in developing countries, 86 per cent of the new renewables are found in OECD countries (IEA, 2002). In any case, given the small amounts of the latter, developing countries are, in fact, much larger users of renewables than industrialized nations. In addition, it is important to remember that, though making a relatively small contribution to the world’s total supply, renewables allow energy to arrive at remote and isolated locations, thus often making a crucial contribution.

Biomass is mostly used in solid form and, to a lesser extent, also in the form of liquid fuels, renewable municipal solid waste and gas. However, recent trends show a faster increase in the use of liquid biomass and municipal waste than solid biomass. In fact, when compared with other renewables, solid biomass showed the slowest growth since 1990. While solar and wind energy supply grew by 19 per cent, solid biomass grew by only 1.5 per cent per year during the 1990s. On the other hand, non-solid biomass and waste such as municipal solid waste, biogas and liquid biomass grew by 7.6 per cent per year. Thus some opportunities are being sized particularly as a result of efforts to find new alternatives to fossil fuels in the transport sector and in waste management. Nevertheless, considering the resource base that is readily available and the great potential to grow biomass, there is much more that can be done to enhance the role of bioenergy.

In the so-called rich and green scenario developed by IIASA/WEC, biomass could account for 20 per cent of the total amount of the world energy in 2100 (Nakicenovic et al., 1998). Obviously, this will not happen by itself, and the slow growth of solid biomass provides an illustration of that. This scenario includes significant technological progress and strong international cooperation around environmental protection and equity issues. It is also important to point out that biomass utilization in the IIASA/WEC scenario differs from the present conditions especially when it comes to technology. In particular, significant changes in the way
biomass is being utilized in many developing countries today will have to be accomplished. We are basically talking about going from traditional to modern and efficient technologies that can provide high-quality energy services, many of which require access to electricity.

There are significant regional differences when it comes to the availability and use of biomass resources in the world (see Figure 1.2). In many regions of developing countries, biomass is the only accessible and affordable source of energy. In Africa, for example, biomass corresponds to half of the total energy supply. Most of the biomass used in the continent is being harvested informally and only a small part is commercialized, with biomass markets usually operating in urban areas only. In many parts of Asia and Latin America, on the other hand, modern and commercial bioenergy options are readily available and significant. The Brazilian ethanol programme is noteworthy as the single most important accomplishment in providing an alternative fuel to the transport sector.

In addition to woodfuels, other biomass fuels such as forest and crop residues as well as animal waste are common sources of bioenergy in poor countries, where also traditional technologies predominate. Besides the amount of biomass that is readily available in the form of residues, and the potential for improved efficiency in technologies being presently applied, many countries still have land available for energy plantations. Integrating biomass harvesting for energy purposes with forestry and agricultural activities is another option. In many regions, the use of biomass still needs to become sustainable, this being true both where traditional and modern technologies are applied.

![Figure 1.2. Regional shares of bioenergy supply. Source: IEA (2003).](image-url)
Figure 1.2 shows how the utilization of biomass is distributed across the globe. What it does not say, however, is how large the actual potential for harvesting biomass resources is in the various regions. In fact, the most promising areas are found in the tropical regions. The best average yields per hectare have been observed in sugarcane plantations in Zambia which have reached 1350 GJ/ha/year (global average 650 GJ/ha/year), followed by best-performing eucalyptus plantations in Brazil with 1000 GJ/ha/year (Brazilian average 450 GJ/ha/year). For comparison we can mention that registered US record yields for maize are slightly over 400 GJ/ha/year while the average is about half, and the high estimates from American commercial forests are less than 100 GJ/ha/year (IPCC/SAR, 2001).

A large part of the biomass in developing countries is used in households for cooking and heating. But biomass is also an important energy source in many industries, for example, in the production of ceramics and beverages, and in drying and processing food. These same industries provide an important demand base and starting point for realizing bioenergy projects in developing countries, not least integrated with other established commercial activities. These opportunities are often forgotten for reasons such as lack of knowledge of how to develop bioenergy systems, nonexistence of supporting policies, lack of managerial capacity and conventional energy planning practices.

Only 13 per cent of the total biomass is consumed in the OECD countries, where it accounts for some 3 per cent of the energy supply. In fact, renewables as a whole correspond to only 5.7 per cent of the total primary energy supply in OECD countries, of which about half is being used to generate electricity. The use of solid biomass has had a positive development in OECD countries, showing an annual increase of 1.8 per cent since 1990 as opposed to 1.5 per cent in non-OECD countries. As previously observed, the segments utilizing municipal solid waste and producing liquid biomass are the ones growing faster. While wind and solar energy have reached growth rates higher than 20 per cent per year, liquid biomass has grown at an annual rate of 84 per cent in the OECD. Certainly, all these large growth rates have to be considered with caution as the starting points for renewables have been quite low.

It is also worth noticing that, although the electricity demand is growing by more than 2 per cent per year in OECD countries, the electricity generation from renewables has only grown by 0.8 per cent per year since 1990. The participation of renewables in the total supply of electricity has decreased in absolute terms in many regions of the OECD since the late 1990s, for example in North America, particularly in the US. The European Union, on the other hand, has had a continuous growth since 1990, thanks to supportive policies, not least those related to urban waste handling.
Biomass only corresponds to 1 per cent of the world electricity generation. More specifically, electricity generation from solid biomass has shown an average increase of 2.7 per cent per year and some 20 TWh have been added to the supply base of OECD countries since 1990, denoting a slight increase in the share of biomass for electricity generation in OECD countries. In fact, renewable municipal waste and biogas are becoming increasingly important in OECD countries. Though both are still at an initial stage, we should expect significant growth in these segments in the years to come. Heat production from biomass has also increased substantially, both in heat plants only and in CHPs, but available data series do not allow further inference.

Biomass currently supplies 3.5 per cent of the energy in the EU, which is equivalent to 45 million toe. However, the interest for bioenergy has increased rapidly both among members and candidate countries. Some EU countries have had outstanding performance in their national biomass programs, for example, the Netherlands, United Kingdom and Denmark, all of which started from very low levels in the early 1990s. Also countries previously outside the EU such as the Czech Republic and Hungary have been investing in bioenergy (IEA, 2003).

In the past few years, the EU has developed common guidelines and energy directives, which are expected to have a significant impact in the coming years, not least on bioenergy use (see also Bauen, Chapter 2). Provided the efforts being made to promote bioenergy succeed, the amount could increase from 45 to 130 million toe in the region by 2010–15. Bioenergy provides a great opportunity to address problems other than energy in the EU, such as decreasing populations in rural areas, employment in peripheral regions, and restructuring of agricultural policies including new uses for idle croplands and reduction of subsidies. A recent Europe-wide study indicates that as many as 900 000 jobs could be created by 2020 from investments in renewables of which 500 000 are in agriculture to produce biofuels (ALTENER, 2001).

In developing countries, electricity generation from renewables has grown by some 3 per cent since 1990, following a parallel track with the increase in electricity demand in these countries at large. Thus the growth of renewables in electricity generation is larger in developing countries than in OECD countries. Certainly, most additions in the developing world come from hydropower, and only few countries are exploring other renewable sources systematically. Indeed, hydropower remains a major renewable option where potential is available. The conventional view favoring centralized energy generation may lead to large-scale projects, heavy financial burden on poor economies and negative environmental impacts. Yet many developing countries do have programs for small hydroplants.

Thus the truth about renewables is that there is a positive trend which may look impressive in relative terms but which is slow in absolute terms. This means that
non-renewables not only remain very strong but are still mainstream. When it comes to biomass, the development has been slow in comparison with the new renewables. It can certainly be accelerated, bringing ancillary advantages to many countries, for example, rural development. To facilitate this process, there is a need for models that allow an effective and rapid assessment of local biomass potentials, while also providing guidelines to support project design and implementation. Certainly, there is no reason for allowing a very rapid move towards fossil fuels in developing countries where a significant untapped biomass potential exits. Reversing that trend is a major global challenge, and the introduction of bioenergy options definitely provides part of the solution.

1.4. THE TURNING POINT

We referred earlier as to what may be a turning point in bioenergy utilization. This idea needs perhaps to be further developed and motivated. During the industrialization period, started in England in the middle of the eighteenth century, fossil fuels gained increasing importance, offering the scale, efficiency and reliability needed to change production systems radically. The supremacy of fossil fuels was reinforced with the advent of the automobile and the choice of oil as the source of liquid fuels to move those engines. This process continued with full speed until three decades ago when oil-producing countries, in a concerted action, forced oil prices up to appropriate larger rents for a resource that the world economy so heavily relied upon.

After the oil price shocks, intense efforts were made to deploy new energy technologies based on resources other than oil, and to improve the efficiency of energy generation, distribution and consumption. Parallel to these efforts, however, a very significant amount of research continued being made on fossil-fuel-related technologies and nuclear power. As a result, while renewable technologies were indeed developed, the relative position of fossil-related technologies was constantly improved both on the supply as well as on the demand side. In addition, most of the non-fossil energy generation capacity added in the last few decades comes from nuclear power, an area that also received significant attention of governments and researchers.

Nevertheless, the balance of efforts made in the last few decades includes a portfolio of renewables, in parallel with a significant decrease in the energy intensity of many segments of the economy, and a trend of decarbonization mainly due to the shift from coal and oil towards natural gas and increasing use of nuclear power (Silveira, 2001). Whether positive trends will persist and be further improved depends on what efforts are made next. For example, recent studies reveal that
increasing amount of investments is no guarantee for improvements in energy intensity, as expanding industries can, in fact, become more energy intensive (Miketa, 2001). We are also used to the thought that the energy intensity of developing countries shall increase as a result of industrialization and modernization. However, if we consider the increasing utilization of combustible renewables and wastes, the energy intensity may have decreased in some developing countries in the past years. Constraints in the utilization of combustible renewables and wastes may be forcing a higher utilization of fossil fuels in developing economies than would otherwise be necessary (Sun, 2003).

When it comes to transport, the sector remains trapped in the oil solution after three decades of research and constant improvements. More recently, the strong dependency of the transport sector on oil resources has received increasing attention due to issues of security, potential oil scarcity in a rather near future, and the climate change agenda (see also Silveira, 2001). In the European Union, for example, security of supply and climate change are two major driving forces to the introduction of renewables. Liquid biofuels provide immediate opportunities to reduce fossil fuel dependency in the transport sector, taking advantage of existing distribution chains for fossil fuels. A major preoccupation is the formation of markets for alternative transport fuels and technologies. However, significant initial steps have been taken recently at the EU level which may have important consequences in the development of markets for liquid biofuels.

But what is actually the turning point that we are referring to? After all, the figures do not indicate any spectacular change in favor of bioenergy. The use of bioenergy is actually growing slower in many cases when compared with other renewable options. Recent trends do not, at first, seem to relate to ambitious future scenarios and identified possibilities for bioenergy options. In fact, the turning point can only be understood as a convergence of factors and tendencies that are likely to favor bioenergy use. Some of these factors are general for all renewables, others are specifically related to bioenergy options. The most important factors are:

- The global climate agenda, which requires a shift from fossil fuels to renewables as a means to reduce greenhouse gas emissions and mitigate global climate change;
- Increasing awareness and understanding of the local impacts of fossil fuel utilization on environment and health (e.g. acid rain, respiratory diseases) and intensified search for sustainable alternatives;
- Decreasing policy support for fossil fuels and gradual reduction of subsidies for nonrenewable energy sources;
- A shift from centralized energy planning due to the privatization of electricity and heat markets, favoring local alternatives and decentralized solutions;
• Awareness of the potential of bioenergy options to foster regional development (e.g. through the creation of jobs);
• Enhancing policy support framework for renewables, including bioenergy, in many countries and regions (e.g. various EU directives);
• Better understanding of the potential integration of bioenergy solutions with established industrial processes leading to economic and environmental benefits (e.g. forest industry);
• Integration of bioenergy options with established energy systems for heat, power and transport (e.g. cofiring, ethanol additives);
• Critical mass of examples of good performance of bioenergy systems including biofuel production, heat and power generation, and demand-side technologies in various countries under different conditions;
• Variety of scales, raw material sources and technologies that can be used for the implementation of bioenergy systems depending on local conditions for raw material production, existing demand for energy services and future potential for expansion;
• Improving conditions for new entries and competition as biofuel markets evolve and the commercial attractiveness of bioenergy options is improved, while risks are reduced;
• Readily available conventional solutions and promising development of new technologies for bioenergy generation, and biofuel production and utilization.

These factors are processes which, when combined in different institutional and regional contexts, have varied impacts and effects. They contrast with the set of conditions that allowed the extraordinary economic development in the past decades and which included cheap energy provided by fossil fuels, lack of environmental concerns and centralized energy planning (see also Schipper et al., 1992). Energy was particularly cheap because there was little preoccupation to internalize the various costs associated with its extraction, transport and use, let alone with the sustainability of environmental and socioeconomic systems.

The present conditions are quite different. In particular, it is most likely that both households and industry will experience significant increase in energy costs in the coming years, if international efforts prove fruitful in moving the environmental agenda forward. In the medium and long term, it is possible to improve the overall efficiency of production systems through dematerialization, new industrial organizational patterns and new forms of land use planning. Due to its potential integration into various production segments and its role in social and environmental sustainability, bioenergy can become an important element in the process of shifting energy systems. The convergence of factors required to reach a turning point has already been reached. Work lies ahead.
1.5. TAKING THE LEAP TOWARDS BIOENERGY

In the past decade, the number of countries exploring biomass opportunities for the provision of energy services has increased rapidly. This has contributed to make biomass, in the form of solid and liquid fuels, an attractive and promising option among available renewable energy sources. This includes solid biomass and waste, which consists of firewood, charcoal, energy crops, and forest and agricultural residues for the production of heat and power, as well as short crops for the production of liquid fuels such as ethanol and biodiesel. Also the increasing attention to urban waste has contributed in drawing attention to bioenergy options. What is in place is a result of combined top down and bottom up initiatives. However, nothing seems more powerful at present than the increasing awareness about biomass potentials resulting from successful experiences in both industrialized and developing countries.

We still need a much more forceful move towards renewables if we are to promote our energy systems to a qualitative leap. In this context, bioenergy offers attractive alternatives which are only partially being explored. The enhancement of bioenergy utilization has to count on modern and efficient technologies, which should be deployed on a commercial basis in order to guarantee energy services of high quality. Commercial options are sorted within competitive markets. But how can we talk about competition between bioenergy and other alternatives when choices are not on the table at a fair playing field?

Recent studies indicate that biomass technologies can be competitive with fossil fuel alternatives. One particular advantage of bioenergy is that it can be organized at small scales, from 1 to 100 MW, thus allowing a slow modular increment in energy supply, avoiding stranded investments, and minimizing risks. At a time of restructuring of the electricity sector, these are essential advantages, as economies of scale may not be easily realized in volatile markets. In addition, risk aversion and high demand for faster returns by stakeholders will tend to favor smaller projects and a gradual change in the configuration of the electricity infrastructure (Patterson, 1999). The solar economy, which includes bioenergy, favors small-scale and decentralized solutions with local distribution, which differ significantly from the centralized and large-scale configuration of existing energy systems (Wicker et al., 2002; Scheer, 1999).

Bioenergy is not a generalized solution for all countries and regions. The dimension of the regional potential for bioenergy needs to be seen in the context of competing uses for resources demanded for the production of biomass. Where land resources are scarce, energy forests may compete with other land uses and lead to negative impacts on food production. However, there are many countries in the world where this is not the case. Many developing countries such as Brazil, Thailand,
Indonesia and Nigeria have large amounts of biomass potential from different sources and are good candidates for bioenergy technologies.

In Europe, the restructuring of agriculture is releasing land, which can be claimed for biomass production aimed at energy generation. If biomass is to become a major source of energy in Europe as a whole, the potential needs to be assessed in terms of the overall environmental and socioeconomic implications vis-à-vis other alternatives. The possibility of increasing supply security through a broader use of bioenergy needs is to be more seriously considered. A more significant increase in the share of biofuels cannot be attained through isolated national initiatives but will require coordinated action, not least to facilitate the formation of biofuel markets (European Commission, 2000).

There is a long way to go before bioenergy becomes a mainstream energy alternative. In particular, there are significant market barriers to be overcome, which can only be achieved through close coordination among the various sectors that need to be involved in bioenergy initiatives. This book discusses some of the opportunities that are already at hand to harness the bioenergy potential and some of the progress that has been achieved in different contexts.

The turning point should rather be understood as a perception among experts, policy makers and industries that a wide window of opportunity has been opened, which should be used to realize the global bioenergy potential. In many cases, the leap is more political than economic given, for example, that the removal of subsidies from nonrenewable alternatives is a necessary step in the process. In many regions, political coordination of efforts is a necessary initial step to establish bioenergy markets. In any case, the leap towards a broader utilization of bioenergy is now more psychological than technological.

REFERENCES


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