Politics of a Fluid Technology: Socio-Technical Trajectories of Forest Fuel Production in Finland

Taru Peltola

Abstract

The utilisation of forest biomass in energy production increased rapidly in Finland in the 1990s. The technology for the production of forest fuels developed enormously and became extremely successful partly because it was able to adapt to different socio-economic contexts within forestry and energy sectors. In this paper I analyse the flexibility of forest fuel technology by focusing on three empirical cases in which forest fuel technology takes on its characteristic form. Based on my analysis I argue that its ability to travel across the different socio-material contexts has consequences on the economic relationships and practices of forestry: on the one hand, forest fuel technologies are shaped by existing forestry practices while on the other hand, new actors have emerged in the field. Forest fuel technologies have thus been capable of producing new political alternatives, different possibilities to act.

Introduction

> *Mottinetti—an internet marketplace for firewood. (…) An easy way to get firewood for winter. You will find information about the firewood suppliers in your home town, and firewood sorted by tree species. You can browse the prices, make comparisons and order by e-mail, mail or phone. (Mottinetti® 2004; translated by the author)*

> *The Regional Forestry Centre {of Southern Ostrobothnia} had to strengthen its role in regional development because its traditional tasks such as ditching and building of forest roads had diminished. In the beginning, they started projects to develop the mechanical wood processing industry but soon they realised that there was also social demand for forest fuel production. (Leskinen 2003, 53; translated by the author)*

> *Bioenergy plays a central role with global warming and the need to stabilise CO_2 emissions (…). In Finland, the development of energy technology has been made the cornerstone for future energy and climate change policies. R&D is regarded the most efficient way to achieve solutions that are of great importance to environment and economy in the long run as well.*

> *The Finnish bioenergy expertise and know-how provide a solid base for the advanced technological solutions. (Tekes 2002, 28)*

The utilisation of forest biomass in energy production seems to be a technological success story in which there are only winners: The increase in wood energy production proves that economic and environmental goals can be combined by using novel technologies. From the perspective of Finnish climate and energy policy, the identity of forest fuel technology is thus clear and fixed. Because forest fuel technology helps to optimise the material flows of energy production, every cubic meter of forest fuel can equally be used as a measure of the sustainability of energy production.

The three quotations above show, however, quite a different picture of the situation. They illustrate the various aspects of forest fuel technology, from household firewood to industrial applications in power plants. Depending on the context forest fuels can be seen as a solution to different problems ranging from global warming to reorganisation of regional forestry organisations. They bring hope for the rural areas and represent new technological pride. The shape and identity of forest fuel technology is different depending on the forum where it emerges. Following de Laet and Mol (2000), this multiplicity can be called *fluidity of technology*. In this paper, I take the fluidity of forest fuel technology as a starting point and explore its ability to change its shape, its moving boundaries and flexible adaptation to different social and economic contexts.

According to de Laet and Mol (2000) the fluidity of a technology might explain its quick spreading or a successful technology transfer. The transfer of forest fuel technologies from Sweden to Finland has indeed been successful. The use of wood fuels has more than tripled in combined heat and power production over the past ten years (FDHA 2003). In 2003 biofuels (including peat) replaced oil as the biggest source of energy with a 27% share in primary energy production (MTI 2003). My aim is not, however, to evaluate whether the multiple identities of forest fuel technology are the key to its rapid success, but I am interested in its fluidity for another reason. By paying attention to its flexibility I am able to study the political aspects of this technology. The political relevance of technology studies has preoccupied researchers throughout the past decades and the ‘political question' has been phrased both in terms of democracy (Who has access to technology?) and power relations (How do technological practices engage persons?) (Gomart & Hajer 2003). My focus is on the latter perspective. I am interested in how the different forms of wood energy fit the economic landscape of forestry. In particular, my focus is on the economic position of forest owners who take part in the fuel production chains: how local possibilities to make economic decisions about the use of natural resources are performed by the different variants of forest fuel technology.

Forest fuels are justified by different policy beliefs about its sustainability. Firstly, bioenergy became important in Finnish energy and climate policy in the 1990s (Tirkkonen 2000, 174). Increasing the use of forest fuels was widely adopted as a policy target in the national energy program (MTI 1999) and the forestry program (MAF 1999). As a consequence, it was hoped that a reduction of 3 million tons of CO_2 could be achieved by 2010 (Tekes 2003). The national goal to increase the volume of wood energy is thus legitimated by climate change. The problem of climate change has been socially constructed by scientific experts and scientific knowledge is used in defining the proper solutions to the problem (Demeritt 2001).

In addition to the scientific idea of sustainability, the usefulness of forest fuel technology is linked with local livelihood and sustainable forestry goals. Forestry has traditionally close ties to agriculture, especially in eastern and northern parts of the country, where forestry has been an important source of extra incomes for farmers. The production of forest fuels has been offered as a solution to the diminishing incomes in agriculture after the membership in EU (Åkerman 2005; Åkerman & Jänis 2005). Moreover, they are a means to persuade forest owners to follow 'good forest management practice'. Thus, instead of a scientifically determined objective principle based on which the technologies can be evaluated, the sustainability of wood energy is a relational phenomenon (see Guy & Farmer 2001, 140).

The different views include perceptions of what kind of wood energy technology is desirable and practical. Wood energy has a long tradition in Finland. Waste wood from industrial processes has been utilised by the forest industry for decades. The amount of forest biomass used as fuel

remained low, however, until the 1990s. Since the mid-1990s, the government has supported the industrialisation of forest fuel production. In addition to investment subsidies in energy production, a special programme on research and development was launched. The Wood Energy Technology Programme (1999–2003) was implemented to create cost-competitive large-scale production technologies for forest fuels (Hakkila 2004, 8). The main goal was to integrate energy production into conventional forestry and procurement of industrial timber (Hakkila 2003, 6). Technologies that effectively increase the volume of bioenergy production are also emphasised by the EU. The achievements of Pohjolan Voima, a Finnish forest industry related utility, for example, were awarded a prize in the European Conference for Renewable Energy in January 2004 (Pohjolan Voima 2004).

The success of industrial forest fuel production is complemented by efforts to promote a new organisational innovation, co-operative heating, in rural areas to create small heating businesses. From the perspective of climate policy these efforts are, of course, marginal because they do not contribute to the volume of bioenergy. For this reason, small businesses are often mentioned as a curiosity and an interesting side-development, not as a primary goal of renewable energy policy.[1] Small businesses would appear to be valuable, however, for rural development and forestry. The government has thus supported small businesses both from sustainable forestry funds and, indirectly, from the EU structural funds through wood energy projects. During the past ten years about 150 co-operatives and small businesses have been founded to supply heating services for municipal networks or premises; they provide heat for more than 170 heating units all over the country (Nikkola & Solmio 2003).

The availability of wood energy in its various forms requires mobilisation of a complex set of resources into a functioning production chain. Forest fuel technologies can thus be understood in terms of collective building through which heterogeneous elements are made to act in concert (see Latour 1999, 174). The processes of collective building take place within the underlying system of production: the existing practices of both industrial forestry and family forestry. When forest fuel technology travels across these different socio-economic contexts, it is simultaneously able to modify or strengthen the economic relations from which it grows. The economic positions of the actors are thus performed through the processes of collective building: the possibilities to act are built into the technologies of the utilisation of the forest resources.

To study the performance of the socio-economic relations, I analyse how forest fuel technologies work in different socio-economic situations. I use three case studies as examples of situations in which forest fuel production takes on its characteristic form and follow a semiotic method to analyse the cases (see Mol & Mesman 1996). I identify what elements in the three different situations constitute forest fuel technologies: how people, machines, forests, knowledge, concepts, ways of thinking, standards and routines are brought together in the narratives of wood energy. I thus pay attention to the meanings assigned to forest fuel technology, the circulation of these meanings and the material organisation of activities.

The empirical material of the case studies consists of written material produced by the chosen companies and interviews with them. The thematically organised interviews focused on the local histories of wood energy: narratives of how and why the actors got involved with forest fuels and how the work has been organised and modified. The interviews are complemented with written material produced by the actors (company brochures, annual reports and yearbooks, conference papers and publications, research reports and promotion material). In addition I use interviews with the promoters of wood energy (the Regional Forestry Centre of North Carelia and the national TTS Institute) and written material produced within the Wood Energy Technology Programme.

The paper is organised as follows. I start by introducing the three cases and describe the different socio-economic variants of forest fuel production (section 'Developing technology for forest fuel production'). After that I show how the different forms of wood energy are framed by modern forestry in Finland and raise the question of forest owners' economic position within the sector (section 'Industrial forestry and farm-based forestry as historically developed frameworks for the utilisation of forest fuels'). In the concluding section I discuss the consequences of fluidity and return to the question of (social) sustainability of bioenergy.

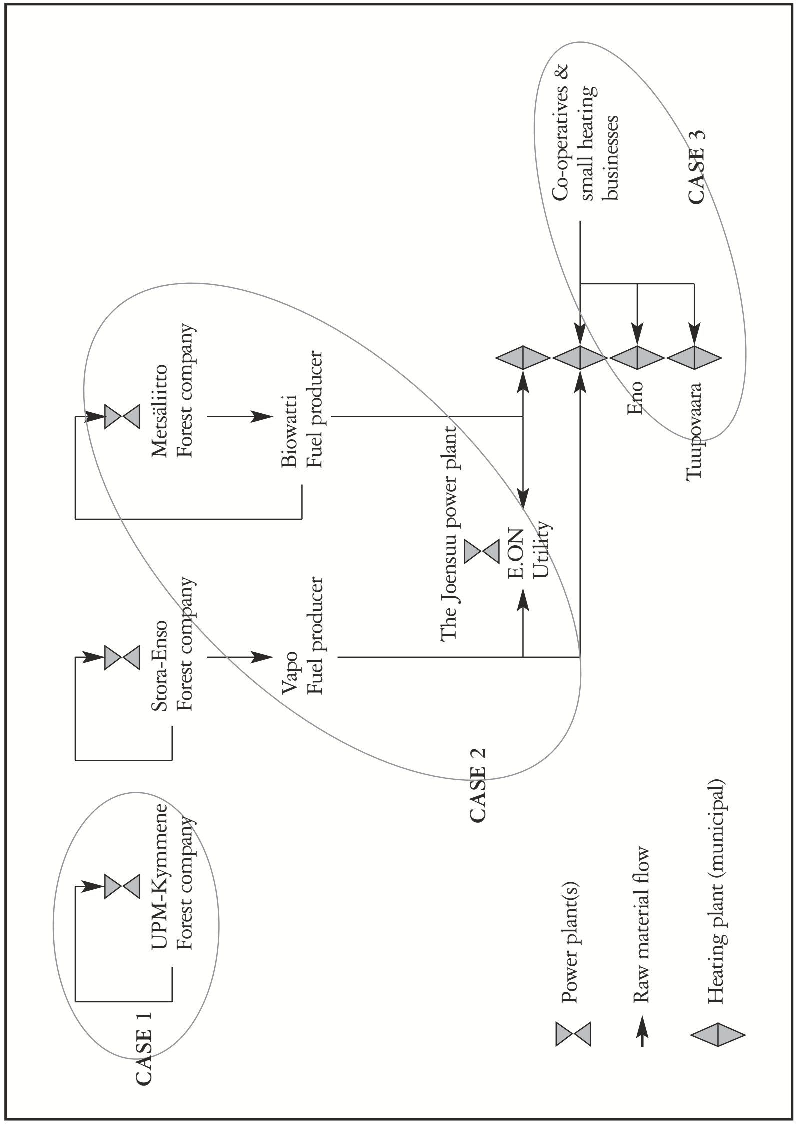
Developing technology for forest fuel production

The three case studies are: (1) the strategy of UPM-Kymmene, a big forest company, to utilise forest fuels in its Kaipola and Jämsänkoski paper mills in central Finland, (2) a commercial production chain consisting of wood fuel producers Vapo and Biowatti and their client utility Joensuun Energia/E.ON in eastern Finland and (3) two small-scale heating co-operatives in eastern Finland (Figure 1).[2] All the activities take place within a region that has been an important provider of industrial raw material in the 20th century (see e.g. Björn 2000).

Despite the same resource base there are significant differences in the scope and scale of the activities studied. The case of UPM-Kymmene illustrates the way how a large forest company draws different elements together to produce electricity from wood fuel for its own pulp and paper mills. UPM-Kymmene is a multinational forest company that operates globally. It owns large forest areas and runs pulp and paper mills and mechanical wood processing plants in Finland. It was among the first forest companies to recognise the potential of forest fuels. Forest industries used to reject forest fuels as expensive and even harmful because they were thought to endanger the raw material supply (Åkerman 2005). Since the mid-1990s all three largest forest companies in Finland, UPM-Kymmene, Stora Enso and Metsäliitto, seem to have changed their opinion about this.

In the second case, Biowatti, Vapo and the Joensuu power plant, which is owned by the multinational utility E.ON, form a commercial production chain for wood energy. Vapo and Biowatti sell fuel to the power plant, which provides heat for the provincial town of Joensuu, and electricity for the Nordic grid. The forest company Metsäliitto founded Biowatti in 1994 and recently bought one third of Vapo to develop commercial wood fuel production. Vapo also co-operates with the forest company Stora Enso. Vapo and Biowatti operate on the national level but they also import raw material from and export fuel to the neighbouring countries. In addition to big clients such as the Joensuu power plant, Biowatti and Vapo also supply fuel to smaller municipal heating plants and thus partly act on the same market as the small businesses and co-operatives.

Figure 1. Utilisation of forest fuels by different actors



In the third case, the Eno and Tuupovaara heating co-operatives act locally, operating only within the municipalities of Eno and Tuupovaara. In Finland, co-operatives and small businesses deliver fuel to municipally owned heating plants or private companies. Some co-operatives own heating systems and provide heating services instead of fuel. The two co-operatives chosen for this study have a mixed strategy of having both invested in their own heating equipment and delivering fuel to municipal systems.

In none of the cases forest fuels are the cheapest way to produce energy. Especially, in the large energy production units there are other fuel choices available: e.g. waste wood from industrial processes or peat. Therefore, in the following my focus is on the economic and social aspects which make forest fuels a feasible solution.

Forest fuels in forest industry: Support for the company strategy

UPM-Kymmene started to develop forest fuel technology systematically in the 1990s (interview 9). It launched a baling technique for cutting residues in co-operation with its partners and tested new methods for exploitation of stumps. These technologies are now utilised to supply forest fuels for the Kaipola and Jämsänkoski mills. Since the mills were not suffering from a lack of energy resources, the development of the new technology had to be justified by other reasons. I found out two basic requirements set by UPM for forest fuel production through which the use of forest fuels was linked with the goals of the company.

First, my informant emphasised that forest fuel production is reasonable when it is integrated into conventional industrial timber production and controlled by the forest company: the production of industrial raw material for the industrial processes or saw mills is the primary goal of the company (interview 9). By combining forest fuel and industrial raw material production UPM is able to optimise the use of existing resources, machinery (harvesters, trucks), labour (re-education and work planning) and infrastructure (information systems, physical structures), to improve the efficiency of forest fuel production.

Integrated into industrial raw material production, forest fuels consist mainly of residues from clear-cutting. Kaipola and Jämsänkoski mills obtain 50–60% of the forest fuels from clear-cutting residues, 35% from stumps that are collected after clear-cutting, and only 5% from small-sized stems from young forest growth. The latter is the most expensive raw material but UPM is willing to buy young stands 'as a favour to the forest owner' (interview 9). They thus accept the more expensive fuel to maintain good relations with forest owners who supply the industrial raw material. Improving efficiency is thus not the only reason for the tight link with the conventional timber production practices, but forest fuels are expected to support the primary activities of the forest company.

The second criterion for forest fuel technology links forest fuels to the company environmental policy. '[B]ecause Jämsänkoski and Kaipola are paper mills, our clients have asked for years about the fuel used in the process (…). The energy strategy of UPM is based on a commitment to use fuels that are CO_2 neutral' (interview 9, translated by the author). By using forest fuels UPM is able to anticipate future changes in environmental regulations and policies, such as the introduction of emissions trading and green certificates (interview 9; UPM-Kymmene 2003; see also Ruokonen 2003; Silvennoinen & Antila 2003).

In this context, forest fuels are a tool in the company's environmental policy. The technology is developed as a means of keeping central European paper customers satisfied without increasing production costs. Without the paper customers and international standards UPM would probably not bother to put any effort into forest fuels. Thus, in addition to local actors and existing resources that are drawn to timber production chains, international actors and their preferences are a crucial element in the forest fuel production chain of UPM. The new technology is expected to secure UPM's ability to stay competitive, strengthen its relations with forest owners and maintain its credibility in international paper markets.

Forest fuels in a commercial wood energy chain: Green business

In commercial power plants, such as the Joensuu plant, forest fuels have been utilised only to a little extent because there are many fuel choices which are cheaper than forest fuels. There are, however, important reasons to increase their share in the future.

Biowatti and Vapo, which are the main players in the commercial wood energy field, started to get involved in wood fuel supply encouraged by the growing demand for wood fuels in municipal heating systems and by utilities in the 1990s. Their client Joensuun Energia, for example, followed the strategy of similar utilities and increased the production of wood energy in its peat power plant as a consequence of the introduction of emission taxes in the mid-1990s (interviews 1, 2 and 7). Vapo, previously a peat producer, had to start to produce wood fuels too in order to stay in the market (interview 1). Biowatti was already in existence because the prospects for wood energy had started to look promising in the early 1990s (interview 6; Biowatti 2003). The tightening environmental regulations thus opened up a new business opportunity.

The increase in the use of wood fuels in the Joensuu power plant was related to production costs: a certain proportion of peat had to be replaced by wood fuels to comply with strict environmental regulations. After that the goals of the Joensuu power plant changed due to the opening of electricity markets in 1995. The current owner of the plant, the multinational utility E.ON, monitors the production volume on a daily basis based on the electricity price (interview 7). This has also changed the role of wood fuels, and made their role slightly contradictory. On the one hand, the representative of Joensuun Energia/E.ON emphasised that the use of wood fuels is determined by the market situation (interview 2). Expensive forest fuels fit poorly into this scheme, and the company prefers to use waste wood from mechanical forest industry. On the other hand, wood energy has become an additional source of profit: '[G]reen electricity for Holland, for Joensuun Energia, it has been a big thing, economically' (interview 7, translated by the author). Instead of being a mere cost factor wood fuels have turned into a strategic element. The new technology is expected to enable successful operation in the electricity market.

Wood fuels used in the plant are mainly delivered by Vapo and Biowatti, or are obtained directly from a nearby Stora Enso pulp mill (interview 7). Tied to the price of electricity and profit-making goals, there is a constant pressure to develop wood fuels into an economically viable alternative. Both companies primarily use the most cost-efficient raw material, i.e. industrial waste wood, but the future growth of the business is tied to forest fuels. 'Because wood energy production has increased [in Finland] industrial waste wood has become a scarce resource. The amount of waste wood won't increase without new investments in [mechanical forest] industry. This means our growth will be based on forests' (interview 8, translated by the author). Both companies have developed methods for collecting clear-cutting residues, and most recently also for mechanised thinning of young forests (interviews 1 and 6; Salo 2004). Their main challenge is to cope with the decentralised resource base. The cost structure is improved by utilisation of existing infrastructure (old peatlands as interim terminals, timber trade organisation provided by Metsäliitto) and equipment (peat and log trucks) (interviews 2 and 8; see also Tekes 2003). The aim is to control the logistic chain and optimise the use of resources in a similar manner than the forest company UPM-Kymmene.

Biowatti and Vapo have been able to stabilise their position in the market through standardisation of forest fuel production. This is important in winning big clients such as the Joensuu power plant, but also smaller municipal energy production units as customers. In the latter case, they also use another strategy. They explicitly claim to produce 'local energy' (e.g. Vapo 2003)—i.e. they use the local image of wood energy in their marketing strategies—although they import raw material even from Russia (interview 2; Biowatti 2002). They have thus adapted the discourse on local economic effects to highly industrialised practices in order to expand their activities.

Use of forest fuels in the commercial chain is based on mixing business strategies and discourses on the environment and local economy. Although forest fuels are more expensive than waste wood, they enable companies to widen their raw material base and provide the prospect of increased profits for the future. Forest fuels are thus needed to create a sense of temporal continuum for a business that is seeking growth.

Forest fuels in co-operative heating: Widening the basis for local livelihood

The third case concerns forest fuels in the municipal sector in which the first experimental wood fuel technologies applied in the 1970s were mostly abandoned during the 1980s due to technical and logistic problems. A second generation of wood fuel based heating systems was born in the 1990s. The new effort was based on a more mature technology as well as a new model for fuel supply. Commercial fuel supply was introduced to solve the logistic problems of the old municipally managed systems. Since the mid-1990s, high oil prices have made wood fuels attractive to municipalities. Vapo and Biowatti are able to deliver wood fuels for a price that is approximately one third of the price of oil.

The growing interest in wood fuels in the municipal sector gave also birth to numerous small heating businesses and co-operatives. The Tuupovaara heating co-operative, founded in 1996, was the first heating co-operative in eastern Finland to import the new organisational innovation from the west coast (interviews 4 and 8); The Eno heating co-operative followed suit in 1999 (interview 3). The local co-operatives have tried to improve their competitiveness by minimising their transportation costs and using existing equipment such as farming tractors. Their price competitiveness compared with big commercial actors, however, remains low (interview 3).

Since the nearly two hundred small businesses have survived, there has to be other ways to compete with the big commercial actors. From the narratives of Tuupovaara and Eno, I identified two different strategies to improve the competitiveness of small businesses. First, good local relations with the municipality were needed to legitimise a higher price. In Tuupovaara the higher energy price was justified by the goal of local economic development. The representative of the municipality explained that: 'Our aim was not to save money but the idea was that by utilising our own energy resources we were able to circulate locally the same amount of money we used to spend on light fuel oil' (interview 10, translated by the author). Also in Eno, the local co-operative secured a steady flow of income by a reasonable contract with the municipality.

In both localities, the discourse on the local economy aligned the interests of local forest owners and the municipality.[3] The focus on the local economy has an effect on the material shape of production. Because the money is circulated locally, the production chains tend to remain short.

Second, both the Tuupovaara and Eno co-operatives strengthened their position and secured their activities by making otherwise risky investments in the heating equipment and networks (interviews 8 and 11). If the co-operative controls the technical structure there is no risk of competition. In both cases, however, significant effort was required to encourage forest owners to make investments outside the scope of their traditional economic activities. To convince the forest owners, wood energy was linked to forestry goals: The idea of an unused resource base which can be exploited for energy production was brought up by the Regional Forestry Centre of North Carelia—an important facilitator of both co-operatives (interview 4).

The idea of unused resources originates from the commonly accepted forestry principle that young, growing forests have to be thinned regularly to improve forest growth. Forest owners are, however, often reluctant because of the costs involved. While forest industry has preferred to harvest mature forests there has been no demand for small sized timber. As a consequence, vast areas of young forests have remained unmanaged, and the problem has been addressed in the national forest policy (MAF 1999; see also Åkerman 2005). In line with forest policy, forest fuel production concentrates on young forests; only one fifth of the fuel supplied by small businesses is based on other sources, such as industrial waste wood or clear-cutting residues (interview 5).[4]

In both Eno and Tuupovaara the majority of the fuel comes from the young forests owned by the members of the co-operative (interviews 3 and 8). My informants, however, also recognised a tension between the forestry goals and energy production: 'I believe [clear-cutting residues] would be the cheapest raw material, and we could get enough of it. But using them would not at all be ideal for forestry in the same way as thinnings are. However, we have to be realistic. (…) If our business gets bigger, we just have to forget the ideal model [of forest management]' (interview 3, translated by the author). The use of less expensive raw materials would improve the price competitiveness of small actors. Forestry goals have been an important stimulus for the use of forest fuels but small businesses may have to expand their resource base in the future. This, however, may be difficult because they would have to compete with the bigger companies for the raw material.

Industrial forestry and farm-based family forestry as historically developed frameworks for the utilisation of forest fuels

My analysis of the three cases shows that forest fuel technology is flexible both in terms of technical structures and institutions. Its success can be built on sophisticated IT based industrial harvesting machinery as well as traditional farming tractors. It can easily adjust to private business practices and international electricity market or it may find its place in a local community. This does not mean, however, that anything goes. Forest fuel technology is fluid within the established practices and institutions of the Finnish forestry and energy production sectors.

The underlying systems of production affect also the economic relations of forest fuel production. Wood energy in general is tied to the structures of the energy sector. Finland is known for its high energy consumption and centralised structure of energy production. This has also affected the development of wood energy. Finnish energy sector has been driven by the needs of forest industry which is the largest consumer of energy. The role of decentralised energy production has played a minor role in Finnish energy policy. Therefore also efforts to develop new small scale technologies have often been deemed unrealistic by engineers (Åkerman 2005).

At the same time, the different forest fuel production chains are based on modifications of existing forestry practices. Industrial forest fuel production relies on standardised industrial forestry practices and small businesses on farm-based family forestry. In Finland, 62% of forests belong to private forest owners (MAF 2000). Forestry forms an important part of rural income although the share of farmer forest owners has decreased. In farms, the practices of forestry are based on the family as the basic economic unit. Governing the activities of forest owners has been a challenge for Finnish forestry, because the forest industry is dependent on the raw material supply from private forests. Family forestry is guided by scientific principles and norms to fulfil the goals of industrial forestry (see Jokinen 2006). The practices of industrial forestry and family forestry are thus closely related. Together these practices affect the way the different fuel chains coexist. In this section I explore this coexistence by focusing on one of the most important aspects of forestry: the timber trade, the mechanism that puts the raw material on the move.

The timber trade in Finland is mainly in the hands of forest companies which prefer standing sales: they harvest the forest themselves instead of buying timber harvested by forest owners and their contractors.[5] The practice was established in eastern Finland as early as the late 19th century when the growing forest industry needed greater amounts of timber than ever before (Björn 2000, 73). This structure has been accepted as a fact in national forest fuel policy: because a major proportion of timber is harvested by industrial production chains it is regarded as a 'natural solution' to integrate forest fuel production into these chains (Hakkila 2003, 12). The forest industry also prefers the existing socio-economic order: the representative of UPM considered it 'difficult' to arrange the production of forest fuels by other than industrial actors (interview 9).

The technological momentum of both forestry as a large technical system (see Toppinen 2000) and the energy production system, which tends to favour big centralised units (Åkerman 2005), seems to make industrial wood fuel production a mainstream solution. According to Björn (2000, 67), the idea of industrial forestry as a superior way of utilising forest resources runs like a red thread through the entire history of Finnish forestry since the establishment of export oriented companies in the 1860s. Wood energy policy is also based on the idea that industrial forest fuel production provides the best means for sustainable energy production. Here Finnish wood energy differs from that of other countries. For instance, in Sweden and Austria, the two European countries where the use of wood energy has increased, the situation is different (see Kostron 1999). In Sweden, where the forest industry does not dominate the timber trade to the same extent as in Finland, small businesses emerged a decade earlier than in Finland. In Austria, where the forest industry has a minor role and clear-cutting is restricted, wood energy is primarily produced by small businesses.

The preference of industrial forest fuel technology has consequences for those involved in the production chains. The efficiency of industrial forestry is based on routinisation achieved through standardisation and

organisation of both forest work and forests. Jokinen (2006) showed how the introduction of the scientific principles of rotation based forestry affected forest owners' practices and routines in a profound way. This took place through the modification of forests into a hybrid of forest management categorisations and the natural entity itself suitable for efficient management and harvesting of the resources. The forest owners, however, had little influence on the development of the mechanised forest management technologies and the industrialised system (Jokinen 2006).

Although forest owners' are organised to secure their interest in the timber market, their position in the timber trade is seemingly contradictory. When forest owners sell timber to forest companies they do not actually know the price of the product they are selling, because forest companies do not reveal the cutting costs (Vaara 1994). Logging contractors who do the actual forest work are also given a marginal position. Since the forest companies determine the cutting machines and methods used as well as the investment schedule and have a monopoly on their services, the logging contractors are not independent entrepreneurs but more like employees who bear the economic risk (Vaara 1994).[6] The forest owners and contractors within industrial forestry—and respectively in industrial forest fuel production—are thus not economic actors in the sense they would be as independent businesses. Their position resembles the farmers' position within the prevailing conventional agricultural system described by Morgan and Murdoch (2000): forest owners and contractors are not *knowing agents*, but economic knowledge and technological expertise is placed and economic decisions are made elsewhere in the production chain. In the forestry sector, this socio-economic order was strengthened by corporatism, suspected cartels of the largest companies (e.g. *Karjalainen* 26.5.2004) and increasing timber imports from Russia.

In industrial forest fuel production, the forest industries thus maintain control of forest work and forest resources. A forest company can decide how it is going to use the resource, and it is difficult for a forest owner, for example, to sell raw material for fuel to one buyer and industrial timber to another. This control of privately owned forests and forest work has been a crucial element of Finnish forestry and has enabled the highly industrialised use of forests (Björn 2000, 70).

The structure of the timber trade directly affects the possibilities of co-operatives and small businesses to act in the field of forest fuel production. The forestry sector has been criticised for allowing little room for independent contractors (Palo 1993). Small businesses do not easily gain access to cheaper forest fuels such as cutting residues, because forest companies control the use of resources.[7] They have to utilise more expensive fuels, such as small sized stems from thinnings and remote lots in which the forest companies or commercial producers are not interested. The preference for industrial forest fuel production thus affects the economic potential of small businesses by affecting their price competitiveness. The problem of price competitiveness is also related to the goals of rotation-based forestry through which forest owners are guided and industrial raw material production is optimised. When small businesses are justified by these, they are supposed to use small-sized timber from thinnings as raw material. A key question for the future is whether the forest owners will gain access to other sources of fuel as well.

Because the practices of conventional forestry seem to be fairly stable, it would be easy to draw a conclusion that the prospects of small businesses are not very promising. However, I would like to put forward a more positive interpretation of the situation. The fact that the production of forest fuels has grown in different directions is a sign of the diversification of the economic landscape of forestry. Although the development of forest fuel technologies can to some extent be identified as 'projects' aiming at fulfilling economic goals of the companies involved, the diversification of practices cannot be reduced to the economic choices of these individual actors. The metaphor of 'path creation' used by Laurent Thévenot (2002) illustrates the situation nicely. According to Thévenot, a hiking trail is not designed or planned as a functional instrument but is a consequence of both physical topography and frequent use. The trail is thus not a product of intentional human action (aiming to create a route from place A to B) but a pattern of human engagement with nature. The technological trajectories of forest fuel production resemble 'path building' in a sense that the routine exchanges with the existing institutional (conventional forestry) and physical environment (forests as a hybrid of management practices and nature) have affected their shape.

Importantly, the routines produced new economic possibilities within forestry. For instance, intensive forest cutting in the 1950s and 1960s followed by the forest owners' reluctance to obey the norm of rotation-based forestry and the forest industries' focus on clear-cutting resulted in large amount of unmanaged young forests. The identification of these forests as a national problem became an integral element of the small scale forest fuel practices. Local routines of forest owners and regional forestry organisations are equally important here. Forest owners were unhappy about their obligation to follow the forestry principles and they started to look for new solutions to the problem by creating local markets for forest fuels. The unsuccessful model of industrial forestry thus gave birth to a new resource that could be exploited in an unusual way. Forest owners were able to use their own experience from acting within the conventional system of forestry to create something new.

Conclusions

The difficulty with fluid technologies is that despite their ability to take different shapes they also appear stable and unified when viewed from any particular, fixed perspective. From the perspective of Finnish climate and energy policy, for instance, the identity of forest fuel technology is fixed and linked to CO_2 emissions. It is assumed that the different wood energy technologies can be evaluated by using the same criteria. Identification of alternative perceptions thus allows us to gain a fuller picture of the situation. The description of differences for purely academic interest in how technologies are constructed, however, was not my primary goal (for the critique of 'neutral' social constructionism see Evans, Guy & Marvin 1999). My account of forest fuel technology as fluid and context dependent, is a political claim in itself. I am addressing an alternative way to assess the technological change: material flows tell little about the social aspects related to the production practices.

My analysis allows me to develop the argument of Guy and Farmer (2001) further. They argue that efforts to construct consensus or build up an 'objective' view on sustainability based on rational science and standardisation ignore competing and often local forms of knowledge. Their idea is close to what Hajer and Fischer (1999, 8) call *cultural politics* of sustainability: the discourses of sustainability have consequences through certain systems of ordering that are maintained or imposed on others. In my view, the hegemony of the scientific concept of sustainability emphasising the material flows of energy production not only dismisses other perceptions of sustainability but also ignores the potential related to the diversification of forestry practices. This means that the possibilities to act within forestry may easily be restricted and the focus on one, fixed idea of sustainability may have concrete consequences on the use of natural resources.

To overcome this dilemma I would suggest that emphasis is also placed on economic agency as an important social aspect of sustainability. Local actors, such as forest owners, have different possibilities to act, make decisions and know within the technological systems. Therefore, the identification of processes through which new political alternatives are formed is important. The thriving of small heating businesses is a wonderful example of new political alternatives. It proves that new actors can emerge even within standardised technologies. The efforts of small businesses to extend their potential to act thus deserve an in-depth inquiry that is beyond the scope of this paper. This kind of change in economic and social relations has been pin-pointed by Palmberg (2001) as a critical factor in promoting innovations and development in low-tech industries such as forestry. This is supported by Tahvanainen's (2004) view that, in the current situation, alternative models in the timber trade might provide a quicker improvement in cost efficiency of forestry than mere technical innovations.

The diversification of forestry practices may thus prove beneficial for the general development of forestry in Finland. For instance, co-operative forest fuel production may open up new possible futures for forestry by creating demand for independent logging businesses and by extending the scope of forest owners' economic choices. The focus on fluidity as a quality of technology helps to trace the processes of diversification and to assess the social sustainability of technologies by emphasising the changing economic positions of actors.

Notes

1 The focus of R&D has been on large industrial solutions. For instance, in a bioenergy conference organised by the Bioenergy Association of Finland in September 2003, only 9 presentations of the total of 118 presentations dealt with small businesses (see FINBIO 2003). A sub-programme of the Wood Energy Technology Programme for small-scale energy production started two years after the main programme (Hakkila 2004). The interview with the representatives of the TTS Institute, one of the promoters of small-scale heating, reveals that small businesses were included into the technology programme almost accidentally, as a tiny part of one project (interview 5).

2 The cases are part of an extensive study on wood energy in Finland funded by the Academy of Finland, Research Programme on Sustainable Use of Natural Resources (project 'Socio-economic conditions for sustainable use of wood fuel' 2001–2004) and Kunnallisalan kehittämissäätiö (project 'Local economic effects of wood fuel production' 2001–2005). I want to thank the co-researchers Maria Åkerman and Leena Leskinen for useful insights into the development of forest fuel technology and for sharing some of their research materials with me. I also thank professor Yrjö Haila, Ari Jokinen and Juha Hiedanpää for their comments on the earlier versions of the manuscript.

3 This discourse has been commonly used to legitimate wood fuels in the municipal sector in Finland. It was used in a slightly different form emphasising self-sufficiency as early as the 1970s. In the early 1990s it reappeared focusing on the role of entrepreneurs in local economy (see also Åkerman 2005; Peltola 2006).

4 There is regional variation in the small-scale utilisation of forest fuels: the working environment offers different possibilities for the small actors. For instance, in southern Finland, where Annosus root rot is a problem, damaged trees are available for fuel production. In eastern and central Finland, there are vast areas of young forests due to intensive forest cutting in the 1950s and 1960s, and thinning of these forests provides resources for energy production.

5 In 2002, 78% of timber trade was effected by the forest companies (FFRI 2003, 150). In a recent newspaper interview, a manager of the North Carelia Union of Forest Owners estimated that in eastern Finland, the three largest companies have a share of up to 90% of the timber market (*Karjalainen* 21.2.2003).

6 The role and economic possibilities of contractors and forest owners is a controversial matter in Finnish forestry. For instance, the studies of Lauri Vaara have been disputed on the basis of weak statistical analysis. The problem of his studies is that it is hard to analyse economic structures when access to statistical information is denied by the forest industry. This example actually illustrates the

profound domination of forest industry that also reaches into the sphere of scientific knowledge production. Vaara's examples of the practices of the timber trade and forest work can, however, be used as qualitative illustrations of the mechanisms that determine the position of actors within forestry. Moreover, forestry professionals also acknowledge these problems of the timber trade and have also brought them up in public (e.g. *Karjalainen* 21.2.2003).

7 In some cases the combustion technology used in small heating units may also exclude the utilisation of fine-graded slash chips.

References

Åkerman, Maria (2005, forthcoming), 'Risusavotasta maaseudun teknologiaihmeeseen. Puun energiakäyttöä tukevat käännökset metsätalouden, energiapolitiikan ja maaseutupolitiikan kentillä', *Alue ja Ympäristö* 34.

Åkerman, Maria and Laura Jänis (2005, forthcoming), 'Lähienergiaa puusta – maatalouden ja energiantuotannon synergiaeduista voimaa maaseudun kehitykseen', *Maaseudun Uusi Aika*.

Biowatti (2003), 'Clean Energy from Wood', a company brochure.

Biowatti (2002), 'Vuosikertomus 2002', annual report.

Björn, Ismo (2000), *Kaikki irti metsästä. Metsän käyttö ja muutos taigan reunalla itäisimmässä Suomessa erätaloudesta vuoteen 2000* [Capitalizing on the forest. Use, users and change in the forest in the wilderness economy on the edge of the taiga in eastern Finland through the year 2000, in Finnish with English summary], Bibliotheca Historica 49, Helsinki: Suomen historiallinen seura.

Demeritt, David (2001), 'The construction of global warming and the politics of science', *Annals of the Association of American Geographers* 91 (2): 307–337.

Evans, Robert, Simon Guy and Simon Marvin (1999), 'Making a difference: Sociology of scientific knowledge and urban energy policies', *Science, Technology & Human Values* 24 (1): 105–132.

FINBIO (2003), *Bioenergy 2003. International Nordic Bioenergy Conference from 2nd to 5th September, 2003. Book of Proceedings*, The Bioenergy Association of Finland.

FDHA, Finnish District Heating Association (2003), Homepage: http://www.energia.fi/page.asp?Section=145, read 20.11.2003.

FFRI, Finnish Forest Research Institute (2003), *Finnish Statistical Yearbook of Forestry 2003*, SVT Agriculture, Forestry and Fishery.

Gomart, Emilie and Maarten Hajer (2003), 'Is that politics? For an inquiry into forms in contemporary politics', in Bernward Joerges and Helga Nowotny (Eds.), *Social Studies of Science and Technology: Looking Back Ahead*, Dordrecht: Kluwer Academic Publishers.

Guy, Simon and Graham Farmer (2001), 'Reinterpreting sustainable architecture: The place of technology', *Journal of Architectural Education* 54 (3): 140–148.

Hajer, Maarten A. and Frank Fischer (1999), 'Beyond global discourse: The rediscovery of culture in environmental politics', in Frank Fischer and Maarten A. Hajer (Eds.), *Living with Nature. Environmental Politics as Cultural Discourse*, Oxford: Oxford University Press.

Hakkila, Pentti (2003), *Developing Technology for Large-Scale Production of Forest Chips. Wood Energy Technology Program 1999–2003*, Technology Programme Report 5, Helsinki: National Technology Agency Tekes.

Hakkila, Pentti (2004), *Developing Technology for Large-Scale Production of Forest Chips. Wood Energy Technology Program 1999–2003. Final Report*, Technology Programme Report 6, Helsinki: National Technology Agency Tekes.

Jokinen, Ari (2006, forthcoming). 'Stand/ardization and entrainment in forest management', in Chuck Dyke and Yrjö Haila (Eds.), *How Nature Speaks: The Dynamics of the Human Ecological Condition*, Duke University Press.

Karjalainen 21.2.2003, 'Metsänomistaja ei pärjää yhtiöille omassa metsässään'.

Karjalainen 26.5.2004, 'Epäilyjä ja ratsioita metsäyhtiöissä'.

Kostron, Sirit (1999), *Biomass Utilisation in Austria and Sweden: A Comparison*, Master's Thesis, Graz: Karl-Franzens-University.

De Laet, Marianne and Annemarie Mol (2000), 'The Zimbabwe Bush Pump: Mechanics of a fluid technology', *Social Studies of Science* 30 (2): 225–263.

Latour, Bruno (1999), *Pandora's Hope. Essays on the Reality of Science Studies*, Cambridge, MA/London: Harvard University Press.

Leskinen, Leena A. (2003), 'Puun energiakäytön edistämisen tavoite metsäkeskuksen toiminnassa', in Jukka Tikkanen, Leena A. Leskinen, Tarja Isokääntä and Esa Heino (Eds.), *Metsäsuunnittelun yhteistoiminnallista perustaa etsimässä. Tuloksia yksityismetsätalouden suunnittelun kentästä*, Metsäntutkimuslaitoksen tiedonantoja 904, Kannus: Metsäntutkimuslaitos, Oulun seudun ammattikorkeakoulu: 51–57.

MAF, Ministry of Agriculture and Forestry (1999), *Kansallinen metsäohjelma 2010* [The national forestry program 2010], Publications of Ministry of Agriculture and Forestry 2, Helsinki.

MAF, Ministry of Agriculture and Forestry (2000), *The State of Forestry in Finland 2000. Criteria and indicators for sustainable forest management in Finland*, Publications of Ministry of Agriculture and Forestry 5a, Helsinki.

MTI, Ministry of Trade and Industry (1999), *Uusiutuvien energialähteiden edistämisohjelma* [Renewable energy program], Publications of Ministry of Trade and Industry 4, Helsinki.

MTI, Ministry of Trade and Industry (2003), *Energy Review* 2, Helsinki.

Mol, Annemarie and Jessica Mesman (1996), 'Neonatal food and the politics of theory: Some questions of method', *Social Studies of Science* 26 (2): 419–444.

Morgan, Kevin and Jonathan Murdoch (2000), 'Organic vs. conventional agriculture: Knowledge, power and innovation in the food chain', *Geoforum* 31: 159–173.

Mottinetti® (2004), 'Polttopuut verkosta', Homepage: www.mottinetti.com, read 13.7.2004.

Nikkola, Ari and Harri Solmio (2003), *Lämpöyrittäjätoiminta vuonna 2002*, Työtehoseuran metsätiedote 668.

Palmberg, Christopher (2001), *Sectoral Patterns of Innovations and Competence Requirements —A Closer Look at Low-Tech Industries*, Sitra report series 8, Helsinki: Sitra.

Palo, Matti (1993), 'Ympäristötietoisen metsäpolitiikan strategia', in Matti Palo and Eeva Hellström (Eds.), *Metsäpolitiikka valinkauhassa*, Metsäntutkimuslaitoksen tiedonantoja 471, Helsinki: 307–467.

Peltola, Taru (2006, forthcoming), 'Calculating the futures: Stability and change in a local energy production system', in Chuck Dyke and Yrjö Haila (Eds.), *How Nature Speaks: The Dynamics of the Human Ecological Condition*, Duke University Press.

Pohjolan, Voima (2004), 'Pohjolan Voiman biopolttoaineohjelma voitti EU-kilpailun', Homepage of Pohjolan Voima http://www.pvo.fi, read 28.1.2004.

Poikola, Juha (2003), 'Practical experience of large scale production of forest chips', in *Bioenergy 2003. International Nordic Bioenergy Conference from 2nd to 5th September, 2003. Book of Proceedings*, The Bioenergy Association of Finland: 233–235.

Ruokonen, Juha (2003), 'New market based instruments: Green certificates and emissions trading—How to optimise when active in both markets?', in *Bioenergy 2003. International Nordic Bioenergy Conference from 2nd to 5th September, 2003. Book of Proceedings*, The Bioenergy Association of Finland: 125–128.

Salo, Matti (2004), 'Kokemuksia eneriapuun tuotannosta nuorissa metsissä', paper presented at the seminar 'Nuoret metsät energialähteenä', 1 September 2004, Tekes: Joensuu.

Silvennoinen, Anja and Heli Antila (2003), 'Emission trading—impacts to energy companies and businesses?', in *Bioenergy 2003. International Nordic Bioenergy Conference from 2nd to 5th September, 2003. Book of Proceedings*, The Bioenergy Association of Finland: 121–124.

Tahvanainen, Timo (2004), 'Metsähake ja puukauppa', in Pertti Harstela (Ed.), *Metsähake ja metsätalous*, Metsäntutkimuslaitoksen tiedonantoja 913, Jyväskylä: Metsäntutkimuslaitos: 37–48.

Tekes (2002), *Growing Power. Advanced Solutions for Bioenergy Technology from Finland*, Helsinki: The National Technology Agency.

Tekes (2003), *Efficient Technology for Competitive Production of Forest Chips. The Finnish Wood Energy Technology Program 1999–2003*, Helsinki: The National Technology Agency.

Thévenot, Laurent (2002), 'Which road to follow? The moral complexity of an 'equipped' humanity', in John Law and Annemarie Mol (Eds.), *Complexities. Social Studies of Knowledge Practices*, Durham/London: Duke University Press: 53–87.

Tirkkonen, Juhani (2000), *Ilmastopolitiikka ja ekologinen modernisaatio* [Climate policy and ecological modernisation—A discoursive study of Finnish climate policy and its connection to the change in the forest sector, in Finnish with English abstract], Acta Universitatis Tamperensis 781, Tampere: Tampere University Press.

Toppinen, Aino (2000), 'Suomen metsäsektori laajana teknologisena järjestelmänä', *Alue ja Ympäristö* 29 (2): 23–35.

UPM-Kymmene (2003), 'UPM-Kymmene, Jämsänkoski ja Kaipola, Ympäristöselonteko 2002' [Environmental report of Jämsänkoski and Kaipola mills 2002, in Finnish].

Vaara, Lauri (1994), *Puun pystykauppa ja sen vaikutukset puuntuotannon yritystoimintaan*, Metsäntutkimuslaitoksen tiedonantoja 483, Helsinki: Metsäntutkimuslaitos.

Vapo (2003), 'Vapo Energy. Local Energy—Close at Hand', a company brochure.

Interviews

1 Vapo Oy Energia, Joensuu 12.2.2003

2 Joensuun Energia Oy/E.ON 14.5.2003

3 Eno heating cooperative 14.5.2003

4 Forestry centre of Northern Karelia, Joensuu 14.5.2003

5 TTS-Institute 22.5.2003*

6 Biowatti Oy, Savonlinna 17.6.2003

7 Fortum-Service Oy, Joensuu 18.6.2003

8 Tuupovaara heating cooperative 18.6.2003

9 UPM-Kymmene Oyj, Jämsänkoski and Kaipola Mills 9.9.2003

10 The municipality of Tuupovaara 22.9.2003

11 Independent logging contractor/Eno heating cooperative 1.9.2004

* *The interview was made by Maria Åkerman*