Box 9.1 Forest biorefinery: an example of policy driven technology

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What is forest biorefinery?

The *forest biorefinery* (FB) is a facility that integrates biomass conversion processes and equipment to produce fuels (e.g., ethanol and biodiesel), electricity, power, and chemicals (e.g., polymers, acids), along with the conventional forest products (pulp, paper, sawnwood, etc.).

The FB can use multiple feedstocks, including harvesting residues, extracts from effluents, fractions of pulping liquors, as well as agri-biomass, recycled paper, and municipal and industrial wastes. It can be a large-scale industrial facility, integrated into a pulp and paper mill, or a medium- or small-scale facility integrated into a sawmill or plywood mill. Most of the discussions have focused on the former case.

An essential part of FB is the objective to more efficiently utilise the various fractions of woody biomass. This biomass is lignocellulosic material, which is made up of three primary chemical fractions: hemicellulose, cellulose, and lignin. All of these can be converted to carbon-neutral renewable energy or chemicals. As Figure 9.1 shows, the conversion technologies can be classified in three different pathways: biochemical, thermochemical, and physical-chemical processing and separation (e.g., Larson et al. 2006, Sivasamy et al. 2007). In addition, the different processes can, to some extent, be combined. Some of the conversion technologies are already mature and commercial; others require development to move to commercial applications.

What drives the development of this technology?

There are forest sector *internal* and *external* factors originating outside the sector that drive the FB development. The internal factors relate mainly to the structural difficulties of the forest industry in the traditional big forest sector countries, such as Canada, Finland, Sweden, and the USA. In these countries, the industry has been suffering from continuing profitability problems, and new investments are going mainly to Asia and South-America. In this context, the industry is re-thinking its strategies, and biorefineries are seen as potentially one important development that could enhance the profitability and viability of operations in the big forest sector countries.

The external factors are likely to turn out to be the more important ones. Not least because they will attract to the forest sector new industries and operators, and diversify the forest sector. These external factors are particularly related to increasing energy consumption, greenhouse gas emissions, and concerns over energy import dependence. These are, in turn, prompting changes in the sources from which energy is expected to be derived in the coming decades. In this context, forests and biorefineries are seen as potentially important sources and producers of carbon-neutral energy. The primary benefits generated by the biorefinery development to the forest industry, and society in general, are often seen to be the following:

1. Through new technology and synergies with current operations, increased production efficiency and profitability of current forest products;
2. Production of new products that are increasingly needed by society (e.g., bioenergy, bio-based polymers, and chemicals);
3. Help to meet regional policy targets (preserves and creates jobs in rural forest-based communities);
4. Help to meet climate change policy targets (replaces fossil fuel-based energy);
5. Help to meet energy security policy targets (replaces imported energy).

Reflecting these objectives, there have been large scale R&D efforts in developing technologies and pilot projects that promise to open up new and more efficient ways to utilise forests and wood fibres in energy production. In these efforts, forest biorefiner-

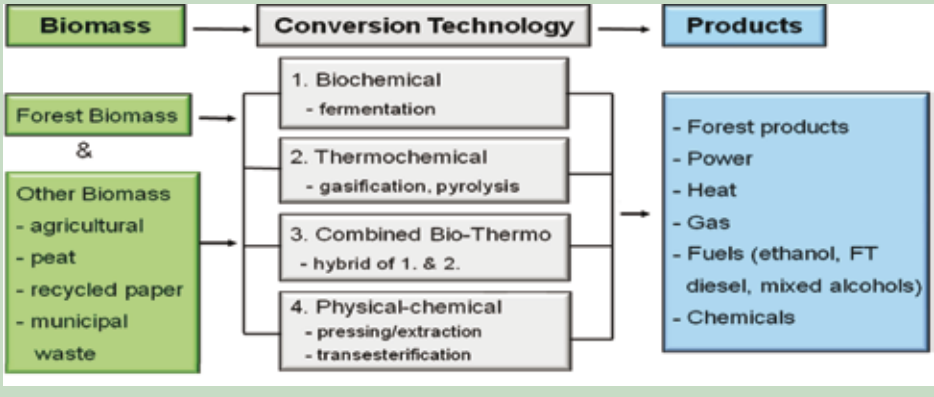

Figure 9.1 Forest biorefinery conversion routes.

Table 9.1 Examples of energy policy priorities and impacts.

	Policy Priority Options	
	Energy Security, Agricultural & Regional Policy	**Economic Efficiency & Costs to Consumers**
Policies / Regulations	tariffs, taxes, quotas, subsidies, standards	R&D support, tradable permits, taxes, investment support to risky projects
Positive Impacts	domestic production, rural employment and income, energy security	efficient resource allocation, cost efficiency, less administration, predictable operating environment
Negative Impacts	resource misallocations, trade wars, complex and bureaucratic, regional differences, uncertainty	loss of domestic production (at least in the short-to-medium term), more hardship in the rural areas, dependency on energy imports

Note: There are various positive and negative environmental implications under both policy priority options.

ies play a central role (a list of some of the current projects is given in Johnson et al. 2009).

Within the forest biorefinery platform, there are a number of different output mix and technology possibilities. Therefore, the number of investment opportunities and risk factors related to forest biorefinery are many. The viability of each specific forest biorefinery product-technology-mix depends on end markets (demand, supply, prices), substitute markets (e.g., oil), biomass markets, and on global, national, and regional policies. These may vary between countries, and even within countries. Also, the policies to support biorefinery development depend on the goals that biorefineries hope to target. For example, depending on the degree that the policy goal emphasises climate change mitigation, domestic energy production, rural employment, energy efficiency, or some combination of these, the optimal biorefinery concept may differ. In short, there is no single best uniform solution for FB, rather a large number of different concepts, raw material options, production processes, and output mixes, each tailored to be optimal for the local conditions and objectives.

Policy challenges and implications

Despite the global trend of market liberalisation, politics will play an ever more important role in the development of bioenergy markets. This is mainly a result of the following twin energy-related challenges: that of not having adequate supplies of energy at affordable prices, and that of environmental harm caused by energy consumption. In order to try to solve these two problems satisfactorily, regional, national, and local level policies are imposed to regulate energy market development.

An overview of the various national policies supporting the production of biofuels in OECD countries is given in Doornbosch and Steenbilk (2007). The study clearly illustrates the following points. First, the policies are necessary to make the production of biofuels viable in current circumstances. Without the subsidies, tariffs, or other forms of policy regulation, there would be no or very little national production of biofuels in most of the countries. Secondly, the policies vary across countries, and across regions within a country. Thirdly, the array of policy measures is large and complex. For example, countries may give subsides to anywhere in the value chain – from growing the raw material (agri- or forest-biomass) to setting mandatory requirements for biofuels usage in transportation. Finally, the current policies could be made more efficient. That is, more economic and environmental benefits could be generated from a given amount of biomass by re-designing the current policies.

Biorefinery development is no exception to the above trend. Various polices in different countries and at the global level are, and will be, implemented to speed up the building of forest biorefineries. The table 9.1 gives one taxonomy of the possible policies and impacts at a general level.

The interest in forest biorefineries is a very recent phenomenon, which means that societies and the forest sector have not yet had much time to reflect on the issues associated with it. Thus, although biorefinery landscape is promising, it is also broad, complex, and even confusing. More research is needed to understand the implications of FBs to society and to the forest sector.

So far, the research on biorefineries has been very much technology-driven and specialised. This is natural, since advances in the technology have been recent, and the possibilities for moving this technology to practice are only just opening up. However, now that the technology is close to the stage where it can be moved to commercial applications, there is a need for synthesis on current knowledge, and analytical assessment of future environmental, economic, and policy prospects. In what circumstances is forest biorefinery profitable? What are the socio-economic implications to the forest sector, at both the national and global levels? What are the environmental impacts?