BIODIESEL MARKET DEVELOPMENT IN EUROPE: LESSONS LEARNED FOR NORTH AMERICA

PHASE 1

Prepared For:

IEA Bioenergy
Task 39

Prepared By

(S&T)^2 Consultants Inc.
11657 Summit Crescent
Delta, BC
Canada, V4E 2Z2

Date: September, 2005

EXECUTIVE SUMMARY

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. The IEA Bioenergy Vision is “To realise the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, to provide a substantial contribution to meeting future energy demands.”

The IEA Bioenergy aim is “To facilitate, co-ordinate and maintain bioenergy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialization of environmentally sound, sustainable, efficient and cost-competitive bioenergy technologies.”

Twenty countries plus the European Commission, take part in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, the United Kingdom, the USA and the European Commission. Work in IEA Bioenergy is carried out through a series of Tasks, each having a defined work programme.

One of the Tasks is Task 39, Liquid Fuels from Biomass. The objectives of this Task are to:

- Provide information and analyses on policy, regulatory and infrastructure issues that will help participants encourage the establishment of the infrastructure for biofuels as a replacement for fossil-based biofuels.
- Catalyze cooperative research and development projects that will help participants develop improved, cost-effective processes for converting lignocellulosic biomass to ethanol.
- Provide information and analyses on specialized topics relating to the production and implementation of biodiesel technologies.
- Provide for information dissemination, outreach to stakeholders, and coordination with other related groups.

As part of Task 39’s ongoing program of promoting the commercialization of biofuels, the task has commissioned three reports that address specific market or policy barriers. These barriers have been identified by members of Task 39 and through analysis of independent reports.

This work will focus on mechanisms for reducing financial and business risk associated with biodiesel. Two other reports are being undertaken; one will examine price distortions and regulatory barriers that exist primarily for biodiesel. The second will focus on the influence of national policy on bioethanol economics, using specific European case studies, in order to determine what policies best support the bioethanol area.

A major barrier to the development of biodiesel in North America is the level of risk that financial institutions and businesses must face. This reduces the interest that lenders and business leaders might have in investing in these types of products. The European lending community has developed awareness of the biodiesel industry through observation of multiple projects. The objective of this work is to review the European biodiesel situation and apply lessons-learned in this region to the North American situation.

The specific objectives of this work are to:

- Identify the approaches to biodiesel market development in the context of the IEA work on creating markets for energy technologies,
- Identify the barriers to biodiesel market development in general,

- Study the biodiesel markets in the leading European countries and determine the approaches used to removing the barriers to biodiesel market development,
- Assess the success of the various approaches in each country,
- Summarize the lessons learned in these leading countries, and
- Discuss the application of the lessons learned to North America.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

IEA Bioenergy is an international collaborative agreement set up in 1978 by the International Energy Agency (IEA) to improve international co-operation and information exchange between national bioenergy RD&D programmes. The IEA Bioenergy Vision is “To realise the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, to provide a substantial contribution to meeting future energy demands.”

The IEA Bioenergy aim is “To facilitate, co-ordinate and maintain bioenergy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialization of environmentally sound, sustainable, efficient and cost-competitive bioenergy technologies.”

Twenty countries plus the European Commission, take part in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, the United Kingdom, the USA and the European Commission. Work in IEA Bioenergy is carried out through a series of Tasks, each having a defined work programme. Each participating country pays a modest financial contribution towards administrative requirements, shares the costs of managing the Tasks and provides in-kind contributions to fund participation of national personnel in the Tasks.

1.1 TASK 39 LIQUID BIOFUELS

One of the Tasks is Task 39, Liquid Fuels from Biomass. The objectives of this Task are to:

- Provide information and analyses on policy, regulatory and infrastructure issues that will help participants encourage the establishment of the infrastructure for biofuels as a replacement for fossil-based biofuels.
- Catalyze cooperative research and development projects that will help participants develop improved, cost-effective processes for converting lignocellulosic biomass to ethanol.
- Provide information and analyses on specialized topics relating to the production and implementation of biodiesel technologies.
- Provide for information dissemination, outreach to stakeholders, and coordination with other related groups.

As part of Task 39’s ongoing program of promoting the commercialization of biofuels, the task has commissioned three reports that address specific market or policy barriers. These barriers have been identified by members of Task 39 and through analysis of independent reports.

This work will focus on mechanisms for reducing financial and business risk associated with biodiesel. Two other reports are being undertaken; one will examine price distortions and regulatory barriers that exist primarily for biodiesel. The second will focus on the influence of national policy on bioethanol economics, using specific European case studies, in order to determine what policies best support the bioethanol area.

A major barrier to the development of biodiesel in North America is the level of risk that financial institutions and businesses must face. This reduces the interest that lenders and business leaders might have in investing in these types of products. The European lending community has developed awareness of the biodiesel industry through observation of multiple projects. The objective of this work is to review the European biodiesel situation and apply lessons-learned in this region to the North American situation.

1.2 Scope of Work

The specific objectives of this work are to:

- Identify the approaches to biodiesel market development in the context of the IEA work on creating markets for energy technologies,
- Identify the barriers to biodiesel market development in general,
- Study the biodiesel markets in the leading European countries and determine the approaches used to removing the barriers to biodiesel market development,
- Assess the success of the various approaches in each country,
- Summarize the lessons learned in these leading countries, and
- Discuss the application of the lessons learned to North America.

The report is being delivered in two stages. The first stage covers the first five bullets. The second stage, to be delivered in 2006 will cover all of the objectives.

2. MARKET DEVELOPMENT APPROACHES

2.1 APPROACHES TO MARKET DEVELOPMENT

The issue of creating markets for energy technologies has been the subject of considerable focus at the International Energy Agency over the past five years. In 2003, the IEA published a report "Creating Markets for Energy Technologies" that considered the process of market development.

> *The technological and market developments required to transform the energy system will be conceived and implemented largely in the private sector. But success in this endeavour will not be determined exclusively by market forces. Governments that value the wider benefits of cleaner and more efficient energy technologies will work in partnership with market actors to ensure there are real opportunities for technologies to make the difficult transition from laboratory to market. This book is about the design and implementation of policies and programs for that purpose.*
>
> *Governments are motivated to assist not only because they have a responsibility for the pursuit of long-term societal goals and stewardship of the planet, but also because they understand that their policy settings help to determine whether markets develop and operate efficiently. Policymakers must therefore understand the markets concerned and they must have a highly developed capacity to mount effective programs. In both cases, experience is the best teacher.*

The IEA reviewed 22 case studies of what they determined where successful energy market developments in IEA countries over the past twenty years. In studying the cases, the IEA considered three perspectives on deployment policymaking. These three perspectives have developed over the last quarter of a century.

- The Research, Development and Deployment Perspective, which focuses on the innovation process, industry strategies and the learning that is associated with new technologies;
- The Market Barriers Perspective, which characterizes the adoption of a new technology as a market process, focuses on decisions made by investors and consumers, and applies the analytical tools of the economist;
- The Market Transformation Perspective, which considers the distribution chain from producer to user, focuses on the role of the actors in this chain in developing markets for new energy technologies, and applies the tools of the management sciences.

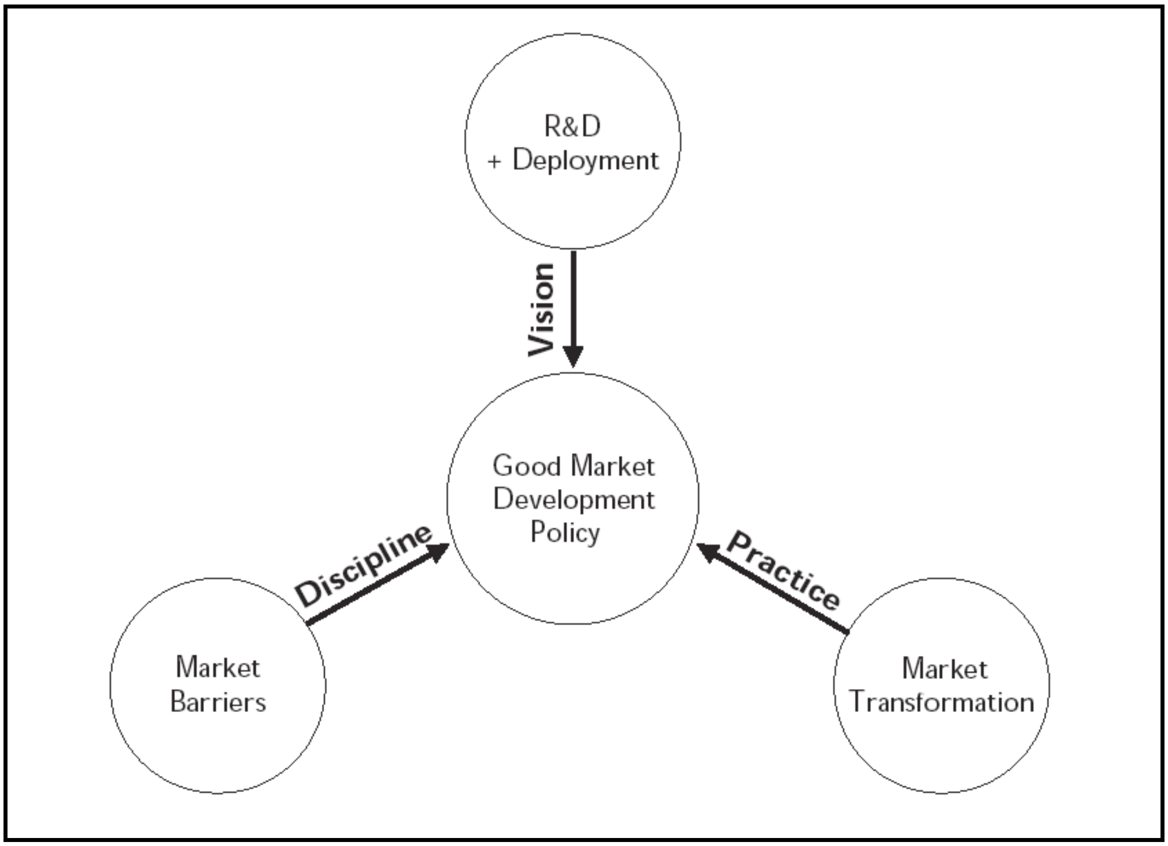
In part, the three perspectives are three vocabularies for looking at the same issue but each adds something that the others are missing. The strength of the R&D plus Deployment concept is its vision of the future and its focus on the technology itself, its costs and performance and the process of market entry through niche markets. The market barriers approach uses economic analysis to improve the understanding of the barriers to market entry and provides some discipline to the analysis of market intervention measures that could be used as policy tools. The Market Transformation perspective encourages sensitivity to the practical aspects of crafting policies that produce the desired effects.

The IEA concluded that the adoption of clean energy technologies would not be likely to succeed unless all three perspective were considered and that it is necessary to:

- Invest in niche markets and learning in order to improve technology cost and performance;
- Remove or reduce barriers to market development that are based on instances of market failure; and
- Use market transformation techniques that address stakeholders' concerns in adopting new technologies and help to overcome market inertia that can unduly prolong the use of less effective technologies.

Visually the IEA summarize the three perspectives as shown in the following figure.

Figure 2-1 Overall Perspective on Technology Market Development



Around this central theme, a close reading of the IEA case studies revealed more detailed messages about the nature of successful policy-making. Some key points are:

- *Deployment policy and programs are critical for the rapid development of cleaner, more sustainable energy technologies and markets. While technology and market development is driven by the private sector, government has a key role to play in sending clear signals to the market about the public good outcomes it wishes to achieve.*
- *Programs to assist in building new markets and transforming existing markets must engage stakeholders. Policy designers must understand the interests of those involved in the market concerned and there must be clear and continuous two-way communication between policy designers and all stakeholders. This calls for the assignment of adequate priorities and resources for this function by governments*

wishing to develop successful deployment initiatives. Programs must dare to set targets that take account of learning effects; i.e., go beyond what stakeholders focused on the here-and now may consider possible.

- *The measures that make up a program must be coherent and harmonized both among themselves and with policies for industrial development, environmental control, taxation and other areas of government activity.*
- *Programs should stimulate learning investments from private sources and contain procedures for phasing out eventual government subsidies as technology improves and is picked up by the market.*
- *There is great potential for saving energy hidden in small-scale purchases, and therefore the gathering and focusing of purchasing power is important.*
- *Most consumers have little interest in energy issues per se, but would gladly respond to energy efficiency measures or use renewable fuels as part of a package with features they do care about.*

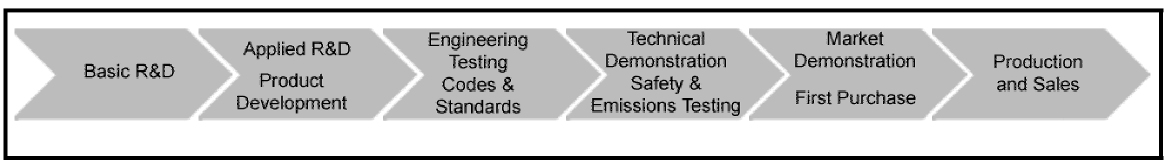
The three perspectives from the IEA have been considered here so that the issues that impede market development for biodiesel and that require addressing from a policy perspective can be identified and addressed.

In the rest of this chapter, the individual perspective is described in more detail and then the market development issues for biodiesel are assessed from that perspective. The description of the different perspectives draws heavily on the IEA report but the tools found in each of the perspectives have been applied to the specific application of biodiesel market development.

2.2 RESEARCH AND DEVELOPMENT + DEPLOYMENT

Many groups consider product or technology development as a linear process which moves from research and development through to the end market as shown in the following figure, which is adapted from an Industry Canada discussion of the process.

Figure 2-2 Stages of Development



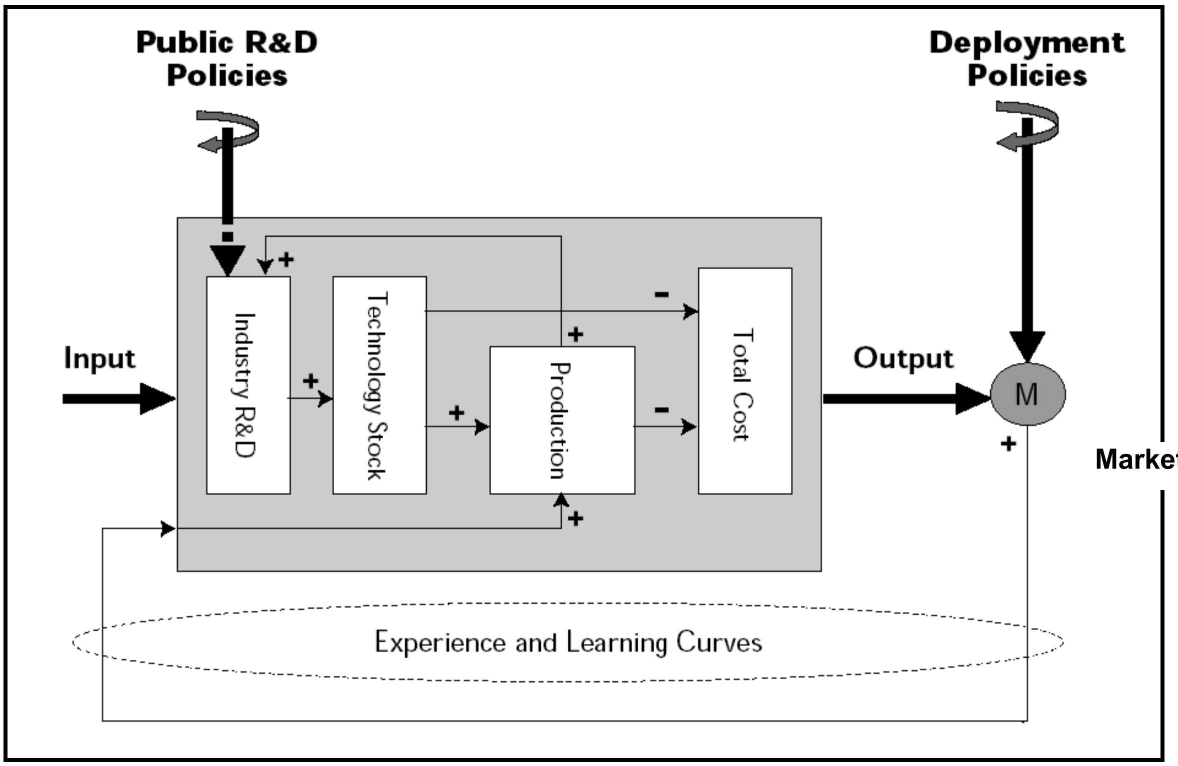
In practice, the technology development process is cyclic in nature rather than linear with decisions being made at each stage having an influence on any eventual market success and in the later stages feedback between the market experiences and further technology development are very important. It is this feedback between deployment and R&D that is critical for success and that is why the IEA called this perspective Research & Development + Deployment.

The market uptake of new bioenergy technologies has two positive effects. First, there is the *physical effect* of using renewable energy and the reductions in greenhouse gas emissions that would accompany this and the second effect is the *learning effect* of how to produce new energy sources less expensively and more effectively. It is the combined effect that produces the real impact for new technologies.

In the case studies that the IEA considered they found that many government sponsored deployment programs defined success in terms of sales growth and market penetration. They found that this was too narrow a view and it neglected the link between the programs and private sector investment decisions. Decision makers in industry often consider the initial costs of market learning too high and too risky. Governments on the other hand have scarce public resources and can't bear the total cost of moving a new technology to market. However, in many of the case studies early government involvement in the deployment process played a crucial role in encouraging private sector involvement and in activating the learning process among the market participants.

The IEA describes the process of the interaction between the governments and the private sector as shown in the following figure.

Figure 2-3 Influences on the Learning Process from Public Policies



The figure summarizes how public sector and industry R&D interact to produce a 'virtuous cycle' in which government support encourages corporations to try out new technologies in genuine market settings. The two vertical arrows represent the encouragement for industry R&D and production with a new technology brought about by government policies. Expanded output and sales stimulate the 'plus' cycle in the diagram: industry R&D increases further, which enhances the technology stock, which in turn further stimulates production. The production increases also stimulate the learning process and the 'minus' cycle in the diagram, resulting in reductions in the cost of production. This further stimulates sales and the cycle reinforces itself. The figure also indicates the role of experience and learning curves, which will be discussed next in this chapter. They provide a quantitative measure of market learning and the efficiency of the feed-back from market experience ("M") to production and industry R&D, which leads to cost reductions and improved technology.

The figure also provides a powerful argument in favour of government support for technology deployment, if government is supporting research it should also be supporting deployment. This argument has also made by several industry stakeholders. This gap between R&D funding and commercial funding is known as the “Valley of Death” and many technology developers state that it is the largest barrier that new technology must overcome on the path to commercialization. The “Valley of Death” is not a phenomenon that is unique to a specific country or product as references to it can be found in the literature of all of the developed countries.

2.2.1 Experience Curves

There is overwhelming empirical evidence that deploying new technologies in *competitive markets* leads to *technology learning*, in which the cost of using a new technology falls and its technical performance improves as sales and operational experience accumulate. Experience and learning curves, which summarise the paths of falling technology costs and improving technical performance respectively, provide a robust and simple tool for analysing technology learning.

Viewed from the Research, Development and Deployment (R&D + D) perspective, the curves provide a method to set targets and monitor programs; this includes a way of estimating program costs and providing a guide to phasing out programs as technologies mature and no longer require the support of deployment measures.

The shape of the curves indicates that improvements follow a simple power law. This implies that relative improvements in price and technical performance remain the same over each doubling of cumulative sales or operational experience. As an example, the following figure shows that the prices of photovoltaic modules declined by more than 20 percent as each doubling of sales occurred during the period between 1976 and 1992 (IEA, 2000). Furthermore, the relationship remains the same over three orders of magnitude of sales.

The experience curve is described mathematically as:

$$\text{Price at year } t = P_0 * X^{-E}$$

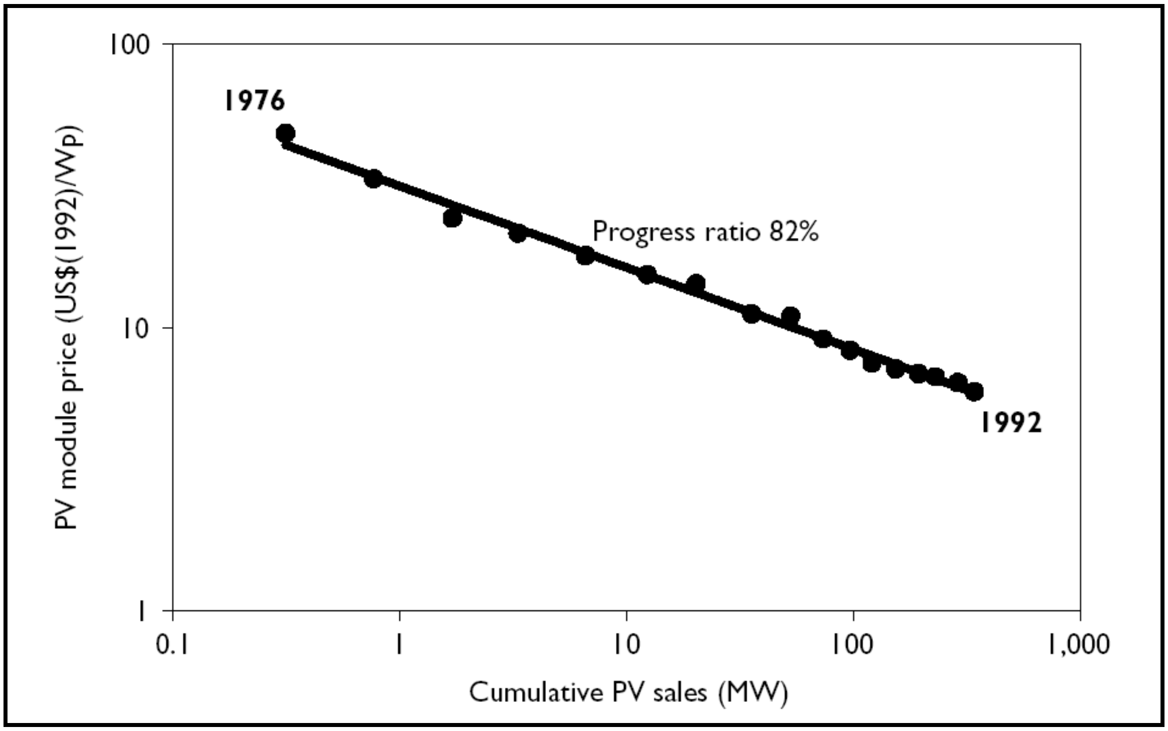
where:

- P_0 = the price at one unit of cumulative production.
- X = the cumulative production of energy, sales, or a similar surrogate for the experience gained with the technology in year t.
- E = the experience parameter which characterizes the slope of the trend line when plotted on a log-log scale.

Progress in the reduction in energy price as technology travels down the experience curve is commonly reported in terms of the progress ratio, or PR. The PR is the energy price after double the cumulative production, as a fraction of the starting price at any point on the line and is calculated from the experience parameter (E) using the equation: $PR = 2^{-E}$.

The Progress Ratio is usually presented as a percentage and in the PV case shown below, the progress ratio is 82%.

Figure 2-4 Photovoltaic Experience Curve



The straight line captures a very important feature of the experience curve. Anywhere along the line, an increase by a fixed percentage of the cumulative production gives a consistent percentage reduction in price. This means that for technologies having the same progress ratio, the same absolute increase in installed capacity will yield a greater cost decrease for young technologies (i.e., they learn faster) than old technologies. This also means that the same absolute increase in cumulative production will have more a dramatic effect at the beginning of a technology's deployment than it will later on. For well-established technology, such as oil refineries using conventional technology, the volume required to double cumulative sales may be of the order of 100 million bbls/day, so the experience effect will hardly be noticeable in stable markets.

There is a significant amount of information on experience curves in the literature for many different technologies. Figure 2-5 shows the distribution of Progress Ratios for 108 case studies for a range of different products in the manufacturing sector (IEA, 2000). The average value of the progress ratio over these case studies was 82%. The consistency of the Progress Ratios over so many different technologies and products means that the approach can be used confidently, with some care, as a policy analysis tool for a range of technologies.

In the energy sector, experience curves have been prepared for many electricity production technologies in the European Union and that data is shown in Figure 2-6. The dominant incumbent technologies have the lowest cost but interestingly the lowest progress ratios. This would suggest that over time, with the learning that arises from increased deployment and increased R&D that is driven by higher sales some of the new technologies will be able to challenge the incumbent fossil technologies on the basis of price while at the same time providing environmental benefits.

Figure 2-5 Distribution of Progress Ratios for 108 Case Studies in the Manufacturing Sector

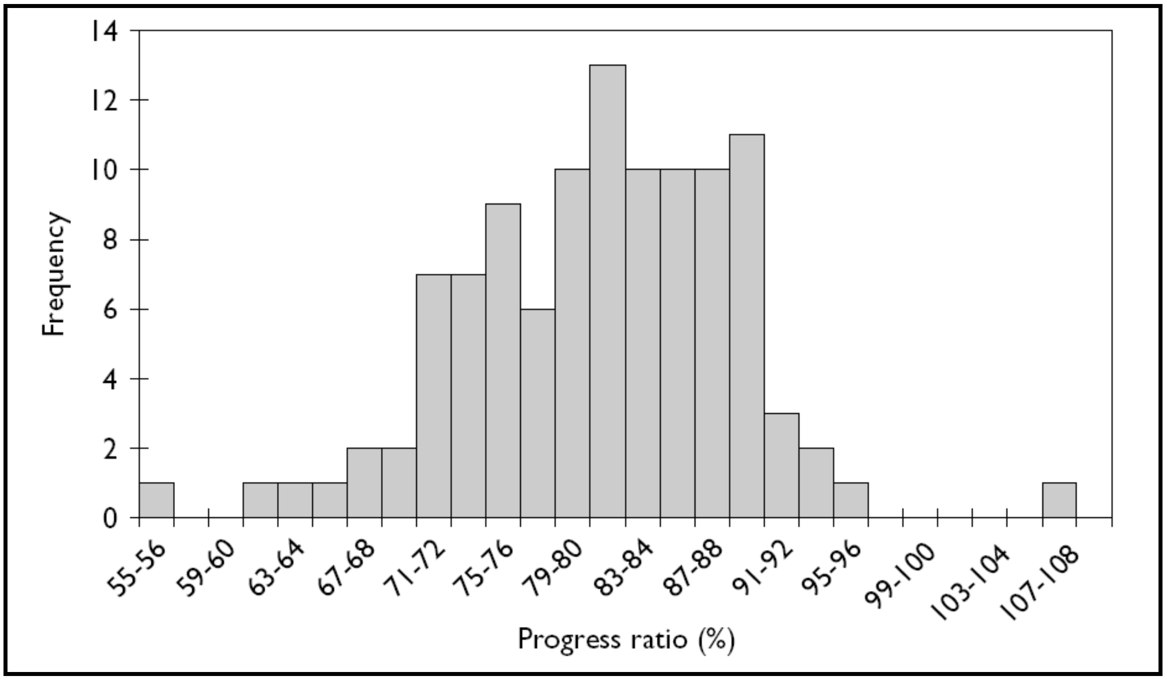
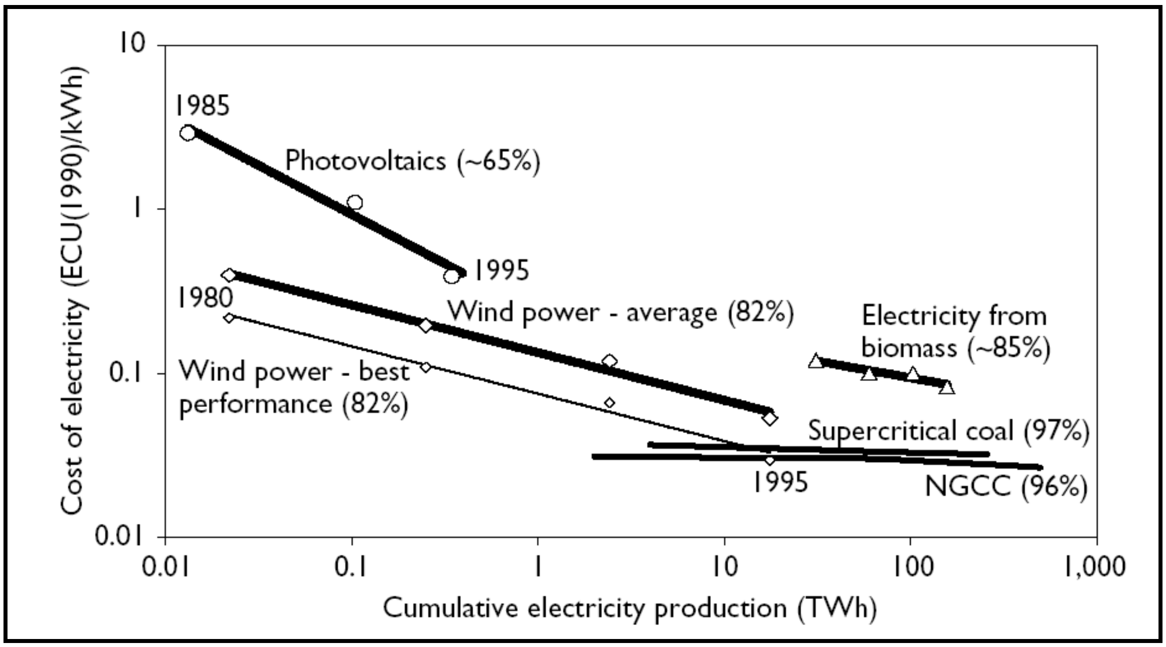


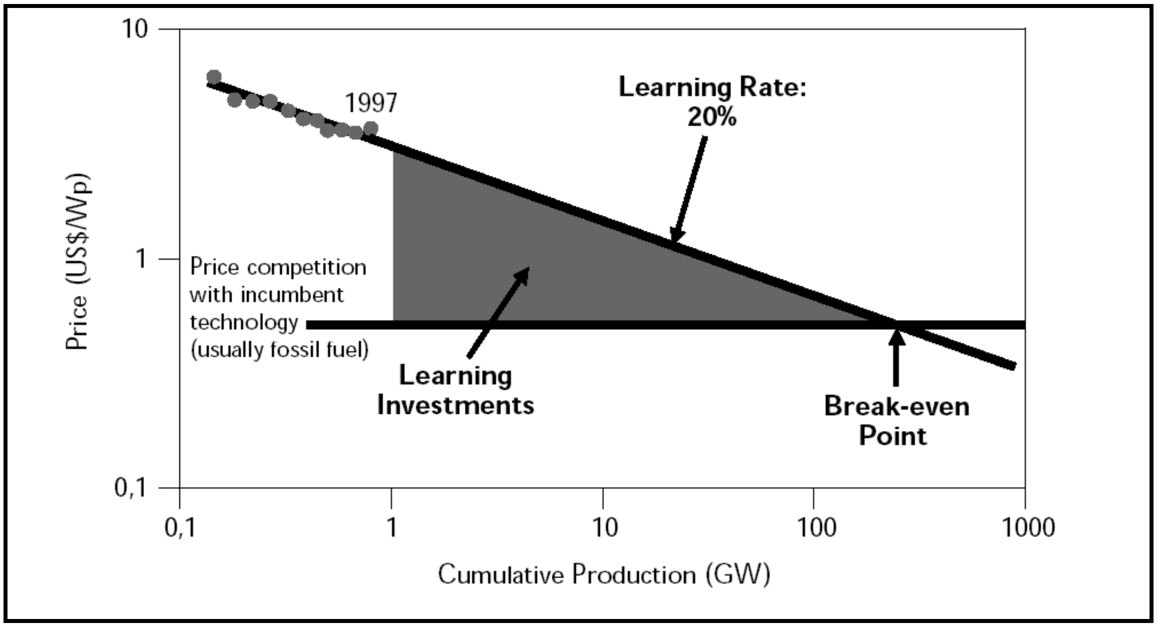
Figure 2-6 Electric Technologies in the EU, 1980-1995



Note that Figure 2-4 uses the installed capacity of photovoltaic technologies for the quantity measure and Figure 2-6 uses the amount of electricity produced as the measure. The experience curves can be applied to both capital cost and the cost of production. The two measures may have different Progress Ratios, as there are costs other than capital (feedstock, operating costs, etc.) that influence the total production cost.

The evidence from experience curves draws attention to the need to provide ***learning opportunities*** for new technologies in markets for energy services. That typically means that a supplier of energy services will have to incur costs that are greater than those incurred when incumbent technologies are used. Figure 2-7 illustrates the point with the experience curve for photovoltaic modules.

Figure 2-7 Projection of Break Even Points



In this example, for photovoltaic systems to compete against currently used technologies in central power stations, the cost of modules has to be brought down to 0.5 US$/Wp, indicated by the horizontal line marked ‘Price competition with incumbent technology’ in the diagram. The experience curve represents the price necessary for a producer of PV modules to cover the cost of production; however, in markets dominated by the incumbent technologies the producer will not obtain this price. Thus, the shaded triangle represents the extra cost, the *learning investments*, that will have to be covered from other sources if the market for PV-electricity is to expand and the cost of production with PV is to fall to the level of the current market price – the breakeven point in the diagram.

While not all technologies will require the same amount of money needed to reach the break-even point for PV, it is clear that large sums of money are needed to finance learning investments. Should they come from investors in the private sector or government? The answer is probably both. The important point here is to be aware of the issues involved in efforts by government to activate private funding of learning investments and shorten the time horizon within which a technology will be considered a commercial endeavour.

The magnitude of the learning investment may also be influenced by the economies of scale. For many of the conversion technologies where the capital cost of the infrastructure is a significant part of the overall product cost, large plants, with their inherent economies of scale, will have a lower required total learning investment than multiple small plants. This requires the development of large markets at the same time, feats that are not easy to synchronize for new products and new technologies. Note also that large is a relative term and different technologies may have different thresholds for large. A large biodiesel plant may produce less energy than a large ethanol plant for example.

The IEA Creating Markets paper concludes its discussion of providing opportunities for technology learning with the following discussion of the role of private and public investments in deployment programs.

As a matter of course, the private sector finances investment in some new technologies that have not yet reached the break-even point (for example, through venture capital). This can be understood by recognising the implications of the experience curve continuing to the right of the break-even point. The expectation is that the cost of using a new technology will fall below the current market price. Since incumbent technologies may still account for the larger market share, they will determine the market price for the energy service produced and the new technology will begin earning net profit that recovers the learning investments. However, existing firms tend to prefer incumbent technologies. Even if they are aware of opportunities for technology learning, they will often be cautious about investing in them and possibly for good reasons from their viewpoint. They may view the learning rate and the associated time path of learning benefits as too uncertain; and any given company may face the risk that some or all of the benefits of its learning investments can end up being captured by its competitors. Thus, if they make learning investments independently at all, they are likely to choose technologies that have already progressed substantially down the learning curve (though exceptions to this are plausible, such as in cases where new technologies have been developed through in-house R&D).

Government deployment programs that provide assistance or incentives for private investment can thus make a crucial difference for major new technologies in the energy sector. Furthermore, the tendency towards inertia on the part of market actors creates a classic case for action from government – an instance of what economists refer to as positive externalities. If private investors are not forthcoming to undertake learning investments in a technology that is judged to be market-ready, society will benefit if government (which may have a different risk profile and lower costs of capital) puts resources into encouraging and facilitating the investment in technology learning. For practical reasons governments are not in the habit of responding to this argument for just any technology, but in the case of new energy technologies that help to achieve the governmental goals of improving energy security and reducing greenhouse gas emissions, the case for action becomes very strong.

This argument of course raises complex questions about 'picking winners' and about how much cost governments should incur when it is not clear how large the future benefits will be and to whom they will accrue. This is a large subject and an exploration of it is beyond the scope of this book. As already noted, the case study project was focused on the design and implementation of successful deployment programs and was not intended to cover the process leading to decisions to establish programs in the first place. However, it is worth noting here that empirically-observed learning effects are helpful when benefit-cost analysis is used to establish whether there is a rationale for a specific deployment program. Some benefit-cost analyses neglect dynamic effects of this sort, in which case these analyses will be biased towards locking in existing technologies and their variants. As well, changes in a technology and organizational learning effects can bring about changes in the nature of an energy service, which means that price and cost observations for the new form of the service may not be directly comparable to prices and costs of the old form of the service. This can lead to inaccurate conclusions about the relative efficiencies of new and old technologies and could affect benefit-cost *calculations. Qualitative changes of this sort are also of interest because they can provide the basis for 'niche markets.*

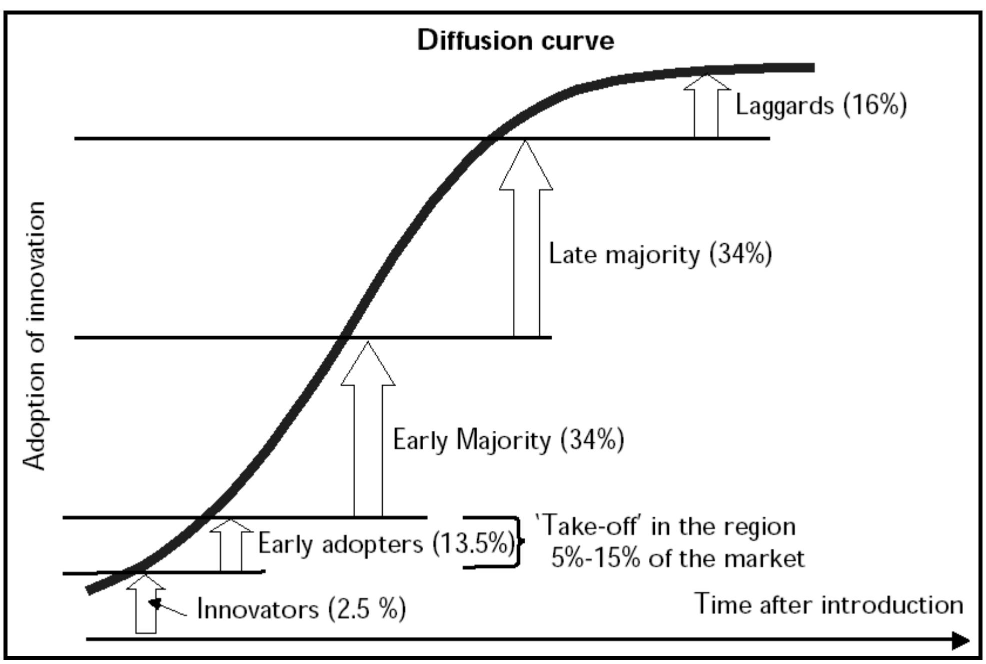
As noted earlier it is important to consider that experience curves can be applied to different aspects of new technologies. One could consider the capital cost of the new technologies and how they might change as more plants are built or one could consider the cost of the energy product itself. This gives some insight in bioenergy opportunities because not all aspects of bioenergy are new. The biomass feedstock has generally been produced for many years and we are a long way down the learning curve for the production, harvesting and transportation of canola or soybeans or animal fats from renderers have been practiced for years. This is not to say that further cost reductions are not possible but they will likely be slower than experienced with the conversion technology. With other feedstocks such as new industrial oilseed crops there are still opportunities for learning for the production of these materials. Not all of the conversion technologies have reached the same stage of development so some have more potential for cost reductions than others do.

The key point is that for emerging technologies the costs can change quite rapidly as the technology is developed. The current costs are not the same as the future costs. Given that the incumbent technologies have a much larger base, the rate of improvement in those technologies is slower than it is for new technologies and the price gap will be reduced over time.

2.2.2 Technology Diffusion

Closely connected with the study of experience curves is the subject of technology diffusion, how new products and services move into the market place. There has been a significant amount of research and a number of publications concerning this subject in the past quarter century as well. The idea that the adoption of successful new products by buyers throughout an economy grows according to an S-shaped curve has long been used in the study of innovation. This S-Curve is illustrated in Figure 2-8.

Figure 2-8 S Curves



The determination of the actual shape of the S curve is quite complex. There are four main elements to the diffusion process. There is the innovation itself, the communication of the innovation, time and the social system that is attempting to adopt the new technology. Each element is critical to the successful diffusion of innovation or technology and is discussed briefly below.

Innovations

The characteristics of the technology, as perceived by the potential user, help to determine the rate at which the new technology is taken up. There are five important considerations to the adoption of new technology. The five factors are:

- the relative advantage of the new product,
- the degree to which it is consistent with the existing social values,
- the complexity of the innovation,
- the observability of the new product or system, and
- the ease with which the new system can be tried by potential users (trialability).

The relative advantage of biodiesel is the degree to which biodiesel is *perceived* to be better than the fuel it replaces. The degree of advantage can be measured in economic terms, but other factors such as social prestige, convenience and satisfaction also play a role in determining the perceived relative advantage. The true objective advantage is not as important as the perceived advantage. It is recognized and important to note that the expected continued improvement in existing technology presents a moving target for new bioenergy technologies and makes a relative advantage of an alternative technology more difficult to achieve and demonstrate. An example of this is the move to ultra low sulphur diesel fuel and the introduction of cleaner diesel engines later this decade. The relative advantage does and will change over time.

Successful innovations must be consistent with the existing values, past experiences, and needs of potential adopters. Technologies that require changes with the values and norms of a society take much longer to adopt. The adoption of these incompatible innovations requires the prior adoption of a new value system. For example, concern for the environment is a value that is becoming part of society’s value system, but it is still a relatively small component of determining the relative advantage of a new technology.

Innovations that are easy to understand by most members of society will be adopted quicker than difficult and complex technologies. For example, liquid biofuels fuels that can be handled like gasoline and diesel are easier for the public to comprehend than gaseous biofuel.

Observability is another quality that influences the rate of adoption of new technologies. The easier it is for individuals to see the results of an innovation the more likely it is that they will adopt it.

It is important for people to be able to try new things without making a permanent commitment. Innovations that are trialable generally are adopted quicker than those that are not. Bioenergy systems that are new and unproven will be slow to be adopted because of the high cost and high risk of a trial.

These five qualities, relative advantage (real or perceived), compatibility, complexity, observability, and trialability have been identified by past diffusion research as the most important characteristics of innovations that determine their rate of adoption. Biodiesel rates high on most of these qualities.

Communications

Communication is the process by which participants create and share information with one another in order to reach a mutual understanding. The essence of the diffusion process is the communication of a new idea from one individual to another. A communication channel is the means by which messages get from one participant to another. Mass media channels are effective at creating awareness of a new idea but interpersonal channels involving face to face exchanges are more effective at persuading individuals to accept a new idea.

Research into the diffusion process has indicated that most individuals do not evaluate an innovation on the basis of scientific studies of its consequences. Instead, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation. This dependence on the experience of near peers suggests that the heart of the diffusion to potential adopters consists of modelling and imitation of those who have adopted previously. Therefore, diffusion is a very social process.

Effective communications also has a financial component. Mass media awareness and interpersonal communications are expensive to implement but effective programs can be developed given sufficient financial resources. Biofuels such as biodiesel and ethanol will require a very large number of people to become aware of the product and its relative advantages.

The challenge of information dissemination was mentioned by many stakeholders as being a real issue and identified as a potential role for government to play. Interestingly those stakeholders involved with biodiesel (products that will require mass communications) did not perceive this as a major barrier.

Time

Time is a third element in the diffusion process and a very important element. The time dimension is involved in diffusion in three ways:

- In the innovation decision process by which an individual passes from first knowledge of an innovation through its adoption or rejection,
- in the relative earliness/lateness with which an innovation is adopted, and
- in an innovations rate of adoption in a system.

The innovation decision process is the process through which an individual passes from first knowledge of innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. There are therefore five main steps in the innovation decision process:

- knowledge,
- persuasion,
- decision,
- implementation, and
- confirmation.

These five steps usually occur in time ordered sequence. There can be exceptions to the order such as when the decision that is taken before persuasion.

Not all individuals proceed through the decision process at the same rate. An individual can be more or less innovative than another person. Individuals can be ranked in order of their innovativeness using the following five classes:

- innovators,
- early adopters,
- early majority,
- late majority, and
- laggards.

Individuals within each class of innovators will have much in common. It is important to note that each class of innovator will rank the relative advantages of attributes differently, to the relative importance of mass media communications vs. interpersonal communication and whether they are active or passive information seekers.

It should also be recognized that it is extremely difficult develop innovations that appeal to the majority if the innovation does not also have some (but not necessarily the same) appeal to the innovators and early adopters. The sequential and social nature of the process makes it difficult and extremely unlikely that steps can be skipped to save time.

Time is also an important parameter of the learning and experience curves. It is also an important aspect of the political and policy process but unfortunately, the time horizons of the diffusion process do not always align with the horizons of the political and policy process. This lack of alignment increases the complexity of the development process.

Social System

The social system is the fourth element of the diffusion process. The members of the social system are engaged in joint problem solving to accomplish a common goal. The members may be individuals, informal groups, or organizations. The most innovative members are not always influential in the decision making process as they often have low credibility due to their willingness to try all new things. Opinion leaders and change agents, people who are able to persuade others to change are the most influential members in the social system. New technologies will not be adopted without these members.

The social system has another important influence on the diffusion of new ideas. Innovations can be accepted or rejected by one individual or by the entire system by a collective or authoritative decision. The individual optional innovative decisions are made independent of other members. These decisions are the classical means by which new ideas have spread through society. Collective decisions are made by consensus of the members of a group. The establishment of car pools would be an example of a collective decision. Authority decisions are those made by a few individuals who have the power, status, or technical expertise to make decisions for all members of the society. Individuals have little or no influence on the decision. Relevant examples would be the establishment of new standards for fuels or vehicle fuel economy, or the use of biodiesel blends in a companies diesel fuel products. The fourth type of decision is contingent decision, this is a sequential decision of two or more of the other types of decisions. This type can be made only after another decision has been made. They tend to have long implementation times. They are also typical of the type found with alternative fuels that require both new fuels and vehicles to be introduced at the same time.

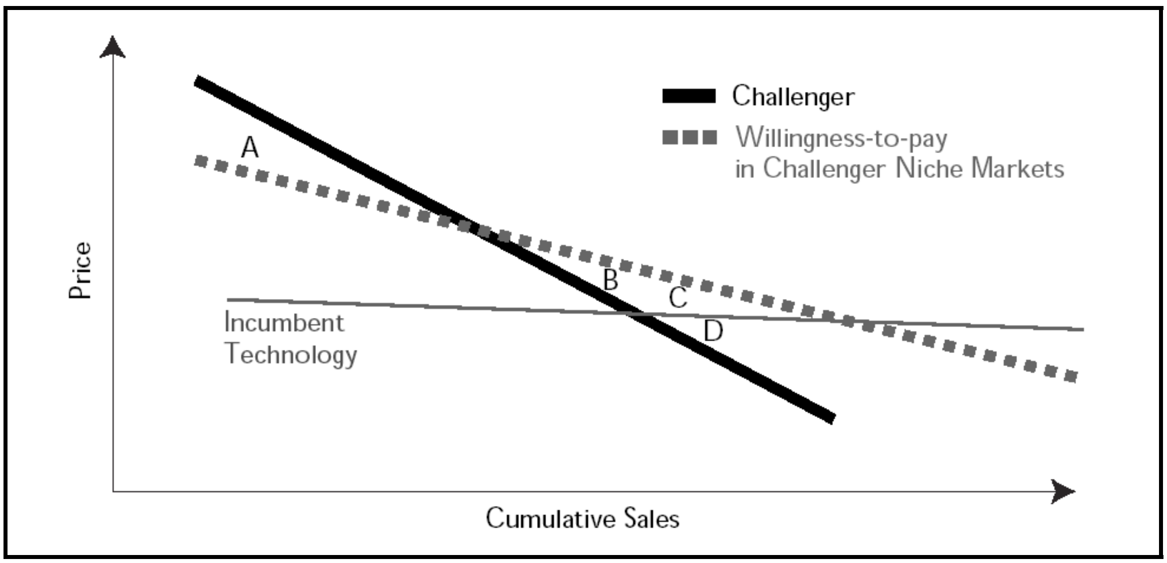
Specific characteristics of new technologies can add value that makes potential buyers with special needs ready to pay extra for energy services produced with them instead of with incumbent technologies. Examples of characteristics (relative advantages) that may provide the basis for a niche market are low emissions, modularity and compatibility of a new power source with electricity load patterns on the grid. These early buyers are often called innovators or early adopters as shown in the figure.

The niche markets may be small relative to the total potential for a technology, but they can be important from the viewpoint of providing learning opportunities. Making use of them in deployment programs can help both to shorten the time before a new technology will be viewed as a viable commercial endeavour and provide a source of business funding for learning investments. Market leaders often use a niche market in developing a ‘challenger’ to an existing technology, viewing it as a stepping stone towards a mass market. The fact that these early adopters are willing to pay more for products that meets their needs means that less money must be invested in the “learning investments” by governments and industry.

Ideally, there is a match between the size of the niche market and a commercial production facility. This allows one or more facilities to be constructed to satisfy just the niche market. In many cases, this is not possible and the niche market opportunity can absorb only a small portion of a commercial plant output and little benefit can be gained from the niche. This is more of a problem in countries with small geographically diverse markets such as Canada, than it is in the United States or Europe with their much larger markets, although even in a unified market such as Europe there can be distortions between countries. A 50 million litre per plant in the United States represents 0.02% of the US distillate market but 0.2% of the Canadian market.

Figure 2-9 illustrates how a niche market can lead to earlier commercialization of a technology and that the bill for learning investments can be split between public and private sources.

Figure 2-9 Experience Curves and Niche Markets



Consider the following scenario. In the situation marked by ‘A’, the cost of the challenger-technology is still higher than the willingness to pay in the niche market. A financial incentive can provide the difference between the actual cost and the price in the niche market. As demand at the upper end of the niche market is satisfied, the price on the niche market is reduced, but learning has also reduced the cost of providing the product. In situation 'B’, cost is below the willingness-to-pay in the niche market and no public money is needed to finance learning investments, though it may still be necessary to assist with indirect support (e.g., labelling schemes and other information devices). In situations ‘C’ and ‘D’, the market leader may be in the enviable position of being able both to brand his products for a niche market that is very profitable (C) and to let one of his lesser brands feature a low-price version of the product that competes with the incumbent technology (D).

The characteristics of the actors in the diffusion curve shown above are summarized in the following table. It is the innovators and early adopter characteristics that are of particular interest since those are the proponents that are willing to pay more and can help to drive the experience curve.

Table 2-1 Consumer Characteristics

Adopter Type	Characteristic	Role And Size
Innovators • enthusiast	Venturesome; Enjoys the risk of being on the cutting edge; Demands technology.	Market drivers. Want more technology, better performance.
Early Adopters • visionaries	Well connected; Integrated in the main-stream of social system; Project oriented; Risk takers; Willing to experiment; Self-sufficient; Horizontally connected and acts as their peers.	
Large Difference between groups above and below.		
Early majority • pragmatists	Deliberate; Process oriented; Risk averse; Want proven applications; May need significant support; Vertically connected and acts as their superiors.	Followers of the market. Want solutions and convenience.
Late majority • conservatives	Sceptical; Does not like change in general. Changes under ‘pressure‘ from the majority.	
Laggards • sceptics	Traditional; Point of reference is ‘the good old days‘; Actively resists innovations.	Economic/ power interest different from status quo?

Creating and exploiting niche markets is an efficient strategy for a deployment program, both to provide learning investments from private sources and to stimulate organisational learning among market actors.

2.2.3 Biodiesel Market Development from a R&D + D Perspective

The development of a biodiesel “market” can be evaluated from the R&D + D perspective. The issues with respect to experience curves and technology diffusion are discussed below briefly.

2.2.3.1 Experience Curves

The potential for learning experiences should be considered from several perspectives including plant capital, plant operating costs, feedstock costs, and revenue enhancement.

Biodiesel production economics are dominated by the feedstock cost. Depending on the plant size and feedstock used, capital and operating expenses contribute from 10 to 30% of the total production costs. No biodiesel experience curves were found in the literature nor was there sufficient historical data available to construct an experience curve for the German biodiesel industry (the world's largest). There has been significant technological innovation in the European biodiesel industry and this undoubtedly has lead to reduced capital costs over time but it is difficult to quantify the impact.

In the United States, there appears to be several design-build contractors (companies that design as well as build plants) emerging to serve the needs of the growing production base. A number of these companies have emerged in Europe and some of the European companies are also active in the US market.

The smaller size and lower complexity levels of biodiesel plants makes them better suited to small specialist engineering firms rather than large multinationals. These small firms appear to be able to deliver a more cost competitive product.

It has been shown that there are economies of scale from constructing larger plants, not so much in terms of production costs but in terms or return on investment. On the other hand building multiple plants leads to capital cost reductions through learning experiences. In relatively small markets, like Canada, where there isn't the potential to build hundreds of plants, several mid sized plants may provide lower per unit capital costs than one large plant since the multiple plants will have the opportunity to learn on each plant and reduce the cost of each plant, whereas, the single large plant has no opportunity to learn and improve the technology or the construction practices.

Whether large or mid sized plants are built, deployment programs that phase the production in over time will be more effective that programs than encourage a rapid expansion of production capacity with no opportunity for learning. These phased programs will have a lower capital investment, not only for governments but for the industry as well. Lower capital investment will ultimately lead to a more financially sound industry.

From a biodiesel feedstock perspective, there is not a lot of potential for lower production costs from moving down the learning curve with the exception of the development of new varieties of oilseeds that are designed to produce oil for industrial applications rather than human food applications. These new crops could have lower protein levels and higher oil contents and or higher yields. The ultimate goal would be to provide the same financial return to the oilseed producer but be able to sell the oil (or oilseeds) at a lower costs than today's crops.

2.2.3.2 Technology Diffusion

The critical first component of the development of the market penetration curve is the identification of the early adopter group. These consumers are targeted for their willingness to pay more or to switch their purchasing habits to lead the market development effort. The step of moving beyond the early adopters is really the critical one for most new technologies. In most cases, the costs at this stage need to be competitive with the incumbent for significant market development to occur.

2.3 MARKET BARRIERS PERSPECTIVE

The Market Barriers perspective views the adoption of new technologies as a market process and focuses on the frameworks within which decisions are made by investors and consumers. Anything that slows down the rate of adoption can be referred to as a market barrier. The emphasis on this perspective to market development should be on understanding the barriers and in what role the government may act to reduce those barriers. The Research and Development and Deployment perspective focussed on the innovation and its relative advantages, the Market Barriers perspective considers more of the social systems and communications issues with respect to diffusion of the technology.

Inertia is likely to be found in well-established markets based on conventional energy technologies that have been around for many decades. For a variety of reasons – such as ingrained consumer attitudes combined with the large expense involved in trying to change them or the advantages that existing sellers have if their technologies are based on costly capital infrastructure that has been paid for in the past – the market system may be sluggish when it comes to welcoming new products. In the past several decades, many proponents of energy conservation and diversification believed that normal market processes were far too slow at bringing about the widespread use of new energy technologies that were urgently needed to enhance energy security and the environment. They suggested that this was due to various barriers in the way of the rapid market penetration of technologies that were obviously superior in their view and they advocated government action to reduce or eliminate them. This view has created some debate about the proper role of government in addressing the barriers with the incumbent energy producers and many economists on one side and energy technology developers and environmentalists on the other side.

Out of this debate came what the IEA are calling the Market Barriers perspective, a view that focuses on the desirability of facilitating the adoption of cleaner and more efficient energy technologies, but by way of policies consistent with the underlying objectives and constraints of a market system. The objective of promoting energy conservation is still there, but subject to the constraint that the policy measures used to pursue that goal are economically efficient. Put another way, it is the perspective that results when the barriers that tend to slow the rate of adoption of new technologies are identified and subjected to analysis within the framework of neoclassical economics.

The various market barriers that are viewed as important are well known. The following table provides a summary list, along with some typical measures that are taken to alleviate the barriers. Note that a list of this sort is not comprehensive and is not meant to suggest that the individual barriers are tight categories. The barriers overlap and there is interaction between them and their effects on decisions to invest in new technologies.

Table 2-2 Types of Market Barriers

Barrier	Key Characteristics	Typical Measures
Uncompetitive market price	• Scale economies and learning benefits have not yet been realized.	• Learning investments • Additional technical development
Price distortion	• Costs associated with incumbent technologies may not be included in their prices; incumbent technologies may be subsidized.	• Regulation to internalize 'externalities' or remove subsidies • Special offsetting taxes or levies • Removal of subsidies
Information	• Availability and nature of a product must be understood at the time of investment.	• Standardization • Labelling • Reliable independent information sources • Convenient & transparent calculation methods for decision making
Transactions costs	• Costs of administering a decision to purchase and use equipment (overlaps with "Information" above).	
Buyer's risk	• Perception of risk may differ from actual risk (e.g., 'pay-back gap') • Difficulty in forecasting over an appropriate time period.	• Demonstration • Routines to make life-cycle cost calculations easy
Finance	• Initial cost may be high threshold • Imperfections in market access to funds.	• Third party financing options • Special funding • Adjust financial structure
Inefficient market organization in relation to new technologies	• Incentives inappropriately split owner/designer/user not the same. • Traditional business boundaries may be inappropriate • Established companies may have market power to guard their positions.	• Restructure markets • Market liberalization could force market participants to find new solutions
Excessive/ inefficient regulation	• Regulation based on industry tradition laid down in standards and codes not in pace with development.	• Regulatory reform • Performance based regulation
Capital Stock Turnover Rates	• Sunk costs, tax rules that require long depreciation & inertia.	• Adjust tax rules • Capital subsidies
Technology-specific barriers	• Often related to existing infrastructures in regard to hardware and the institutional skill to handle it.	• Focus on system aspects in use of technology • Connect measures to other important business issues (productivity, environment)

Not all of these barriers apply to bioenergy in general or to biofuels specifically. In the following table, the market barriers are assessed for bioenergy in general and some other energy technologies (IEA, 1995). It is apparent from the table that the barriers that bioenergy faces are not that different from the barriers facing other forms of renewable energy or even new forms of fossil energy.

Table 2-3 Summary of Market Barriers by Technology

Barrier	Small-scale Hydro	Windpower	Clean Coal	Bioenergy
Cost	0	0	++	++
Price Distortion	++	++	++	++
Informational	+	+	+	++
Risk	+	++	++	++
Financial Barrier	++	+	++	+
Market Organization	++	*	+	*
Regulatory Processes	++	++	++	++
Equipment Turnover Rate	+	+	++	+
Technology Specific Barriers	none	Systems integration	Infrastructure complexities	none
Environmental	++	++	++	++

0 For some applications costs are close to competitive with established technologies
+ Weak barrier, not a key constraint
++ Strong barrier, primary focus of sector participants
* Not obviously applicable

According to the principles of market economics, governments should intervene in the economy only in a situation in which the market fails to allocate resources efficiently and where the intervention will improve net social welfare. In the ‘strong‘ form of this view, barriers in the way of the adoption of new technologies should be dealt with by government action only if they involve *market failure*. In those cases, government should intervene to correct the market failure (again, subject to the intervention increasing net social welfare). Once this has been done, according to the market barriers perspective, government should leave decisions on the purchase of new technologies to the private sector. Therefore, one should consider to what extent the barriers identified involve market failure and whether there are any qualifications to the market failure argument. It is critical to note that not all market barriers involve market failure.

Some of the market barriers shown in Table 2-2, such as higher product costs, the risk of product failure, the high cost of finance for small borrowers, and others included in the table, are normal and inherent aspects of the operation of most markets and they should be allowed to influence decisions in energy markets just as they influence decisions in all other markets. These barriers do not usually satisfy the market failure criterion because they involve necessary costs that have to be covered for all goods and services; the existence of the barriers themselves does not provide a reason for favouring new energy technologies, which (in the classical economists view) should have to compete for investment dollars with everything else of value if resources are to be allocated efficiently.

Most instances of market failure involve *externalities,* which occur in a market transaction if any of the costs or benefits involved in it is not accounted for in the price paid for the product that is sold. If there are costs that are external to the market (i.e., the buyer does not pay some of the costs incurred in producing the product), a negative externality occurs. If there are external benefits, a positive externality occurs.

An example of a classic market barrier that can involve market failure is the cost and inconvenience to consumers of finding and analyzing information about energy-saving equipment (the communications issue of technology diffusion). Consumers require small amounts of technical knowledge to become aware that a useful new energy-efficient product is available and to evaluate the claims of competing brands. Given the administrative costs involved in large numbers of small market transactions, it is hard to imagine that such an information service would be offered exclusively by private firms through individual market transactions. Neither would potential suppliers of such information be very interested in such a market because they would know that the consumer who buys such information could so easily pass it on to others. Thus too little of this kind of information service would be provided relative to the benefit of it to consumers. These factors rationalize the involvement of government agencies in disseminating information on energy efficiency.

Certain aspects of a market's structure may lead to inefficiency. For instance, a firm with monopoly power may be able to fend off competition from a new technology. In some countries or local markets, suppliers of financial services may not face much competition and this can result in unnecessarily high interest costs for financing purchases of energy-saving equipment.

The equipment turnover barrier may be high for those technologies that address markets that are not growing fast and are served by a few dominant players that fight for market share. The transportation fuels market would be a classic case. Bioenergy technologies that try to penetrate this market could be termed disruptive technologies. They must fight with the incumbent technology for the relatively scarce market. Markets that are growing fast and served by many participants are generally easier to penetrate and the technologies that will address these markets could be considered incremental technologies. The incremental technologies will have lower market barriers.

One can see that government action may be warranted in the case of some market barriers and not in others. In some situations, dealing with barriers in a pragmatic way can be a matter of making sure that normal aspects of market infrastructure (e.g., consumer protection laws, laws of contract) are working well in markets for energy technologies. Table 2-4 classifies the barriers identified in Table 2-2 as normal barriers or market failure barriers.

Table 2-4 Classification of Market Barriers

Barrier	Barrier Type
Uncompetitive Market Price	Normal
Price Distortion	Market Failure
Information	Market Failure
Transactions Costs	Market Failure
Buyer's Risk	Normal
Finance	Normal
Inefficient Market Organization	Market Failure
Excessive/ Inefficient Regulation	Market Failure
Capital Stock Turnover Rates	Market Failure
Technology Specific Barriers	Normal

2.3.1 Biodiesel Development from a Market Barriers Perspective

Each of the identified barriers for new energy technologies will be evaluated to determine its applicability to biodiesel market development.

2.3.1.1 Normal Market Barriers

There are four types of normal market barriers identified, uncompetitive market price, buyer's risk, finance, and the potential for technology specific barriers. These are discussed below.

Uncompetitive Price

The cost of producing biodiesel is higher than the cost of diesel fuel, although the absolute value of the difference between the two is a function of commodity prices. In times of high crude oil prices and low agricultural prices, the gap can be small (or not exist at all) and when fossil energy prices are low, the gap can be large. In the regions of the world where biodiesel has been used as a diesel blending component or diesel fuel substitute the gap has been eliminated through the use of tax incentives provided by governments. These tax incentives can be viewed as learning investments. Governments have also invested in research and development in order to help to drive down the costs of production.

Even where there is an incentive there is concern on the part of some lenders, developers and marketers that the incentives could be removed in the future making their investments in biodiesel production and marketing unprofitable.

Biodiesel also faces the problem of commodity price volatility. The changes of a few cents per litre in the selling margins could have a large impact on profitability. In the case of biodiesel, both the feedstock costs and the selling prices can have price swings up to 40 cpl over relatively short periods of time. There is very little correlation between diesel fuel prices and vegetable oil prices, which serves to further increase the commodity price risk.

Biodiesel will likely require either large incentives to overcome the unattractive price and the price volatility issue or a complicated support program that is flexible and responsive to changing market conditions that will ensure that the biodiesel price is competitive with diesel fuel but that the programs that yield the competitive price are not too costly.

Buyer's Risk

The Buyer's Risk could also be termed business risk and it is important to note that it is the perception of risk that may be more important that the actual risk. The gap between perception and actual risk is larger when an industry is new and one of the measures that reduced this gap and the buyer's risk for any venture is experience.

The business risks for biodiesel operations are not untypical of those for other agricultural processing industries. Typical categories for the risks are:

- Risks related to equity financing
    - The idea for a biodiesel plant development may originate with a small group of individuals who then undertake to raise equity for the project. There is no guarantee that the process can be successfully completed once it is started. In most cases, the investments made by individuals are placed in trust until certain thresholds are met and are returned if the equity drive fails, the original proponents may still lose their initial investment.
    - Individual equity drives can have additional specific risks such as restrictions on locations of participants, the presence or lack of brokers, the lack of a secondary market to sell shares in the future, no guarantees that future sales of units will not dilute the original shareholders.
    - These risks are generally reduced or eliminated once the equity drive has been successful.

- Risks related to debt financing
  - There are no guarantees that after the equity is raised that sufficient debt will be available to complete the project. The project may be abandoned and some of the invested money lost.
  - Lenders may place restrictions on the corporate activities that reduce the rights and flexibility of the operation and the equity holders.
  - The inability to generate sufficient revenue from the operation to support the debt may reduce the value of the equity raised.
- Construction and development risks
  - The owners are not generally experts in construction and design and must rely on third party specialists to carry out this work. Much of the ultimate operating success of the facility may be dependent on the performance of the contractors and the quality of their work.
  - The equity and debt is often raised before definitive agreements for construction are in place. There is a risk that there could be increases in cost and reductions in performance at this stage.
  - In some cases in the US, the contractors and designers are taking equity positions in plants, which can lead to conflicts of interest.
  - There may be unforeseen issues arise during construction.
  - The plant may not perform as expected or it may cost more than expected. Generally, increased costs must be covered by equity injections.
- Operation risks
  - A Board of Directors often controls the operation and there may be some conflicts of interest between the Board and shareholders in general.
  - In the case of new operations, the company often has no experience with biodiesel, and co-products production and marketing and relies on third parties for some functions that are critical for success.
  - Demand for the products is generally driven by factors outside of the influence of the owners.
  - In some cases, new unproven technologies are being considered for adoption or demonstration. These carry high levels of risk.
- Biodiesel production risks
  - The actual production of biodiesel is dependent on the supply of the raw materials, which fluctuate in price and quality. Higher input costs cannot always be recovered in the selling prices.
  - Profitability is also dependent on the existence of production and tax incentives, which are not usually guaranteed.
  - The industry may be competitive and they may be more competitive operations, which can produce and sell biodiesel at lower costs.
  - Successful operations require skilled operating personnel. These may be difficult to obtain and retain in some locations.

- Plants are subject to environmental regulations, which may change over time.

- Corporate structure risks
  - Depending on the corporate structure chosen there may be additional risks for investors. In a partnership, the distributions of cash may not be sufficient to cover the investors tax liability.
  - Cash distributions are not guaranteed and may fluctuate with plant performance and market conditions.

It can be seen that the Buyer's risk generally is reduced as a project proceeds through fundraising and construction. There are methods of reducing some of these risks through insurance, bonding and structural approaches but these generally add cost to a project. In general, the more successful projects that there are, the lower the perception of risk becomes.

Once a plant is operating and has demonstrated that it meets the design criteria then the risks tend to be mostly commodity risks. In some cases, it may be possible to hedge and offset these risks but these programs can be expensive and they may not be available to all producers.

The types of policy measures that can be considered to address this barrier are investments in demonstration projects, programs to reduce commodity risks, and assurances that there will not be changes in government programs that would negatively impact performance.

Finance

A barrier that is somewhat related to Buyer's Risk is that of finance. Most projects are financed by a combination of equity and debt. Raising the debt portion can be challenging for a number of reasons including imperfections in market access to capital. Debt providers generally have no opportunity to participate in any project upside so they focus on ensuring that there are no downsides to their participation. They focus on the issues of what could go wrong.

Lenders have many opportunities presented to them and they chose those opportunities that provide them with their best returns or most limited risk. Many lenders also specialize in certain sectors of the economy. These are sectors which they understand the risks and rewards. New sectors require lenders to become comfortable with the risks or at least the perception of the risks. The first projects are therefore the most difficult to finance since there is no track record which lenders can rely on. It is extremely important that the first projects be successful. Problems or failures with early projects increase the difficulty in demonstrating that new projects won't have the same problems.

Note that in cases where there is imperfect access to capital, finance barriers could be considered a market failure barrier and increased government involvement may be warranted. The involvement could include special funding, third party financing options, loan guarantees or other approaches.

Technology Specific Barriers

There can be technology specific barriers to the creation of a biodiesel market. One example is the issues raised by adding biodiesel to diesel fuel. The process increases the blends propensity to gel in cold weather conditions. In the existing diesel fuel distribution infrastructure, this creates the need to handle the product in a different manner. This need for special handling creates additional costs but they can be overcome as shown by the widespread use of biodiesel in Europe where many of the same issues have been addressed.

An issue that continues to be raised relating to biodiesel is the issue of prions from an animal infected with BSE finding their way into animal fats and surviving through the biodiesel production process and combustion in an engine. The issue has been investigated (National Renderers Association, 2004) and addressed and does not appear to be a feasible pathway. The prions are found in the protein of animals and not in the fat, the acids and bases used in the biodiesel production process are known biological disinfectant agent, and the combustion process in the diesel engine exposes the fuel to very high temperatures. There continues to be evidence gathered on the issue to refute the argument and the industry will likely have to deal with the issue from a communications perspective for some time.

Technology specific barriers can also be related to the skills necessary to handle the differences between new systems and the existing infrastructure. Programs to overcome these barriers generally focus on increasing knowledge and promoting a full systems approach to dealing with issues.

2.3.1.2 Market Failure Barriers

Market failure type barriers are more difficult for individuals to overcome since they are systems related. A stronger case can be made for government intervention to address these barriers. The five categories of market failure barriers are discussed below and whether or not they are barriers to the development of a biodiesel market.

Price Distortion

Price distortion arises when some of the costs or benefits that arise from using a product are not reflected in the selling price. The most common example of this is the environmental costs that arise from using products that pollute the environment. These costs are real and are paid for by society through reduced crop production, increased maintenance costs and higher health costs. They are not generally included in the product cost.

Governments can and have taken action to remove these price distortions. One example with transportation fuels was the tax differential applied to leaded gasoline by the Canadian federal government and some of the provinces prior to the ban on the use of leaded gasoline. That additional tax, which removed the financial incentive for using lower cost leaded gasoline, was very effective at accelerating the switch from leaded to unleaded gasoline.

In the case of biodiesel, the lifecycle analysis indicates that there are greenhouse gas reductions from using the fuel and there are also reductions in the emissions of some of the tailpipe contaminants from using the fuel. These should have some value and could be used to offset the higher cost of the fuel.

Information

Markets work best when all participants have the information required to make informed decisions. The time and effort required to gather and analyze the information about new products can act as a serious impediment to their adoption. It was shown earlier that the communication of information about innovations is a very social process and one that can take considerable time, effort and financial resources. Proponents of new energy technologies often do not have the necessary resources to make this happen.

Policy options that can be used to address the issue of insufficient information include providing reliable independent information, standardization and labelling activities.

Transaction Costs

Closely aligned with the issue of information is the issue of the cost of making decisions. Large numbers of small purchases are costly and can overwhelm the benefits of choosing cleaner energy technologies. If consumers had to make a separate purchase for the biodiesel portion of their diesel purchase the added inconvenience and cost of the transaction would make many buyers and sellers think twice about the purchase.

This is not likely to be the case for biodiesel since the transaction for the biodiesel is likely to be upstream of the point of consumer purchase and be a transaction between the biodiesel plant and the diesel fuel marketer. Downstream of this transaction, all subsequent transactions should be transparent. Transaction costs are not likely to be a significant barrier to the development of a biodiesel market.

Inefficient Market Organization

Inefficient market organization applies when one firm or a small group of firms act in a similar manner and using the advantages of being the incumbent suppliers to resist the market penetration efforts of the new technology. In the case of transportation fuels, there are many end users of the fuel but they all purchase the product from a limited number of companies. These are also the companies that produce the competing product, diesel fuel. In order for biodiesel to penetrate the market and be available for the ultimate end user, it must be integrated into the existing distribution system.

Excessive/Inefficient Regulation

Regulations and standards are often prescriptive and not directly performance driven. This can be effective and efficient in cases where there is significant experience with a product and the performance can be controlled in a prescriptive manner. The system does not function particularly well when new products are introduced that may not have the wealth of experience associated with their use and may not behave in exactly the same manner as the incumbent technology.

In many countries, regulations are developed through a consensus process involving producers, consumers, and regulators. In most cases, the producers are the most knowledgeable members of the panels and exert a strong influence on the outcome. In the case of new products, the incumbent producers can use this dominance to resist change to the specifications that might favour a new product.

The best North American example of the problems that inefficient regulation imposes for biodiesel is probably with the T90 limits for blends. Pure biodiesel is composed of esters and many have T90 points above the limit for all hydrocarbon diesel fuel. As more biodiesel is blended into diesel fuel, the blend reaches a point where it no longer meets the T90 specification. The question should be do esters have identical combustion properties to the hydrocarbon components used in diesel fuel? Only if the answer is yes can there be any justification for enforcing identical specification on biodiesel as used for petroleum diesel fuel. This issue has held up the development of a biodiesel blend specification in Canada and the United States for some time. In the United States, the National Conference on Weights and Measures withdrew a proposed requirement that all biodiesel blends meet the national specification for petroleum diesel. NCWM is a professional organization that promotes uniformity in U.S. weights and measures laws, regulations, and standards to achieve equity between buyers and sellers in the marketplace. Many states are presently looking to NCWM for guidance on fuel specifications for biodiesel and blends, and they will likely implement the standards adopted by NCWM. This is significant because there are biodiesel properties that are different from petroleum diesel, so not all blends will meet the diesel specification.

The NCWM is also dealing with a proposed requirement to label biodiesel pumps. There are currently discussions underway to identify the need for labels and what the labels might say. This could be an important issue because in the 1980's some states required ethanol blends to be labelled and some gasoline marketers used this requirement to cast doubt on the quality of ethanol gasoline blends.

Capital Stock Turnover

The petroleum industry has invested significant money in the construction of refineries to convert crude oil into gasoline and diesel fuel. The addition of a fuel component produced outside of this existing infrastructure has the potential to reduce refinery throughput, which has a negative impact on the economics of refining. If the volume of additional product supplied to the system is large enough, it could result in marginal refineries being closed and written off.

The turnover of refinery stock should not be a real barrier to increased biodiesel use. Increased demand for diesel fuel, and refinery closures provide opportunities to include biodiesel in the diesel pool without rolling back refinery production.

2.3.2 Summary Market Barriers

The market barriers identified for biodiesel are summarized in the following table.

Table 2-5 Summary Market Barriers - Biodiesel

Barrier	Biodiesel from Animal Fat	Biodiesel from Vegetable Oil
Normal Market Barriers		
Uncompetitive market price	Medium	High
Buyer's risk	Medium	Medium
Finance	Medium-High	Medium-High
Technology-specific barriers	Low	Low
Market Failure Barriers		
Price distortion	Low	Low
Information	Medium	Medium
Transactions costs	Low	Low
Inefficient market organization in relation to new technologies	High	High
Excessive/ inefficient regulation	Medium	Medium
Capital Stock Turnover Rates	Low	Low

For the normal market barriers, the category of uncompetitive prices is rated as being a medium to high market barrier. The range is created by the different feedstock costs.

The buyers risk is primarily influence by the relative lack of experience with the design, construction and operation of these plants in most countries.

The financing risk is rated medium to high. These facilities are difficult to finance because they are still relatively new and do not have a long successful track record. The producers are dependent on the tax incentives for their profitability and the markets for the products are not well developed in many countries.

For the use of biodiesel, there is considerable know-how in Europe with respect to the distribution and use of that is directly transferable to North America and the technology related barriers are ranked low. There have also been generally good experiences with the many demonstration projects that have been undertaken in Canada and the United States.

In the cases of the market failure type barriers, the use of biodiesel provides some reductions in greenhouse gas emissions and reductions in some of the criteria air contaminants from vehicles, these benefits are not factored into the price of the product and thus there exists some price distortion.

The market organization may be inefficient related to biodiesel. The distribution of biodiesel from the producer to the final user is essentially controlled by a small group of integrated oil companies. This group has been reluctant to embrace alternative fuels. This group has used the argument of reduced refinery throughput and stranded assets in the past as justification for not using these alternatives. Under current market conditions of refinery closures, and increased demand these arguments are weak.

The incumbent fuel marketers have used the inefficient standards and regulatory system as a means to slow the development of appropriate standards for biodiesel. The lack of appropriate standards will slow the market development of the higher percentage biodiesel blends.

2.4 MARKET TRANSFORMATION

The term *market transformation* refers to a significant or even radical change in the distribution of products in a given market. A *market transformation program* refers to actions taken by government (or sometimes by some other entity acting in the public interest) to facilitate the market transformation process. In effect, the long-term objective of most such initiatives is to make a new efficient or low impact technology or product-type the preferred ‘norm‘ in a market place.

The objective of a market transformation program is to make changes that are both substantial and sustainable. An isolated instance in which a government supports the introduction of a new energy technology does not constitute a market transformation program. Market transformation is about creating substantial change in the market for a particular class of products: changes in the behaviour of consumers so that they choose to buy more efficient goods or services; changes in the behaviour of producers, so that they bring to the market only efficient (or at least more efficient) models; changes in the behaviour of wholesalers and retailers in regard to what they make available to final buyers; and changes in the capabilities of suppliers in related markets to provide whatever ancillary goods and services are needed (e.g., suppliers of equipment parts and other intermediate goods, installers, repair companies). When the process is completed, a successful market transformation program will have had a lasting and significant effect.

This perspective thus also addresses the social aspects of technology diffusion but in a different way from the Market Barriers perspective. It focuses more (but not exclusively) on the end use of the technology or the market rather than on the whole supply chain.

In the work of the IEA on creating markets, the idea of a market transformation perspective is further expanded. It considers the market transformation perspective as fitting into a larger picture of what can be done by governments to help build markets for new energy technologies. The RD&D and the market barriers perspectives are useful, however these perspectives do not address an important additional process affecting market deployment. The RD&D perspective deals primarily with the implications of learning and the interactions between R&D and market development, particularly for the cost and performance of new technologies. The market barriers perspective identifies obstacles in the way of new technologies and suggests ways to deal with them that conform to the constraints of market economics, but does not deal in depth with how to implement change. Although economic analysis is rich in insights about problems in existing markets, it does not say very much about the steps needed to create new markets out of the entrepreneurial process. Correspondingly, the IEA focuses the market transformation perspective on the outcome to be achieved and then runs the logic back through all the factors that would be necessary to attain that outcome: improving technology cost and performance and removing barriers, but also actively creating the conditions that facilitate the rapid market uptake of new more efficient products.

The idea at the centre of the market transformation perspective is that people involved in technology deployment policy should think about what is needed to encourage the adoption of new products in the same way that private-sector suppliers think about it. That is, they have to understand in depth what makes the market for a new product take off, and then use that understanding to identify aspects of market structure and behaviour that affect product acceptance and also happen to be determined or affected by government actions. The idea is to apply the kind of expertise used by business to develop markets in pursuing the objectives of government policy in the energy sector. Unlike a business, however, the designer of a market transformation strategy is consciously pursuing a public policy objective; and therefore needs to exercise great care not to usurp the proper role of the market in 'picking winners' (and losers).

Market transformation programs involve governments in influencing market decisions, but an important aspect of the market transformation perspective has come to be an emphasis on designing that influence so as to interfere with normal market processes as little as possible. The objective is to affect private energy-related decisions by reducing market barriers, changing incentive structures, providing public information, and encouraging competition in the aspects of products that determine energy efficiency and emissions. Good market transformation programs are about raising the profile of energy variables in market activities and making once-only adjustments to the background infrastructure in which markets operate; and doing that in ways that are consistent with a public-good approach to policy making in a dynamic economy. It is not about regulatory tribunals, price controls and other forms of intervention that have been overly used and therefore discredited.

The actual process of transforming markets is described by the IEA as follows:

> *Developing effective market transformation policies is straight forward in principle, but far from easy in practice. The straight forward principle is first to develop an understanding of the buyer-relevant characteristics (both positive and negative) of the technologies being promoted and the workings of the markets that will potentially be transformed; and then to identify strategies that would help to boost the positive attributes (including high energy efficiency) and overcome the negative ones (e.g., high purchase costs, a lack of a proven track record, etc.). The practice is far from easy because products and markets differ in ways that might be well understood by suppliers but will not be easily grasped by policy practitioners who arrive on the scene with quite different backgrounds. Furthermore, as noted above, care must be taken not to interfere with the normally efficient aspects of market-based resource allocation.*
>
> *In large part this challenge is dealt with through diligent and open minded interaction with people involved in the target markets and by an openness to a variety of expertise. Market transformation practitioners need to be wide-ranging and eclectic in regard to the bodies of knowledge they draw upon. A variety of disciplines are relevant, such as marketing, economics, psychology, management science and engineering; and experience in the target market is obviously a big plus when it comes to qualifying for a job on a market transformation project.*

The starting point for the development of market transformation programs is to identify the technologies and the markets to be worked upon. Central to this is an evaluation of the potential for increasing societal welfare through government action. In the present context this means exploiting a potential for improving energy efficiency in a way that generates net benefit but would not be brought about by normal market processes, at least not as quickly.

Such unexploited potential may exist for various reasons. For instance, the technology to improve the energy efficiency of a given type of household appliance might be available but not yet incorporated to a significant degree into widely marketed models. Suppliers in that market might find their current range of models to be quite profitable; they might be aware of the possibility of improving energy efficiency without adding greatly to their production costs, but may not view its incorporation into their products as a high-priority option in their overall marketing strategies. This might involve a belief that consumers are more likely to focus on initial purchase costs and non-energy aspects of performance than to take account of energy costs over the product's life cycle. Indeed energy might contribute a relatively small portion to total life-cycle costs. In such a situation, a range of market transformation actions can be effective in tilting supplier strategies towards introducing the new technology. In a market with several suppliers it can be possible to do this by taking action that will focus competition on energy efficiency; for instance, with a combination of actions that reinforce each other, such as by working with suppliers through a procurement program while at the same time enhancing the likelihood that buyers will pay attention to the energy-using characteristics of the appliance by way of an energy labelling system combined with advertising and sales training programs. In other types of markets it may be necessary to intervene more aggressively to set the transformation in motion; for instance, by amending mandatory product standards.

In practice the market transformation practitioner has to deal with many complications because target markets can be very complex. Many energy services can be provided in more than one way and markets interact with each other and often disaggregate into systems of sub-markets. Thus even the initial step of specifying the market to be worked on has to be understood as an open process with feedback loops – all of the areas to be worked on may not become clear until after the work has begun.

A key aspect of the Market Transformation process is to identify all of the important decision makers according to the different roles they play. In the technology diffusion process, the importance of these key influencers in promoting the uptake of new technology is well understood. The following table illustrates that the number of different market players can be large and varied. While some of the roles played by market actors overlap and many actors have multiple roles, the table indicates that consulting with stakeholders, and involving some of them in the transformation process in other ways, is a large job. It is nevertheless a centrepiece of most market transformation programs. The chances of having a performance enhancement or a new product accepted can be greatly increased through the involvement of important market players, especially when the changes are technically complex and currently accepted products are well established.

Table 2-6 Types of Market Actors Involved in Case Study Projects

Typical Role	Market Actor
Buyer	Facility operators
Buyer & seller	Distributors, wholesalers, retailers, purchasers, contractors, service companies, utilities, energy distributors
Development	Planners, architects
Development – manufacturing	Manufacturing companies, parts suppliers
Financing	Funding brokers & other financial institutions
Information dissemination	Energy agencies, mass media companies & agencies, individual investors
Policy & funding	Government agencies, other public institutions
Policy – formulation & decisions	Politicians, regulatory agencies & other public authorities
Represent special interests	Trade associations, consumer associations, other NGOs
Basic research	Universities
Research & development	Research institutes, corporate research labs
Seller	Equipment installers, energy distributors
Special tasks (e.g., policy analysis)	Consultants
Technology user	Homeowners, consumers, customers, end-users

Working with stakeholders can be done by tapping into existing networks, such as trade associations and consumer groups, or by building new networks of contacts. For instance, in technology procurement programs developing cooperative networks among buyer-groups is important. Industry associations may develop their own networks to work together on building the foundations for the offering of a new product. Some, but not all, of these strategies are applicable to some of the biomass energy opportunities

Three broadly based models that are often used in market transformation programs are:

- Procurement Actions
- Strategic Niche Management
- Business Concept Innovation.

2.4.1 Procurement Actions

Procurement processes are natural vehicles for encouraging technology market development – they offer an entry point for influencing industry decisions in a framework that governments know well. In the market transformation perspective, a procurement specification list provides a useful pathway for program designers to get into the details of market operations.

Technology procurement can be viewed as a tool that can influence the whole chain of innovation and commercialization. One strength of the procurement model is that it allows policy designers to address issues such as how do you entice consumers to buy energy-efficient equipment when the cost of energy is only a small component of its total cost and the consumer is much more interested in characteristics of the equipment other than its energy efficiency? The answer is to entice equipment producers to embed energy-efficient technologies in products designed with other characteristics that consumers think are important. This is not high-level R&D, but it is an important bit of common sense. In the new products that resulted from the procurement programs in the case studies, equipment suppliers were able to make improvements quite easily. However, prior to being nudged by the procurement programs, they had little incentive to develop improved versions of their products that would substitute for existing versions that were already profitable.

Procurement programs arouse a latent potential and encourage new thinking that results in both technical and commercial development. In many respects, this is addressing the relative advantage of the new technologies. What is important is to consider all aspects of the new technology and not just what may seem to be the key aspects.

There is great potential for variety in the design of procurement programs. The IEA identifies several different approaches that could be taken with procurement programs.

- *Components vs. systems:* The target technology may vary from specific components of a technical system to a whole system or facility. A single component may be a generic technology and widely applicable, whereas a system may have local features. A system may involve more flexibility and leave room for different approaches, whereas a component-approach is often tied to a certain technology. Risk and complexity increase when going from a single component to a system.
- *National vs. international programs:* Procurement programs are usually arranged nationally but made open to competition from international manufacturers through national regulation and trade agreements. International procurement processes increase the purchasing power of buyer groups and more strict criteria can be applied.
- *Single-stage vs. multi-stage programs:* Most programs are single projects based on one product specification. An interesting innovation would be to introduce a multi-stage process that builds on the strengths of a particular procurement approach. Some examples: the first stage might be national and the second stage international in order to multiply the effects of the program and its appeal to suppliers; the first stage might involve a system component and the second the whole system; or the first stage might focus on working with manufacturers and the second with consumers.
- *Externally-led vs. self-organized programs:* Technology procurement must be highly organized and carefully managed to be successful, which means that leadership is important. But some versions of the procurement model can take shape spontaneously. For example, it could arise when an established network of buyers comes to a voluntary consensus that a tendering procedure would benefit all members of the group. The Internet is a tool that might be effectively used to collect buyers and build purchasing power.
- *Technology-focused vs. ordinary procurement programs:* The typical market transformation procurement program has involved a strong focus on the technical characteristics of a relatively new product that requires some development to respond better to competition from established products. In an ordinary procurement program, the focus may be on creating more purchasing power to reduce the price of better-than-average products.

Focused procurement programs may also be associated with other market transformation actions that affect the market concerned. For instance, new information dissemination programs and an energy labelling system might be timed to interact with the results of a procurement effort. Similarly, the development of buyer-groups might be timed contingently to follow the successful completion of the technical development aspect of the procurement arrangement. This kind of staged approach relates to the next model of Market Transformation.

Procurement programs are ineffective where the volume of product represented by the purchasers is not sufficient to cause the creation of production economies of scale. In general, the more capital intensive the production process, the less likely that procurement actions will be a useful tool for market development.

2.4.2 Strategic Niche Management

A technology niche market is one that offers sellers some limited level of protection against competition from existing products and therefore provides some room for experimentation, trial and error, and product modifications. At the same time, the new technology is embedded in a wider market. This provides the opportunity for a different kind of market transformation strategy.

Niche markets help to set important processes of change in motion: interactive learning, institutional adaptation, networking and technical development efforts that are necessary for the wider implementation of a niche technology. Thus a market transformation program could accelerate this process by focusing on aspects of change that depend on government actions (such as adjustments to standards and codes, public information, etc.) and providing leadership in bringing users, suppliers and other market actors together in an interactive learning process. This sort of approach to market transformation programs involves more risk, but could be important in areas that require difficult changes in market infrastructure.

When trying to create the market niche in which such a strategy may be applied, it would be important to require a good fit between the technology being launched and the expectations of the market. This requires close consideration of market characteristics by the market transformation practitioner in ways that parallel the approach of the firms launching the new product. For instance, it is important to choose a niche that takes full advantage of the merits of the new technology, to concentrate initially on a limited number of applications and work first in small geographical areas. Working with forms of the technology that have the potential for scale economies increases the chances of success and it is helpful to focus on customers and users who are demanding and likely to lead the market in adopting new products.

2.4.3 Business Concept Innovation

An innovative business strategy may also provide a framework for market transformation policies of a different kind. In some parts of the energy sector traditional business models have involved little emphasis on innovation as a tool for creating competitive advantage; this can also be said about some other sectors of the economy in which large amounts of energy are consumed; e.g., the construction sector. An example in the energy sector is the traditional electric or natural gas utility, which in the past focused strongly on its core business.

Regulatory regimes created a static environment that was not conducive to innovations in the products and services put on the market by these companies. Regulatory reform has changed that. In a more competitive environment, companies find that they have to pay attention not only to production efficiency and cost, but also to the specific needs of their target customer groups and to the more subtle characteristics of how they deliver their services. Thus, an electricity company may find that it can attract end-use customers by offering a variety of services. E.g., household consumers may respond to the offer of maintenance services, information technology devices that improve household management or reduce energy costs, and 'green energy' packages. Industrial customers respond to time-of-use pricing, energy performance contracting or options to be involved in distributed generation facilities.

This suggests that there are situations in which market transformation techniques can be fit into or coordinated with regulatory reform. While the reform may be primarily motivated by other objectives, opportunities to achieve technology deployment objectives by encouraging new business concepts may take shape as part of the process of competitive change that is set in motion. A Finnish project on the use of diesel engines for combined-cycle power generation showed that the scope for government-industry cooperation on business concept development is not limited to areas of regulatory reform. It involved support for the development of compact and modular combined heat and power systems by a major diesel equipment producer. Leading users and several providers of finance joined together to undertake a full-scale demonstration project. New ways of providing competitive energy solutions and total energy service concepts were developed. These have proven successful and have led to increased sales.

The cluster concept where the output from one operation is used as the feedstock for another operation is an example of a business concept innovation that is used for market transformation. In Europe there are now some community anaerobic digesters than produce heat and power from the manure from a number of farms, this is an innovative business concept. Partnering firms with feedstock resources, production expertise, with market developers who will explore and create new bioenergy markets but who lack the operational expertise would be an excellent example of Business Concept Innovation.

The idea of a market transformation perspective is in the early stages of its development relative to the other two perspectives discussed. It is a compendium of ideas that have taken shape out of the experience of policy practitioners and it is still evolving. It is nevertheless an important part of the discussion because it is about the details of getting the job of deployment policy done. There exist many opportunities to release the potential for cleaner and more efficient energy use.

2.4.4 Biodiesel Development from a Market Transformation Perspective

Up until the beginning of 2005, biodiesel has been marketed in North America as a niche fuel. Almost all of the customers were paying more for the fuel because of its higher cetane properties or its environmental benefits. Consumption in the United States in 2003 was only about 100 million litres of biodiesel. The biodiesel costs were more than twice the price of petroleum diesel and the pricing was benefiting from a USDA program that contributed about $1 per gallon (US$/USG) through the Bioenergy Program. It is likely that production costs were high because the existing plants are not operating at capacity. This situation has started to change in 2005 with the introduction of tax incentives in the United States that helped to remove the price barrier.

Biodiesel market development in North America has been based on a combination of strategic niche management and procurement actions. The industry in North America has targeted public fleets for biodiesel demonstrations. These are generally high profile fleets which in some cases has helped to get major oil companies involved in blending the biodiesel and these fleets have also provided some leadership on fuel use that has been followed by some private sector fleets.

In some cases, public fleets have combined their purchasing power to implement biodiesel demonstration programs across a number of fleets. This has resulted in two benefits, the first is the networking opportunity for like minded purchasers and the second is that the combined purchases have reduced the costs of dealing with small volumes of fuel. Biodiesel has been purchased in bulk rather than in containers as a result of the combined volumes.

There are also many groups who see business concept innovation as the way to develop the biodiesel market. Many of these groups are co-operatives who envision collecting waste restaurant grease and converting it to biodiesel through relatively small scale systems. Co-operative members would be expected to donate labour to the enterprise and be able to purchase biodiesel at a low cost due to the "free feedstock" and donated labour. There are challenges to this approach with respect to guaranteeing the quality of the final product and in building a large enough enterprise to make a significant impact on the biodiesel target volume.

On a larger scale, the rendering business in North America is experiencing many challenges as it adapts and responds to the changing market conditions resulting from BSE in North America. While this has not had a major impact on the quoted prices for animal fats in North America it is believed to have presented many challenges to the renderers including the need for more segregation of feedstocks and reduced demand for some fat products. There may be an opportunity for some of the largest producers of animal fats to bypass the rendering industry and supply their waste product directly to the biodiesel producer. This would result not only in a guaranteed supply for the biodiesel producer but it may also allow for more stable longer term pricing of the feedstock or perhaps even feedstock prices tied to petroleum diesel fuel prices. This would remove the commodity price risk from the biodiesel producer and should ease financing.

Tying the pricing of the feedstock prices to the price of biodiesel may not be that large a transformation for some fat producers. Darling International Inc. is a publicly traded renderer operating primarily in the United States. In their Management's Discussion of Results in their quarterly report for the second quarter of 2004 they state that a portion of their raw material costs are tied to the prices that they receive for their products. They do not provide additional detail on which materials and products are dealt with in this manner but at least the concept is not foreign to the raw material producers. The transformation will be applying the concept using a different benchmark product. It was noted earlier that there is no correlation between soyoil (and thus indirectly animal fat prices) and diesel fuel price. A fat producer who chooses to sell a portion of its fat priced relative to animal fat prices and a portion priced relative to diesel fuel may have a more stable revenue stream.

This particular Market Transformation approach is probably not applicable to vegetable oil based biodiesel.

2.5 Summary Market Development

This section of the report has considered the development of biodiesel production and marketing from a market development perspective using the IEA developed template for creating markets. It has been determined that there are four primary and two secondary barriers to the development of a biodiesel market in most markets. The primary market barriers have been determined to be:

1. High biodiesel price. In some regions, this has been partially offset by a government tax incentives. The two primary biodiesel feedstocks, animal fats and vegetable oils have quite different cost structures, which require different levels of support to equalize the price of biodiesel with diesel fuel.
2. Inefficient market organization. The major petroleum are not the end users of biodiesel but they do provide the distribution system by which biodiesel reaches

the end consumer. Some oil companies have made commitments to biodiesel but most have shown little interest in the fuel.

3. Finance risk. Raising the debt portion of the required capital can be difficult. There has been some significant consolidation in the finance sector in many countries over the past decade and there are now fewer institutions that are willing to invest in new agricultural enterprises.
4. Business risk. Successful new businesses must raise equity and debt financing, have plants designed and built, operate the new facilities and adapt to changing market conditions. This is difficult to do the first time but becomes easier with each new successful operation as can be seen with the US ethanol industry.

Secondary barriers are those that exist but are now show stoppers. They do impede or slow down market development but do not stop it, there have been determined to be:

1. Price distortion. The marketplace does not place a monetary value on environmental impacts. Fuels that reduce greenhouse gases or exhaust emissions sell for the same price as fuels that don't impact emissions. In most cases, this price distortion is offset by the tax incentives offered by the federal government and some of the provinces.
2. Excessive/inefficient regulation. Biodiesel has some different properties than petroleum diesel fuel. The standards developing bodies in North America have been trying to have biodiesel blends meet the same specifications as petroleum diesel. This would limit the biodiesel content of blends to less than 5% in spite of the many successful demonstrations of 20% biodiesel. Biodiesel has a different chemical composition than petroleum diesel and it is reasonable to expect that performance based specifications would be a better approach than the prescriptive approach that is currently being followed.

When biodiesel market development is considered from the perspective of R&D + D there are several issues that were identified.

1. It does not appear that anyone has developed an experience curve for biodiesel yet. Many biodiesel proponents expect that biodiesel production costs will decline with time and experienced gained. Production costs are dominated by the feedstock cost and while it is likely that efficiency gains will be made in many areas of biodiesel production, the impacts of these gains will be small compared to the feedstock costs.
2. The primary focus for research and development opportunities should be on developing lower cost feedstocks. Many proponents believe that industrial varieties of oilseeds can be developed that will result in the same or higher returns to the producer and result in lower costs to the biodiesel producer.
3. There should also be research efforts on developing value added applications or uses for the co-products of the production process and on enhancing biodiesels positive attributes and on reducing the cost of the negative attributes.

In the case of biodiesel market development, the R&D+D perspective offers less insight in to the issue of creating markets than the Market Barriers perspective. Significant investment in R&D will assist the industry in becoming more efficient but R&D success will not result in solving all market development issues.

When biodiesel market development is considered from the perspective of Market Transformation, the opportunity appears to be finding feedstock suppliers that would be willing to price the animal fats (or theoretically vegetable oils) based on the selling price of biodiesel. This would reduce or eliminate the commodity price risk associated with biodiesel production. The concept of tying the raw material costs to the selling price of the product is a concept that is used today by some companies in the North American rendering business. In some countries, the creation of producer owned biodiesel companies is an indirect means of achieving this goal. Like the R&R+D perspective transforming the supply chain for biodiesel production is not likely to result in the solution of market barriers for biodiesel.

In the next sections of the report, the focus will be on an examination of the primary and secondary market barriers identified above and how these have been addressed in various European countries and what the impact of the solutions on the development of the biodiesel market in these countries has been. Later in the report, the lessons learned from Europe will be considered for the development of a biodiesel industry in the United States and Canada.

3. BIODIESEL MARKET DEVELOPMENT IN EUROPE

The biodiesel industry has been flourishing in Europe in recent years. Combinations of agriculture, tax, energy and environmental policies have coalesced to make biodiesel production and use a viable enterprise. New energy policies being developed by the EU should see the industry continue to grow over the next ten years. These issues are briefly discussed in the following sections.

The European Union Common Agricultural Policy (CAP) requires producers to set aside a portion of their arable land to reduce food supplies. The current set aside rate is 10%. Producers are paid for the land that is taken out of production. For land that would have been used for oilseed production, producers are paid €63 per tonne of oil seeds multiplied by the historical yield for the crop. The producer can grow oilseeds for biodiesel production on this land and theoretically accept a lower price for his oilseeds compared to the food market.

Many countries in Europe reduce the fuel tax on biodiesel and ethanol to encourage their use. In the past these exemptions were granted for research and demonstration programs but recent changes to the energy tax system for the EU countries has allowed countries to establish lower tax rates for biofuels without the restrictions on the size of the programs that previously existed. The amount of tax exemption available is identified in each of the countries below.

In 2003, the European Union introduced a directive that sets targets for biofuels production and use. The target is 2% of fuel use in 2005 and rising to 5.75% by 2010. The targets are very substantial and are seen as a means of reducing dependence on imported oil in the community. Two percent of EU diesel fuel usage in 2003 would have required about 3 million tonnes of biodiesel for the EU and 5.75% of diesel fuel usage in 2010 is projected to require about 10 million tonnes of biodiesel. The production of biodiesel in the EU is estimated to have totalled 1.9 million tonnes in 2003 (European Biodiesel Board, 2005).

3.1 GERMANY

Germany is both the largest producer and consumer of biodiesel in Europe. The fuel is produced almost exclusively from rapeseed oil and until 2004 was used as B100. In 2004, a tax exemption was introduced for biodiesel blends and the fuel is now offered as a B5 blend by a number of major oil companies.

There are 25 plants in operation with a production capacity of 1,145,500 tonnes per year (2004) with a further eight plants under construction or expansion that will have the capacity to produce a further 930,000 tonnes per year (IWR, 2005). The estimated production in 2004 was 1,035,000 tonnes. The details of the operating and planned production facilities are shown in the following table. It can be seen that until recently small and large plants have been built. The new plants under construction are all large plants.

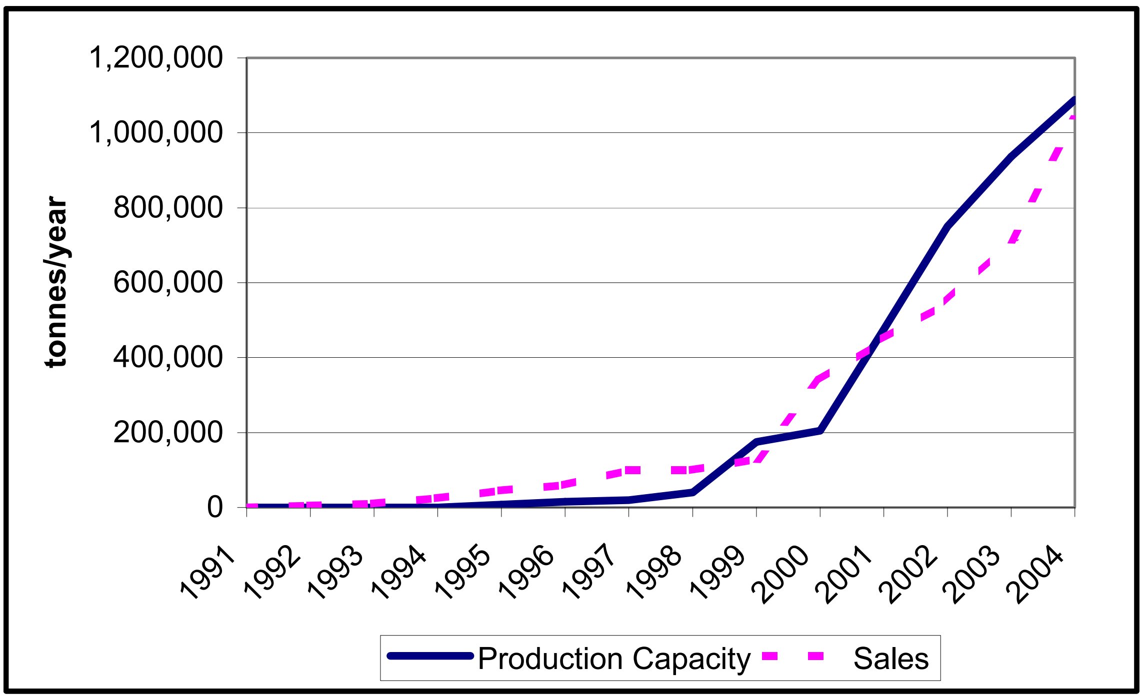
Table 3-1 German Biodiesel Plants

Operator	Location	Capacity (t/a)	Start Date
Mitteldeutsche Umesterungswerke Bitterfeld	Bitterfeld / Sachsen-Anhalt	150,000	09/2001
NEVEST AG	Schwarzheide / Brandenburg	150,000	10/2002
Rheinische Bioester GmbH	Neuss / Nordrhein-Westfalen	150,000	12/2002
Natur Energie West	Marl / Nordrhein-Westfahlen	125,000	04/2002
Oelmühle Hamburg AG	Hamburg	120,000	09/2001
Oelmühle Leer Connemann GmbH & Co. KG	Leer / Niedersachsen	100,000	09/1995
Campa Biodiesel GmbH	Ochsenfurt / Bayern	75,000	01/2000
Bio-Ölwerke Magdeburg	Magdeburg / Sachsen-Anhalt	75,000	03/2003
Biodiesel Wittenberge GmbH	Wittenberge / Brandenburg	60,000	08/1999
Petrotec GmbH	Südlohn / NRW	55,000	05/2002
Thüringer-Methylesterwerke GmbH & Co. KG	Harth-Pöllnitz / Thüringen	45,000	01/2002
Rapsveredelung Vorpommern GmbH & Co. KG	Malchin / Mecklenburg Vorpommern	37,000	05/2004
J.C. Neckermann GMBH & Co	Halle/ Saxonia	36,000	2005
EOP Elbe Oel AG	Falkenhagen / Brandenburg	30,000	05/2003
Biodiesel Kyritz GmbH	Kyritz / Brandenburg	30,000	09/2003
Kartoffelverwertungsgesellschaft Cordes & Stoltenburg GmbH & Co.	Schleswig / Schleswig-Holstein	15,000	05/2003
SARIA Bio-Industries GmbH & Co. Verw. KG	Malchin / Mecklenburg Vorpommern	12,000	10/2001
Biodiesel Bokel GmbH	Bokel / Niedersachsen	10,000	09/2002
Hallertauer Hopfen-Verwertungsgesellschaft	Mainburg / Bayern	8,000	04/1995
Landwirtschaftliche Produkt-Verarbeitungs GmbH	Henningsleben / Thüringen	5,000	04/1998
BioWerk Sohland GmbH	Sohland / Sachsen	5,000	07/ 2002
BioWerk Kleisthöhe GmbH	Uckerland / Brandenburg	5,000	02/2003
Delitzscher Rapsöl GmbH & Co. KG	Wiedemar/Saxonia	5,000	01/2003
BKK Biodiesel GmbH	Rudolstadt / Thüringen	4,000	12/2001
Verwertungsgenossenschaft Biokraftstoffe	Großfriesen / Sachsen	1,500	04/1996
Total		1,308,500	
Planning or Under Construction			
Oelmühle Hamburg	Expansion	180,000	Late 2005
NEW GmbH	Expansion	125,000	Mid 2005
Biodiesel Wittenberge GmbH	Expansion	25,000	Late 2005
Rheinische Bioester GmbH	Expansion	50,000	Mid 2005
NUW Neubrandenburger	Schwedt/Brandenburg	150,000	Late 2005

Umesterungswerke GmbH & Co. KG			
Marina Biodiesel GmbH & Co. KG	Brunsbüttel / Schleswig-Holstein	150,000	Late 2005
SARIA Bio-Industries GmbH & Co. Verw. KG	Malchin / Mecklenburg Vorpommern	100,000	Early 2006
Rheinische Bioester GmbH	Expansion	150,000	2006
Total in development		930,000	
Projected Capacity end 2006		2,238,500	

Some of these plants have the capacity to make esters for the chemical market as well as the fuel market. In the early years of the program, it was chemical plants that supplied the biodiesel market. Sales of biodiesel in Germany commenced in 1991 with some dedicated biodiesel for fuel production starting in 1996. Sales only began to increase in 1998 with the increase in both the price of crude oil and the tax on petroleum diesel (and thus the tax exemption on biodiesel). The production capacity of the German biodiesel plants was much larger than their actual production rate until 2004 as shown in the following figure.

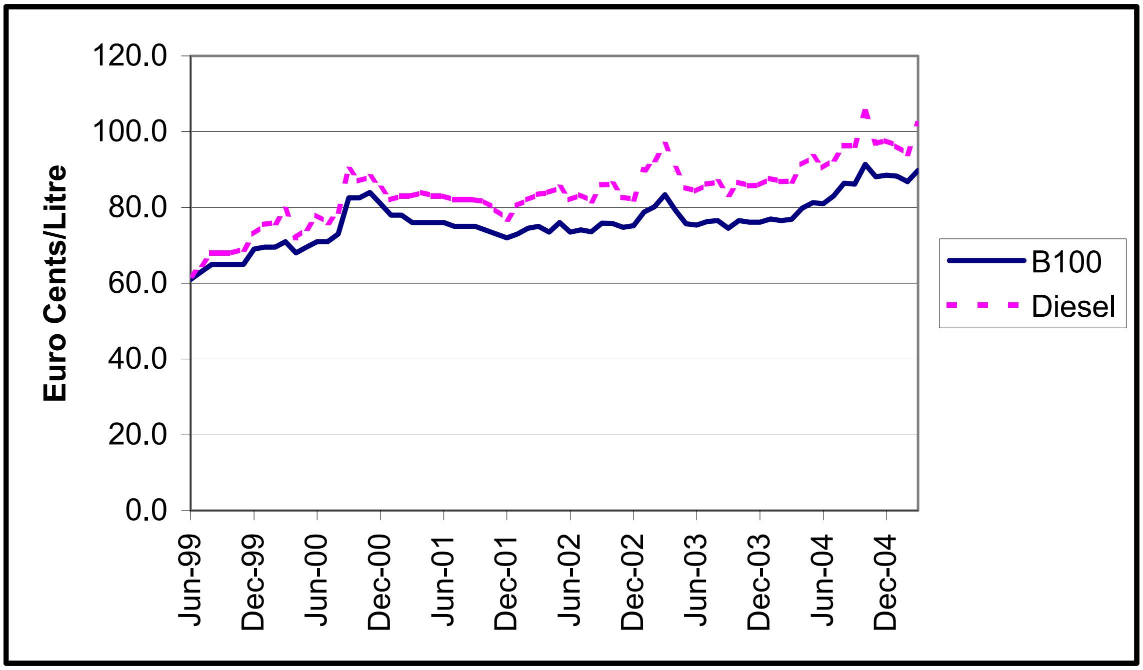
Figure 3-1 Plant Utilization



The biodiesel was used primarily as B100 as that fuel has had a 100% tax exemption (€ 0.47/litre, 0.70 cpl Can) in Germany, whereas, until 2004 the lower level blends did not. The B100 is sold at over 1900 service stations, most of them independent stations. About 40% of the sales volume is through these retail stations and 60% is through bulk deliveries to fleets. The current combination of the feedstock price and the tax incentive allows the biodiesel to be retailed for about €0.10/litre (16 cents/litre Can) less than the petroleum diesel fuel. This large price difference is undoubtedly a significant factor in the growth of the market and the prices for biodiesel and petroleum diesel are compared in the following figure (IWR). It is interesting to note that the biodiesel price has tended to follow the petroleum price indicating that the biodiesel producers are probably accepting the petroleum price risk (and rewards).

In 2004, B5 blends have been introduced into BP/Aral and Shell service stations in Germany. These low level blends are now widely available and have further led to the rapid increase in biodiesel production and use in Germany.

Figure 3-2 German Biodiesel Prices



The economics of biodiesel production in Germany was reported on in 2002 (IFO). A medium and a high price scenario were developed as part of this work. The results for the biodiesel production stage of the study are shown in the following table. These results are for a biodiesel plant integrated into an oilseed crushing operation. The net revenue of stand alone facilities is lower by about €50/tonne. Note that one tonne of biodiesel contains approximately 1,135 litres.

Table 3-2 German Biodiesel Production Costs

	Medium Price Scenario	High price Scenario
	€/tonne biodiesel	€/tonne
Revenue		
Biodiesel	579.2	723.99
Glycerine (920 €/tonne)	82.88	82.88
Fertilizer (102 €/tonne)	2.04	2.04
Sub Total	664.12	808.91
Costs		
Rapeseed Oil	511.29	613.55
Processing costs	68.00	68.00
Sub Total	579.29	681.55
Net Revenue	81.83	127.36

3.1.1 Price Barrier

Germany provides two examples of the importance of eliminating the price barrier. While a tax exemption for B100 has been in place since the early 1990's and some biodiesel has been sold since then, it was not until 1999 that the combination of increasing crude oil prices and an increase in the tax on petroleum diesel resulted in biodiesel being cost competitive with diesel fuel. Once this level had been reached then sales of biodiesel began to expand rapidly.

From Figure 3-2 it is apparent that as the price of petroleum diesel rose it was possible to increase the price difference at the pump between diesel fuel and biodiesel. This discount at the pump compensates for the lower volumetric energy content of the biodiesel and provides some incentive to consumers through a lower cost per mile driven.

This price competitiveness for biodiesel was only for B100 as low level blends still had to pay the full fuel tax until the beginning of 2004. With a tax exemption provided for low level blends starting in 2004, this market has expanded rapidly.

3.1.2 Inefficient Market Organization

The German diesel fuel market is approximately 3.3 billion litres per year. The 2004 biodiesel sales represent about 3.0% of the diesel fuel market.

Until 2004, the sales of B100 have been almost exclusively through the independent service stations and sales direct to users with their own storage tanks. The elimination of leaded gasoline in Germany in 1996 resulted in many stations having an additional storage tank that was no longer required. Many of the independent stations took advantage of this infrastructure and began to offer B100 in addition to petroleum diesel fuel. Biodiesel sales allowed the independent stations to differentiate themselves in the marketplace and to increase their margins in a very competitive market.

The major petroleum companies have only offered low level biodiesel blends since early 2004 when a tax exemption was introduced on blends. This will now open up a much larger market for biodiesel in Germany.

3.1.3 Finance Risk

Many of the German biodiesel plants are located in the former German Democratic Republic This is considered a structurally weak region. Therefore, companies looking to build plants in this region can receive reimbursement of between 25-40% of their construction costs from various EU and German programs. The support depends on the size of the company and the number of new positions created. The EU program may soon no longer be applicable to Germany because with the EU expansion the average EU wealth indicators have dropped and Germany may no longer be below average.

Many of the companies that have invested in biodiesel production were cash rich and looking for additional investments in the agricultural sector. Only a couple of new biodiesel companies went the venture capital route and one of those is now in the process of becoming a public company.

The combination of significant government capital support programs and the ease with which equity could be obtained reduced or eliminated the finance risk for most German biodiesel producers.

3.1.4 Business Risk

Many successful biodiesel production operations are now available as examples. Investors and lenders have many examples that can be followed now. This increases the level of comfort with the industry and reduces the risk levels.

3.1.5 Price Distortion

Biodiesel production and use provides documented environmental benefits that are not directly included in the price that consumers pay for their fuel. This is a classic example of the creation of a price distortion barrier. In Germany, it is not a significant market issue because the fuel tax incentives that are provided for biodiesel more than offsets the price distortion issue.

3.1.6 Regulations

Up until 2004, the structure of the tax regulations for petroleum fuels precluded the provision of a tax incentive for the use of other than B100. This had the practical impact of limiting the market to independent service stations and fleets with their own refuelling facilities. Since the beginning of 2004 when the tax exemption was expanded to include blended fuels, this has no longer been an issue and low level blends are now offered at a number of major brand service stations. These blends are limited to 5% biodiesel by the petroleum diesel fuel specification. Biodiesel blends above 5% are not allowed under the national fuel specification even though there has been considerable experience with B100 in the country. This regulatory barrier has not yet had a significant impact on market development but it has the potential to do so in the future should production capability exceed the demand for fuel.

3.1.7 Summary

There are several lessons that can be learned from the development of the biodiesel market in Germany. The first is that for large scale market penetration it was necessary to equalize the price of petroleum diesel and biodiesel. Early efforts to introduce biodiesel at higher prices than petroleum diesel limited market uptake but did help to show for the general public that the fuel was technically feasible in the German environment.

A large portion of the financing risk was offset by government programs that were available, not specifically for biodiesel but for any new business development in the less advantaged regions. This combined with the relatively profitable existing agricultural co-operatives greatly reduced the barrier of access to capital.

The very first biodiesel producer was a large existing oil mill with considerable technical expertise. They also developed their own esterification process and thus were comfortable with the manageability of the technical risk. Their received some funding from the EU for their first plant and thus their success was widely communicated as a requirement of the funding.

There were fuel marketers that were willing to offer a new fuel to consumers and once the tax exemption was in place and the crude oil price high enough that all players in the supply chain, the biodiesel producers, the fuel marketers and the customers could improve their financial position the market developed rapidly. This was done in spite of a regulatory environment that effectively eliminated low level biodiesel blends which probably have greater broad market appeal than B100.

The large number of biodiesel producers has provided significant opportunity for innovation in the manufacturing process and the learning that arises from multiple plants being built. This will provide a significant advantage should any or all of these companies move to expand their activities to other geographic areas.

All four of the primary barriers to creating a biodiesel market were addressed in Germany between about 1992 and 1998 when the market first started to take off. Some of the barriers were addressed by the government, some by the industrial participants with government support and some, such as rising oil prices, were fortuitous.

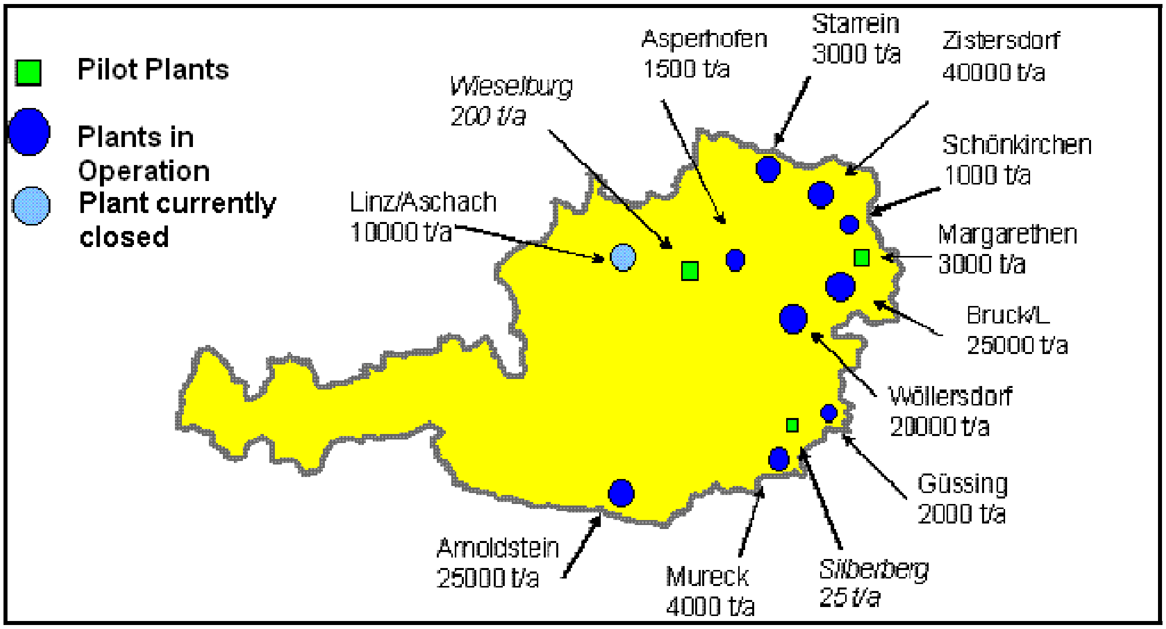
The secondary barrier of inefficient regulation has taken longer to address. It should be noted that this barrier has been used both against and by the biodiesel producers. Low level biodiesel blends were first non-competitive due to the tax regulations and are now limited to 5% by the petroleum diesel fuel regulation. The biodiesel specification in Germany has an Iodine number requirement that is effective in reducing competition for the rapeseed biodiesel producers in Germany from soy biodiesel producers in North and South America.

3.2 AUSTRIA

Biodiesel production in Austria commenced in 1988 with several small 500 tonne per year facilities built by agricultural co-operatives. In 1990, the first industrial scale facility was built is Linz/Aschach but that plant was eventually closed as it was not profitable. These plants pre-date the first German biodiesel plants. There are currently four large scale facilities and five small scale plants operating along with three pilot plants. The plants are shown in the following figure (European Commission, Austria).

The total production capacity is about 125,000 tonnes per year but production in 2003 amounted to only 55,000 tonnes, with 90% of that being exported from the country as the price which can be obtained for biodiesel in Italy and Germany is currently higher than that in Austria.

Figure 3-3 Austrian Biodiesel Plants

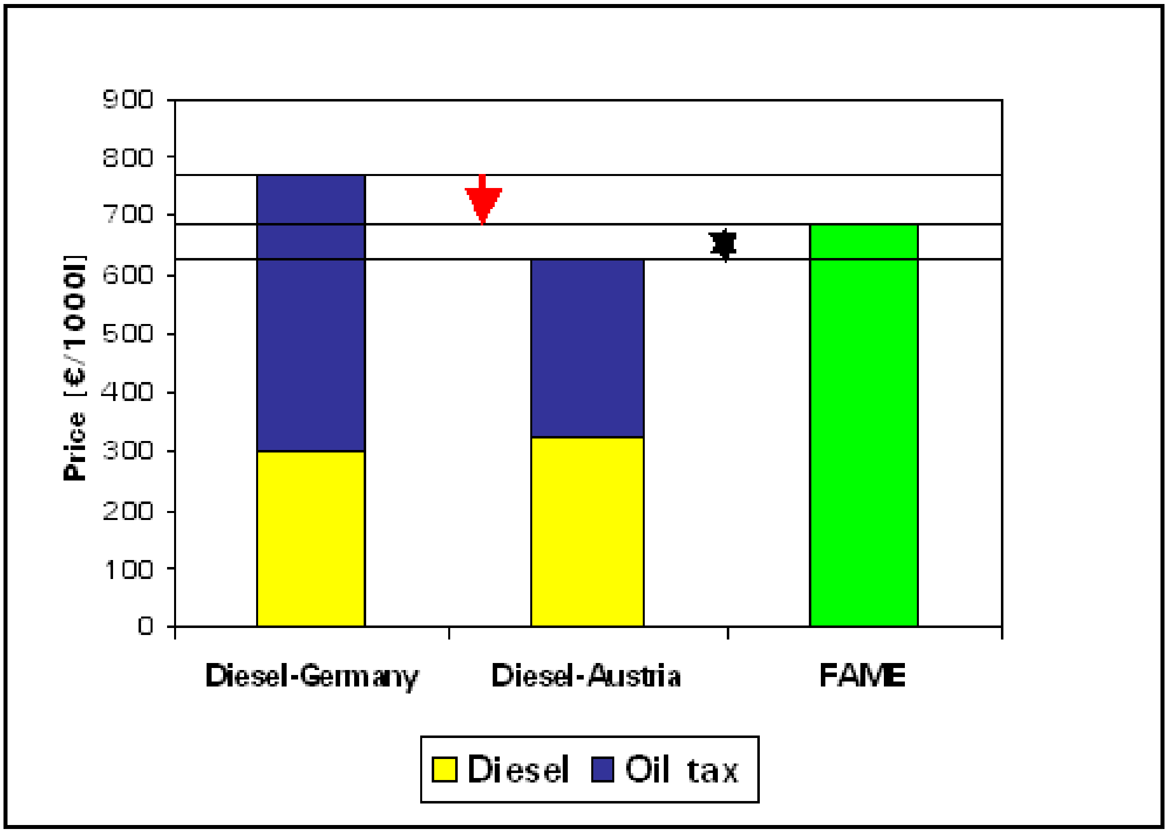


3.2.1 Price Barrier

A tax exemption was introduced in Austria in January 2000. This provided for a full exemption of the tax on biodiesel if it was blended at less than 2% or used as a neat fuel (B100). The fuel tax on diesel in Austria is 0.302 €/litre (50 cpl Can). This is about one third less than the tax incentive in Germany and thus Austrian biodiesel producers have been able to get a higher price for their production if the material is exported.

The higher selling price for biodiesel in Germany and the lack of barriers to the movement of product across the border means that the biodiesel selling price in Austria is set by the level of tax exemption in Germany and not the tax exemption in Austria. This essentially creates a condition where the use of biodiesel in Austria is not economic as a result of the tax and thus tax exemption in Austria being lower than in Germany. This is shown in the following figure (Boehme). The biodiesel prices allows the fuel to be sold at a discount in Germany but must be sold at a premium in Austria. This situation has impeded market development.

Figure 3-4 Comparison of Austrian and German Fuel taxes



3.2.2 Inefficient Market Organization

The Austrian market for diesel fuel is about 6.7 billion litres per year. The petroleum refining industry in Austria is dominated by OMV, the former national oil company. They have not incorporated any biodiesel into their fuel up until 2005. Biodiesel has been offered for sale by several small petroleum marketing companies in Austria but the combination of higher price and limited availability has limited the sales.

To overcome the market access barrier the Austrian government has moved to mandate biodiesel to comply with the EU biofuels directive. The proposal requires fuel suppliers to include biofuels in all of their products at the following levels:

- From October 1 2005. 2.5% - biofuels or other renewable fuels – based on the energy content,
- From October 1 2007. 4.3% - biofuels or other renewable fuels – based on the energy content,
- From October 1 2008. 5.75% - biofuels or other renewable fuels – based on the energy content.

OMV are now planning to incorporate 5% biodiesel into their fuel starting in October 2005. Initially the biodiesel will be mostly imported but three large plants are now under development to supply the market. Some of the feedstock will have to be imported so locating on the river for transportation is an important aspect of the production plans. The first plant is being developed by J.C. Neckermann together with Raiffeisenlandesbank Upper Austria (RLB OÖ) in the port of Enns. About 100,000 tonnes of biodiesel derived from rapeseed should be produced in the plant per year, start of production is expected for summer 2006. The biodiesel will be purchased by OMV who will add it to their fuels. The operating company will be Enns Biodiesel GmBH & Co KG. This company is owned by Neckermann (51%) and Invest Unternehmensbeteiligungs AG (49%). The production of 100,000 tons requires 80,000 to 90,000 hectare of rape acreage. At the moment, only 44,000 hectare exist in Austria, therefore feedstock imports will be required. Neckermann has already a production site for biodiesel in Halle/Saale (Germany), which is currently being started up.

3.2.3 Finance Risk

Two of the newest Austrian biodiesel plants, located in Arnoldstein and Zistersdorf, have obtained their equity from existing companies. The Biodiesel Kamten GmBh plant in Arnoldstein is 90% owned by a company in the rendering business and 10% owned by an independent petroleum marketer. Twenty one percent of the capital costs were covered by grants from the local government. The second new plant, Biodiesel Raffinerie GmBH in Zistersdorf is 93% owned by Donnau Wind KGE a company engaged in wind power. The remaining 7% is owned by the technology supplier (Donnau also has a 25% interest in the technology supplier). This plant also received financial support from the EU and the local government as well as an Austrian bank.

The biodiesel industry in Austria has been able to offset some of the finance risk through capital grants supplied by several levels of government, In several cases, Austrian banks have taken equity positions or supplied debt on favourable terms.

3.2.4 Business Risk

There are several biodiesel technology suppliers in Austria that have demonstrated their technologies around the world. The academic sector in Austria has also been heavily involved in developing technology for biodiesel production and some of the process developers have licensed technology initially developed at the universities.

Feedstock supply issues would appear to be critical in Austria with limited domestic oilseed production and a tax structure that is less attractive than neighbouring countries. As a result, many of the biodiesel producers are either agricultural co-operatives or are involved in the rendering industry and have access to feedstock through their other business operations. The new large biodiesel projects being developed to supply the mandated market are locating close to the Danube River to take advantage of lower cost water transportation.

3.2.5 Price Distortion

Price distortion is a potential barrier in all countries but the level of tax incentive available in Austria is higher than any likely calculation of the degree of distortion created by not including environmental externalities in the price of the fuel. It is therefore an important component of tax incentive justification but not a market barrier in it’s own right.

3.2.6 Regulations

The tax incentive regulations provided for tax incentives for very low level blends and B100 but not for the more moderate blends of B5 to B20. This has been a impediment to market development. The fuel quality specifications in Austria are similar to those of Germany and provided a quality barrier for the use of some vegetable oils.

3.2.7 Summary

The contrast in market development between Austria and Germany is interesting. In spite of the earlier imitation of development efforts in Austria, the market growth has lagged far behind Germany. It would appear that the factors that contributing to this include the presence of a dominant refiner and the resulting minor market share held by independent oil marketers, the difference in the tax structures between Germany and Austria encouraging the export of production rather than local consumption, and the structure of the tax regulations which allow only less than B2 or B100 to be marketed with a tax incentive.

The structure of the tax incentive in Austria compared to Germany foster a high degree of innovation in the Austrian biodiesel industry. A number of plants and process developers investigated and implemented multiple feedstock strategies. The alternative feedstocks included waste frying oils and tallow. These were generally available at lower cost but required more sophisticated processing systems. The industry responded to the challenge and several Austrian process suppliers have been successful in other areas of the world.

The problem of market access is now being addressed by the mandate taking effect in late 2005. The very rapid increase in demand will initially probably favour the importation of biodiesel made in other areas, as it will take some time for local production to be developed and local feedstock production to increase to meet the new demand. These imports may be higher priced and could result in increased pump prices.

3.3 FRANCE

France was the world leader in biodiesel production and marketing in the early 1990's. The development of the industry in France was quite different than in Germany or in Austria and can be characterized as tightly controlled. The government established quota's for production (that were largely met by established oilseed crushers) and several major oil companies introduced biodiesel blends in specific market areas. The market development was not generally subject to free market forces, with little growth allowed under the production quota system until 2005.

3.3.1 France

France has a quota system in place for biodiesel production. Up to 2002, 317,500 tonnes of biodiesel could be produced in five plants, one of which is in Germany (Ademe). The quota has been increased to 387,500 tonnes per year in 2003 and the amount produced in France was 310,000 tonnes in 2003. The capacity already exists for this higher production. The production and sales for the French plants are shown in the following table. All of the plants use rapeseed except Cognis, which uses sunflower oil. The plants are all fairly large with none of the small plants that are seen in Germany.

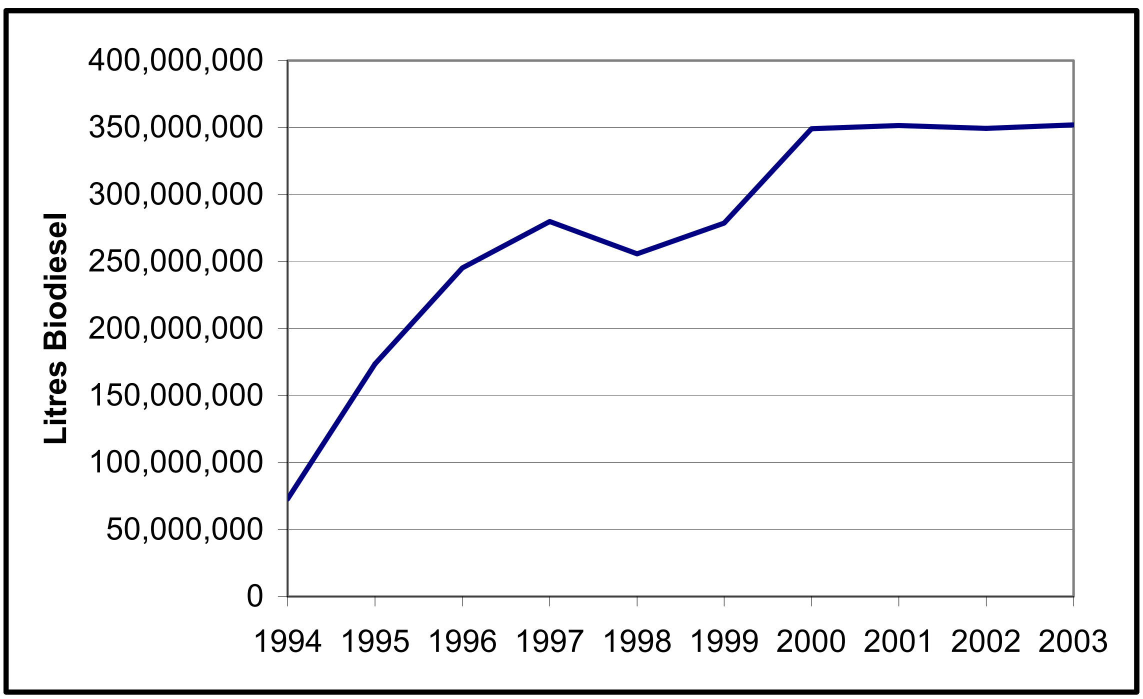
Table 3-3 Biodiesel in France 2001

Company	Place	Capacity	Allotted quota	Marketed
		Tonnes/year	Tonnes/year	Tonnes/year
Connemann	Germany	80,000	10,000	9,890
Novaol	Verdun	60,000	33,500	32,947
Diester/Robbe	Venette	60,500	60,500	56,008
Diester/Dico	Rouen	180,500	180,500	179,854
Diester/Cognis France	Boussens	60,000	33,000	32,001
Total		441,000	317,500	310,700

Diester has another facility under construction that will have the capacity to produce 160,000 tonnes per year when it opens in 2005. France has announced a plan to triple biodiesel production by 2007. The plan authorizes another four 200,000 tonne per year biodiesel plants.

The biodiesel is used in 5% in retail diesel fuel and some home heating oil and at 30% blends in some fleet applications. The French tax exemption is €0.37/litre (58 cpl Can). There is close co-operation between the biodiesel producers and parts of the oil industry in France so that the blends are sold in Shell and Total stations and not just the independent service stations. The biodiesel sales growth is shown in the following figure.

Figure 3-5 French Biodiesel Sales



3.3.2 Price Barrier

The French tax exemption is higher than Austria but lower than in Germany. The biodiesel production is all at large integrated oil mills and the French industry is probably mostly low cost producers. The high rates of utilization of the established quota's is probably indicative of the profitability of the biodiesel producers.

The quota system was the French government's way of ensuring that the tax exemption was for demonstration projects, which was the only way that low level blends could be incented under EU tax regulations up until 2004.

3.3.3 Inefficient Market Organization

Two of the major oil companies have been market leaders in the marketing of biodiesel in France. The fuel has been used in both low (B5 at retail) and mid (B30 to fleets) level blends since the tax support in France did not have restrictions because of its status as a demonstration program.

With the increase in French biodiesel production forecast over the next several years it will be interesting to see how the marketing of the fuel develops and whether new market participants such as the hyper-markets will become involved.

3.3.4 Finance Risk

The large established companies that have the production quotas would be able to finance the biodiesel production facilities internally so there was little finance risk involved in the development of the French industry.

3.3.5 Business Risk

The production companies all have significant technical capabilities and the production of biodiesel from vegetable oils would represent any significant technical challenge or risk for them.

3.3.6 Price Distortion

The level of tax incentive was obviously large enough to provide increased margin for all of the participants in the supply chain so the issue of price distortion was not an issue in France.

3.3.7 Regulations

Regulations do not appear to have influenced the French program. Blended fuels between 5 and 30% have been marketed in spite of a lack of specifications worldwide for B30 type fuels.

3.3.8 Summary

The French industry development is quite interesting. Unlike most countries, it has been lead by the large established market players in both the agricultural processing and fuel marketing sectors. This has resulted in fewer barriers than entrepreneurs typically face when they attempt to establish new industries.

There are economists who will argue that the economic benefits to society are not maximized when new industries develop in this manner but the reduced barriers also mean that less time and effort is expended on non-productive activities like lobbying and financing so that this sort of industry development is efficient.

3.4 ITALY

Italy has the third largest biodiesel production capacity in Europe. Like France, it has used a quota system with the historical quota being 125,000 tonnes, but this was increased to 300,000 tonnes for 2003 and then, due to budget constraints it was reduced to 200,000 tonnes for 2005. The industry took advantage of the higher quota and produced 273,000 tonnes in 2003. 70% of the feedstock for biodiesel production in Italy has been imported rapeseed oil from France and Germany. Domestic oil is used for only a small proportion of production and can vary from 10,000 to 60,000 tonnes per year with sunflower being the dominant domestic oil. The production capacity in Italy has been much larger than the quota have allowed as shown in the following table. There have been some additional smaller players enter the production sector in the past couple of years.

Table 3-4 Italian Biodiesel Capacity

Companies	Productive capacity	Assigned Quota ‘00-‘01 (t/year)
Novaol	125,000	47,500
Comlube	40,000	5,000
Defilu	35,000	3,000
Ital Bi-oil	80,000	3,500
Industrie Generali	closed	-
Estereco	20,000	3,500
Fox Petroli	70,000	36,000
Bakelite Italia	150,000	15,500
Sisas SpA	closed	10,000
Olmuhle Gmbh	-	1,000
Total	520,000	125,000

Most of the biodiesel in Italy is used for domestic heating uses rather than transportation fuels. This heating oil is taxed at approximately €0.54/litre (0.87cpl Can). The biodiesel is tax-free.

3.4.1 Price Barrier

The biodiesel price barrier in Italy has been addressed for heating oil with the tax exemption provided for the fuel. The tax incentive is higher than in the neighbouring country Austria so exports have not been a significant issue for the industry. The quota system of allocating production has encouraged a domestic processing industry based on imported feedstocks.

3.4.2 Inefficient Market Organization

The focus on the domestic heating oil market shifts the focus away from the highly competitive diesel fuel market. The high level of tax exemption would allow for some increased margin for all participants in the supply chain and thus encourages production, distribution and marketing as well as biodiesel use.

Interestingly several producers are players in the petroleum sector. Fox Petroli is an importer and distributor of petroleum products with their own terminals and truck distribution fleet. Comlube is a supplier of petroleum lubricants to the automotive sector and the metal working industry.

While the use of biodiesel as a transportation fuel is not the primary market in Italy many of the manufacturers and marketers have an association with racing cars using diesel engines powered by biodiesel. The high performance image that is associated with racing cars often appeals to early adopters and can be an effective means of establishing market entry.

3.4.3 Finance Risk

The Italian biodiesel producers have mostly been large companies that have some other involvement in the vegetable oil sector, the chemical products industry or the petroleum industry. These companies would have the capability of raising general corporate debt rather than relying on just project finance.

One of the challenges that the producers will have is the low level of plant utilization that is allowed under most of the quotas. The varying level of the quota from year to year will increase the risk of the business in the eyes of most lenders and thus increase the finance risk for new entrants to the business.

3.4.4 Business Risk

The involvement of large companies with technical resources lowers the level of business risk associated with biodiesel production. Business risk would not appear to be an issue in Italy.

3.4.5 Price Distortion

The tax incentive available for biodiesel use for heating oil is substantial and will be higher than the environmental costs associated with heating oil use. Price distortion is therefore not a major issue with biodiesel in Italy.

3.4.6 Regulations

The use of a quota system has been effective in France and Italy in attracting large companies to become producers. The quotas have the effect of guaranteeing a certain degree of market access and limiting the competition. In Italy, the varying aspect of the quotas with funding availability will not be attractive to producers and may also cause issues for marketers as it will impact the availability of product.

3.4.7 Summary

The Italian biodiesel sector has developed quite differently than in other European countries due to the tax incentive being available for heating oil rather than transportation use. The use of a quota system was a means of circumventing the EU rules on mineral oil taxation and exerting a high degree of control over the ultimate size of the market. The Italian quotas were much smaller than the French quotas and it has resulted in the quota being only a small portion of the production capacity. It may be that with the growth in biodiesel demand in the past year than the Italian producers are able to use this excess production capacity to export production to other countries.

3.5 UNITED KINGDOM

Biodiesel production and use in the UK has lagged that of some of the other EU countries with approximately 9,000 tonnes produced in 2003 and 2004 by BIP (Oldbury) Ltd. This situation is changing rapidly as several new biodiesel plants in the UK have recently started production.

The four large biodiesel producers in development are summarized in the following table.

Table 3-5 UK Biodiesel Producers

Company	Location	Capacity	Feedstock
Argent Energy	Motherwell, Scotland	50 million litres	Tallow
Biofuels Corporation plc	Seal Sands, Middlesbrough	284 million litres	Vegetable oils
Greenergy	Immingham	115 million litres	Vegetable oils
D1 Oils	Portable	9 million litres	Vegetable oils

3.5.1 Price Barrier

In its 2002 budget, the UK Government confirmed its support for biodiesel by announcing a new duty rate for biodiesel of 20p per litre (0.30 €/litre) below the rate for ordinary ULSD. This took effect on 26 July 2002 with the introduction the Biodiesel and Bioblend regulations 2002. The subsequent budgets have confirmed this level of support and the 2005 guaranteed that this support would stay in place until at least 2007-2008 fiscal year (UK Treasury).

This level of support is lower than Germany and some other countries. It is probably at the low end of the support required using five year average oil prices but it could be feasible with the current high oil prices.

3.5.2 Inefficient Market Organization

The early marketers of low level biodiesel blends have been dominated by the super market sector and the independents. As of the end of 2004, only 92 service stations were retailing biodiesel (Energy Institute). The large increase in biodiesel production scheduled for 2005 and 2006 will require a very significant increase in product availability or be exported.

Tesco, the supermarket chain has announce plans to sell biodiesel at 40% of it's stations in 2006. They have estimated that they could consume more than 20 million litres of biodiesel in a 5% blend. Biodiesel is also offered at the retail level by Sainsbury and Murco service stations. ConocoPhillips has expressed some interest in purchasing some biodiesel for blending as well.

3.5.3 Finance Risk

Biofuels Corporation and D1 Oils are new public companies that have raised their equity through initial public offerings on the stock markets. This is a very different departure from the typical practice of using government grants and existing company equity for most of the European biodiesel producers.

3.5.4 Business Risk

In their share offering prospectus Biofuels Corporation identified a number of risks to their operation. The risks are typical of those found in share offerings for processing industries. They include:

- Commodity price risk, the cost of raw materials and products may not move in the same direction,
- The plant when built may not operate as designed,
- Management may not have the expertise to respond to challenges facing the company,
- The environmental performance of the facility may not meet the local regulations,
- The company relies on third parties to fulfil their contractually agreements with the company and they may not be able to do so. This includes feedstock suppliers, technology providers and customers.

The companies establish programs and alliances to minimize these risks but it is generally more difficult for new inexperienced companies to address these issues than companies with experience in the field.

3.5.5 Price Distortion

While the tax incentive in the UK is lower than some other countries it is still probably higher than the level of price distortion caused by the external environmental costs associated with diesel fuel use and is therefore not a significant barrier to biodiesel production and use in the UK.

3.5.6 Regulations

The UK Government has conducted a feasibility study and consultative process to explore the prospects for a Renewable Transport Fuels Obligation (RTFO) as a possible mechanism to promote renewable fuels into the long term. It would be limited to the road transport sector, at least initially. An RTFO would place a legal obligation on specified transport fuel suppliers to supply a specified proportion of their road fuel supplies to their customers in the UK from renewable energy sources. The government held a series of stakeholder workshops to discuss how an RTFO might operate, and also commissioned two pieces of research on some of the detailed design aspects. The study is due to conclude shortly and Ministers will consider the findings in the context of developing the UK's revised Climate Change Programme, due for publication before the end of the year.

This would effectively create a mandated demand for biofuels in the UK. Not surprisingly, there was some opposition to the concept from the petroleum industry in the UK.

3.5.7 Summary

The UK market for biodiesel is at a relatively early stage of development. It would appear that the relatively low level of tax support is encouraging the development of large plants that are positioned to be able to import low cost feedstocks, to supplement the local supply, as well as to be able to access the higher return markets in Germany for the product produced.

The UK also appears to be well positioned to be able to access capital markets for both equity and debt. Of all of the European countries, it appears to be unique in this perspective.

The local market for biodiesel has been lead by the independent petroleum marketers as has been the case in many of the European countries with the exception of France. The development of large scale local markets may depend on the governments decision with respect to the proposed RTFO.

3.6 DENMARK

Denmark has one of the highest proportions of bioenergy in their total energy mix of all European countries with 5.1% of the total energy supplied by bioenergy versus and average of 3.2% for the EU-15 in 2001 (Eurostat). The bioenergy is generally not used in transportation applications and the government has indicated to the European Commission that it does not plan to implement the biofuels directive for transportation (European Commission, Denmark). The government continues to support R&D on biofuels but believes that other uses of bioenergy are more cost effective than producing and using biofuels.

In spite of this approach to biofuels development, there is one biodiesel producer in Denmark. Emmelev A/S starting producing biodiesel in 2002 and has increased production from 7,000 tonnes/year in the first year to 60,000 tonnes per year in 2004. The plant has a maximum capacity of 100,000 tonnes per year. The feedstock for this plant is rapeseed oil.

3.6.1 Price Barrier

Denmark has not traditionally provided a tax exemption for biofuels. As of Jan 1, 2005 the diesel fuel tax is 2.75 DKK/litre (55 cpl Can), which is composed of 0.243 DKK/litre (4.86 cpl Can) as a CO_2 tax and 2.507 DKK/litre (50.1 cpl Can) as an energy tax. The biodiesel is now to be exempt from the CO_2 tax, a change from the previous policy.

A biodiesel tax advantage of 4.86 cpl is not nearly enough to compensate for the increased production costs nor to compete with neighbouring jurisdictions and as a result the only use of biodiesel in the transportation sector in Denmark has been for demonstrations.

Biodiesel used for heating applications is exempt from taxes whereas heating oil is taxed at 2.10 DKK/litre (42 cpl Can). This level of tax exemption is closer to the differential product costs and some biodiesel is used in boiler applications.

The biodiesel production in Denmark is therefore mostly exported to Germany, Norway, the UK, Sweden and Iceland. The producing company has been able to rapidly expand their production by focussing on the export market.

3.6.2 Inefficient Market Organization

The lack of a significant tax exemption to eliminate the price barrier makes it difficult to introduce the fuel into the broader market. The government is considering using biofuels in vehicles serving a clearly defined area, and thereby requiring a lower incentive.

The government recognizes that the main disadvantage in the short term is that many otherwise suitable areas are already covered by agreements and contracts between transport operators and private companies, etc., so it is not easy to influence the choice of fuel.

One of the most suitable areas is public transport by bus, which accounts for at least 2% of the total fuel consumption for transport. Here, fossil diesel can probably be mixed with more than 5% biodiesel (RME) in many cases, without technical problems or the associated costs of modifying engines. Moreover, new buses, which will probably be no more expensive to purchase, will be able to run on mixtures containing a large proportion of biodiesel, providing a route for phasing in biodiesel. Local buses in particular areas of several other EU countries run on diesel mixed with e.g. 30% biodiesel, or entirely on biodiesel. Other biofuels are used in like manner, in high concentrations.

Other areas being considered include the Danish state Railways, The Greater Copenhagen Authority, taxis and the military.

3.6.3 Finance Risk

The one biodiesel producer in Denmark appears to have reinvested the proceeds from one part of the company into biodiesel production. There is no indication that capital incentives from any level of government were involved.

3.6.4 Business Risk

Emmelev has been in business since 1838 (Simonsen). It started as a small grain milling operation and has grown to be come a significant oilseed crusher and biodiesel producer. Sales in 2004 reached 52 million €. The company appears to be owned by the same family that started the business 175 years ago.

Over the years, major changes have occurred in Danish farming, and the family adapted the company to the changes. By 1960 feed products had become the largest component of the business but in the 1990’s that industry consolidated into just a few major players and that portion of the company was sold in 2000. In 1992, the company invested in an oil mill and in 2001, the investment in biodiesel production was made to complement the oil mill.

3.6.5 Price Distortion

The small CO_2 tax and biofuel tax exemption in Denmark is an attempt to remove price distortion from the pricing of fuels. It amounts to about $15/tonne (Can) of carbon dioxide. This is not an unreasonable level, although European prices for carbon dioxide tax credits have been trading around 20 €/tonne in mid 2005.

The reduction of exhaust emissions resulting from biodiesel use is not considered in the tax regime and thus some degree of price distortion still exists.

3.6.6 Regulations

Regulations have had little impact on biodiesel production in Denmark since most of the production is being exported.

3.6.7 Summary

The biodiesel industry in Denmark is a very interesting case. It is export focussed since the Danish tax exemption is not competitive with those in neighbouring jurisdictions. It appears to be family owned and have been privately financed with little or no assistance from governments yet production has expanded rapidly over the past three years. This example is quite different than the examples found in other European countries.

4. MARKET DEVELOPMENT LESSONS LEARNED

From the review of market developments in the six countries considered, there are some common lessons that can be learned and are of potential interest to stakeholders in other counties considering biodiesel market development. These are discussed below in relation to the market barriers identified. It is interesting that in most cases, there is a great deal in common between the countries but there is one case where the situation is quite different. The exception is not always the same country.

4.1 PRICE BARRIER

The price barrier must be addressed for biodiesel consumption to be encouraged in a producing country. In Denmark, where there is no local tax incentive, biodiesel production has only been facilitated by the presence of the large German market in close proximity and the lack of trade barriers that would restrict the access to the market.

What is also apparent is that the price barrier needs to be addressed in a uniform manner in all countries that could be considered a supply orbit. The challenges that have faced biodiesel marketers in Austria, where the national tax incentive is not enough to equalize the biodiesel and petroleum diesel selling price because the selling price is set by the German tax incentive, is a example of this.

It is possible that the same situation may develop in the UK, where the producers are looking to the German market for a portion of their production.

France and Italy have used a quota system to allocate access to the tax incentive and this has encouraged local production to satisfy the local demand. In both cases, some of the quota has been allocated to producers outside of the country but that the majority of the quota is used for domestic producers.

4.2 INEFFICIENT MARKET ORGANIZATION

In all of the countries except France, the market development has been lead by the independent marketers and refiners rather than the major integrated oil companies. In Germany, after many years of development, the majors are now marketing biodiesel blends but without the independents, the market would never have developed to the point that it has. The independents have a relatively small share of most national markets but it is obvious that they are the key to developing alternative fuels markets in most countries.

France is an interesting situation as the major oil companies, Total and Shell, were early adopters of biodiesel blends. The independent marketers in France have not been significant biodiesel marketers. It may be that the situation will change in the next few years as the availability of biodiesel will expand with the increase in the production quotas recently announced.

4.3 FINANCE RISK

Government grants and internal funds from existing company operations have been the source of capital in most of the countries building biodiesel plants. In most countries, the early plants have been part of existing large companies that have expanded their existing oilseed or chemical processing operations to include biodiesel production. It has only been later that standalone facilities have been built once the perceived finance and business risk has been better understood.

The situation in the UK has been different, with a couple of biodiesel companies accessing the public markets for equity capital. These companies have also been able to access senior project debt to complete their capital needs. This makes the UK situation unique even compared to the biofuels industry in North America.

4.4 Business Risk

The European biodiesel industry has had relatively few business failures in the past 15 years. This is quite remarkable given the relatively low capacity operating rates that many companies experienced when the production capacity and the markets were expanding rapidly. This is quite different from the situation in the United States with the ethanol industry where there were many failures among the 1980’s ethanol plants.

It is possible that the low rate of business failures is a function of the plants being well-designed and built, and low levels of financial leverage. The fact that in many countries the first biodiesel plants were additions to existing processing operations was probably beneficial. The exceptions in terms of business failures include some early Austrian plants were the market did not develop and a recent German plant where the developer had renewable energy experience but not biofuels and the facility was leveraged.

4.5 Price Distortion

Price distortion was identified as a secondary barrier and as expected, in those countries where there has been a tax incentive the issue of price distortion has not been a significant issue. That is not to say that lower emissions are not important but rather that most governments have made the decision to provide tax incentives based on a broad range of issues. The tax incentive available in Denmark for transportation fuels is based solely on GHG emission benefit and it is not sufficient to equalize the price of biodiesel and petroleum diesel, especially with the large German market offering attractive selling prices.

4.6 Regulations

Regulatory issues were also identified as a secondary barrier. There are certainly examples where regulations have slowed the market development, such as the early German tax incentive only being for B100 and not B5 and the major oil companies wanting to use the fuel in low level blends.

Italy and France have used regulations to shape the structures of their domestic industries. The industries in these two countries have developed quite differently than in those counties that have taken a more open market approach to development. The key factor is that both the regulated approach and the more free market approach have lead to significant industries in the different countries.

5. Application of Lessons Learned to North America

5.1 United States

5.2 Canada

6. SUMMARY AND CONCLUSIONS

7. References

Boehme. 2005. Biofuels. Implementation of the Biofuels Directive 2003/30/EG in Austria. 5th Global Forum on Sustainable Energy, Vienna, May 2005. http://www.gfse.at/publ/ppt/20050512/wg1_boehme.ppt

Energy Institute. 2005. Media Release. http://www.energyinst.org.uk/content/files/mr56.pdf

EU Observer. 2005. Biofuels Barometer. http://www.energies-renouvelables.org/observ-er/stat_baro/eufores/baro167b.pdf

European Biodiesel Board. 2005. Statistics. http://www.ebb-eu.org/stats.php

European Commission. 2004. Austria. Biofuels in the Transport Sector in Austria in 2004. http://europa.eu.int/comm/energy/res/legislation/doc/biofuels/member_states/2003_30_at_report_en.pdf

European Commission. 2004. Denmark. Statement on the Implementation of the EU Biofuels Directive. http://europa.eu.int/comm/energy/res/legislation/doc/biofuels/member_states/2003_30_da_report_en.pdf

IEA, 1995. Enhancing the Market Deployment of Energy Technology A Survey of Eight Technologies, http://library.iea.org/dbtw-wpd/textbase/npold/npold_pdf/enhance_10.HTM

IEA, 2000. Experience Curves for Energy Technology Policy, http://www.iea.org/books/studies/2000/curve2000.pdf

IEA, 2003. Creating Markets for Energy Technology, http://library.iea.org/dbtw-wpd/Textbase/nppdf/stud/02/creatingmarkets.pdf

IFO. 2002. Macroeconomic Evaluation of Rape Cultivation for Biodiesel production in Germany. March 2002.

IWR. 2005. Biodiesel Production in Germany. http://www.iwr.de/

Simonsen, M. 2005. Baltic Biorefinery Symposium. May 2005. http://websrv5.sdu.dk/bio/BBS/Pres/Morten%20Simonsen.pdf

UK Treasury. 2005. 2005 Budget Papers, Protecting the Environment. http://www.hm-treasury.gov.uk/media/AA7/59/bud05_chap07_171.pdf