Kansas State University

Bio-trade & Bioenergy Success Stories

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1. Introduction

Growing demand for energy, rising prices and concerns over supply of fossil fuels, and an increasing concern over global warming has led to increasing use of energy from renewable biomass. However, not all sectors in all regions showed the same progress in biomass development. Some regions were particularly successful, others were not. It is of particular interest to determine "what are the factors that made some product-markets more successful than others".

In this paper three case studies of successful product-markets are examined: Austria - wood pellets; Canada – wood pellet production and export & BioOil development; United States – ethanol production. The paper reviews historic backgrounds and pre-conditions in these countries encompassing biomass supply and demand, economic situation, policy and regulatory framework, and state of technology. Subsequently, the political, economical, social and technological changes that led to development are analysed, and the phase of market maturity is examined. The paper concludes by summarizing lessons that can be learned and conclusions that can be drawn from these cases.

2. Austrian Success Story- Wood Pellets

2.1. Introduction

The use of wood pellets in Austria as fuel for domestic stoves and boilers has been an amazing success story over the last ten years. In this period the production capacity of wood pellets continuously expanded. However, in 2006 exorbitant market growth caused pellet supply problems and a subsequent collapse of market confidence. This report gives insights into the development of the Austrian pellet market from 1984 through the growth period to the market of today.

2.2. Starting point, Pre-conditions: A brief historical review

2.2.1. Supply

Austria is a densely wooded country. According to the Austrian forest inventory (1986/90) 3.9 million ha, nearly 50 percent of Austria, is forest. Commercial forestry takes place in a high proportion of this area (86% or 3.3 million ha). As a result, the Austrian forest and wood industries is well developed. Due to the large role of the Austrian wood processing industry, Austria is a major importer of round wood (and exporter of wood products).

On the supply side there are two groups: the sawmill industry and manufacturers of biomass boilers. First attempts with pellets in Austria were made in 1984, when a company from Styria started to produce pellets from bark[1]. This company's aim was to sell pellets as a fuel for wood boilers that were especially produced for this purpose. The targeted markets were urban regions that were not connected to the district heating system. This project was stopped due to technological problems.

However, the sawmill industry was faced with a situation of sawmill residue supply exceeding demand, and therefore the value of sawmill residues was constantly decreasing. In 1986-90 prices for sawdust fell by more than 50%, and prices for wood chips fell by 20% to

[1] Haas J. et al. 1998

remain at a low level.[2] Because of falling prices the sawmill industry looked for new channels of sale for residues. Besides using residues as material for animal bedding (e.g. kitty litter) and material for binding oil, the production of wood pellets was considered as an interesting opportunity. At the same time, some Austrian producers of biomass boilers started to gain experience with pellets in the US market where the use of pellets for heating had started earlier. The Austrian company Rika introduced pellet stoves into Europe in 1989 and the US market in 1991, and sold more than 3000 stoves overseas in that year.[3]

2.2.2. Demand

Most (56%) of commercially used forests are owned by small scale (<200ha) owners, most of them farmers. Because of this division in the property of forests there a lot of households that have access to fuel wood. Therefore, and because of the good availability of woody biomass, Austria has a long tradition in heating with biomass. In 1988 about 21% of all dwellings were heated with biomass. Figure 1 shows the development of the number of dwellings with biomass heating in Austria.

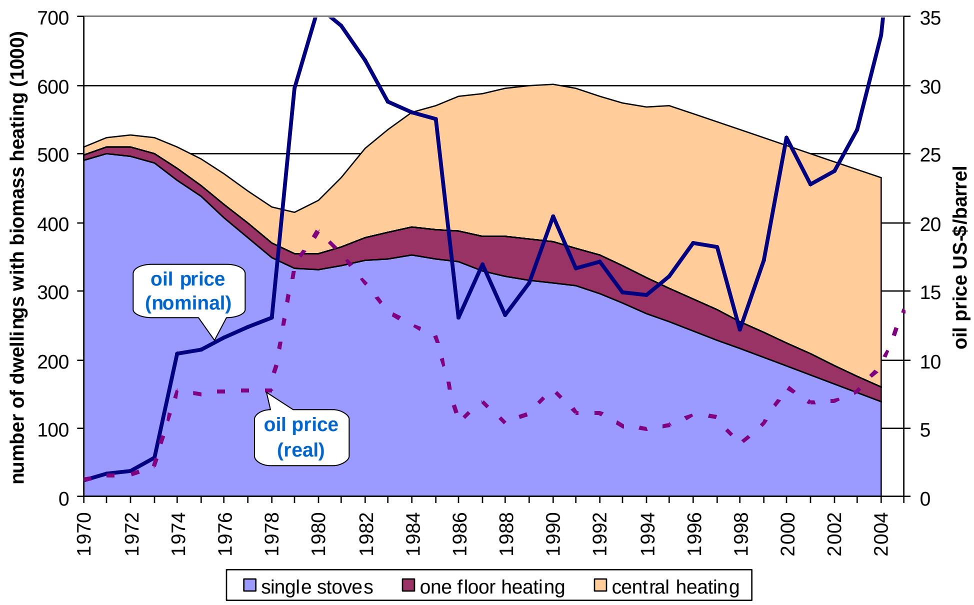

Fig. 1 - Development of the number of dwellings with biomass heating in Austria from 1970 to 2004; Source: Statistik Austria

As shown in Figure 1, from 1970 onward single stoves were increasingly substituted with central heating systems. After a phase of a decrease in the overall number of dwellings with biomass heating from 1972 to 1978 there was a strong increase in the number of dwellings with central heating, especially after the second oil crisis in 1979/80. Afterwards, when oil prices were falling again, the number of dwellings heated by biomass decreased significantly from the beginning of the 1990's. There was a trend to automated, easy-to-use and comfortable oil, gas and district heating.

2.2.3. Economic conditions

[2] Association of the Austrian Wood Industries 2008
[3] Haas J. et al. 1998;

After World War II, the forest and wood sector was a very important factor in the Austrian economy. In the 1960's there were more than 4000 sawmills in Austria. With a significant rise in the productivity of sawmills there was a phase of consolidation in the forest and wood industry. The number of sawmills was reduced to 1831 in 1993[4]. At the same time, the relative share of the forest sector on the overall economy substantially decreased in the last few decades and the number of persons employed in this sector has constantly decreased because of the increase of productivity.

The phase of consolidation and market concentration was accompanied with a decrease of prices for wood products. As shown in Figure 2 the price of wood residues decreased by more than 40% in the period 1986 to 1996. Low prices were one of the main reasons for sawmill industry to actively look for other markets for their residues. In the period after the first and the second oil crises, and before the break-through of pellets in Austria in 1996, the oil price has more or less stabilised at a relatively low level (see Figure 1). Thus we can conclude that the oil price had a low influence on the development of the pellets sector in this period.

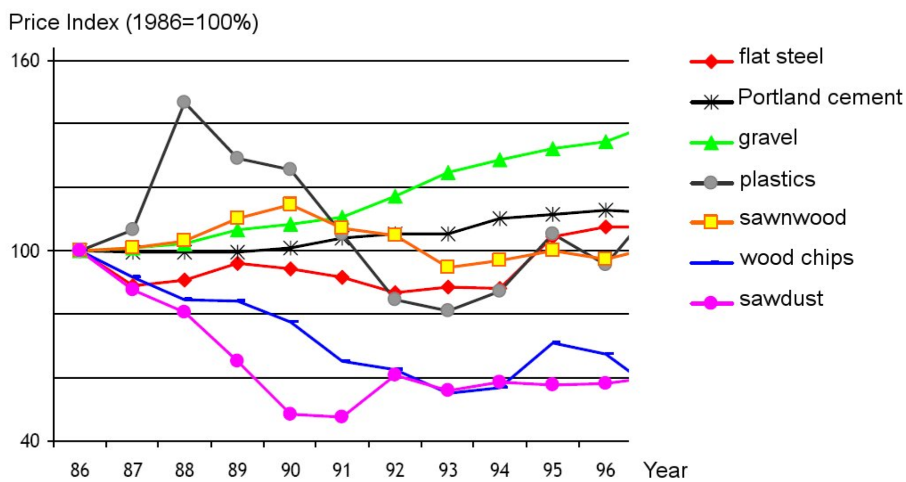

Fig. 2 - Development of price indices of different commodities in Austria; Source: Association of the Austrian Wood Industries, Statistik Austria

2.2.4. Policy and regulatory framework

Since the beginning of the 80's (after the second oil crisis) the Austrian government forced the use of bioenergy mainly to reduce the dependence of imports of coal and oil. There were a variety of measures to facilitate the marketing of renewable energy sources both at the federal and the provincial level, ranging from fiscal measures and subsidies to emission standards. The main promotion instruments for biomass heating systems were determined by the provincial governments in the nine provinces.

One of the most important instruments for promoting the use of renewable energy in Austria has been subsidies. For housing there are different forms of supply-side subsidisation (public subsidised loans, grants towards construction cost and interest or annuity subsidies) for

[4] Schwarzbauer P. 1998

biomass heating in all provinces. There have also been subsidy programmes for district heating and the use of biomass energy in business and industry.

2.2.5. State of biomass technology

Despite all measures to promote the use of biomass for heating, the percentage of dwellings with biomass heating was steadily declining. While the percentage of dwellings with biomass heating was 21% in 1988, this percentage fell to 19% in 1994. The energy carrier that showed the highest growth rates in this period was natural gas (from 17% to 28%). The percentage of dwellings with oil heating increased from 25% to 27%. In the same time the percentage of dwellings with coal heating declined from 19% to 9% and the percentage of dwellings with electric heating fell from 9% to 8%. In addition the percentage of dwellings with district heating grew from 7% to 10%.[5]

So the biomass boiler industry was facing a difficult situation in a highly competitive market. Low prices for fossil fuels and the trend to clean, comfortable and automated heating technologies forced the biomass boiler industry to further develop their products. Figure 3 shows the development of the efficiency and the emissions of biomass boilers. Due to a strong effort in technology development, the efficiency of biomass boilers significantly increased from an average of 55% in the beginning of the 80's to about 85% in the middle of the 90's. In the same time period the emissions of carbon monoxide was strongly reduced.

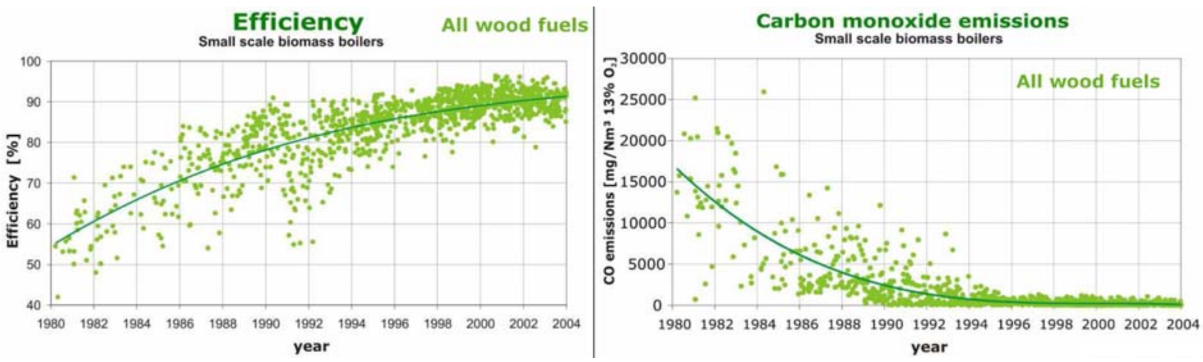

Fig. 3 - Development of the efficiency and carbon monoxide emissions of small scale biomass boilers in Austria; Source: Haslinger et al. 2008

Another biomass technology that developed strongly in that time was wood chip boilers in small scale rural district heating systems. According to Haas et al. 1998 this technology can be seen as the parent technology to pellet boilers for central heating. At the beginning this technology faced problems with system reliability and stability as well as high investment costs. One reason was a lack of quality standards for the design and operation of district heating systems as well as the fuel quality.

2.3. Period of change: what made things happen

2.3.1. Stakeholder behaviour - Supply side

[5] Haas J. et al. 1998; Statistik Austria

According to a report[6] of the Austrian Energy Agency, it was a report on TV that was the trigger for the production of pellets in Austria. Umdasch, an Austrian company and important producer of plywood, had produced wood briquettes since 1980. In 1994 Rudolf Huber, the company's sales manager for biomass for heating was watching a report about Rika and their export of more than 10.000 pellet stoves to the US market. With the hope and expectation for new channels of distribution, Umdasch decided to test the Austrian heating market in close collaboration with Rika. For this reason they started to import pellets from Sweden and the US in the very same year. After this phase of evaluation Umdasch was encouraged to produce pellets on its own.

The production of pellets started slowly with an estimated volume of 5,000 tons in 1995. As demand for pellets increased, the volume of pellets produced and the number of pellet producers rose annually. Whereas in 1998 there were 7 companies producing pellets, in 2000 there were already 12 production facilities.[7] According to the Market Actor Database on the pellets@las homepage, there are 30 pellet manufacturers in Austria at the moment. Figure 4 shows development of pellet production and production capacity. With and average growth rate of 45%, the market is truly a booming market.

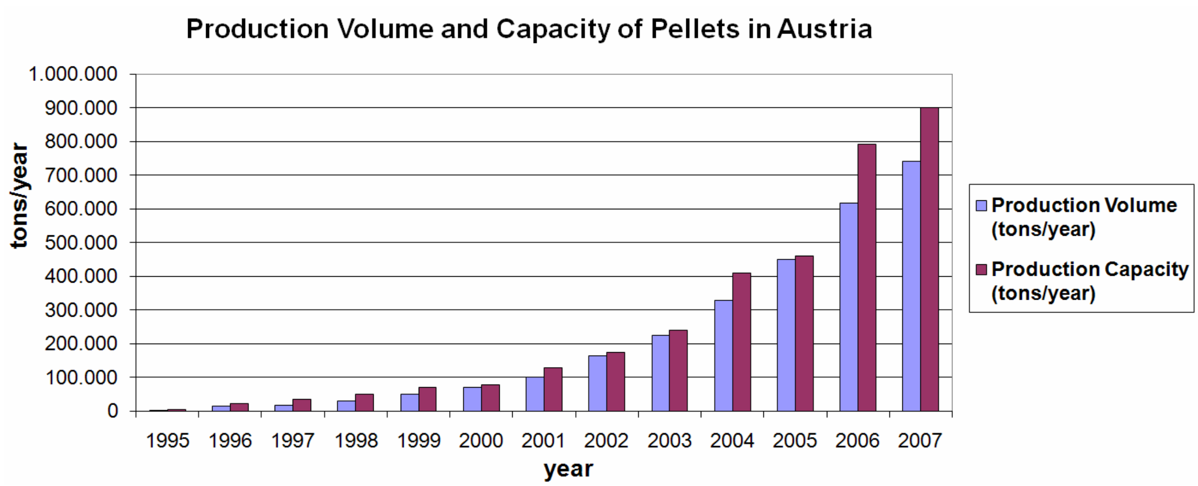

Fig. 4 - Development of Production Volume and Production Capacity of Pellets in Austria; Source: Pellets@las, Geißlhofer et al. 2000, EEG

In the beginning pellets were distributed over the existing distribution networks for briquettes. Having long experience with the distribution of briquettes helped to address the problem of long delayed times of delivery when after a cold winter in 1997 a lot of people wanted to refill their stocks at the same time. The volume of pellet production exceeded the domestic demand by far. So, soon significant cross-border trade with pellets, especially to Italy and Germany developed (see Figure 5).

[6] Nemestothy K. 2006

[7] Haas J. et al. 1998; Geißlhofer A. at al. 2000

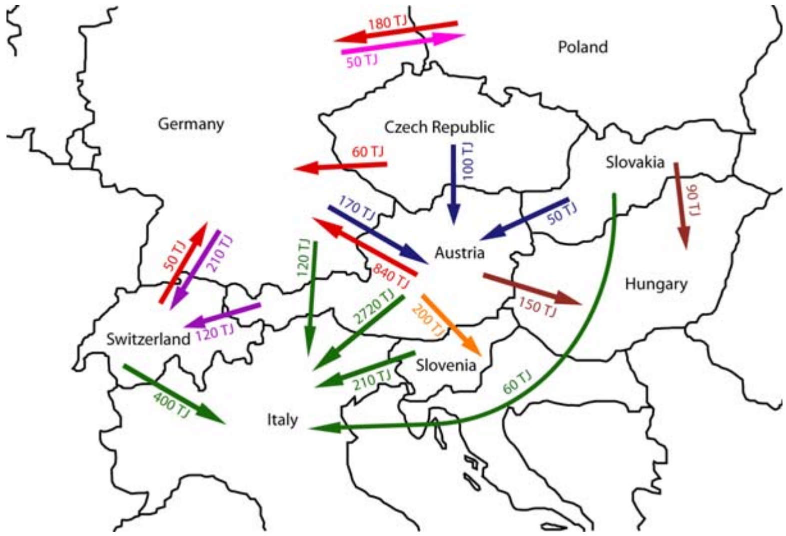

Fig. 5 - Cross-border trade with pellets in Central Europe, 2005; Source: Eurostat, MPO, CZSO, EEG[8]

Things went well for pellet producers for a long time. Production capacity expanded continuously and overall sales volume increased, supported by exports. However, strong consumer demand for pellet stoves and thus pellets, combined with shortage in wood supply led to a pellet shortage and a dramatic rise in pellet prices, from an average 160€/t in 2005 to 265€/t in 2006. On the consumer side there was a huge loss of confidence in the pellets market. The rise in pellet prices caused major damage to the image of the entire pellet industry. Manufacturers of pellet boilers were faced with a drastic drop in sales of pellet boilers (see Figure 7) and have only now recovered. The pellets industry tried to generate confidence by a further expanding production capacity and by building up higher storage capacity, but it still has to deal with this problem.

2.3.2. Stakeholder behaviour - Demand side

In Austria, the use of wood pellets is strongly focused on small scale heating systems. Pellets produced by Umdasch in 1994 they were mainly fired in stoves. Stoves were sold in specialist shops that dealt with only a single line of stoves. In contrast to other countries, the use in medium and large scale applications is very restricted. What are the reasons for this development?

In general, the following reasons can be regarded as main drivers for pellet utilization (in comparison to other forms of biofuels):

1) Higher energy density and thus lower transport costs compared to wood chips
2) Applicability for (co-) firing in (former) coal power plants
3) Higher comfort as heating fuel in small scale applications compared to other solid fuels

Looking at the Austrian situation, we can see the following:

The first of these aspects up to now had no major relevance in Austria because transport distances are in general moderate. The country is small and the major applications are

[8] There are several methodological problems and data uncertainties with respect to the international trade with pellets. This figure is based on several assumptions which are documented e.g. in Haas R. et al. 2008.

situated in rural areas near to biomass supply. This might change with an increasing number of bioenergy systems in urban locations.

Also the second aspect has no high relevance for Austria. The number of coal power plants is relatively low due to the availability of hydro power and the lack of domestic coal resources. Up to now, no coal power plant has been rebuilt for biomass fuels and no co-firing plant exists.

In Austria the number of wood heating systems in rural areas is traditionally high. This led to the third aspect, higher comfort for small scale heating systems, having the highest relevance for the use of wood pellets in Austria up to now.

Against the background of rising prices for fossil fuels from 1998 onwards, the demand for pellets grew steadily (see Figure 6).

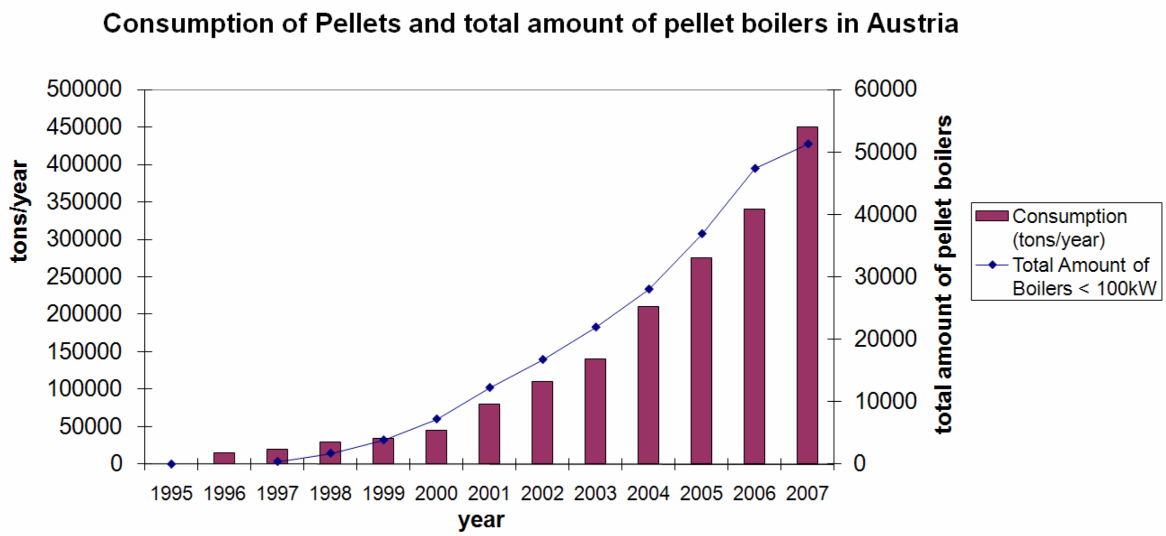

Fig. 6 - Development of the consumption of pellets and the total amount of pellet boilers in Austria; Source: Pellets@las, Geißlhofer et al. 2000, EEG

While the number of sales of small-scale biomass boilers fired with log wood or wood chips remained static 1990-07, sales of pellet boilers rose considerably (see Figure 7).

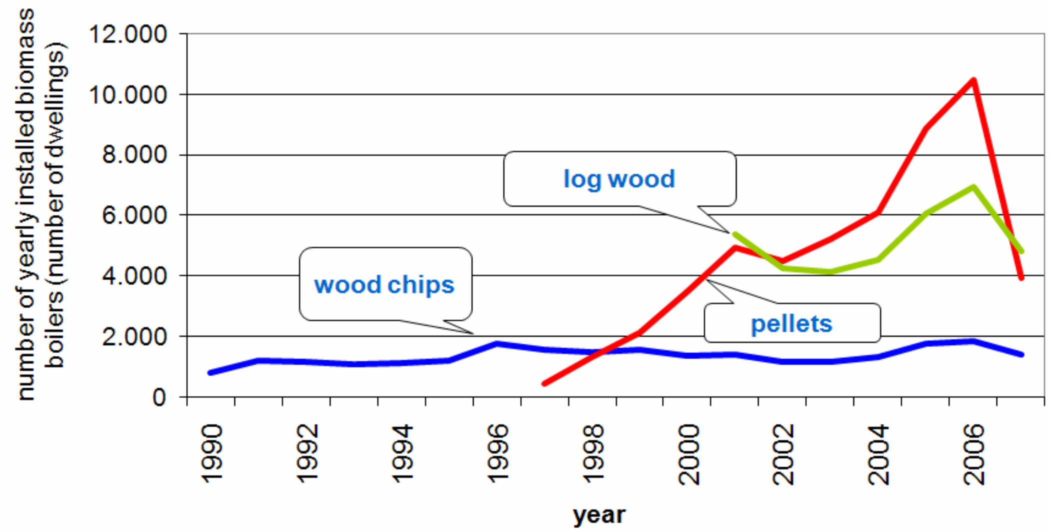

Fig. 7 - Development of the number of yearly installed biomass boilers in Austria; Source: NÖ LWK, EEG

After years of rapid growth the Austrian pellet boiler market peaked in 2006. In 2007 there was a collapse in pellet boiler sales, with 10,500 pellet boilers sold in 2006 compared to only 4,000 in 2007 (see Figure 7). What has happened in the pellet market in 2006 and 2007? What was the reason for this dramatic collapse in the pellet boiler sales? It was not a single incident but the combined impact of many circumstances. As shown in Figure 7 there was an enormous increase in the number of new pellet boilers until 2006. Demand for pellets grew steadily along with production capacity. A very long and snowy winter in 2005/06 caused shortages in the supply of round wood to saw mills by 20-30%, and with it shortages in the supply of sawmill residues. These shortages could not be compensated for by imports because neighbouring countries had to face a similar situation. There was a great demand for pellets in other countries, especially in Italy and the Netherlands. So, the market faced an increase in demand (domestic and abroad) and a decrease in supply. Some pellet producers saw the chance of a short-term economic profit, exacerbating the situation.
This led to a rise of pellet prices in Austria in 2005 and resulted into exorbitant increases in 2006. Pellet prices in November 2006 were at an average of € 265 per ton. All customers could be supplied, but had to accept partial shipments and considerable waiting times in many cases.

In the same time a report on the environmental impacts of burning wood pellets was published. One result of this report was that burning pellets caused high emissions of particulate matter. Although that was true for the first generation pellet boilers this is totally unfounded in reference to modern pellet boilers. Nevertheless there was a broad discussion about the emissions of particulate matter in connection with pellet boilers that again resulted in negative headlines.

On the demand side there was an enormous loss of confidence in the pellets market. This led to the dramatic collapse in the pellet boiler sales in 2007 described above. Now consumers are very cautious and the market for pellet boilers is still recovering.

2.3.3. Economic conditions

As shown in Figure 1 the prices of oil were at a relatively low level during the development and introduction phase of pellets in Austria. For this reason, the price of oil is not generally regarded as the trigger for the break-through of pellets in late 1990s. Later of course the rise of energy prices from 1998 onwards supported and accelerated the growing demand for pellets.

From 2001 to 2005 saw dust nearly doubled in price because of severe competition of pellet producers and the pulp and panel industries for the same raw material. However, the pellet market was in oversupply of pellets resulting in a continuous fall of pellet prices in that period, due to technological learning and due to economies of scale.

When there was a long and extremely snowy winter in 2005/2006 this situation suddenly started to change (see Figure 8). Because of the long winter the heating period was long too and therefore there was a great ongoing demand for pellets. At the same time removals of round wood decreased by 20-30% because of the extreme amount of snow and so there was a shortage of round wood. Given this situation of supply and demand the price of pellets went up dramatically to 265€/t (see Figure 8).

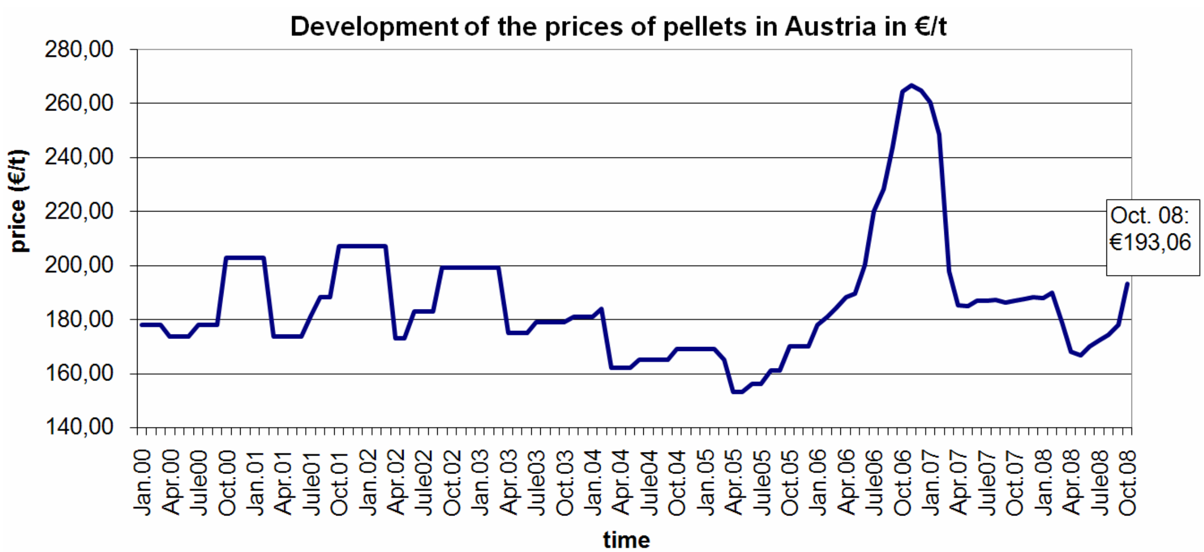

Fig. 8 - Development of prices of wood pellets in Austria in €/ton, based on an ordered quantity of 6 tons, VAT of 10% and transport included; Source: proPellets Austria

The windstorm Kyrill that affected Western Europe in January 2007 caused widespread forest damage through wind throw and as a result there was plenty of round wood. At this time, pellets prices fell to a lower level of 190€/t. Similarly, windstorms Paula and Emma in 2008 caused prices for pellets to go down again to approximately 174€/t.

2.3.4. Political and environmental issues

Austria has been very successful in recent years in developing sustainable energy technologies like solar water heating and biomass heating technologies. One reason for this is the promotion of the use of renewable energy with subsidies. The following figure (Figure 9) shows the development of investment grants for small-scale biomass boilers.

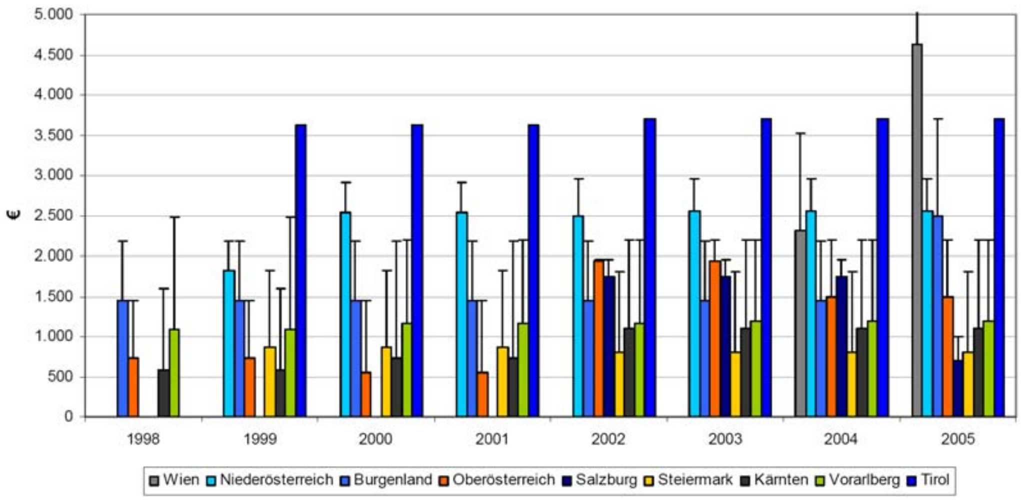

Fig. 9 - Development of investment grants for small-scale biomass boilers in the Austrian provinces; Source: EEG

Whereas in 1998 there were only investment grants in Burgenland, Oberösterreich, Kärnten and Vorarlberg, the situation has changed for the better in the following years. Since 2004 investment grants for biomass boilers have been implemented in all nine provinces and investment grants have increased steadily. The impact of these measures was the acceleration of substitution of old and inefficient single stoves and boilers with modern low-emission systems. As a result world-class technologies have been developed in Austria that have turned into exporting industries.

With regard to energy R&D funding in Austria, there have been improvements and Austria has slightly increased its funding in recent years. In 2002 the goals of Austria's R&D policy were laid down in the "Austrian Energy Research and Energy Technology Concept" document. The main objectives of this document were to promote sustainable development, to boost existing strength, to engage in European energy R&D activities and to focus on results-oriented programmes. A strategy process called "e2050" was launched in 2005 with the aim to develop a long-term strategy for Austrian research on energy technologies. Based on this strategy the government has developed different programmes for the energy sector to support R&D in renewable energy and energy efficiency and for market demonstration and deployment. The programme "Energy for the Future" was created in 2007 with a budget of 20 million Euros with the aim to support high-quality technology R&D projects.

In Austria restrictive regulations for the emissions of heating systems have been adopted. Although it was hard for the industry to meet the demands this was an important driver for the competitiveness of the Austrian biomass boiler industry.

2.3.5. Technological progress

One reason for the rapid growth of the pellets market was the ability of stove and boiler manufacturers to develop reliable systems that were also easy to use. As explained above the efficiency of existing small scale biomass boilers has been at a high level and carbon monoxide emissions have been quite low since the mid 1990's. Wood chip boilers were a well-developed and mature technology, and based on this technology automated pellet boilers were developed. Consequently pellet boilers for central heating could compete with boilers for oil and natural gas. Today a broad variety of combustion systems are available and advanced technologies are ensuring low emissions, high efficiency, high reliability and a high degree of comfort.

The introduction of quality standards for pellets with the ÖNORM M 7135 ("Pellets and briquettes – requirements and test methods") in 2000 was another step to push the Austrian pellets market and to provide confidence to consumers. Product standards for fuels are an important requirement for the development of appropriate combustion systems.

2.3.6. Phase of market maturity

It is not quite clear whether the Austrian pellet market has already reached maturity. The situation in 2006, with a dramatic increase of pellet prices and a decrease of pellet boiler sales, could have been a watershed in the development of the Austrian pellets market. The future improvement of this market will highly depend on whether the pellets industry can regain the confidence of prospective customers. Heating system manufacturers in Austria and distributors of pellets now try to gain confidence by building long term contracts and guaranteeing maximum prices for pellets.

At the moment it seems that the pellets industry is well on its way. Building up larger stock capacities and production capacities are important for reaching price stability. International trading of pellets will be another chance for securing supply and demand and could benefit the market stability and the competitiveness of prices.

2.4. Conclusions

There were a lot of different factors that led to the successful development of the Austrian pellets market, including rising oil prices. The following is a summary of the preconditions in Austria, the challenges and barriers that had to be overcome, and how these problems were addressed.

Since Austria is a densely wooded country with considerable availability of woody biomass, there is a long tradition of heating with woody biomass, particularly in the rural areas. This supported the development of a biomass boiler industry, and consequently a lot of technological know-how now exists in this sector and there are well developed distribution channels both for biomass boilers and biofuels.

After the first oil crisis the government began to implement subsidies for biomass heating. Restrictive regulations regarding the emissions of heating systems in Austria helped extend the technological progress of the Austrian biomass boiler industry. Increases in prices of fossil fuels after the year 2000 provided a strong economic incentive to launch pellets as a fuel in the rural areas of the Austrian domestic heating market. Together with a higher demand for comfort (substitution of single stoves and wood log boilers by automated heating systems) and an increase in the environmental awareness of many of the people in Austria, these factors provided the basis for a successful development of the wood pellets market in Austria, with an average growth rate of 45% in the period of 1995 to 2006.

What problems occurred and how have these problems been addressed? In the beginning when pellet boilers were introduced to the Austrian heating market, there were many problems with reliability of pellet boilers and quality of pellets. Accompanied by public subsidies for research and development, these problems were addressed with great effort by the pellet boiler industry. Investments in R&D were the most effective strategies to enhance reliability of pellet boilers to compete with mature technologies (oil and gas fired heating systems). Additionally there was special training for installers on the specifics of the pellets technology. The introduction of quality standards for pellets was an important step to push the Austrian pellets market and to provide confidence to consumers.

In the period of change when the pellet market was booming the biggest challenge was an increase in pellet prices of more than 50% at the end of 2006. This price development was triggered by the following reasons:

1) An increase in the demand for pellets in Austria and its neighbouring countries. Due to a higher price level for pellets in Italy there was an expansion of exports to this country in particular.
2) A winter with an extreme amount of snow. That led to a decrease of the removals of round wood by 20-30% and a resulting decrease of the amount of sawdust available.
3) The market dominance of a few key players of the Austrian pellet market.

The rise in pellet prices damaged the image of the entire pellet industry. On the consumer side there was a huge loss of confidence in the pellets market and manufacturers of pellet boilers were faced with a drastic drop in sales of pellet boilers of more than 60%. To sort out this problem the pellet industry made a coordinated effort to generate confidence by expanding production capacity and by building up higher storage capacity. Some producers even started the sale of pellet boilers combined with guarantees for pellet prices for a few years.

Canadian Success Stories- Wood Pellet Exports & Pyrolysis Oil Development

2.5. Introduction- Wood Pellets

Canada has succeeded in growing from a being a non-factor in global pellet trade to becoming one of the world's leaders in wood pellet production and trade in 10 years. The factors contributing to this success story include; a surplus of low-cost mill residue, excess pellet production capacity due to a decline in US pellet demand, meaningful policies in Europe promoting biomass use, and the will of entrepreneurs to dream the impossible and ship pellets 14,000 km to Europe. Canada has succeeded in building market share by continuing to emphasize quality product and efficient, dependable long-distance delivery.

2.6. Starting Point, Pre-conditions: Brief Historical Review- Wood Pellets

2.6.1. Supply

Canada is rich in fossil fuel resources, which in 2000 provided 80% of Canada's primary energy. Due to the number of fast flowing rivers, a large portion of power production was hydro, only 6% was from renewable biomass. Canada is also rich in forest resources: 41% of its land area (402 million ha[9]) is forest; 235 million ha is commercial forest, and 120 million ha are managed for timber. In 1998 estimated production of wood residues (sawdust, shavings and bark) was 17.7 million BDt[10], shown in Table 1. Approximately 12.3 million BDt of residue was used in the production of fibre board and other value added products or was used for energy, while 5.4 million BDT was surplus.

Table 1 - Wood Residue Profile 1998 (M BDt)

	Produced	Used	Surplus
BC	7.75	5.69	2.06
Quebec	5.73	4.09	1.64
Alberta	1.57	0.67	0.90
Ontario	1.53	1.08	0.45
Other	1.12	0.77	0.35
Canada	17.7	12.3	5.4

In 1996 there were 5 plants that manufactured wood pellets, each with a capacity of 40-60,000 tonnes producing a total of 173,000 tonnes.

2.6.2. Demand

Due to the vastness of its forest resources, in the mid 1990's, Canada was one of the dominant pulp, paper and lumber producers in the world. In 1997 Canada produced 25 million tonnes of paper grade pulp, and exported 10.2 million tonnes. To reduce production costs and keep competitive in a global industry, pulp and paper mills increasingly developed heat and power from large cogeneration units using mill residues. Most pulp mills had wood rooms and thus generated onsite wood residue, but they also supplemented biomass supply from nearby sawmills. Power generally was used by the pulp mills, and excess was sent to

[9] State of Canada's Forests 1999-2000

[10] Canada's Wood Residues- A Profile of Current Surplus and Regional Concentrations- Canadian Forest Service, Terry Hatton- March 1999

the grid. By 2000, there were 48 cogen plants producing over 1600 MW of power. A few independent power producers also took advantage of zero-cost feed stock and built large cogen plants to manufacture and deliver power to the grid. Some sawmills used bark heaters in dry kilns, but most kilns were fueled with fossil fuels. Thus, most of the residue in Canada was used by the forestry industry for heat and power.

In 1997, the production of pellets was 173,000 tonnes. A mere 63,000 tonnes was sold domestically, usually in bags to consumers who had pellet stoves. 110,000 tonnes were sold into the US market, mostly the Seattle area in the West and the New England region in the East. Beginning in the 1980's the Seattle area was promoting use of wood stoves, but only in those areas not on the natural gas grid. By the 1990's the Seattle pellet market was approximately 400,000 tonnes, but in the latter half of the 1990's the Seattle natural gas grid was extended, people bought natural gas furnaces, and the market for pellets fell 100,000 tonnes. The BC pellet producers had to find new markets.

2.6.3. Economic Situation

After spiking to over $60 per barrel in 1980, world oil prices fell to the $20-25 range in 1986, where they remained until 1999. Canada maintains a world oil price even for domestic uses, thus in Canada energy prices were relatively low. To transport the vast oil and gas reserves, companies built pipelines running the length of the country, and established a massive infrastructure for supply of natural gas. Most major cities and towns were on a natural gas grid by the 1990's, and gas was relatively inexpensive. For the forestry business, energy was an expense nonetheless, and so to reduce costs biomass increasingly was used for energy. Mill residue was generally free, since sawmills did not wish to add to the growing pile beside their mill. The greatest surpluses of mill residue were in BC.

In remote locations off the grid, localities were not encouraged to utilize biomass. The government actually flew oil to remote communities at huge cost to supply heating oil.

2.6.4. Policy and Regulatory Framework

In the 1990s it was recognized that bark piles sitting beside sawmills and pulp mills may leach undesirable compounds into the environment. As such, three provincial governments, including BC, required incineration of mill residue that was not used in the year of production. The other forest provinces began forcing mills to send excess mill residue to costly managed landfill sites. Thus mills were glad to have other enterprises take the residue off their property at no charge.

The United Nations Framework Convention on Climate Change set the tone for ghg reductions in Rio de Janeiro in 1992, and subsequently the Kyoto protocol was adopted in 1997, with binding ghg emissions targets set for industrialized countries. Canadian companies initiated ghg reductions, but most ghg reductions in that period were NOT due to political agreements, but simply to reduce costs or make money.

2.6.5. State of Technology

Pellet making technology is relatively simple. Raw material, usually forest chips, shavings or sawdust, is delivered in batch loads and stored at the manufacturing site in order to feed the continuous pelletizing process. Raw feedstock must be dried, usually to 12% moisture. Drying is usually done in drum driers that consume a large amount of energy, thus drying is a focal point of research to reduce costs. Feedstock also must be ground into a uniform size. In pelletizing, the raw material is usually heated to reduce abrasiveness and separate the lignin, and then it is forced through a press under very high pressure, creating the pellets. Then the pellets are cooled to allow the natural bonding agents to set.

Pellet burning boilers of all sizes were available in Europe, but in North America new technologies and improved environmental performance were largely unknown.

2.7. Period of Change- What made things happen- Wood Pellets

2.7.1. Supply

A number of changes occurred in 1997-2008. Although production of mill residues rose 23% to 21.2 million BDt 1998-04, the surplus had diminished from 5.4 to 2.7 million BDt due to the number of new bioenergy projects, and other uses. By mid 2008, estimated mill residue available for energy was 2.4 million BDt, as shown in Table 2[11]. The provinces of Ontario, Alberta and BC each had surplus residues of approximately .5 million BDt, but these sources were widely spread. With mill residues almost totally absorbed in some regions, bioenergy projects began turning to heritage bark piles, piles of bark that have been left beside mills for 10-30 years in Ontario, Quebec and other provinces. The estimated amount of bark that is usable for energy (dry with little contamination) and is still available is 18 million BDt, or 1.8 million BDt annually if mined over 10 years. These sources are suitable for heat and power, but in some cases not for pellets. All the forestry provinces are now looking to forest harvest residues as the next great source of biomass feedstock. The amount available, mostly sitting at roadside, is estimated at 12.9 million BDt annually. It consists of both white and brown wood and in most cases is appropriate for pellet manufacture. There is also a huge amount of agricultural biomass available. Crops are grown on 36.4 million hectares in Canada. Crop residues that are recoverable, sustainably removable, and available for energy are estimated at 17.3 million BDt annually. Non-merchantable standing timber is also in plentiful supply, but at $80/BDt it has been considered too expensive for energy.

Table 2 - Annual Biomass Availability (Million BDt)

	1997	2004	2008
Mill Residue Surplus	5.4	2.7	2.4
Heritage Bark Piles		1.9	1.8
Roadside Harvest Waste			12.9
Agricultural Residues			17.3
Total Annual Biomass			34.4

Due to area shortages in mill residue, some pellet manufacturers been using harvest residue without difficulty since early 2008 to supplement the feedstock mix. The collapse in the US

[11] Canada Report on Bioenergy 2008- Douglas Bradley, Climate Change Solutions

housing market during 2008 caused a great shortage of mill residue and now manufacturers must use a higher proportion of forest fibre. This situation is not expected to impede volumes, but with fibre prices increasing 4 fold, delivered pellet will be 40-50% higher.

While much of committed forest biomass still goes to forest industry cogeneration, in the last 10 years pellet manufacturing has grown exponentially, shown in Figure 10. There are now 29 operating plants, and more being built. Estimated capacity was 1.6 million tonnes in 2007, 2.0 million in 2008. Production grew from 173,000 tonnes in 1997 to 1.4 million tonnes in 2007.

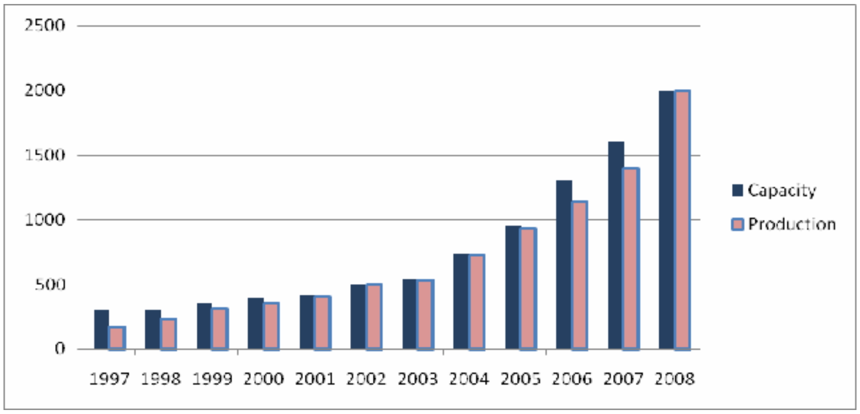

Fig. 10 - Pellet Capacity and Production 1997-2008 (000 tonnes)

Ten of Canada's 29 plants are in BC including Premium Pellet, Pacific Bioenergy, Pinnacle, Armstrong, Westwood, and Princeton Cogen. All are on rail lines and connected to port facilities in Vancouver and Prince Rupert. A new pellet loading facility at Vancouver can process 1 million tonnes annually, and can be expanded to 2 million tonnes. The Mactara plant in Nova Scotia the East Coast also exports to Europe through the port of Halifax.

There are now 4 plants in the interior in Alberta, Manitoba and Ontario, however these locations are far from ports and thus production is either sold locally, or shipped by rail to US markets. There are 10 other plants reasonably close to ports in the Atlantic Provinces and in Quebec that have the capability to export. More importantly, communities in Eastern Canada are extremely interested in utilizing local surplus biomass either for heat and power, or for making Bioproducts such as pellets. This is especially so in Quebec, which has considerable excess biomass in bark piles and forest residue.

2.7.2. Demand

Demand for Canadian pellets has changed fundamentally from 1997, and has changed the face of international pellets trade. Canada proved that woody biomass in the form of pellets can be traded over great distances across oceans, making pellets a world commodity. The first intercontinental shipment, 15,000 tonnes, occurred in April 1998, going from the Pellet Flame plant in BC to Vancouver, through the Panama Canal, to Helsingborg Sweden. In 1997, 110,000 tonnes, or 64% of Canadian production, was exported, all to the US as shown in Table 3. By 2007, pellet production grew to 1.485 million tonnes and exports were over 1.2 million tonnes, 83% of production. More importantly, European markets grew from zero to 60% of Canadian pellet exports in 10 years, displacing the US as the major trade partner. Markets include large power companies in Belgium, Netherlands and Sweden, and also large district heating companies in Sweden. European pellet consumption is estimated at 7.0 million tonnes in 2007[12], and production at 5.6 million tonnes. Thus Canada now comprises 53% of European imports of pellets.

Table 3 - Sales of Pellets from Canada (million tonnes)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Domestic	63	72	79	125	76	99	88	87	88	135	250
US	110	105	115	155	155	230	210	265	265	400	495
Offshore	0	60	120	160	170	170	235	375	583	600	740
Total	173	237	314	440	401	499	533	727	936	1,135	1,485

The Wood Products Association of Canada has been working for several years to develop a pellet market in Asia with only marginal success. Japan now takes 120,000 tonnes but the market size is projected to reach only 400,000 tonnes. China exports what little it produces.

The Canadian Bioenergy Association and Wood Pellet Association of Canada are jointly planning an initiative called "Go-Pellets" to encourage more domestic markets for pellets, by promoting awareness of pellet advantages, lobbying for incentives, and promoting information transfer. However, even with this program domestic use of pellets is expected to grow slowly because the systems of guaranteed supply in Canada have yet to be set up.

2.7.3. Economic Conditions

In 1998-2007 world economies grew without recession. In Canada, and in particular in BC, clean mills residues were still relatively plentiful. In this growth period, many pellet plants in Canada were built using mill residue that was either free or acquired at very low cost, reaching only $10-20/BDT by 2007. Also, the price of crude oil rose from $30 in 2003 to $60 a barrel in 2006, finally reaching a record $130 in 2008. High crude prices were instrumental in speeding use of pellets. Even when some EU countries reduced incentives to utilize wood pellets, other EU countries implemented new incentives. During this period ocean shipping rates were comparatively stable, remaining in the $25-35 range over several years.

The 2007-08 period posed new challenges for pellet producers. The sub-prime mortgage crisis in the US caused US housing starts to collapse, drastically reducing the amount of lumber production and thus mill residue production in Canada. Residue prices not already under contract have doubled to over $35/BDt in some regions, where residue is even available. Now, projects will have to go further afield for biomass and pay more. Heritage pile bark is essentially free, but it is often 40-50% moisture, and has to be dried. This bark is also brown wood, and brown pellets can only be used in the large heat and power plants, not in small heat applications. Harvest waste contains much more whitewood, but it can be costly; $24/BDt for biomass at 50 km, $45-55/BDt for biomass up to 100 km.

[12] John Swaan, Wood Pellet Association of Canada- 2008

A major factor in project economics and thus prospects for increased trade is ocean transport. In the last 2-3 years tremendous growth in trade of all goods between China and many other countries has tied up a significant portion of available shipping. Shipping rates began to skyrocket in late 2006, reaching almost $100/ton pellets in 2007. Much of current Canadian pellet trade is under 1-5 year shipping contracts at low rates, however pellet manufacturers whose contracts ended recently have been faced with cost difficulties. Thankfully, new shipping capacity is coming on-stream. In fact, a number of factors have caused shipping rates to decline 30% in August 2008 alone.

2.7.4. Political and Environmental Issues

Canada and the US continue to lag the EU on climate change legislation, largely because the Kyoto Protocol did not accommodate the North American situation as it did for Europe. Canada is committed to reducing ghg emissions, but it is proceeding in several different ways. The Province of BC implemented a carbon tax and now is assessing its effectiveness. The federal government has committed Canada to a 20% reduction in overall emissions from 2006 levels by 2020, and is implementing a plan whereby emitters will be required to reduce emissions for every unit of production by 18% by 2010, and by an additional 2% every year after. To meet these targets, large emitters can draw from a range of options, including an offset system that is projected to be implemented in 2010. It is uncertain how this legislation will affect pellet use domestically. In Canada wood resources are largely the jurisdiction of the Provinces, not the federal government, and all the forestry provinces are moving forward with mechanisms to allow swift and fair access to harvest residue.

The EU has established different emission targets for each EU country in a burden sharing framework. Targets are legally binding, with heavy penalties for non-compliance. EU countries subsequently adopt their own policies and incentives to reach their targets. For example, the Netherlands established a feed-in-tariff system in 2003 that was hugely successful, increasing renewable electricity from .8% of production in 1989 to 6.2% in 2005, largely by co-firing pellets in coal power plants. The program resulted in a huge increase in world trade in biomass such as pellet and palm oil, but the program was also very costly and it was ended by 2007. Sweden implemented an energy tax and a carbon tax, significantly increasing the amount of both domestic production of pellets, but also import of pellets. The UK implemented a system of Renewables Obligations with associated Certificates (ROCs), however the ROC system favours domestic agricultural residues and crops, and thus international trade was not largely effected. Changes in individual country incentives simply redirect pellets from one EU country to another, but imports will continue to grow.

Shipping is much changed from 1997 when small volumes were transported in small ships. The Wood Pellet Association of Canada (WPAC) has developed an ocean transportation system for pellets in large bulk tankers, a system gradually being copied in other parts of the world. WPAC established the code for transportation of wood pellets in the world-wide International Maritime Organization regulations. It also developed a Material Safety Data Sheet for pellets in bulk and in bags, recommendations that have shaken up the European pellets market. The Data Sheet will have a profound impact on the handling routines for pellets as well as design of equipment for storing and combusting pellets.

2.7.5. Technological Progress

Transporting pellets 14,000 km is a major expense for producers. Transport costs can be reduced if pellets had more energy per unit volume. Today much research is being undertaken in Canada, Sweden, Finland and Norway to increase pellet density from 750 kg/m^3 to 850-900 kg/m^3. This line of research involves explosion pulping, impregnating the wood with high-pressure steam and disintegrating it so that the fibres are less resilient and compress more easily. A second line of research is for wood to undergo mild pyrolysis, somewhat like torrefaction, whereby 30% of the mass is lost, but only 10% of the energy. The denser pellets will not only result in lower transportation costs, but large power plants would not have to spend major capital on pre-processing of pellets since the retention time of the dense pellets is more akin to coal than traditional pellets.

Both of the above processes produce a hydrophobic (waterproof) pellet, which has great advantages in transportation. Potential for water damage would be very much reduced, and it would have implications on the type of storage needed. Pilots are producing these dense pellets now, but they will not likely be available commercially for 1-2 years.

2.7.6. Phase of Market Maturity

Figure 11 illustrates the standard product life cycle. When a product is introduced to the market, the first phase, it usually requires an intense marketing effort to promote awareness and develop sales. Sales are low and prices are often high, though price discounting is often required to build market volumes. In the growth phase, markets are established and growing, competitors are entering the market, and competition for sales increases. At the top end of this cycle, manufacturers try to extend the life cycle by differentiating the product to keep customers and sales. Eventually the market reaches maturity; low-cost producers flood the market with product, reducing margins, and higher cost producers begin to exit the market. The product becomes a commodity. Eventually sales decline as new better, cleaner or more efficient or convenient products take over.

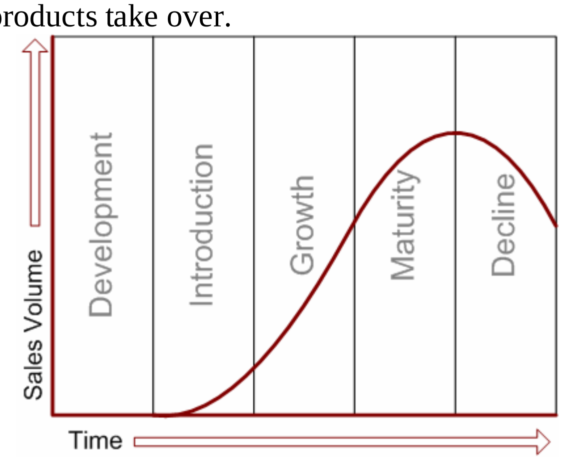

Fig. 11 - Product Life Cycle

Pellets are now in the growth phase. World demand for pellets is increasing due to climate change policies, particularly in the EU after the start of the first Kyoto period on Jan 1, 2008. Production has increased rapidly, in particular in low-cost regions, such as the Baltic. New producers, especially in the Baltic, began producing low-quality product, but gradually they are learning to manufacture better quality. Russia has huge potential, but manufacturing in

Russia continues to lag. Medium-cost producers, such as Canada, are focusing on making the most efficient, low-cost supply chains, and are establishing a reputation of reliability in terms of product quality and delivery consistency. Having established pellet quality control and investing in efficient port loading capacity, Canada has established large-volume, low-cost ocean transport supply chains, and is able to deliver consistent quality pellets in the volumes and delivery schedule contracted. It is a preferred customer in many markets.

Barriers and problems to trade remain. Canada is still at risk to high ocean freight rates which can reduce profitability to the point of dropping out of the supply picture. In addition, in BC and other regions, most of the mill residue at $10-20/BDt is committed and the next source of biomass is more costly forest harvest residue at $25-50/BDt. Ways must be found of reducing feedstock costs and supply chain costs to stay in the market. Both BC and Canada are implementing climate change polices that may increase demand for feedstock for domestic bioenergy heat and power projects. The Go-Pellets program may increase domestic pellet markets and draw away from trade. On the positive side, WPAC is progressing with research that will make a denser, water-proof pellet that will cost less to ship and will be more valuable to customers, perhaps even commanding a premium price. In addition, for the second year in a row, the Northwest Passage between Canada and the Arctic has been ice-free, possibly opening up a shorter and more-competitive sea lane to Europe. New pellet capacity may be built in Ontario and Quebec.

2.8. Conclusions- Wood Pellets

Canada has been hugely successful in increasing international trade in wood pellets. A number of drivers, or preconditions for success, evolved to make this happen, including;

- Excess production capacity due to a decline in demand in traditional US markets
- Slowly growing domestic pellet market, insufficient to absorb local production
- Plentiful and cheap feedstock; mill residue at $0-10/BDt
- Meaningful policy incentives targeted at European energy companies to increase production of renewable power and fuels, such as pellets
- The will of entrepreneurs to dream the impossible, and transport pellets 14,000 km

Although all these preconditions need not have been in place, they were sufficient to cause meaningful international trade. As long as climate change legislation is in place to replace coal and oil energy with renewables, trade will grow. Human ingenuity will find ways to reduce average feedstock costs, make supply chains more efficient, and continue to supply quality pellets. All it will take is a strong and growing market. For Canada the risk will be the quality and volume of pellets coming from much shorter distances; Poland, Russia, and other Baltic countries. The market will either have to grow more rapidly than supply, or Canada will have to differentiate its pellets for market customers in quality and environmental sustainability.

2.9. Introduction- Pyrolysis Oil

Canada is also a world leader in the production of bio-oil from fast pyrolysis. Ensyn, the world's first commercial producer of bio-oil, built markets for bio-oil in food and chemicals in the US, expanding production to Canada. With crude oil price at high levels and climate change legislation being felt, Ensyn is poised to enter lucrative energy markets. Dynamotive Energy developed an alternative patented fast-pyrolysis process and now has built the two world's largest bio-oil plants in Ontario. Its business model to license production has enabled Dynamotive to begin establishing biofuel companies around the world so that these subsidiaries can develop and implement market strategies specific to their markets. Production from it's two plants will be sold out after customer testing is completed.

2.10. Starting Point, Pre-conditions: Brief Historical Review- Pyrolysis Oil

2.10.1. Supply

Bio-oil from fast pyrolysis is a dark-brown, free-flowing liquid fuel that is derived from biomass. In 1998 Ensyn Technologies of Canada was the only company in the world with commercial scale technology to produce such bio-oil. In 1989 it licensed the technology to a US company, Red Arrow, with the rights to sell into the food flavouring market. Ensyn helped Red Arrow build 6 plants in Wisconsin, with total capacity of 100 tonnes per day biomass.

There were no bio-oil plants in Canada, but plenty of feedstock. As indicated earlier, even though Canada used 12.3 million tonnes of mill residue for energy in 1998, there were still 5.4 million tonnes of surplus wood residue each year that were either incinerated for no value, or left in piles at the side of saw mills and pulp mills.

2.10.2. Demand

Bio-oil was essentially a new and largely unknown product in the 1990's. While bio-oil is suitable for substituting for heavy oil in many applications such as in boilers or stationary engines, Ensyn found the chemicals and food markets in the US to be more lucrative. Ensyn used bio-chemicals extracted from the bio-oil to create over 30 commercial products for use in the production of food flavors and adhesive resins for the construction industry, while the non-biochemical fraction was used in heating applications in Wisconsin.

2.10.3. Economic Situation

As indicated earlier, the world oil price was a relatively low at $20-25US per barrel in the 1990's. As a result many bioenergy projects were not economic without considerable financial incentives. For this reason, Ensyn chose the food and chemicals markets.

2.10.4. Political and Environmental Issues

Although the UNFCCC set the tone for ghg emissions in 1992 and the Kyoto Protocol was adopted in 1997, Canada and the US were slow to adopt ghg reduction programs, largely because the Kyoto agreement seemed to fit the European situation but not that of North America. By adopting a bubble approach, Europe and had already achieved significant progress toward Kyoto objectives merely by shutting down the UK coal industry and inefficient factories in East Germany, neither initiative done for climate change reasons. Canada on the other hand had an increasing population requiring heat and light in a cold northern climate, and at the same time was increasing oil and gas production to enable the US to wean itself of Middle East oil. Thus ghg reduction was not a driver for bio-oil production.

Incinerating mill residues was only beginning to be seen as an environmental problem as well as a waste of energy, so there was no rush to utilize them.

2.10.5. State of Technology

Many pyrolysis processes to produce bio-oil have been researched and studied in the last 20 years in Europe and North America. European technologies and processes did not prove commercial due to difficulties with product deterioration, especially when transporting bio-oil. In North America, Ensyn's proven Rapid Thermal Processing (RTP)™ technology was the world's only pyrolysis technology that operated on a long-term commercial basis during the 1990's. In the RTP process , residual forestry biomass or agricultural biomass is introduced into a vessel and rapidly heated to 500°C by a tornado of hot sand and then rapidly cooled within seconds to produce a pourable liquid "bio-oil", a by-product char and non-condensable gas, both of which can be efficiently used to provide process energy.

2.11. Period of Change- What made things happen- Pyrolysis Oil

2.11.1. Supply

Ensyn built its first Canadian plant in 2004, a 100-tpd plant in Renfrew Ontario. This plant sold the chemicals fraction to Red Arrow in the US for the flavouring market, and used the non-aqueous fraction for heat at the plant. Projects by Ensyn now underway in Canada[13] and Asia will result in bio-oil plants 5-10 times larger than its 100-tpd Renfrew plant. Agreements for such a plant in Canada have been signed. These plants will target the energy market, including heat, power and fuels.

In 2000 Dynamotive Energy Systems (Vancouver) acquired a patent to an alternative fast pyrolysis process from Resource Transforms Ltd, and a year later built a 10-tpd commercial demonstration plant in Vancouver to validate the technology. After many successful tests, in 2003 Dynamotive began construction on a 100-tpd commercial-scale demonstration plant in West Lorne Ontario. It was completed in 2005 and was to produce 23,000 tonnes pure bio-oil for the energy market. In 2007 it underwent a 30-tpd expansion and efficiency improvement, starting up in February 2008. Dynamotive and a partner built a new 200-tpd plant in Guelph Ontario that started up in March 2008, and it is now the largest bio-oil plant in the world. By building 200-tpd plants and designing 500-1000-tpd plants and plant clusters, the cost of producing bio-oil is coming down, making it more competitive against alternative fuels.

The Dynamotive business model is to generate its revenues from sales of bio-oil and char as well as in project development, license fees and royalties on its proprietary technology and products, and services contracts from licensees. The company has established biofuel companies in the US, Canada and Argentina, and intends to establish additional companies in Brazil, the Far East and other key markets so that these subsidiaries can develop and implement market strategies specific to these markets. There are several other plants in various states of planning in Canada, the US, and in many other world locations.

Although a considerable volume of palm oil has been shipped from Malaysia to Europe and rape seed oil from Canada to Europe, no pyrolysis oil has yet been transported over long distance by ocean shipping, essentially because no large volumes have been produced yet.

[13] Ensyn Web Site

Transporting bio-oil by ocean freighter is still an unknown quantity. Bio-oil is acidic, with a pH of 2-3, thus it requires stainless steel or similar piping and tanks for storage and transport. This is being accomplished easily now with trucks and rail for land transport, but for ocean transport chemical tankers are required. Such tankers tend to be small, 5,000 tonnes capacity, and are thus expensive on a per ton basis. Pellets are dry, easy to handle and are now shipped in large 30,000 tonne tankers. Bio-oil, as a liquid, can be loaded faster than pellets, however bio-oil must go up the learning curve in establishing efficient and competitive long distance ocean transport, usually attained only with high volumes.

2.11.2. Demand

In 1998-2008, bio-oil produced at the Ensyn plants went to US chemicals and food markets, though some was used to heat the plants themselves. Demand did not grow quickly because the food market had a limited size, and because bio-oil as a substitute for fossil fuel was largely unknown and only tested in small volumes.

Dynamotive targeted the energy market and with its 10-tpd demonstration plant immediately proceeded to test its bio-oil successfully with over 100 feedstocks and in various applications including; replacing heating oil #2 in a large aluminum plant, replacing fuel oil #6 in a greenhouse, and replacing natural gas in a redesigned 2.5 turbine for power. In the expanded 130-tpd plant at West Lorne up to 60% of the BioOil production fuels one 2.5MW turbine, with power fed into the Ontario grid; the remainder is exported to the US where it is substituted for heating oil #2. The Guelph plant is still being ramped up, but its production is destined for heat and power production in the US. Dynamotive aims to expand markets for bio-oil with a process that will make bio-oil fully compatible with stationary and possibly transportation fuel infrastructures.

Markets for bio-oil will be where revenue net of manufacturing and transportation costs is greatest. Canada is a huge potential market, in particular lime kilns in pulp mills where replacement of all the fossil fuel would require over 1 million tonnes bio-oil. However, some of these pulp mills may opt for a gasification option, as is being tested now in BC mill, rather than a bio-oil option. Since running a 2.5 MW turbine for power is proven, power production in small communities is an option.

The all-but-ready market is Europe. Incentives are generally much stronger than in Canada and the EU is further along in mandating Kyoto objectives. One key market initially is expected to be pulp mill lime kilns in Sweden, Finland, Spain and Portugal, a market size of 1.4 million tonnes, the equivalent of 28 200-tpd bio-oil plants. Another major market will be co-firing in large coal power plants in the UK and Netherlands, or as one of many feedstocks in 100% biomass plants in the UK, Belgium or the Netherlands. Early power markets are estimated at 2.9 million tonnes for coal co-firing, 3.1 million tonnes for co-firing with oil, and 4.5 million tonnes co-firing with natural gas power plants that have been configured for oil. There are also market niches, such as replacing diesel in small <20MW turbines in Germany. Another market will be in district heating plants in Finland, Sweden, and possibly Denmark, initially at 1 million tonnes.

2.11.3. Economic Conditions

As indicated in 2.2.3 the world oil price has been rocketing upward since 1992, hitting record levels of $130US per barrel in 2008. High oil prices have significantly improved the economics of bioenergy and using biofuels. Despite shortages of residues in some regions, many communities began looking at bioenergy heat and power options in order to wean themselves of costly fossil fuels. Companies trying to improve profitability are more prone to consider switching from fossil fuel oil to bio-oil.

During the 1998-2006 period, BioOil faced the same biomass situation as pellets; lots of clean white mill residue, much of it for free, and the rest at low cost in the 10-15$/BDt range. In 2008 mill residues are scarcer and prices are very high owing to the slowdown in US housing starts. On the positive side bio-oil can use bark as a feedstock, which in many cases pellets cannot, and thus bio-oil can take advantage of low-cost heritage bark piles. Dynamotive built its Ontario plants to use nearby, low-cost post-industrial wood.

2.11.4. Political and Environmental Issues

In the EU the Kyoto trial period began in 2006, and the actual Kyoto commitment period began in 2008, with stiff penalties for non-compliance. EU companies are very interested in utilizing bio-oil, including large power companies, and small power applications. However, in order for this market to grow such applications have to be proven at a large scale, and volumes of bio-oil have to be proven to be consistent in quality and delivery.

In Canada GHG legislation is finally coming into play with industry now having to hit GHG emission targets in 2010.

Certification is a major issue in renewable fuel production and usage. In developing legislation in the Netherlands, bio-oil from fast pyrolysis of wood from sustainable sources was lumped in with other bio-oil from feedstocks such as non-renewable palm oil. Trade in bio-oil will require understanding of these differences and proper reflection in legislation.

2.11.5. Technological Progress

Recognizing that char contained considerable energy yet was a low-value by-product, Dynamotive experimented and succeeded in mixing proportions of char with bio-oil to create a higher energy density “intermediate” bio-oil, which could be used in boilers applications.

The Dynamotive research centre is currently working on 2-phase upgrading of bio-oil. First phase upgrading results in a product that is lower in oxygen (10%) and water content (2-5%), has a heating value of 35 GJ/tonne, is pH neutral, and is miscible with hydrocarbons. This hydroreformed bio-oil can then be hydrotreated to produce a fully diesel-like product with over 40 GJ/tonne.

2.11.6. Phase of Maturity

Although bio-oil has been manufactured and sold in small volumes for almost 20 years, it is largely an unknown commodity in energy markets. It is only really at the ‘introduction’ stage of the product life cycle. Ensyn claims its technology is easily scaled-up and is confident that it can build and operate 500-1000-tpd plants. When construction begins it will already have committed domestic customers. Trade is an option depending on price. Dynamotive has already built world-scale plants, but is still in the phase of ramping up production. Many customers are just at the point of trying out the product to see how it works in commercial operations. Success in these trials should mean rapid increases in production and rapid uptake by energy plants, both domestic and off shore. A barrier to long distance trade is to find right-sized ocean tankers that can be accommodated in smaller outgoing and incoming ports but still be large enough to minimize shipping costs.

2.12. Conclusions- Pyrolysis Oil

In bio-oil, the drivers for production and trade were;

- Successful research into alternative renewable fuels
- Canadian government programs that supported new technologies
- Successful sustained production of bio-oil from fast pyrolysis
- Successful customer trials in substituting bio-oil for fossil fuel in several applications
- The will of Canadian entrepreneurs

Bio-oil has been a biofuel success story for research and production. It is still on the verge of being a success story in sales and trade. Holding up faster development of bio-oil production and trade has been the lack of sufficient trials with prospective customers. They are happening now.

3. United States Success Story- Ethanol and Biodiesel Production

3.1. Summary

In 1992, the US government passed the Energy Policy Act (EPAct) in response to increasing dependence on imported petroleum and a growing urgency to improve air quality. This act established a goal for alternative fueled vehicle acquisition such as with ethanol. In 1998, this Act was amended to include biodiesel. In 2005, another Energy Policy Act was passed that contained a renewable fuels standard (RFS) requiring 7.5 billion gallons (28.4 billion L) of alternative liquid fuel (ethanol and/or biodiesel) be produced by 2012, with gains in later years to be in line with growth of the gasoline sold.[i] Also, a ban was effectively placed on MTBE (Methyl Tertiary Butyl Ether), which was a gasoline additive used as an oxygenate and to raise the octane number, due to its ability to adversely affect drinking water, which led to an increase in ethanol production as a fuel additive. In 2007, the US government refined the 2005 RFS and passed the Energy Independence and Security Act (EISA), which increased goals for alternative fuels from biomass sources, primarily ethanol and biodiesel, to 36 billion gallons (1.4 trillion L) per year by 2022.[ii] This was in response to (1) increased dependence on petroleum imports, (2) increased fuel prices caused by increased worldwide demand, and (3) a realization of the impacts of greenhouse gases on climate change.

Production of ethanol and biodiesel in the United States has grown dramatically since about 2000. This success story will detail the energy-, environment-, and economic-related events that spurred this growth.

3.2. Introduction

This success story essentially starts with events taking place between 2000 and 2005 and continues through 2007, when several energy-, environment-, and economic-related events came together to increase the rate of ethanol and biodiesel production. Before this time, production of both fuels was extremely low, primarily because petroleum prices were low, petroleum imports were low, and there was a lack of understanding of the environmental benefits of either fuel or a compelling reason to use them (e.g., greenhouse gas [GHG] emissions and global warming). In addition, no government mandate for alternate fuel production existed. As leaded gasoline was being phased out in the mid-1970s, MTBE (Methyl Tertiary Butyl Ether) became a viable replacement as an oxygenate and dominated the market until about the year 2000.

The combination of these factors offered very little competitive advantage for either ethanol or biodiesel. However, since 2000, much higher petroleum prices, a realization of our dependence on petroleum from unfriendly nations, and a definite and greater awareness of the GHG emission benefits each fuel provides have helped drive increased production of both fuels. These three main reasons, coupled with other more minor ones and two recent US government mandates for renewable fuel production, have dramatically increased the volumes of each fuel in the marketplace.

3.3. Starting point, pre-conditions: A brief historical review

3.3.1. Supply and Demand

Before 2000, supply of both ethanol and biodiesel was low (almost nonexistent in the case of biodiesel) due to a variety of factors:

- Low petroleum prices (main reason)
- Lack of federal volumetric mandate(s) for either ethanol or biodiesel to offer a "springboard" for increasing production
- Competition from MTBE as an oxygenate
- Lack of economic benefit with respect to the environmental benefits of either fuel.

Even with the federal subsidy of \$0.54 to \$0.60 per gallon (\$0.142 to \$0.158 per liter) from 1980 to 1999, average ethanol production was approximately 700 million gallons (2.65 billion L) per year, which amounted to less than 1% of total US gasoline consumption during that period.[iii] Biodiesel production was well below 500,000 gallons (1.9 million L) per year during this time as well, and a fair percentage of that was due to the 1998 revision of EPAct, which allowed biodiesel to be used in alternate fuel provider, state, and federal fleets to meet EPAct requirements.[iv] Biodiesel was the most cost-effective alternate fuel for compression-ignition engines versus CNG or LPG, which required much greater infrastructure development.

Supply was also low for both fuels because nearly all ethanol being produced came from corn grain and biodiesel from soybeans, both primarily grown in the Midwest section of the United States and also having other agricultural-related markets. That coupled with low petroleum prices, the fact that ethanol provides 40% less energy content per gallon (biodiesel 8% less) and consumers were aware of this, and no real cost-effective means of transporting either fuel (e.g., pipelines) to either coast with much higher population densities and petroleum consumption, meant demand was also low.

Also, in 1975, the US government began a phase-out of lead in gasoline that was to occur over a 25-year period. MTBE, an oxygenate derived from natural gas, was used as a replacement and dominated the market, thereby making it difficult for ethanol, also an oxygenate, to compete on both an environmental and economic basis.

3.3.2. Economic conditions

The main reason ethanol and biodiesel were not able to possess large market volumes prior to 2000 were almost exclusively due to the very low prices for petroleum. In the case of biodiesel, the feedstock cost from soybeans made it economically infeasible to compete against petroleum-based fuels. Figures 12 and 13 present national average retail gasoline and diesel prices in the United States for the 15 years prior to 2006.[v]

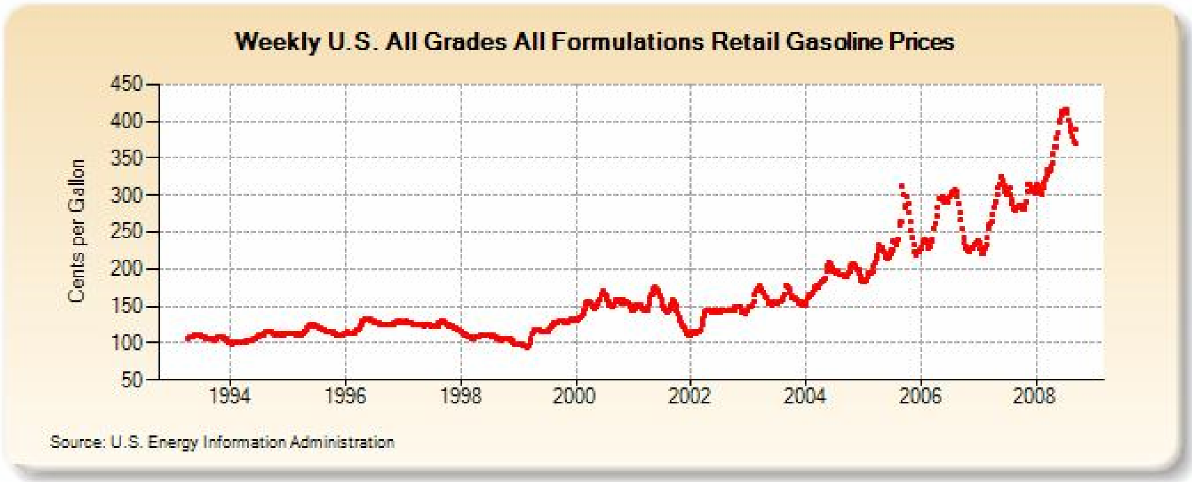

Fig. 12 - Retail gasoline prices (1993–2006).

Fig. 13 - Retail diesel prices (1993–2006).

In the mid-1990s, corn prices (to which ethanol production is extremely sensitive) more than doubled, which raised the price of ethanol. The same held true for biodiesel as market demand did not exist primarily because of feedstock price (almost exclusively soybeans) in relation to current diesel prices.

3.3.3. Policy and regulatory framework

During this period, the US government subsidized production of ethanol between $0.54 and $0.60 per gallon ($0.142 to $0.158 per liter). No subsidy existed for biodiesel during this period. In addition, no government mandates existed with respect to either fuel that would help provide a boost for production. Demand for either fuel was not high or sufficient during this time due to relatively low petroleum prices, low import levels, and no real need to focus on the environment impacts from transportation fuels from a GHG or global warming perspective.

3.3.4. State of biomass technology

The majority (if not all) ethanol production used a conventional starch fermentation conversion process (Figure 14). Ethanol could not be transported via pipelines because of its ability to absorb water and other potential impurities in the pipeline. Biodiesel production used a transesterification conversion process (Figure 15). Because of low production volumes and limited demand, there was no research done at the time on biodiesel transport in pipelines.

Both conversion processes are still in use today, as well as a wet milling process for ethanol production, but onsite energy efficiencies have dramatically improved in the past 20 years, making each technology more cost-effective.

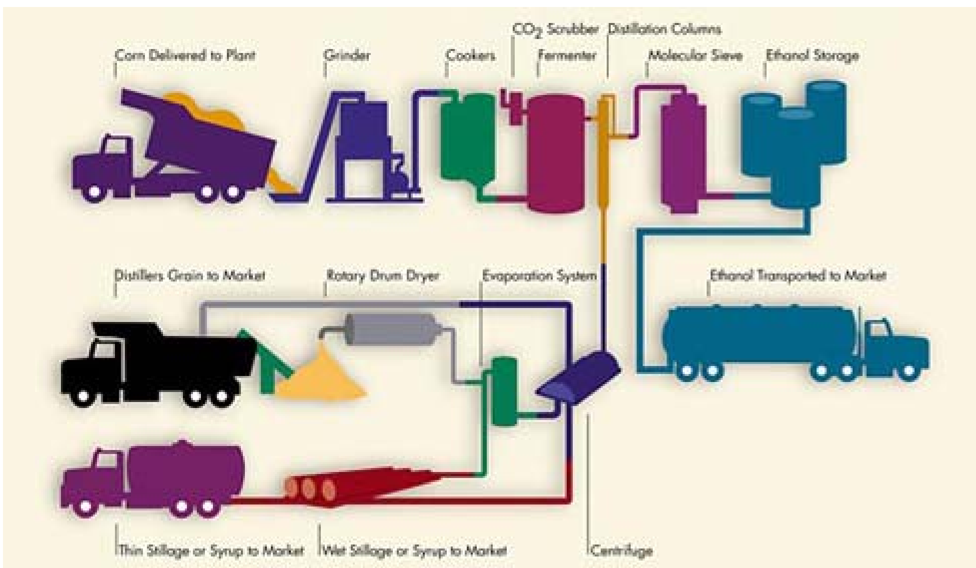

Fig. 14 - Basic process flow diagram for dry mill ethanol production.

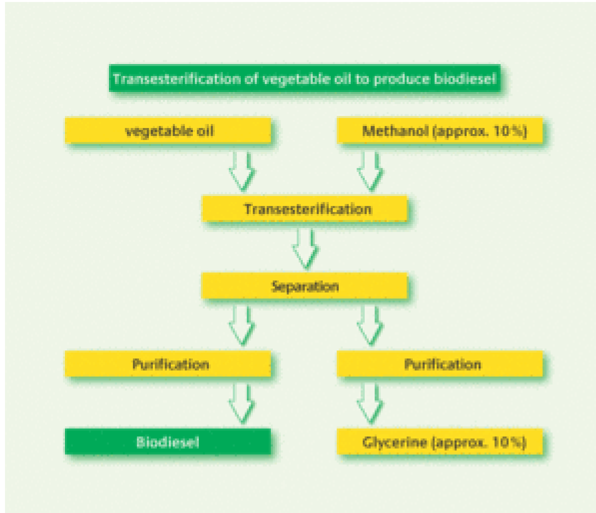

Fig. 15 - Basic transesterification process for converting oils and fats into biodiesel.

3.4. Period of change: what made things happen

3.4.1. Stakeholder behaviour

The need for developing and/or expanding new sources of energy in the United States and worldwide has increased dramatically within the past decade. From 1999 to 2000, a number of factors involving energy, the environment, and economics changed, and policy directed at each of these began to be established. These factors and policies drove production of ethanol and biodiesel at a greater rate than the previous two decades. Some specific noteworthy conditions arose and were effective in influencing action:

- Energy prices had increased dramatically because of increased worldwide demand led by China and India
- Awareness of environmental hazards related to energy consumption increased dramatically, especially with respect to GHG emissions and global warming
- The US Environmental Protection Agency (EPA) mandated a decrease in nitrogen oxides (NOx) and particulate matter (PM) from diesel fuel[vi]
- Use of MTBE as an oxygenate was phased out
- National and energy security issues increased as our dependence on foreign countries increased, particularly in areas controlled by governments unsympathetic to American interests.

3.4.2. Supply side

Between 2000 and 2005, supply of ethanol, and to a lesser extent biodiesel, began to rise because of the five previously mentioned factors. Certain state and federal government restrictions banned MTBE use in motor gasoline because traces were found to contaminate drinking water sources. As a result, ethanol (the main alternative to MTBE as an oxygenate) began to increase its national market share.

During the same period, petroleum prices began to rise and more than doubled because of global political situations as well as a dramatic increase in the expansion/growth of other national economies, mostly China and India. Because of a short-term lack of supply, US petroleum imports reached an all-time high in 2005, increasing almost one billion barrels more per year compared to 2000.

World demand for petroleum is expected to continue to rise as a lag time exists between demand and consistent supply. Figure 16 presents the rise in petroleum prices ($ per barrel) for the period of 1980 to the present.[vii] This factor was a chief reason for the increase in alternate fuel legislation proposed in the Renewable Fuel Standard of 2005 and the Energy Independence and Security Act of 2007, which spurred significant volumetric increases in both ethanol and biodiesel and was directly related to energy security, the environment, and consumer economics with respect to higher energy prices.

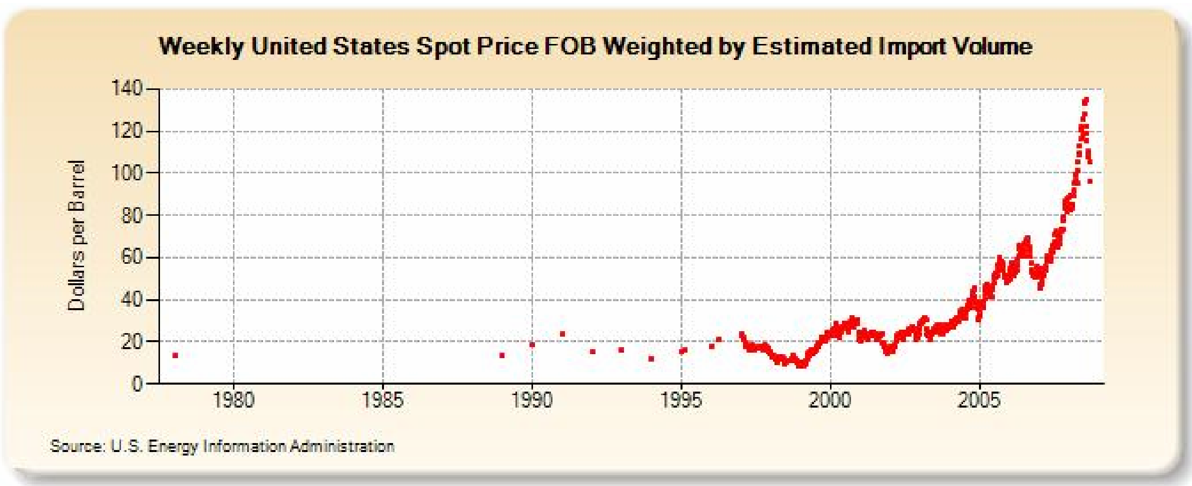

Fig. 16 - Increase in US petroleum import costs per barrel.

Between 2000 and 2007 (latest figures available) ethanol production more than quadrupled to roughly 6.5 billion gallons (24.6 billion L), and biodiesel production increased from 2 million gallons (7.6 million L) to almost 500 million (1.9 billion L).[iii, iv] Ethanol production in 2006 was up almost 1 billion gallons per year (BGY) (3.8 billion L per year) over 2005. These increases can be directly attributed to a need for expansion of the motor pool fuel base along with sustained higher energy prices that reached over $5.00 per gallon in some locations in the United States. Incentives for production at the federal level, as well as within some states, also contributed to these increases. Figures 17 and 18 show ethanol and biodiesel plants currently in production and those under construction in response to increasing demand for alternate fuels.[viii] In a number of states, tax incentives exist in addition to current incentives provided by the federal government for building ethanol and biodiesel plants, such as property tax exemptions.

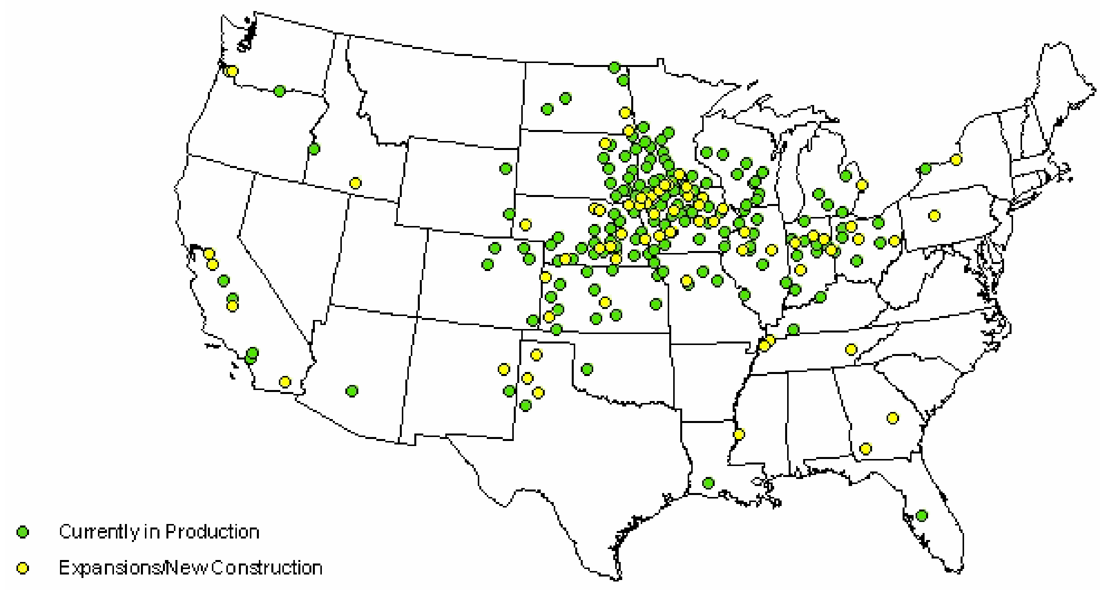

Fig. 17 - US ethanol plant capacity – spring 2007.

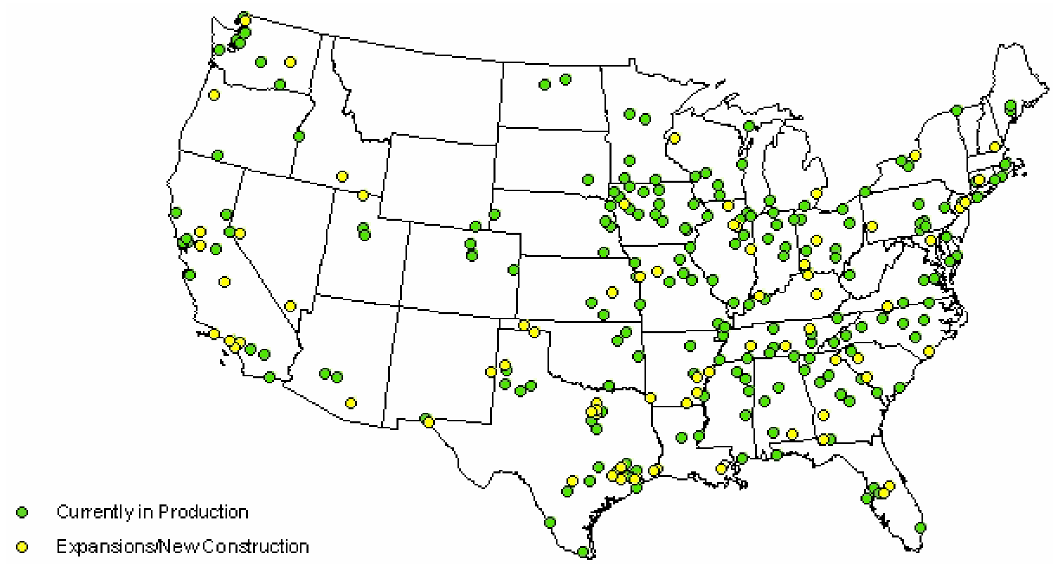

Fig. 18 - Existing biodiesel plants – fall 2008.

3.4.3. Demand side

Major stakeholders involved in the market transition occurring between 2000 and 2007 were US government agencies (Department of Energy and Department of Agriculture and the EPA); state governments and energy, agriculture, and environmental agencies (particularly in states with large corn and soybean production); and nongovernment organizations (NGOs), such as the Renewable Fuels Association,[ix] the National Corn Growers Association[x], the National Biodiesel Board,[xi] the United Soybean Board,[xii] and other smaller environmental organizations. These same stakeholders will also be present through 2022 when the full volumetric potential of the EISA is to be realized.

3.4.4. Current Status

Conventional Starch-Based Ethanol

Ethanol production is expected to increase in 2008, which can be attributed to a number of factors, the most prevalent of those being the continuation of the subsidy of $0.51 per gallon and the new EISA mandate. Also, global demand for alternate fuels is rising (ethanol in particular), and with increased production the United States could play a role in supplying that particular demand. Another contributing factor was that national automakers began producing more flex fuel vehicles; each of the “Big Three” automakers have made a pledge to have one-half of their vehicles be flex fuel by 2012.

Cellulosic Ethanol

The 2007 EISA establishes an annual goal of roughly 16 billion gallons (60.5 billion L) of cellulosic-based biofuels in addition to the 15 BGY (56.8 billion L per year) from starch resources by 2022. While sufficient demand for ethanol exists within the United States and for possible export markets of both starch and cellulosic-based resources, the current technology for ethanol production from cellulose is not economically competitive without significant federal assistance at this time.

Biodiesel

Demand for biodiesel has now exceeded 600 million gallons (2.3 billion L) in the United States, with current industry capacity around 2.2 billion gallons (8.3 billion L). This demand is a direct result of a number of factors:

- Continued support for the “blenders tax credit,” which provides an excise tax rebate of $1 per gallon of vegetable oil or animal fat-based biodiesel blended with conventional diesel fuel ($0.50 per gallon for waste greases)[xiii]
- Potential 78% decrease in GHG emissions and tailpipe emissions over that produced by conventional diesel fuel[xiv]
- Easy and cost-effective solution for complying with EPAct requirements for compression-ignition engines
- Capability to completely offset losses in lubricity in small (< 2%) quantities because of the introduction of ultra low sulphur diesel fuel[xv]
- Strict fuel quality program led by an international fuel specification (ASTM D 6751) and national fuel quality program (BQ-9000).[xvi, xvii]

3.4.5. Future Status

The 2007 EISA mandates that ethanol production from both starch-based sources (primarily corn grain and grain sorghum), cellulose-based (primarily herbaceous energy crops and to a lesser extent agricultural crop residues), and biodiesel reach 36 billion gallons (1.4 trillion L) of biofuel production (ethanol, bioethanol, and biodiesel) per year (BGY) by 2022. Of that amount, starch-based ethanol is capped at no more than 15 BGY (56.8 billion L per year). Biodiesel must reach 1 BGY (3.8 billion L per year) by 2012. The remaining volumes of biomass-based fuels are to be derived from cellulosic materials. This EISA mandate sets goals for various biofuels by which the market can respond to making appropriate investments in research and production. This, in conjunction with a heightened awareness over long-term energy security for the United States and the environmental impacts of continued fossil fuel use, has prompted increases in current as well as planned future ethanol and biodiesel production. Table 4 presents the 2007 EISA provisions for renewable liquid fuel development.[xviii]

Definitions of each EISA-mandated Biofuels and Greenhouse Gas Emission Reduction Targets

Conventional Biofuels (Corn Ethanol) - Renewable fuel derived from corn starch. The renewable fuel produced from facilities that commence construction after the date of enactment (December 19, 2007) must achieve a 20% reduction in GHG emissions compared to baseline life-cycle GHG emissions of gasoline and diesel.

Table 4 - EISA provisions for biofuel development, present to 2022 (BGY).

Calendar Year	Conventional Biofuel	Advanced Biofuel	Cellulosic Biofuel	Biomass-Biobased Diesel	Undifferentiated Advanced Biofuel	Total Renewable Fuel
2008	9					9
2009	10.5	0.6		0.5	0.1	11.1
2010	12	0.95	0.1	0.65	0.2	12.95
2011	12.6	1.35	0.25	0.8	0.3	13.95
2012	13.2	2	0.5	1	0.5	15.2
2013	13.8	2.75	1		1.75	16.55
2014	14.4	3.75	1.75		2	18.15
2015	15	5.5	3		2.5	20.5
2016	15	7.25	4.25		3	22.25
2017	15	9	5.5		3.5	24
2018	15	11	7		4	26
2019	15	13	8.5		4.5	28
2020	15	15	10.5		4.5	30
2021	15	18	13.5		4.5	33
2022	15	21	16		5	36

Advanced Biofuels - Renewable fuel (other than ethanol derived from corn starch) that is derived from renewable biomass and has life-cycle GHG emissions, as determined by the EPA Administrator, that are at least 50% less than baseline GHG emissions. This term includes "cellulosic biofuels" and "biomass-based diesel." The schedule for Advanced Biofuels includes the schedule for Cellulosic Biofuels, Biomass-Based Diesel, and Undifferentiated Advanced Biofuels.

Cellulosic Biofuels - Renewable fuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass and that has life-cycle GHG emissions, as determined by the EPA Administrator, that are at least 60% less than the baseline life-cycle GHG emissions.

Biomass-Based Diesel - Renewable fuel that is biodiesel as defined in Section 312(f) of the EPAct of 1992 (42 U.S.C. 13220(f), which according to the EPA is, a diesel fuel substitute produced from nonpetroleum renewable resources that meets the registration requirements for fuels and fuel additives established by the EPA under Section 7545 of the Clean Air Act. It is derived from renewable biomass and has life-cycle GHG emissions, as determined by the EPA Administrator that are at least 50% less than baseline GHG emissions. It does not include the co-processing of biomass with a petroleum feedstock, which is classified as an "advanced biofuel."

Undifferentiated Advanced Biofuels - Renewable fuel (other than ethanol derived from corn starch) that is derived from renewable biomass and has life-cycle GHG emissions, as determined by the Administrator, that are at least 50% less than baseline GHG emissions. This term includes "cellulosic biofuels," "biomass-based diesel" and "co-processed renewable diesel."

Baseline life-cycle GHG Emissions - The average life-cycle GHG emissions for gasoline or diesel (whichever is being replaced by the renewable fuel) sold or distributed as transportation fuel in 2005.

Life-cycle GHG Emissions - The aggregate quantity of GHG emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes) related to the full fuel lifecycle. This lifecycle takes into consideration all stages of fuel and feedstock production and distribution, from feedstock generation or extraction, through the distribution, delivery, and use of the finished fuel, to the ultimate consumer. Mass values for all GHGs will be adjusted to account for their relative global warming potential.

Recent analyses by Michael Wang at Argonne National Laboratory have addressed energy inputs and outputs of several conventional and advanced biofuels such as corn-based ethanol, agricultural crop residues (corn stover), a dedicated energy crop (switchgrass), and forest residues.[xix] Results of these analyses indicate definite reductions in fossil fuel use (petroleum, natural gas, and coal) from corn-based ethanol in comparison to a baseline case focused on conventional gasoline production and significant reductions when the three cellulosic options are considered. The same relative level of GHG reductions were seen with all four feedstocks with the cellulosic-based feedstocks achieving large reductions in carbon dioxide, methane, and nitrous oxide. A life-cycle analysis conducted with respect to using soybeans for biodiesel found energy gains to be roughly 3.2 to 1, and GHG emission reductions compared to conventional diesel fuel were nearly 80%.[xx]

The worldwide emphasis on GHG reductions and provisions for capping emissions has begun to spur demand for bio-based fuels although additional research is needed on many aspects including land use, water, and emissions.

3.5. Economic conditions

As previously mentioned, higher petroleum prices coupled with increasing import volumes were main contributing factors leading to increased demand for ethanol and biodiesel. Also, the federal government has continued the subsidy for ethanol blending and the "blenders tax credit" for biodiesel, which has helped each fuel maintain and build on earlier market shares.[xxi] However, no direct economic value has been realistically placed on the GHG benefits associated with the use of either fuel that could further increase their economic competiveness with conventional fossil fuels, even with a potential global carbon market. This is primarily due to differences in the science surrounding evaluation of total life-cycle costs and benefits.

As long as petroleum prices remain high, and GHG reductions and other environmental and health-related benefits remain in the forefront from the production and use of these fuels, there will be an economic incentive to continue production.

3.6. Political and environmental issues

In 2005, the US government passed the renewable fuels standard (RFS), which was designed to double the amount of ethanol and biodiesel produced in the United States by 2012. Specifically, ethanol and biodiesel production was to increase to 4 BGY (15.1 billion L) in 2006 and to 7.5 BGY (28.4 billion L per year) in 2012. This legislation also mandated 250 million gallons (9.5 billion L) of cellulosic ethanol be produced starting in 2013. In 2007, the US government passed further legislation (EISA 2007), which provided for much greater increases in both ethanol (starch and cellulosic-based) and biodiesel production over the next 14 years.

This legislation did not provide any provisions for the continued liability protection from the use of MTBE in gasoline, which has also contributed to the rise in ethanol production. All states have now banned MTBE.

3.7. Technological progress

The prospect for producing significant volumes of ethanol from dedicated cellulosic energy crops or waste resources appears to have significant potential in terms of improved energy ratios (renewable energy output versus total fossil energy inputs), environmental quality (air, soil, and water), and greater net returns to agriculture from the possible use of marginal (nonprime farmland). Recently, the US Department of Energy funded six different projects focused on cellulosic resources for ethanol production that will use such resources as corn stover and small-grain straws, municipal solid waste, yard and vegetable waste, and wood waste.[xxii] The total annual capacity of these six plants will be over 225 million gallons (8.5 billion L).

3.8. Phase of market maturity

Currently, production of ethanol is expected to reach approximately 13 BGY (49.2 billion L), with nearly all of that coming from starch-based agricultural commodities. Biodiesel production is forecast to be roughly 600 million gallons (2.3 billion L) per year from a variety of vegetable oils, animal fats, and waste greases. Presently, cellulosic-based resource-to-conversion economics are still not competitive with conventional starch-based ethanol conversion or with a large-scale refinery, but the EISA has made available a means to perform further research to determine the actual magnitude of these projected improvements.

With the advent of the 2007 EISA mandates for both ethanol and biodiesel, an aggressive goal has been set for alternate liquid fuel development and production that will help the United States work toward goals related to energy security and improvement in environmental quality on a national scale. Cellulosic resources for ethanol production are still in an infancy stage with more research needed in resource development, sustainability, economic competiveness with respect to the agricultural land base, and technology attributes associated with efficient and economical conversion. One goal of the recent EISA legislation will be to help quantify some of these issues to provide guidance on how to most efficiently move the renewable liquid fuel industry forward.

3.9. Conclusions

During the period of 2000 to 2007, several energy, environmental, and economic-related events took place in the United States that helped create demand and, thereby, increase total quantities of both ethanol and biodiesel. The main driving forces behind these increases were state and federal legislation that (1) outlawed the use of the nation’s primary oxygenate, MTBE, and (2) placed mandates on levels of alternate renewable liquid fuels with the goal of decreasing our dependence on foreign oil while improving the nation’s environmental quality.

4. Overall conclusions

There were many common threads to each of the success stories described; initially there was a large amount of biomass (or biomass potential), rising world oil prices, lack of home market, and increasing environmental awareness. While all of these factors influenced the success of each venture, none of these was the catalyst that made it happen. In each case there was a trigger, usually an entrepreneur.

In Austria, there was a long tradition of wood heating, boiler technology knowhow, and distribution channels for biomass boilers. In addition governments began implementing incentives for pellet boiler utilization. Besides the Austrian sawmill industry tried to become less dependent from the board- and paper industries, who have been the main consumers of sawmill residues for a long time.
But the trigger was an individual, Rudolf Huber, sales manager of a plywood company, who saw pellet boilers being exported from Austria to the US and envisioned that pellet boilers could be used in Austria to create a whole new market for pellets. Due to a high level of technical training of workers, the pellet boiler industry was able to develop efficient and reliable boilers and pellets soon became a well accepted fuel for small scale heating systems.

In Canada, there was a huge supply of mill residue mostly in BC and a growing pellet market in Europe supported by climate change legislation, but no-one had attempted to ship pellets 14,000 km before. It took the collapse of the nearby Seattle pellet market to trigger entrepreneur John Swaan to risk sending pellets all the way to Sweden. He did successfully, and from that time Canadian supply grew quickly. Similarly with BioOil, there was no local market, and US markets were only the relatively small food and chemicals markets. Envisioning a world where fossil fuels had to be increasingly replaced by renewable fuels, entrepreneur Andrew Kingston acquired key patents and risked leapfrogging plans to build a 35 tpd demonstration plant and instead built a 100 tpd plant to produce BioOil from post-industrial waste wood.

In the United States, low oil prices made manufacture of ethanol and biodiesel uneconomic, and even rising oil prices early in the decade were not a sufficient catalyst to drive a major expansion into ethanol and biodiesel production. There was no single entrepreneur, but the entrepreneurialism of a nation. Presidential policy to increase energy security by decreasing dependence on oil from unfriendly nations drove the United States find new domestic sources of energy. Rising oil prices and agricultural subsidies enabled a corn-based ethanol feedstock commodity market to compete with petroleum markets.

There were certainly problems in growth phases in all cases. In Austria a snowy winter, loss of some wood supply and growing pellets demand elsewhere caused massive price increases locally, and the industry suffered a calamitous loss in confidence by consumers, from which it is still recovering. The problem is being solved with major pellet production increases to ensure supply, and long-term fixed price supply contracts for consumers. In Canada, a surge in shipping costs caused by the booming Chinese economy caused Canadian pellets almost to be priced out of the market. To minimize this risk pellet suppliers have been focusing on maximizing efficiency in all parts of the supply chain. In addition, there were problems with pellet quality when shipped over long distance. This aspect has fuelled progressive research, new quality control and guidelines to ensure delivery of quality pellets. In BioOil, there were all the normal start-up glitches when ramping up to commercial scale production. While these issues have been largely resolved by replacing poor components with more robust ones, BioOil producers now face the challenge of convincing customers to use an entirely new product. Sadly in Canada, solid ghg reduction incentives are still lacking. In the United States, the massive diversion of corn from food to ethanol resulted in skyrocketing prices for corn, good for farmers, but not good for ethanol producers. Thankfully, fossil fuel prices rose as quickly so that ethanol never lost its competitiveness.

To stimulate a biomass market a number of pre-conditions and controls are preferred;

- It is helpful to have a long-term high world oil price to provide a direct price signal to consumers
- It is important that government be committed to renewable energy and implement meaningful policies both on the supply side and the demand side including: renewable energy targets, direct incentives, carbon trading options etc
- There should be several sources of raw biomass supply to minimize the instance of shortfall to producers
- The market must have assured supply of biomass products for any eventuality
- It is helpful to have delivery systems that are not subject to large price swings
- Product quality is more than an objective, it is a necessity

Table 5 – Summarization and comparison of the Bio-Trade & Bioenergy Success Stories

	Austria	Canada	Canada	USA
	Pellet Exports	Pellet Exports	Bio-oil Prod'n/Exports	Ethanol Production
Drivers	Surplus mill residues. Government subsidies for renewable energy.	Surplus mill residues. Kyoto-driven EU demand for biomass.	Kyoto driven demand for renewable fuels.	Low farm incomes. Dependence on oil from unfriendly nations. Increase in oil price.
Trigger	Entrepreneur believing Austria could be a market for pellet burners.	Entrepreneur believing pellets could be shipped over great distances.	Entrepreneur acquiring patents to new biomass conversion technology.	1992 Energy Policy Act with renewable fuel vehicle targets. Ban of MTBE fuel additive. Increase in fuel goals.
Result	Major increase in pellet production and exports.	Major increase in pellet production and exports.	Successful production of Bio-oil at commercial scale.	Ethanol production went up 4X 2000-07.
Hurdles/barriers	Skyrocketing pellet price in 2006 caused collapse in consumer confidence and boiler sales.	Major increase in ocean shipping rates put exports at risk.	New Technology at commercial scale. Unknown product in marketplace.	Early on low oil prices and lack of specific targets hindered ethanol production.
Was it a commercial Success?	Yes. Production grew from 700% and Austria is a major exporter to EU countries.	Yes. Canada now #1 world exporter of wood pellets.	Yes, for one producer in the food market. As a "new product", the energy market remains to be built.	Yes. Production went up 4 fold.
Common pre-conditions	Long-term high world oil prices. Government committed to renewable energy through enabling policies. Assured excess supply of biomass Delivery systems not subject to large price swings			

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