Biofpr
Biofuels Bioproducts & Biorefining

Bioenergy production chain development in the Netherlands: key factors for success

Johannes (Hans) W.A. Langeveld, Biomass Research, Wageningen, the Netherlands
Ria Kalf, KEMA, Arnhem, the Netherlands
H. Wolter Elbersen, Agrotechnology and Food Science Group, Wageningen, the Netherlands

Received December 17, 2009; revised June 8, 2010; accepted July 8, 2010
View online at Wiley Online Library (wileyonlinelibrary.com); DOI: 10.1002/bbb.240;
***Biofuels, Bioprod. Bioref.* 4:484–493 (2010)**

Abstract: Development of bioenergy production in the Netherlands is lagging. This paper presents an inventory of problems met by new bioenergy chains and compares these to literature and to other countries. Theoretical frameworks suggest that five elements are crucial for successful bioenergy chain development: (i) availability of (proven) technology; (ii) access to information; (iii) access to feedstocks, financial means, and markets; (iv) locations for new installations; and (v) efficient lobby activities and public support. Nine bioenergy chains were interviewed. Problems that are reported relate to insufficient knowledge of new technological concepts, and of nuisances (noise, emission, odor, and other) caused during bioenergy production. Feedstock markets (wood, byproducts, waste) and product markets (heat, CO_2) are underdeveloped, while some chains are experiencing extra problems finding a suitable location or obtaining necessary permits. Problems related to insufficient public support are most relevant for bioenergy chains depending on tax exemptions (pure vegetation oil transportation fuels) or requiring adaptation of legislation (location permits for farm fermenters). An international comparison to barriers for biofuel suggests that economic factors (including lack of capital), limitations in know-how and institutional capacities, underdeveloped biomass and carbon markets, problems in chain coordination, and limited public support are largest problems for new bioenergy chains. Recommendations to stimulate bioenergy production in the Netherlands refer to performance standards for new installation types, information on feedstock availability, protocols for heat exchange and on improved credit facilities. © 2010 Society of Chemical Industry and John Wiley & Sons, Ltd

Keywords: supply chain development; fermentation; combustion; biogas; biofuels; stakeholders

Correspondence to: Johannes (Hans) W.A. Langeveld, Biomass Research, P.O. Box 247, 6700 AE Wageningen, the Netherlands.
E-mail: hans@biomassresearch.eu

SCI

Bioenergy in the Netherlands

The Netherlands is a small but densely populated country consisting of an extended delta and higher sandy and clay areas, plus old and newly developed polders. Farmers combine effective agricultural production with imports of animal feed and other biomass. High availability of agricultural biomass is fed into a network of large-scale food, feed, and chemical industries, which is combined with effective logistical (harbors, rivers) and knowledge infrastructures.[1] The energy sector, using gas in the Netherlands and oil from overseas, can absorb much of the biomass components that cannot be utilized in food and feed production.

Dutch environmental policy historically has focused on water and air quality, addressing issues like waste-water treatment, eutrophication, and – more recently – emissions of NOx, ammonia, nitrate, and fine particles. Policy objectives include the reduction of greenhouse gas (GHG) emissions by 20% by 2020 (as compared to 1990), an annual 2% energy saving and a 20% share of renewable energy by 2020. In 2001, the government initiated stakeholder platforms to define desirable transition pathways to help realize these objectives.[2] One of these platforms recommended to (i) accelerate biomass-based innovations; (ii) stimulate sustainable biomass trade; and (iii) develop synergies between chemical, energy, and agro-food industries.

In theory, basic conditions for such a development are met. Available biomass (primary, agro-industrial byproducts, wastes), transport and logistics infrastructure, and the presence of agro-related (food, feed) and chemical industries provide a solid basis for biorefinery and bioenergy development while opportunities for the use of biorenewable feedstocks in chemical production chains (alongside petrochemical feedstocks) are increasing.[1] It requires that efficient use is made of available biomass and effective cross-sectoral collaboration can be organized. In practice, however, to date (large-scale) biofuel production, biorefinery, or other biobased production still are in the infant development stage. This may be explained by the fact that current energy institutions, oriented toward fossil fuels, are showing a certain resistance to reorient towards biomass. Large efforts are also needed to reorient the focus of the chemical industry, as in developing infrastructure for the utilization of excess process heat and bioenergy infrastructure in general.[2]

On a total land area in the Netherlands of 4 million ha of which half can be cultivated (0.8 million ha of arable land and 1.0 million ha grasslands plus some 0.4 million ha of forest area), annual biomass production amounts to only 31 million tonnes,[3] representing 527 PJ or 17% of the national annual energy consumption.[4] Biomass imports supplement a further 33 million tonnes, while exports amount to 22 million tonnes (620 and 405 PJ, respectively). Domestic production plus net imports thus are equal to one-quarter of the annual energy requirements,[3] but clearly not all is available for energy production. Future (2030) primary coproduct (forest and crop residues, straw) availability in the Netherlands has been estimated at 6 million tonnes of dry matter or some 100 PJ with secondary and tertiary coproducts amounting to 12 million tonnes.[5]

Stimulated by an active renewable energy policy, a large number of initiatives have been started to produce the necessary heat and power, biogas, and biofuels. The total bioenergy contribution in the Netherlands in 2008 is estimated by CBS at 97 PJ.[7] Three-quarters of this was generated by biomass combustion, most by burning biomass waste and co-firing of biomass in existing coal-fired power plants; biogas production contributed 9.3 PJ, biofuels 14 PJ. The share of total energy production is 3.4%, recovering from a dip in 2007 (2.4%, down from 2.8% in 2006).[8] The number of successful initiatives in bioenergy production varies for each bioenergy category (combustion, biofuel, fermentation). Nine large-scale biomass combustion installations were running at the end of 2007, with a cumulative input of 4500 tonnes/y of biomass.

At the end of 2006, the Netherlands had some 80 small-to-medium scale bioelectricity installations, 15 of which were combustors and 64 digesters. In addition, some 400 small-scale combined heat and power projects had been planned in 2007, but due to recent changes in subsidies, a large number of these were either aborted or put on hold.[8] With respect to biofuels, consumption amounted to 429 kton in 2008, equally distributed among biodiesel and bioethanol. Domestic bioethanol production (less than 7 kton in 2008) can cover only a small share of bioethanol consumption (close to 200 kton),[7] the rest being supplied through imports.

Conditions for bioenergy chain development

Current developments suggest that the realization of the stated policy objectives requires more focused efforts. Dutch renewable energy policy is criticized for a lack of consistency and a lack of long-term financial support. In addition, other problems, not related to policy support, may also play a role. Any new bioenergy production chain should bring together new feedstocks, markets, and actors. Often, initiators and entrepreneurs are confronted with huge barriers.[9] The current study presents a survey of problems encountered by entrepreneurs starting new bioenergy chains in the Netherlands. It analyzes the experiences of a number of real-world cases and compares these to the outcomes of theoretical frameworks that list preconditions for successful bioenergy chain development.

The *Functions of Innovation Systems Theory* states that successful development of new initiatives requires: (i) availability of relevant technical knowledge; (ii) willingness of entrepreneurs to implement new technologies; (iii) active diffusion of knowledge; (iv) definition of a vision of the future of bioenergy; (v) availability of financial means for investments; (vi) creation of a new market; and (vii) an effective political lobby. [10] According to the *Q-methodology*, developed to study people's subjectivity with respect to (more or less) controversial issues, stakeholders' attitudes toward new technologies depend on the type and background of information that they receive and the way perceived risks are presented. Basically, stakeholders tend to be more supportive of technological innovations if they are informed in a balanced way by sources they trust.[11]

Bos *et al.* studied the early development of innovative biobased production chains in the Netherlands.[9] They conclude that successful chains require (i) sound technologies for product development; (ii) active development of market demand; (iii) ability to make sufficient investments in production development and marketing; and (iv) availability of laws, regulations, and standards that allow new products to fit in. Successful new chains, further, (v) were often in some way linked to existing agro-food production chains.

These findings are confirmed by an overview of experiences of bioenergy production presented by Spruit and van Lange who report that (i) legislation in the Netherlands is often restrictive against new bioenergy initiatives.[12] Obtaining necessary permits may, for example, be frustrated by complex regulations on emissions of toxic residues, or by the fact that existing legislation on noise or odor nuisance does not provide requirements for biogas installations. In addition, (ii) the success of bioenergy chains is limited by the fact that the focus is skewed toward electricity, thus ignoring potential gains of heat production and utilization. Further, (iii) it is often very difficult to raise sufficient capital as new chains lack assets that are requested by banks to serve as guarantees for obtaining loans. The fact that banks may also tend to require long-term contracts, which are not common in agriculture, to back their loans provides an extra barrier to obtain sufficient financial means.

There are striking similarities between the points that are raised by the different sources cited above. Table 1 lists five conditions for successful development of new bioenergy chains: (i) access to (proven) technology; (ii) mature information and knowledge infrastructure; (iii) access to

Table 1. Conditions for initiating a new bioenergy production chain.

Condition	Background
1. Availability of technology	Initiators need access to relevant technology. Some may look for new techniques, other for proven technology.
2. Access to knowledge and information	Entrepreneurs need to be informed on technological, economic, and political developments. Insufficient (access to) knowledge may cause delays in decision-making and frustrate chain development.
3. Access to feedstocks, credit, and markets	Successful production chains link to both feedstocks and markets. This may be cumbersome when feedstock availability is limited and markets are not mature. Banks may be reluctant to provide credit when links are not guaranteed.
4. Availability of a suitable location	Spatial planning in the Netherlands is very strict. Obtaining a permit to build and operate a bioenergy installation may become cumbersome due to strict legislation on emissions, odor, or noise.
5. Effective lobbying	Effective lobby activities can take different forms. Some entrepreneurs get support during the project preparation phase; for example, in obtaining permits or initial (investment or research) funds. Lobbying activities can also be helpful in organizing tax exemptions or public support.

Biofuels, Bioprod. Bioref. **4**:484–493 (2010); DOI: 10.1002/bbb

feedstocks, credit and markets; (iv) availability of a suitable location; and (v) an effective lobby.

Introducing new bioenergy initiatives in the Netherlands

One might argue that the relatively reluctant bioenergy chain development in the Netherlands is to be attributed to the fact that some of these necessary preconditions are not met. To test whether this is the case, the experiences of nine recent Dutch bioenergy chains are analyzed. They were selected from a list with 70 initiatives, described elsewhere,[8] using the following criteria:

- coverage of major bioenergy products (electricity, heat, biofuels, biogas);
- distribution over geographical regions;
- inclusion of small as well as larger initiatives; and
- inclusion of successes and failures.

Selected initiatives include chains producing biofuels (2), biogas (3), and electricity/heat (4). In addition, four interviews were held to obtain background information on bioenergy production and utilization in the Netherlands. These include a firm selling bioenergy installations, a (public) investment fund, a policy-maker, and a company processing animal manure that might enter biogas production but so far has developed no plans to do so (Table 2). The selected cases cover all available chain sizes currently found in the Netherlands. Most have running facilities, but two still are in the start-up phase. All regions are represented with exception of the southeast and the northwest; the northeast appears to dominate.

Representatives of the chains (mostly owners or managers) were interviewed by a team of researchers. Questions in a standard questionnaire included: (i) finding a location and obtaining permits; (ii) feedstock and technology used; (iii) chain organization; (iv) experiences with (local, provincial) government; and (v) knowledge or information requirements. Table 3 presents an overview of major bioenergy chain characteristics. Biogas is produced from sewage sludge or manure plus coproducts (usually maize). Combustion chains use wood from logs, waste or pruning debris. Biofuels are produced from glycerol or rape seed.

Key problems for new bioenergy chains

Most bioenergy chains apply more or less standard technical installations, be it that these are further improved (usually on site and for own use only). Adapting available technologies generally required more time and effort than was expected. One biofuel producer developed a new, patented technology. No problems were reported in obtaining

Table 2. Background information on the interviews and production chains.

Code[1]	Chain type	Status production chain	People interviewed
G1	Medium to large digester	Running successfully.	Research manager
G2	Small-scale farm digester	Planned but not running, may be aborted.	Initiator farmer
G3	Medium-sized digester	Running after a smooth start-up.	Owner farmer
C1	Medium-scale combustion plant run by electricity company	Running but had start-up problems	Research manager
C2	Large combustion plant run by an electricity company	Running but had start-up problems.	Managers
C3	Medium-sized combustion installation linked to a greenhouse	Running. Problems with housing of the installation.	Owner warehouse
C4	Small farm combustion plant	Running after a smooth start-up.	Farmer/managers
F1	Large methanol plant	Startup, so far running smoothly.	Plant manager
F2	Medium to large pure oil plant	Running, after construction problems.	Owner
O1	Public investment fund	–	Expert
O2	Provincial authority	–	Policy-makers
O3	Manure cleaning plant not producing any bioenergy	Running, no problems.	Research manager
O4	Installer of fermentation and combustion installations	–	Director

[1] Fermentors (G); combusting chains (C); fuel producers (F); other chain types (O).

Table 3. Chain organization: feedstocks, installations, and collaboration.

Code	Feedstock, installations	Technological information and knowledge	Chain organization
G1	Sewage sludge cleaned in water separator	Sufficiently available	Sludge via plant owner, utilizes some heat.
G2	Manure, silage maize in farm digester, not yet operational.	Sufficiently available	Manure via own farm plus participating farmers.
G3	Manure, silage maize, other coproducts in standard thermophylic digester.	Lack of proven technology	Manure via participating farmers. Coproducts purchased (at increasing cost, variable quality).
C1	Waste wood burnt in fluidized bed installation.	Sufficiently available	Wood via co-owner.
C2	Wood logs burnt in fluidized bed installation.	Sufficiently available	Wood is purchased (difficult process), heat sold to city heating system.
C3	Wood-pruning debris burnt in standard installation with enhanced performance	Problems with construction of the building	Wood purchased (long term contract), heat/CO_2 sold to neighboring warehouse.
C4	Wood-pruning debris burnt in standard installation.	Sufficiently available (focused on proven technology)	Guaranteed wood supply via participating farmers; additional wood purchased (at increasing cost).
F1	Glycerol from biodiesel production converted in innovative, patented gasification process.	Sufficiently available	Glycerol purchased (sufficiently available, quality and prices vary).
F2	Rapeseed converted in improved installation.	Sufficiently available	Rapeseed purchased from local farmers (availability below expectations).
O1	Not relevant	Not relevant	Not relevant
O2	Not relevant	Not relevant	Not relevant
O3	Calf manure cleaned in improved process.	Sufficiently available	Manure via participating calf meat producers (long-term contracts).
O4	Design of innovative installations with customers.	Not relevant	Not relevant

technology or information on available technologies. However, some initiators could not obtain (fermentation, combustion) installations with a proven track record (efficiency, reliability), as installers would not (or could not) provide guarantees as to the (minimum) performance level. This holds true especially for installations for combustion and biofuel production; biogas producers, in contrast, indicated they had access to sufficient examples of proven technology. All initiatives report they had sufficient access to knowledge or information; some chains did their own research or experimenting while others obtained information through partners involved in the production chain. In all cases, it was felt that lack of technical information was not a major constraint for chain development.

Reliable information on emissions/nuisance (odor, noise, emissions, required transportation movement) was often lacking for new installations. This sometimes frustrated the process of obtaining the necessary operational permits and communicating with civilians living near the planned production plant. Access to feedstocks (manure, maize, wood, glycerol, rape) was often obtained by participation of specific partners in the chain. In the process, long-term contracts were generally being pursued to guarantee future feedstock availability. Chains that are able to access a steady feedstock supply in practice found that they are better off than chains where biomass is not guaranteed. Some chains report problems in sale of (excess) heat.

Most initiatives are located on existing (industrial) sites (Table 4), often next to other industrial plants. Some installations were built on newly developed sites. Two biogas chains encountered problems in obtaining operational permits, mainly related to (potential) odor nuisance and traffic movement. Legislation on permits is often perceived as being illogical while some qualify law enforcement (to limit nuisance of the production plant) as a more restraining factor. There is a general feeling that authorities react in a bureaucratic way, and have little understanding of (or appreciation for) their position (some report that they felt

  | *Biofuels, Bioprod. Bioref.* **4**:484–493 (2010); DOI: 10.1002/bbb

Table 4. Problems related to location, permits, and experiences with authorities.

Code	Location	Nuisances, permits	Experiences with authorities
G1	Industrial site in village center (next to a water cleaning installation).	Water cleaner has a history of odor and noise nuisance. Major efforts for odor control.	Not positive. Strict rules applied in a bureaucratic way.
G2	Expected to build installation on farm.	Not filed for a permit yet.	Positive
G3	Industrial site next to a water cleaning installation. Nearby residents.	Site with history of odor nuisance. Residents worried about odor and traffic. One filed several lawsuits but lost.	Mixed experiences. Some support but often bureaucratic attitude.
C1	Industrial site (next to waste-wood collector). Residents and highway nearby.	Received few complaints that were solved smoothly.	Rather positive
C2	New site near major city. Linked to city heating system.	Unknown	Positive
C3	On warehouse terrain, links to other warehouse.	Received few complaints. Has been solved smoothly.	Positive
C4	Isolated installation on site obtained from city council.	Near residents. Received only one complaint. Has been solved smoothly.	Positive. Rules strict and illogical but wisely applied.
F1	Former methanol plant on industrial site. Other industries nearby.	No complaints. Large distance from residential areas.	Positive. Rules strict and illogical but applied more or less smoothly.
F2	Industrial site. Other industries nearby.	No complaints.	Positive
O1	Not relevant	Not relevant	Not relevant
O2	Not relevant	Not relevant	Not relevant
O3	Four installations each on new sites. No other installations.	Not relevant	Initially positive but increasing bureaucratic harassment by province.
O4	Not relevant	Not relevant	Positive attitude in past. Current attitude is negative.

they are harassed or thwarted). Most chains initially receive some support (often non-financial) from local or provincial authorities. As a rule, it took a lot of time and effort to provide the data for obtaining permits. In addition to these impediments, bioenergy chains may be operating in areas where public support is limited or uncertain. This sometimes has a negative effect on policy-makers and/or civil servants (for example when applying for subsidies or permits).

A wider perspective: comparing problems with those of other (bioenergy) supply chains

Not all problems listed are equally relevant. Some refer to practical problems that are also met while establishing a conventional production chain: finding a market, selecting a reliable production technology, and obtaining financial means or a suitable location with all necessary permits. While such problems are occurring in a wide range of sectors, they may be more relevant for emerging bioenergy chains. This holds true especially when technologies are still under development, feedstock or output markets are not fully mature, and banks and authorities still undecided on their attitude (supportive, discouraging) toward production routes.

Still, for bioenergy chains, such problems can offer extra barriers to their development. This is usually related to the new and innovative character of the product or production technology. Table 5 provides an overview of problems related to the conditions that have to be met for successful development of bioenergy production chains. Problems occurring in bioenergy chains are compared to those of other, more or less similar chains. Problems related to obtaining a suitable location and access to credit and public support are also met by other chains, although not necessarily of the same magnitude. Other problems, related to proven technology (heat or CO_2 markets, or lobby for bioenergy) are more exclusively dealt with by bioenergy chains.

It is worthwhile extending this analysis to bioenergy chain development in other countries. Before this is done, we considered the position of bioenergy in the Netherlands in an international perspective. Notwithstanding its track

Table 5. General problems and specific problems for bioenergy production chains.

	Non-bioenergy chains	Specific for bioenergy chains
1. Availability of technology	No specific problem	Insufficient access to proven technology for combustion of (waste or freshly harvested) wood, and for some forms of biofuel production.
2. Access to knowledge and information	No specific problem	Reliable, neutral information needed on feedstock quality and availability and on nuisances (odour, noise, emissions) from bioenergy production processes.
3. Access to feedstocks, credit, and markets	No major problem (until recent outbreak of 'credit crisis')	Especially problematic for chains depending on 'new' feedstocks (waste or chipped wood, manure, coproducts, waste) or supplying 'new' products (heat, CO_2)
4. Availability of a suitable location	General problem in the (densely populated) Netherlands	Has been especially problematic for digesters, as a general concept on the aspect of fermentation (agricultural or industrial) was lacking
5. Effective lobbying/public support	Support for intensive live-stock production is limited.	Tax exemptions needed for biofuels require political support. General opposition to concept of fuels made from food products (fuel *vs* food).

record as a successful food producer and exporter, progress in bioenergy production in the Netherlands so far has been modest. One might have expected otherwise as highly productive agriculture, massive biomass imports, as well as competitive industries for food, feed, and chemicals plus one of the highest population densities in the world make it an excellent position for the development and production of bioenergy and biobased products. [5] There are, however, also some drawbacks – high land prices (leading to high prices for biomass feedstocks) probably being one of the most important ones. Also, the Dutch record in bioenergy policies is rather bleak while, more in general, the Netherlands is classified as being moderately innovative, lagging behind innovation leaders like Germany, Finland, and Sweden.

In order to compare the outcomes presented to the position of bioenergy production chain development elsewhere, we focus on four countries: Germany and France (major agricultural producers in NW Europe), the USA and Canada (agricultural producers in North America). A comparison of the cases analyzed in this paper to examples of bioenergy production in these countries suggests that Dutch cases are of a rather small (or medium) scale, especially those related to biofuels and biogas production. Exceptions are co-generation of electricity using biomass and methanol production based on glycerine from biodiesel chains, represented by codes C1 and F2 in Table 2, respectively. Bioenergy production chains elsewhere (and especially in the four countries under review) tend to be of a larger scale – be it that farm-based biogas production usually is of a merely smaller size (e.g. in Germany).

A second difference between Dutch bioenergy chains and their foreign counterparts is the fact that for the former, strong links with agro industry seem to be mostly lacking. There is one example where an agricultural entity in the Netherlands successfully developed a biobased product but this refers to polylactic acid (PLA) rather than bioenergy production. Direct links between agro-industrial complex and bioenergy are basically absent. This is in contrast to other countries, where agro industries are more directly involved in bioenergy production (e.g. corn- or soybean-based biofuel production facilities in the USA, or forestry-based initiatives in Canada). In France, for example, two of the main bioenergy initiatives (ARD and Rocquette´s Bio-hub) have ties to agricultural production chains.

A direct consequence of a more direct agro-industrial involvement in bioenergy production in France, Germany, the USA, and Canada is a strong integration along the production chain, starting in biomass feedstock production and going all the way up to the production and distribution of the end product. These countries also show striking differences to the Netherlands with respect to bioenergy policies, which generally are more consistent and providing more (types of) support for the emerging bioenergy industry. France and Germany, for example, were early in adapting standards for biofuel production and use, Canada in developing extensive research programs including both private and public institutions, while the USA has been very active in supporting the production of biofuels. It is also implementing one of the most extensive green procurement programs currently known.

  | *Biofuels, Bioprod. Bioref.* **4**:484–493 (2010); DOI: 10.1002/bbb

Notwithstanding these differences, problems encountered by bioenergy production chains in all five countries are showing major similarities. According to McCormick and Kåberger (2007)[13] for example, biofuel implementation in the EU is hampered by mostly non-technical issues such as economic barriers (non-matching of subsidies for fossil and nuclear energy production), limitations in know-how and institutional capacity, and problems in supply-chain coordination. This by-and-large confirms results presented here for the Netherlands. Also for Canada, barriers for bioenergy development largely coincide with those identified for the Netherlands: lack of capital, underdeveloped markets for biomass and carbon, and (perceived) misinformation on bioenergy's environmental impact considerably limiting public support.[14] No comprehensive study specifying problems met by bioenergy producers in the USA was obtained. It may be expected that these problems may also apply, be it that capital availability and biomass supply are much less relevant.[15]

Improving conditions for chain development

Returning to the position of developing bioenergy chains in the Netherlands, we now discuss ways to improve the conditions for bioenergy chain development. Starting with technology availability, the role of reliable, predictable, and proven technology can hardly be overestimated. While the chains included in the analysis made different choices with respect to technology selection (ranging from turn-key to the design of a new and highly innovative concept), most interviewees stress the need for reliable and predictable technologies to be able to choose from. There is a general perception that new initiatives will perform better if they (can) select proven technological standards. Under Dutch conditions, the availability of such standards appeared better for digesters and (to a lesser extent) for combustion installations than for biofuel production. This is expected to change as the number of bioenergy installations increases.

The availability of (proven) technology can be improved by coordinating the development and testing of technologies. This could be done in combined efforts by public institutions, private companies, and sectoral representative organizations. It could be linked to efforts to improve dissemination of knowledge on installation techniques, on feedstock availability and markets. It is stressed here, however, that insufficient access to knowledge or information apparently played no major role in the start up of chains included in this analysis. To a certain extent, this seems to contradict the perceived lack of (information on) proven technology although the issue of knowledge dissemination is much wider. In addition, there appears to be a demand for unbiased (scientific) information on potential emissions and nuisances of bioenergy installations. This is expected to facilitate better evaluation of permit requests as well as discussions with residents living near (potential) installations.

With respect to feedstock and product markets, attention was drawn repeatedly to the relevance of guaranteed (pre-arranged, long-term) biomass supply and sales of byproducts. This holds true especially for chains depending on byproducts (wood cuttings, coproducts for digestion of manure) and waste (wood, industrial waste), thus digesters and combustion chains. Efforts to obtain sufficient feedstocks of good quality, at reasonable prices, can be time-consuming. More in general, information on the availability and quality of such streams in different regions of the country should be improved.

A special note should be added on the utilization of heat. All but one or two of the chains included in this study did not make full use of available heat (this applies both to digesters and combustion chains). The reason for this is twofold. Often, the demand for heat in the vicinity is limited and needs to be further developed. In practice, however, fulfilling a (potential) demand for heat is hampered by insufficient (transport) infrastructure and the unwillingness of recipients to participate in the necessary investments to overcome this lack. Protocols for interactions between heat producers and customers may aid in clarifying the role each player may have in a successful cooperation. Government itself could, in the planning or operating of public buildings or by means of a green procurement program, put more emphasis on the use of excess heat.

The role of financial institutions and credit facilities is critical in the development of new bioenergy chains, as these institutions are crucial in providing (part of) the necessary funding. The interviews showed clearly that banks and investors often play an important role during the start-up process of new chains. Entrepreneurs may lack the financial resources to provide necessary funds, especially when they are confronted with major drawbacks during chain development or start up. This holds true more so for chains producing biogas (usually financed with contributions from participating farmers) and (wood) combustion chains than for biofuel producers. Part of the financing problems relates to the reluctance of city councils to invest in energy infrastructure (e.g. for heat transport).

Starting new bioenergy chains is often a tedious, time-consuming, and frustrating endeavor, with (often small) steps forward alternating with (sometimes huge) steps backward. One chain appeared unable to cash a subsidy that had been awarded because obtaining a permit was taking far more time than planned. Another had to replace a newly installed combustion oven because of malfunctioning. Such drawbacks have an impact on cash needs, sometimes to the extent that the position of major investors determines the fate of the entire chain. Combustors and biofuel producers largely depend on financial institutions; biogas chains require fewer investments and often have some kind of financial means available from participating farmers. Given the relevance of credit availability for bioenergy startups, it is recommended that measures be taken to increase credit availability for new production chains in this sector.

Finding a suitable location, including the process of obtaining necessary licenses, is also a tedious and time-consuming (and often frustrating) exercise. While some initiatives obtained production sites without major hiccups, most chains experienced some kind of drawback. It is striking that many chains selected existing locations, even if these already had a history of noise complaints or odor nuisance problems. The reason for this is unclear. It might suggest that problems related to obtaining permits still are underestimated in some cases. Alternatively, there may be other (e.g. financial) reasons to select existing sites – even if they have distinct disadvantages.

Some chains were confronted with opposition to the planned building of a new installation from residents and, sometimes, the local authorities. In one case, this delayed the construction for a period of two years. In most cases, however, some kind of agreement was usually reached within a much shorter period. Entrepreneurs demonstrated markedly different attitudes toward complaints of residents. As a rule, proactive and open communication can lead to a more swift agreement. Availability of accurate, up-to-date, neutral, and reliable information on emissions and other nuisances of bioenergy plants can play a crucial role in this process. Increasing availability and distribution of this type of information therefore should be encouraged. Such information can also help to improve public support for bioenergy producers.

More generally, the development of a successful bioenergy chain requires a consistent, supportive policy. Wiesenthal *et al.* (2009), discussing biofuel supporting policies in Europe, conclude that development of a biofuel market in a given country requires active and consistent national policies that can provide favorable economic and legal conditions for new chain development.[16] In the case of biofuels in the EU, for example, this has been the timely development and implementation of biofuel standards and an engine with biofuel compatibility (e.g. in France, Germany) and complementary economic measures aimed at the stimulation of specific biofuels (such as subsidies for production facilities, user incentives, and feedstock subsidies). According to the authors, it is the combination of measures – economic and legal conditions plus complementary economic measures – that define the potential success of the development of a new biofuel in a given country.

Conclusion

While the Netherlands has defined clear objectives aiming at increased domestic bioenergy production, in practice, new bioenergy production chains are meeting manifold problems. Generally, conditions in the Netherlands do not facilitate smooth, successful, bioenergy chain development. If the Dutch government is to realize its bioenergy objectives, improvements will be needed in the availability and dissemination of technology, the development of biomass and bioenergy (heat) markets, credit availability, and processes for obtaining location permits. In general, more policy and public support is needed.

Acknowledgement

The research presented in this paper has been financed by the Climate for Knowledge Research Programme co-funded by the Dutch Ministry of Housing, Spatial Planning, and Environment. It was partially co-funded by the Netherlands Ministry of Agriculture, Nature and Food Quality via the Climate Research Programme under number KB-02-001-010.

References

1. Sanders JPM and van der Hoeven DA, Opportunities for a bio-based economy in the Netherlands. *Energies* **1**:105–119 (2008).
2. VROM 2001, *Een wereld en een wil: werken aan duurzaamheid*, Vierde Nationaal Milieubeleidsplan (NMP4). Ministry of Housing, Spatial Planning and Environment, the Hague (2001).
3. Rabou LPLM, Deurwaarder EP, Elbersen HW and Scott EL, *Biomass in Dutch energy sector in 2030* (in Dutch). Amsterdam, ECN, 54p (2006).
5. Sanders JPM and Langeveld JWA, A biobased economy for the Netherlands, in *Biobased economy: principles, potentials and impacts of biofuels and platform chemicals,* ed by Langeveld H, Sanders J and Meeusen M. Earthscan, London, pp. 341–360 (2010).
6. Sanders JPM, van Korven AAJ, Engelen-Smeets ERW, Reith JH, Bruijnenberg PM, Schonewille JW *et al.*, *Duurzame productie en ontwikkeling van biomassa, zowel in Nederland als in het buitenland*, Utrecht, SenterNovem (2006).
7. Centraal Bureau voor de Statistiek (CBS), *Duurzame energie in Nederland 2008*. CBS, Den Haag/Heerlen (2008).
8. van Ree R and Annevelink B, Status Report Biorefinery 2007 (2007). Available at: http://www.senternovem.nl/mmfiles/Statusdocument%20bio-energie%202007%20-%202DEN0811_tcm24-255981.pdf [September 21, 2009].
9. Bos H, Slingerland M, Elbersen W and Rabbinge R, Beyond agrification: twenty five years of policy and innovation for non-food application of renewable resources in the Netherlands. *Biofuels Bioprod Bioref* **2**: 343–357 (2008).
10. Negro S, Functions of Innovation Systems. A new method to accelerate dedicated innovation (in Dutch), Utrecht University, the Netherlands. Available at: http://www.senternovem.nl/mmfiles/Negro%20Presentatie%20Expert%20Meeting%20Vergisting%20091008_tcm24-285319.pdf [July 20, 2010].
11. Cuppen E, Breukers S, Hisschemöller M and Bergsma E (forthcoming). Q-Methodology to select participants for a stakeholder dialogue on energy options from biomass in the Netherlands. *Ecol Econ* **69**:579–591 (2010).
12. Duurzame energie regio achterhoek. Eindrapport DE-scan en marktverkenning. Project 03.006. Projectbureau Duurzame Energie, Arnhem (2008). Available at: http://www.regioachterhoek.nl/files_cms/bestand/25561.pdf. [November 7, 2008].
13. McCormick K and T Kåberger, Key barriers for bioenergy in Europe: Economic conditions, know-how and institutional capacity, and supply chain co-ordination. *Biomass Bioenerg* **31(7)**:443–452 (2007).
14. McCallum B, Addressing barriers testricting bioenergy system applications in Canada. Ensight Consulting, Hunter River, PE (2008).
15. Walburger AM, Le Roy D, Kaushik KK and Klein KK, Policies to stimulate biofuel production in canada: Lessons from Europe and the United States (2006). Available at: http://www.biocap.ca/rif/report/Walburger_A.pdf [June 1, 2010].
16. Wiesenthal T, Leduc G, Christidis P, Schade B, Pelkmans L, Govaerts L and Georgopoulos P. Biofuel support policies in Europe: Lessons learnt for the long way ahead. *Renew Susy Energ Rev* **13**:789–800 (2009).

Johannes W.A. Langeveld

Johannes (Hans) W.A. Langeveld is Director of Biomass Research in Wageningen, the Netherlands and author of *The biobased economy. Biofuels, materials and chemicals in the post-oil era* (Earthscan, 2010). He holds an MSc in Agronomy from Wageningen University and has worked on land use modeling and sustainable agriculture. He turned to bioenergy in 2006 and has worked for IEA Bioenergy Tasks 30 and 42, for the UN and Wageningen University and Research Centre.

Ria Kalf

Ria Kalf works with KEMA, a Dutch-based consultancy institute focusing on energy-related projects. Secretary-General of the Dutch Platform Bio-Energy, and a chemical engineer, Ria has been working in the field of energy and environmental issues since the 1970s. She joined the Dutch Project team *National Action Plan Biomass*, and was a member of the Working Group Permits and Chairperson of the Working Group Communication. From 2000 to 2006, she consulted on bioenergy for the National Project Agency for Renewable Energy, supporting the development of bioenergy projects at local and national level.

H. Wolter Elbersen

Dr. Elbersen is senior scientist at The Food & Biobased Reseach institute of Wageningen University and Research centre. In the last 15 years he has executed a wide variety of nationally and internationally sponsored projects on energy crops, biomass availability and on setting up sustainable biomass supply systems.