

**FIELD TRIAL WITH GM POPLAR WT/52-3 IN THE NETHERLANDS
FOR BIO-ETHANOL PRODUCTION:**

IS IT NEEDED OR USEFUL?

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INTRODUCTION

On 24 October 2008 the Flemish Institute for Biotechnology (VIB)¹ submitted an application for a permit for a small-scale field trial with genetically modified (GM) poplar WT/52-3 to the Dutch competent authority (CA) for Directive 2001/18/EC². On 29 January 2009 the Dutch CA published its draft decision to grant the permit. Until 11th of March 2009 the public may submit objections against the draft (decision to grant a) permit.

The draft permit issued by the Dutch CA is solely based on an evaluation of the potential risks of the field trial to the environment and human health. The Dutch CA considers an evaluation of the need or usefulness of this field trial as well as other deliberate releases of genetically modified organisms (GMOs) beyond the scope of the Dutch legislation implementing Directive 2001/18/EC.

Notably, the European Environment Council recently invited Member States to collect and exchange information on other aspects related to environmental releases of GMOs, such as socio-economic benefits and risks and agronomic sustainability.³ Thus, for an integral appraisal of an environmental release of a GMO, not only its potential risks to the environment and human health must be evaluated. Other legitimate factors and the wider context also have to be examined.

Against this background Greenpeace-Netherlands requested Schenkelaars Biotechnology Consultancy to provide an analysis of the potential need or usefulness of the field trial with GM poplar WT/52-3 in the Netherlands.

In order to comprehend what stakes might be involved, the first part of this paper is mostly descriptive, addressing:

- The Dutch permit application procedure.
- The draft decision to grant a permit for a field trial with GM poplar.
- The field trial's wider context.

The second part aims at:

- Developing a framework for the usefulness/need analysis.
- Applying the developed framework for analysis of the usefulness/need of the field trial with the GM poplar in the Netherlands.

Finally, the author is solely responsible for the accurateness of the data, information and analysis presented in this paper as well as its conclusions.

¹ Vlaams Instituut voor Biotechnologie (acronym: VIB).

² Ministerie voor Volkshuisvesting, Ruimtelijke Ordening en Milieu (acronym: VROM).

³ On 4 December 2008, at the 2912th Environment Council Meeting in Brussels, the Council pointed out that “under Directive 2001/18/EC, the Commission is to submit a specific report on the implementation of the Directive, including an assessment, inter alia, of socio-economic implications of deliberate releases and placing on the market of GMOs.” The Council further invited “the Member States to collect and exchange relevant information on socio-economic implications of the placing on the market of GMOs, including socio-economic benefits and risks and agronomic sustainability (...).”

THE DUTCH PERMIT APPLICATION PROCEDURE FOR FIELD TRIALS

Implementation of Directive 2001/18/EC in the Netherlands

As is laid down in Directive 2001/18/EC on the deliberate release of GMOs, applicants are obliged to submit a notification to the national competent authority (CA) before deliberate release can be undertaken. Directive 2001/18/EC applies to field trials (Part B) and to the placing on the market of GMOs as or in products (Part C).

The procedural time taken between filing out an application and the start of the experiment is generally 23 weeks.⁴ This excludes the time needed to obtain, if deemed necessary, additional information from the applicant. Applications should be filed at the GMO Office.⁵

As Directive 2001/18/EC has been implemented in Dutch legislation by adaptation of existing legislation, there are legal provisions for public information on a proposed Part B release. In case of an application for a Part B releases, the CA provides information on: the nature of the draft decision, the public authority for making the decision, the envisaged procedure, the opportunities for public participation, the public authority where information has been deposited for public examination, the public authority where comments and questions can be submitted.

In addition, publicly accessible information includes: A general description of the GMO(s); The name and address of the applicant; The purpose of the Part B release; The location(s) of the site(s) where the Part B release will take place; The intended use of the GMO(s); A description of potential effects on the environment and human health; A description of measures to limit adverse effects; A description of the plan for monitoring effects; A description of measures to treat GMO waste of the Part B release; A description of the emergency response plan; The main reports and advice issued by the advisory committee, and; A non-technical summary.

Moreover, there are also legal provisions for public participation in decision-making on a proposed Part B release. The public participation procedures allows the public to submit comments on the draft decision within 4 weeks and to appeal against the decision within 6 weeks. The text of the final decision indicates how account has been taken of the outcome of the public participation.

In case a public interest organisation or individual considers that in the decision the CA has not taken due account of the outcome of the public participation procedure, they have access to judicial procedures to challenge the decision before a court of law, i.e. Council of State⁶.

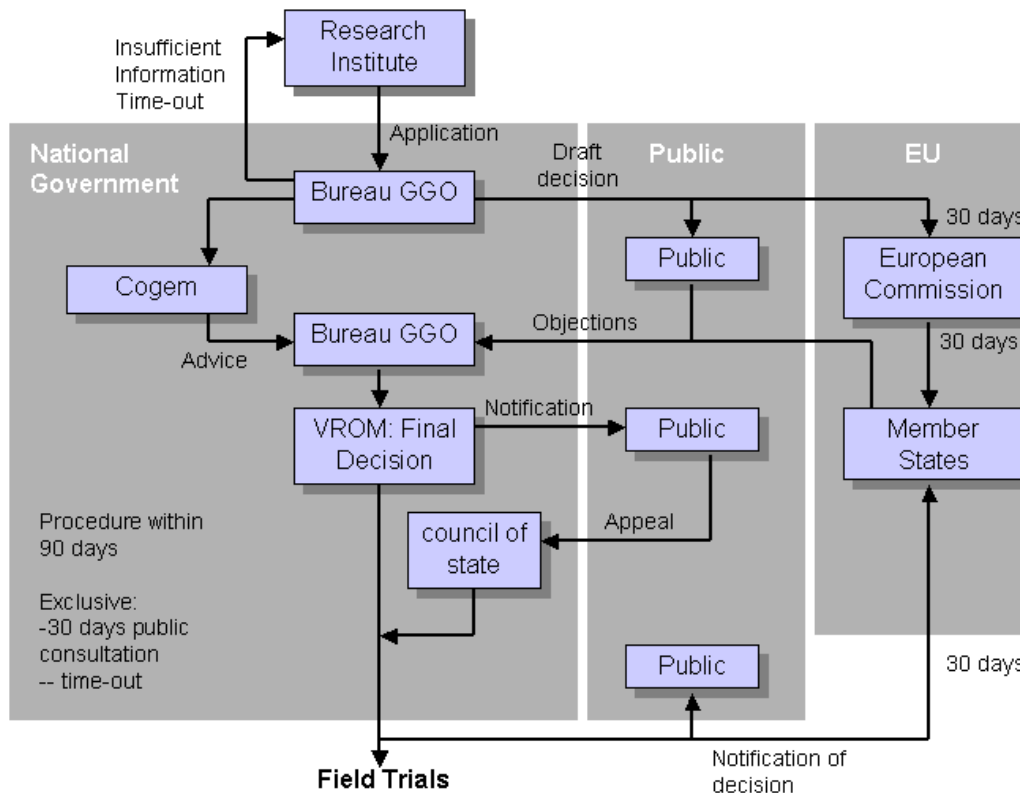
Figure 1 provides an overview of the Dutch permit application procedure for a Part B release.

⁴ See <http://www.vrom.nl/go-vergunningverlening>

⁵ The GMO Office (in Dutch: Bureau GGO) is the administrative body of the Dutch competent authority for Directive 2001/18/EC, i.e. the Ministry of VROM (see footnote 2), which may seek scientific-technical advice on a proposed release from the Commission on Genetic Modification (COGEM).

⁶ In Dutch: Raad van State.

Figure 1: Permit application procedure for a field trial with GMO(s) in the Netherlands



Abbreviations & Acronyms: Bureau GGO = GMO Office; Cogem = Commission on Genetic Modification, i.e. biosafety advisory body; VROM = the Netherlands competent authority for Directive 2001/18/EC; Council of State = court of law that decides on appeals (see also footnote 5).

Source: SBC, 2003⁷

The draft decision to grant a permit for a field trial with GM poplar WT52/3

Procedure

On 24 October 2008 the VIB submitted an application for a permit for a small-scale field trial with GM poplar WT/52-3 to the Dutch CA. On 29 January 2009 the Dutch CA published its draft decision to grant the permit.⁸ The total size of the trial site is about 460 m². The location of the release site is nearby the town Colijnsplaat of the municipality Noord-Beveland in the Province Zeeland in the Netherlands. The period of release will be from 1st of May 2009 until 31st of December 2021. Until 11th of March 2009 the public may submit objections against the draft decision to grant a permit (in short: draft permit).

GM poplar WT/52-3

The GM poplar line WT/52-3 that will be tested has been derived from grey poplar (*populus x canescens*) female line 717-1-B4. Line WT/52-3 has been obtained through transformation

⁷ See <http://www.sbcbiotech.nl/page/downloads/Workability%20Practices%20Part%20I.pdf>

⁸ See <http://www.vrom.nl/ggo-vergunningverlening>

with *Agrobacterium tumefaciens*, using a vector with a gene cassette with the cDNA sequence encoding for the enzyme cinnamoyl CoA reductase (CCR) in a sense orientation and the gene encoding for hygromycin B phosphotransferase (*hpt*) as selection marker. The sense *ccr* is regulated by a double CaMV 35S promoter and CaMV 35S terminator derived from cauliflower mosaic virus. The *hpt* gene is regulated by a promoter of the nopaline synthase gene and a pAg7 terminator derived from *Agrobacterium tumefaciens*. Absence of vector backbone sequences *nptIII*, *ColE1 ori* and *oriV* (*RK2 ori*) in GM poplar WT/52-3 has been demonstrated.

Risk assessment and risk management⁹

Previous field trials in France (B/FR/99.02.15) have shown that the GM poplar line WT/52-3 contains about 20 % less lignin, 23 % less hemicellulose and 17 % more cellulose compared to non-GM poplars, due to downregulation of the enzyme CCR.

These field trials in France have also shown that all tested CCR-downregulated GM poplars, including WT/52-3, showed 14 to 23 % lesser growth.

Moreover, there were no indications that the GM poplar will differ in its reproductive capacities compared to wild type poplars. Flowering time and intensity of the GM poplar did not appear to be affected compared to wild type poplars. It is however not known whether flowers would have developed fully normal because buds had to be removed before flowering.

It should further be noted that lignin is involved in major biological functions for tree growth and development, like mechanical support, water conduction, pathogen resistance and abiotic stress response. Field trials with this GM and other GM lignin-modified poplars over more than twelve years have demonstrated that lignin modifications easily translate into changes of water conduction and mechanical support. Apparently, a balance has to be found between a lignin modification that can be of interest for certain applications, like paper/pulp and/or bio-ethanol production, on the one hand and the impact of the lignin modification on tree growth and development on the other hand. The outcome of these field trials this GM and other GM lignin-modified poplars also suggests that lignin-modified GM poplars have a lesser or at least equal fitness compared to wild type poplars.

The issue whether lignin-modified GM poplar will have changed interactions with insects and pathogens has been reviewed in literature, leading to the conclusion that changes in the composition or amount of lignin will have hardly any or no effect on insects or interactions with pathogens.

Another potential effect of lignin modification might be a more rapid degradation of GM poplar material by (micro-) organisms in the soil, as some laboratory studies have suggested. Though, such an effect has not been observed under field conditions, suggesting that environmental conditions might have a greater impact on wood degradation than lignin modifications.

Adverse effects on vertebrates or humans as a consequence of exposure to the GM poplar are not expected, as there are no reasons to assume that lignin modification might result in altered toxic or allergenic properties compared to wild type poplar. It should be noted that poplar pollen is known as a moderate allergen. However, in this case a potential change of its

⁹ The information provided in this section originates from the VIB's application documents and the Dutch CA's decision documents, including its environmental risk assessment of the field trial with GM poplar WT/52-3. Technical comments on the official risk analysis and risk management measures are subject of a separate paper commissioned by Greenpeace-Netherlands to Schenkelaars Biotechnology Consultancy; this paper is in Dutch because it may be used in legal procedures against the Dutch CA's decision-making.

allergenicity will have no impact on human health, because the GM poplar to be released is a female line that cannot produce pollen.

Moreover, a literature search did not result in data on potential effects of lignin modification on vertebrates, such as hare, rabbit and deer. It is known that there is a great variance in food preferences of these vertebrates for certain (non-GM) poplar hybrids and clones, possible caused by the variance in content of fenolic glycosides that play a role in their defence against mammals. Although it is known that the genetic modification leads to increased concentrations of certain fenolic glycosides, like vannilic acid and synapic acid glucoside, it is assumed that these concentrations are within the variance found for these substances in nature.

According to the draft permit, the small-scale field trial will be set up as a short-rotation poplar coppice. At the trial site, 120 young rooted GM poplars WT/52-3 as well as 120 clones 717-1-B4 will be planted, surrounded by two buffer rows with non-GM control poplars. Before planting the soil will be cleared and fertilised, while after planting only weed will be controlled during the first season. Before the start of the second growing season (2010) the trees will be cut down to stimulate the formation of many stems per plant. At the end of the third growing season (4th year) biomass will be cut down, chopped and transported to Gent, where it will be processed into bio-ethanol in a laboratory and a biofuel pilot plant. This cycle will be repeated once. At the end of the seventh growing season the trees, including roots, will be grubbed, chopped and transported to Gent to be processed into bio-ethanol or incinerated.

During the growing seasons visual inspections of the GM poplar trees will take place monthly and during the flowering season weekly, in order to remove buds before flowering and seed set. Though, it is not expected that the trees will flower, because grey poplar is generally sexually mature after five years to eight years, only in some cases four years, while the branches will not become older than three years.

As the GM poplar is a female clone, it is not expected to develop male flowers, and, as a consequence, it is not expected to produce pollen and hybridise with related poplar species.

Moreover, rootstocks will be removed every year. At the end of the field trial rootstocks and suckers will be destroyed. Subsequently, the site of the release will be left fallow and controlled for rootstocks for at least two years. If thereafter rootstocks are still found, the monitoring period will be prolonged.

Finally, the field trial site will be surrounded by a fence to prevent accidental trespassing and accidental removal and spread of GM poplar material.

The twofold purpose of the field trial with GM poplar

According to the VIB, the field trial with GM poplar in the Netherlands has a twofold purpose: “*to test whether wood produced under realistic field conditions (seasons, harsh weather, wind, a real soil) also produces more bio-ethanol*”, and; “*to observe the interaction of the trees with a number of micro-organisms and insects and the response of the trees to climate stress.*” In an annex to the permit application, the VIB provides a protocol that describes in more detail how it will investigate changes in interactions of the GM poplar with micro-organisms and insects and its response to climate stress. During two growing seasons (year 3 and 4) interactions of the GM poplar with the pathogens *Melampsora pinitorca*, *Hypoxyllum mamatum*, *Xanthomonas populi* and *Chrysoma populi* will be studied in comparison with wild type poplar. Also, in year 3 and 4 its sensitivity of the GM poplar to damage by frost and wind will be determined, while growth, morphology and flowering time and intensity will be studied during the whole release period.

THE FIELD TRIAL'S WIDER CONTEXT

Risk research

One of the purposes of the field trial is to study the GM poplar's response to biotic stress by a few pathogens and abiotic stress by frost and wind. It can be argued that studying the GM poplar's response to biotic and abiotic stress is in fact aimed at understanding factors that might affect the GM poplar's productivity, which is a technological objective (see below).

On the other hand, it might be qualified as 'environmental risk research', aiming at understanding under which conditions the GM poplar can be released 'safely' into the environment, which is a major objective of GMO regulatory policy. However, the draft permit foresees several physical containment procedures with the aim to limit potential environmental risks of the field trial to the trial site, which makes it difficult to gain understanding of the potential environmental risks of large-scale or commercial releases of the GM poplar.

For example, in its advice to the Dutch CA, the Cogem concludes that without precautionary measures it cannot be fully excluded that the GM poplar, despite being a female clone, might lead to spread and establishment of GM material in poplars beyond the trial site.¹⁰ In its draft permit, the Dutch CA therefore prescribes several physical containment measures, such as prevention of flowering and control of rootstocks. As a consequence, the question whether spread and establishment of GM material from GM poplar in poplars beyond the trial site constitutes an environmental risk cannot be answered through this field trial. Yet, if the GM poplar is found suitable for large-scale or commercial releases, the potential environmental risks of introgression of transgenes from the GM poplar to non-GM poplars still have to be understood, because physical containment measures, like removal of flowers, from the GM poplar grown in large-scale short rotation coppice will then be practically impossible.

The Cogem explicitly points out that if the field trial would later be scaled up, more data would be needed: "*The applicant could for instance pay attention to the composition of the soil micro-flora, as previous studies yielded inconsistent results*". The Cogem therefore recommends to study the effect of the GM poplar on two species of lignin-degrading fungi. It did however specify which effects on these fungi would be considered an environmental hazard.¹¹

¹⁰ Cogem, CGM/081205-01, 5 december 2008.

¹¹ The Cogem's recommendation raises the question whether knowledge of the potential effects of the GM poplar on two species of lignin-degrading fungi as such will really assist decision-makers at the Ministry of Environment. It seems that this recommendation stems from a ecological method of research, which has several characteristics that limit its usefulness to decision-makers: 1) a reluctance to define problems in relations to policy objectives; 2) testing null hypotheses of non difference between transgenic and non-transgenic organisms; 3) a preference for detailed description of ecosystems structure, complex models and precise predictions of uncertain relevance, and; 4) favouring test of hypotheses under field conditions. A more effective method of research for decision-making follows principles exemplified by ecotoxicology: 1) research problems are selected by policy relevance; 2) testing of risk hypotheses that predict no harm of transgenic organisms to things of value; 3) a preference for tests of ecosystem function, simple comparative models and accurate and relevant, if qualitative, predictions, and; 4) favouring tests of hypotheses under conditions that provide most rigour. See for extensive discussions; see 1) Raybould, A., (2007) Ecological versus ecotoxicological methods for assessing environmental risk of transgenic crops, *Plant Science* 173: 589 – 602, and; 2) Johnson, K.L., *et al.* (2006) How does scientific risk assessment of GM crops fit within the wider risk analysis?, *Trends in Plant Science*, 12(1): 1 – 5.

It should further be noted that the field trial will neither yield data on the potential risk of increased allergenicity¹² of the GM poplar's pollen compared to that of wild type non-GM, nor data for determining whether potentially increased concentrations of vanillic acid and synapic acid glucoside in the GM poplar are within the variance found in nature.

In conclusion, the field trial's purpose to study the GM poplar's response to biotic stress by a few pathogens and abiotic stress by frost and wind mainly serves the technological objective of a 'productive' GM poplar under field conditions. The investigations foreseen by the VIB can hardly be qualified as 'environmental risk research', while physical containment measures imposed by the Dutch CA might limit the potential environmental risks of the field trial. The field trial will therefore not lead to an adequate scientific understanding of the potential risks of the GM poplar in scaled up releases or commercially worthwhile short rotation coppices. In case of an application for a scaled up field trial with the GM poplar in the Netherlands, a lack of scientific understanding of the potential environmental risks may well result in a denial by the CA to grant a permit, given its regulatory policy objective of 'safe' releases of GMOs into the environment.

A novel production technology for bio-ethanol

As indicated earlier, one of the purposes of the field trial with GM poplar WT/52-3 in the Netherlands is to test whether wood produced under realistic field conditions also produces more bio-ethanol. As such, this particular field trial can be viewed as one step in a larger research programme of the VIB. This view is confirmed by the VIB in several of its public communications in relation to this field trial through its website, press releases and statements.¹³

Under the heading "The Poplar Files" on its website, the VIB provides extensive information on its research on poplar over the last decade. The main objective thereof is to alter the wood composition of poplars, in order to "*make them more suitable for the production of bio-ethanol (and, in addition, for the production of paper that weighs less heavily on the environment)*". In the case of GM poplar WT/52-3 (grown in greenhouses), the VIB points

¹² The field trial with this GM poplar might thus lead to altered interactions with the environment (compared to its non-GM parent) and, as a consequence, some of these altered interactions could potentially result in risks to the environment and human health. With a view to the formula that a risk is the likelihood of the occurrence of a hazard, the Dutch CA identifies the following hazards of the field trial with the GM poplar: Feral poplars could become more difficult to remove from agricultural areas, or, could disrupt ecosystems outside agricultural areas; Food webs around poplars could become affected, and; Growth of poplars, other trees and plants could become delayed because of effects on soil fertility. However, based on the biological characteristics of the non-GM female clone as parent, the genetic modification techniques, the inserted gene-construct, the environment, and the physical containment, cultivation and monitoring measures foreseen in the draft permit, the Dutch CA argues that the likelihood of occurrence of each of these hazards is so small that the environmental risks of the field trial are to be considered negligible. Concerning potential human health risks, the CA argues as follows: "*If the product of the ccr sense construct would have a toxic or allergenic effect for humans, it could have an adverse effect on human health, depending on the magnitude and the way of exposure. However, transgenic trees or parts thereof are not suitable for human consumption. There will thus be no exposure following incidental consumption, while exposure as a consequence of contact with the trees will in any case be of minimal nature (...)* The risk of toxic or allergenic reactions is negligible."

¹³ <http://www.vib.be/InfoEdu/EN/THE+POPLAR+FILES/>

out that laboratory results suggest that its wood yields an increase of 50 % of bio-ethanol.¹⁴ In other words, the technological objective of VIB's research is the development of a novel technology for the production of certain goods that are currently produced with other technologies.

With a view to this technological objective, one of VIB's researchers, Wout Boerjan, describes the major scientific goal of Bio-energy group at the VIB Department of Plant Systems Biology as *"to understand the biosynthesis, polymerization and structure of lignin and how lignin biosynthesis integrates into plant metabolism and development. This will provide fundamental knowledge that is necessary for, or engineer plant cell walls that are easier to convert to bio-ethanol. Both Arabidopsis and poplar are used as model systems. The genetic resources available in poplar (...) allow approaching the bio-energy problem from a genetics point of view and immediately in a target bio-energy crop"*.¹⁵

The scientific objective of the VIB research programme on poplar is thus directly linked with the technological objective of developing a novel way of producing bio-ethanol, because *"lignin is the main limiting factor because it limits accessibility of the cellulose microfibrils to enzymatic depolymerization"*(into glucose which is subsequently fermented into bio-ethanol). The VIB researcher also directly links the technological objective to global societal issues. To his opinion, *"it is now well recognized that burning fossil fuels and deforestation are major contributors to climate change, and that plant biomass can serve as an alternative renewable and carbon-neutral raw material for the production of bio-energy (...) Trees, such as poplar and willow, have large potential to become major energy crops for the future"*.

In September 2008 the VIB research programme on poplar gained, in its own words, international recognition thanks to a considerable injection of € 1.25 million from Stanford University, a world-renowned research university in the United States of America. As a consequence, the VIB's research programme on poplar became linked with the Global Climate and Energy Project (GCEP) of Stanford University. The GCEP started with a budget of about \$ 225 million, provided by industrial sponsors, among which Exxon Mobile, Toyota, General Electric and Schlumberger, and several other academic institutions and universities in the US, Switzerland, Belgium, France, the Netherlands (Delft, Utrecht), Sweden, Spain, Japan and Australia.¹⁶ Moreover, the VIB is also one of the ten public and private partners of the European four-year collaborative platform 'EnergyPoplar', co-ordinated by the French research institution INRA, funded by the European Commission with € 3 million and launched in March 2008.¹⁷

Given the direct link between the technological objective and the potential societal usefulness or need, the wider context of the field trial with GM poplar WT/52-3 in the Netherlands is being shaped and re-shaped by the outcomes of political negotiations, policy making and societal discussions on issues, like climate change and renewable energy, at local, regional, national and international levels. These societal issues are further intricately linked to other societal issues, such as agriculture and forestry, rural development, nature management, biodiversity conservation, transport, trade, mobility, science and technology and international development co-operation.

¹⁴ The VIB does not substantiate this claim by providing detailed data and the calculation methods it has used to arrive at this figure. In fact, it is even not clear what exactly has been compared.

¹⁵ <http://www.vib.be/Research/EN/Research+Departments/Department+of+Plant+Systems+Biology/Wout+Boerjan/>

¹⁶ See <http://gcep.stanford.edu/>

¹⁷ See <http://www.energypoplar.eu/index.php>

In this wider context, myriad of (inter)national parties with commercial and non-commercial interests aim at having an impact on the shaping of the field trial's wider context. These parties include operators in agro-food and energy supply chains, national governments, large-scale energy end-users (industries, transport firms, power and heat utilities), investors, venture capitalists, research institutions, farming and forestry organisations, consumers and citizens in urban and rural areas, political parties and non-governmental public interest organisations.

In conclusion, the field trial with GM poplar WT/52-3 is one step in a technological route for a novel way of producing bio-ethanol with a series of intricately linked scientific, technological and societal objectives and interests, ranging from understanding and engineering lignin biosynthesis in model plants and new energy crops and developing novel ways of producing bio-fuels to mitigation of climate change, reduction of dependency of fossil oils.

Bio-fuels markets and policies

Global bio-fuels market developments¹⁸

A few years ago, many governments from northern and southern countries started to implement policies to promote the use of renewable energy, such as hydro, geothermal, solar, tide and wind energy as well as biomass-derived energy, including bio-fuels. Particularly in the case of bio-fuels, the reasons for promoting renewable energy production and use vary from the wish to decrease dependency on imports of fossil oil from politically unstable regions to aspirations such as lower greenhouse gas emissions, improved local air quality, enhanced rural economic development, and less waste.

The emerging bio-fuels market is a submarket of the overall biomass market, which is a complex interaction of several competing primary sources of biomass, conversion routes and applications such as heat and electricity generation, chemicals and transportation fuels. Over the next two decades, it is expected that bio-fuels will be used primarily for road transport. In 2006 the International Energy Agency (IEA) projected that bio-fuels' share of global transportation fuels will increase from 1% in 2004 to 6.8% in 2030. The IEA further expected that the biggest increase in demand for bio-fuels will occur in India, other Asian countries, Brazil and other Latin-American countries with an annual growth rate of 5 %, while the annual growth rate of bio-fuels demand in North-America and Europe is projected at 2 %. Outside these regions the use of bio-fuels is expected to remain very modest. Compared to the share of transportation fuels based on fossil fuel, the share of transportation bio-fuels is expected to be a modest 6 – 8% by 2030, except in the EU, where it is expected to be 12 %, and Brazil, where it is projected to be 30%

Yet, estimates of growth rates of bio-fuels markets are rather speculative, as there are major uncertainties about the price volatility of transportation fuels derived from fossil oil over the next ten years and the use of bio-fuels by light and heavy vehicles. There are also major uncertainties about the production costs of various 1st and 2nd generation bio-fuels, because price developments are hard to predict for feedstocks, including crop and woody biomass (residues), and because there could be greater competition between food, feed, bio-fuels and electricity. Government interventions, such as different tax regimes for bio-fuels and fossil

¹⁸ Schenkelaars, P. (2007) The Future of Biofuels: global markets and forecasts to 2017, Pira International Ltd., United Kingdom; see <http://www.piranet.com/>

fuels, obligatory or non-binding targets for using blends of bio-fuels and fossil fuels, will seriously affect the end-use prices of bio-fuels and fossil fuels. In addition, substantial capital investments are needed for research and development, the construction of large-scale bio-fuel production plants and distribution infrastructure and the adaptation of vehicle engines.

The bio-fuels market is at an early stage. Apart from Brazil, producers have only recently begun sizeable production, primarily driven by government policies based on supply security, the potential of bio-fuels to reduce greenhouse gas emissions or to enhance rural development. The current bio-fuels market is largely national and regional. Global trade is developing but is thus far rather limited, mainly due to national policies; tax exemptions vary from country to country and taxation is a potential hurdle to imports. New companies dedicated to bio-fuels have stimulated the use of domestic agricultural resources as biomass for bio-fuel production.

1st and 2nd generation bio-fuels¹⁹

1st generation bio-ethanol – produced from sugar cane in Brazil, maize in the US, and sugar beet and wheat in Europe – is expected to account for the most of the increase of global bio-fuels production and use, as its production costs are expected to fall faster than those of biodiesel from rapeseed oil in Europe, soybean oil in the US and Brazil and palm oil imported from Malaysia and Indonesia.

Thus far, 1st generation bio-ethanol and biodiesel require government interventions, so that they can compete with fossil fuels, as their production costs are much higher than for transportation fuels derived from fossil oil. Opinions differ on whether this also applies to bio-ethanol from Brazilian sugar cane, currently the cheapest to produce of all bio-fuels. Whether or not the market for 1st generation bio-fuels can develop further, and how quickly, will largely depend on government policies and developments in the fossil oil market.

Except for bio-ethanol from sugar cane, the energy and greenhouse balances of the 1st generation bio-fuels are not very beneficial, and some may even be negative. There are serious disputes in the scientific literature about the proper ways to calculate energy and greenhouse gas balances. Notably, based on cost and environmental reasons, biomass so far seems better employed in power and heat generation than in 1st generation bio-fuels for transport.

Since a few years public interest groups, also in the Netherlands, have started to scrutinise the environmental costs and benefits of 1st generation bio-fuels, including biodiesel production from Indonesia and Malaysian palm oil and Brazilian soybean oil. They fear that large-scale expansion of feedstock production through plantations will increase pressure on sensitive and valuable ecosystems, such as rainforest, savannah and wetland. They are also concerned about poor labour conditions and competition with food or fodder crops. Along with processors, retailers and banks, public interest groups are now negotiating import criteria for sustainable palm oil and soy. But it is a complex process to develop a sustainability assurance schemes for bio-fuels and it seems almost impossible to trace a shipment of palm oil or soy to its port of departure and the plantation where the fruits were harvested.

While 1st generation bio-fuels have high production costs and low or almost zero potential to reduce greenhouse gas emissions, many anticipate that 2nd generation bio-fuels from woody

¹⁹ See previous footnote.

biomass and residues will have a better economic and environmental performance. In many countries, development of 2nd generation bio-fuels follows two basic paths:

1. The first focuses on improving technologies for conversion of cellulose-rich biomass into sugar then cellulosic-bio-ethanol, including the development of new enzymes able to degrade lignin and other components of wood; it also investigates new energy crops such as switch grass and miscanthus, trees such as poplar, willow and eucalyptus, and agricultural and forestry residues and municipal wastes.
2. The second focuses on conversion of biomass through gasification and thermochemical routes, resulting in Fischer-Tropsch (FT) biodiesel, also known as biomass-to-liquid (BTL) biodiesel, hydrothermal upgrading (HTU) biocrude oil or pyrolysis oil.

With a view to the lignin-modification of GM poplar WT/52-3, both technological development paths to 2nd generation bio-ethanol raise a similar question: If the new lignin-degrading enzymes would have a good performance, or if gasification and thermochemicals routes would have good yields, would there be a need for GM poplar with less lignin?²⁰

No 2nd generation bio-fuels has yet been produced on a large and commercially worthwhile scale. Several large-scale demonstration plants are now being constructed in the US and Europe.²¹ Some expect commercial production facilities to come on stream within five to ten years. Although many expect 2nd generation bio-fuels to be more cost-effective and have a better environmental performance than 1st generation bio-fuels, biomass for power and heat generation is likely to remain more cost-effective than using biomass to produce 2nd generation bio-fuels.

Many have argued that the potential for land-use conflicts between food, feed and bio-fuel will decrease when 2nd generation bio-fuels from cellulose-rich biomass can be produced from non-agricultural land, such as forest areas and marginal land.²² But then there could be competition between wood for bio-fuels, wood for power and heat generation and wood for

²⁰ In the paper and pulp industry, which represents 6% of total global annual industrial energy use, replacement of Tomlinson recovery boilers by Black Liquor Gasification Combined Cycle (BLGCC) technology could potentially be a commercially worthwhile approach. In standard kraft pulp mills, the black liquor produced from de-lignifying wood chips is normally burned in a large Tomlinson recovery boiler. Because of the high water content of black liquor, commonly burned at a solids contents of 65 – 75%, the efficiency of existing recovery boilers is limited. Electricity generation is also limited, because the recovery boilers produce steam at low pressures for safety reasons. However, gasification of black liquor offers opportunities to increase efficiency, as it yields biosyngas that can be used in gas-turbine power generation for electricity production and as feedstock for the production of liquid transportation bio-fuels and other biochemicals. See: Schenkelaars, P. (2007) The Future of Biofuels: Market Opportunities for Pulp and Paper Manufacturers, Pira International Ltd, United Kingdom; see <http://www.piranet.com/>

²¹ Based on comparison of biochemical and thermochemical platforms, it has been calculated that 2nd generation bio-fuels will come at very high capital cost – more than five times that of comparably sized (maize and wheat) starch-bio-ethanol plants – based on the current state of technology. In terms of least capital cost, the order of preference for (2nd generation) cellulosic-bio-fuels is: 1) thermochemical hydrogen; 2) methanol; 3) ligno-cellulosic ethanol, and; 5) Fischer-Tropsch (FT) diesel. See Wright, M.M., *et al.*, (2007) Comparative economics of bio-refineries based on biochemical and thermochemical platforms, *Biofuels, Bioproducts & Biorefining* 1: 49 – 56.

²² In the case of *jatropha* (India, Africa) it has also been argued that it could be grown on marginal lands. In practice, however, the crop might also be grown on lands previously used for cultivation of food/feed crops because of financial economic reasons.

material applications such as timber and paper and pulp. Table 2 summarises some key drivers and barriers to bio-fuel adoption.

Table 1: Key drivers and barriers to bio-fuel adoption

KEY DRIVER	KEY BARRIER
Fiscal support measures and obligatory requirements for the use of bio-fuels and/or blends of bio-fuels and fossil fuels.	Limited feedstock availability and increasing feedstock prices in relation to price levels of fossil resources.
Government support through R&D programmes and agricultural, energy, trade, transport and consumer policies as well as government procurement programmes.	Potential trade conflicts because of different interpretations of WTO rules.
Political willingness to decrease dependency on imports of fossil resources from unstable regions, to act out of environmental considerations and/or to support rural (re)development.	Major capital investments for new bio-fuel production plants and several technological bottlenecks, particularly for 2 nd generation bio-fuels.
Interest and efforts of oil companies, car manufacturers and farmers.	Land-use conflicts because of competition for biomass between food, feed, bio-fuel and electricity companies.
Compatibility with production and distribution infrastructure for petrol and fossil diesel	Considerable uncertainty about methodologies for assessing environmental costs and benefits for bio-fuels could influence government support and political willingness.
Development of bio-fuels standards and technical quality specifications.	Criticism from non-governmental organisations regarding the social and environmental costs of 1 st generation bio-fuels could lead to lack of public acceptance.

Source: Schenkelaars (2007)

Bio-fuels policies in the EU and the Netherlands

The Ministry of VROM (also the Dutch CA for Directive 2001/18EC) indicates on its website that the European policy on bio-fuels was established on 8th of May 2003 in EU Directive 2003/30.²³ This actually comprises directives: a new directive to promote bio-fuels and an amendment to an existing directive on the excise duty tariffs for bio-fuels. According to the directive on bio-fuels, 5.75% of the energy content of fossil fuels must be made up of bio-fuels by 2010. The directive also calls on member states to indicate on an annual basis how they intend to reach the target at the national level. Since 2007, 2% of petrol and diesel marketed by oil companies on the Dutch market must be bio-fuels. For the Netherlands, 2% corresponds to three million hectolitres of bio-fuels and 5.75% corresponds to nine million hectolitres.

In 2008 the obligatory requirements for blending of bio-fuels and fossil fuels prompted an environmental organisation to express its concerns about the social and environmental drawbacks of 1st generation bio-fuels to the Minister of VROM.²⁴ The Minister responded by indicating to share its concerns surrounding the sustainability of bio-fuels and the changes and shifts in land-use. The Minister further pointed at the active role of the Netherlands at the

²³ <http://www.vrom.nl/pagina.html?id=37483>

²⁴ http://www.vrom.nl/docs/200803_biobrandstof.pdf

European level to promote the sustainable production of biomass for bio-fuel productions. To the Minister's opinion, the Dutch efforts had contributed to a new EU directive on renewable energy that was being drafted with provisions for the sustainability of bio-fuels. Finally, the Minister indicated to share the view of the environmental organisation that the development, production and use of 2nd generation bio-fuels should be promoted and favoured over 1st generation bio-fuels.

Short rotation coppice GM poplar in the Netherlands

As has been noted above, the field trial with GM poplar WT/52-3 in the Netherlands in one step in a technological route for a novel way of producing bio-ethanol. If this or another GM poplar are found to be sufficiently 'productive', this could eventually lead to (commercial) large-scale Short Rotation Coppice (SRCs) of GM poplar plantations, probably not too far way from processing plants for 2nd generation bio-ethanol. With a view to economies of scale, such processing plants will highly likely require substantial amounts of feedstock, e.g. GM poplar wood.²⁵

In the Netherlands, growing (GM) poplar in SRC would be a fully novel (agro-forestry) practice.^{26, 27} In other European countries, like Sweden and the UK, SRCs of trees, like poplar and willow, have been expanding as a source for renewable energy since the beginning of the 1990s. Given the Dutch unfamiliarity with SRC, a practice note of 2002 by the UK Forestry Commission provides some clues, as it reviews existing knowledge and gives guidance on site selection and preparation, plantation design, planting, weed control, crop management, pest management and yield.^{28, 29} While the practice note can be regarded as a rather detailed grower's manual, particularly aspects as crop and pest management, weed control and fertiliser requirements are probably of most direct relevance for understanding potential effects of SRC on the environment, biodiversity, land use and landscape:

- The establishment of SRC plantations has more in common with agricultural or horticultural crops than forestry.³⁰ It is impossible to overemphasise of establishing an SRC crop (tree) in completely weed-free conditions. Both poplar and willow are intolerant of weed competition, and even low levels of weed cover will cause uneven growth and greatly reduced yields. A completely weed-free site is required at planting.

²⁵ In the absence of detailed data and calculation methods used by the VIB for its claim that bio-ethanol production of GM poplar wood increases by 50%, it is not possible to estimate the acreage with SRC GM poplar needed as feedstock for a commercial processing plant, also because there are so far only experimental pilot-plants. Perhaps the following *might* provide a clue: In 2009 Alco Bio Fuel, one of Ghent Bio-Energy Valley's private parties, will need almost 400.000 tons of grains, mainly maize and wheat, for its bio-ethanol plant with an annual capacity of 150 million litres. This amount of feedstock corresponds with 15 % of the total grain acreage in Belgium (Agrarisch Dagblad, 04.02.2009).

²⁶ The draft permit indicates that poplar is wide-spread in the Netherlands, where it grows at riversides and along roads, dykes, etc.; the draft permit does not make any reference to short rotation poplar coppice as a common practice in the Netherlands.

²⁷ This also implies that there is no baseline of a standing agricultural practice in the Netherlands, against which to compare and assess the environmental risks of GM poplar WT/52-3.

²⁸ Tubby, Y. & Armstrong, A. (2002) Establishment and Management of Short Rotation Coppice: Practice Note, Forestry Commission, UK; see <http://www.forestry.gov.uk/>

²⁹ See for a scientific review into the ecology of SRC on farmland, addressing two key issues – wildlife use and pest control: Sage, R.B. (1998) Short Rotation for Energy: Towards Ecological Guidelines, Biomass and Bioenergy, 15(1): 39 – 47.

³⁰ Sage (1998) notes that “SRC is an appropriate crop for previously cultivated land. Planting SRC on unimproved grassland, wetland or woodland sites may spoil existing wildlife habitats (...) SRC could fragment certain grassland habitats, valuable to wildlife as large continuous areas”; see footnote 21.

Weed control can be divided in three phases: before cultivation, shortly after planting and after cut back and harvesting. All perennial weeds should be sprayed with a broad spectrum contact herbicide like glyphosate before any cultivation takes places.³¹ Once the crop has been planted and the soil has been consolidated, residual soil-acting herbicides should be applied to control germinating weeds. This is essential to maximise SRC survival and early growth. The dense canopy of a vigorous SRC crop should subsequently shade out most weeds once the crop has become established. Subsequent weeding should only be required after harvesting.

- Willows and poplars are host to a wide range of fungal pathogens, like rust (*Melampsora*), and leaf-eating insects, such as brassy and blue willow beetles of the chrysomelid family. Different varieties of willows and poplar have different degrees of susceptibility to the various species and races. There are many insecticides available that will control beetles, but their overall application to coppice is difficult, environmentally undesirable and probably uneconomic. However, limited and targeted use of insecticides as an emergency control measure may be acceptable under some conditions. It is further recommended planting mixtures of five or six varieties to limit rust infection. Establishing large plantations of a single, currently resistant high-yielding variety to maximise financial return in the short term is a high-risk strategy and not recommended.
- The use of inorganic fertiliser may economically and financially only be justified, if the crop responds by producing enough wood to offset the energy used and cost incurred. Research so far has shown that a positive response to fertiliser application is not guaranteed. As the crop is harvested after leaf fall, nutrients contained in the foliage are recycled back into the soil. Only nutrients in the harvested coppice stems are removed from the site. Leaf litter turn and atmospheric nitrogen inputs will compensate for a large amount of the nutrients removed. Though, new, higher yielding SRC varieties may remove larger quantities of nutrients and require greater fertiliser inputs.
- It is standard practice to cut back growth from willow and poplar stools at the end of the first year to encourage the formation of multi-stemmed stools in the following growing season. Subsequently, after two to four years SRC is harvested after leaf-fall and before bud burst. There are no hard and fast rules for cutting cycle length. Basically, there two harvesting systems. The crop can be cut and chipped in one operation, or the crop can be cut and the stems left intact to air-dry, with chipping carried out as a separate operation at a later date.
- It is important to bear in mind that at the end of a three-year cutting cycle the SRC crop may be up to 8.0 meter in height. Before selecting sites of SRC plantations, it is therefore important to consider the impact this will have on the landscape. In the UK SRC must conform to the UK Forestry Standard, including landscape design.
- The habitat created by an SRC plantation is very different to those found within conventional agricultural crops. Willow and poplar support a large number of insect species most of which cause little damage to the crop. Many songbirds are attracted to

³¹ Besides lignin-modifications, there are worldwide numerous public and private R&D efforts that aim at developing GM trees with resistance to herbicides, like glyphosate, and/or to insects, abiotic stress, etc.

SRC, especially willow plantations. Shade tolerant plants may become established under the dense canopy, while headlands and access rides can provide a 'woodland edge'-type habitat where flowering plants may thrive. On the other hand, large-scale SRC plantations may have a negative impact on local populations of birds dependent on farmland.

At this stage, given the unfamiliarity with commercially worthwhile SRC poplar plantations in the Netherlands, their potential impacts on the environment, biodiversity, land use and landscape are difficult to appraise. The sustainability criteria for biomass production that are currently being negotiated at the EU level will probably make such an appraisal mandatory. Nonetheless, it is already clear that SRC poplar plantations in the Netherlands will have profound impacts, especially for the Dutch landscape currently dominated by farmland crops, such as maize and wheat, and grasslands, as SRC poplar might reach heights of about 8 metres³², while it may result in significant changes in land use as well.

In conclusion, bio-fuel market developments, European government policies and societal discussions on 1st and 2nd generation bio-fuels, such as bio-ethanol from GM poplar WT/52-3, are at an early stage. With the exception of Brazilian sugar cane bio-ethanol, none of the 1st and 2nd generation bio-fuels is or will be able - without government interventions - to compete with fossil fuels. Governments in Europe are now negotiating legislation on how to produce biomass for bio-fuels in a sustainable way. Notably, woody biomass for electricity and heat generation is likely to remain more cost-effective than using it to produce 2nd generation bio-fuels. Moreover, there might be other technological routes for production 2nd generation bio-ethanol from woody biomass that probably do not require genetic modification of the wood composition of poplar. In addition, commercially worthwhile production of bio-ethanol from GM poplar requires the introduction of Short Rotation Coppice (SRC), which is a (agro-forestry) practice novel in the Netherlands with profound consequences for the environment, biodiversity and, in particular, the Dutch landscape currently dominated by farmland crops and grasslands, as SRC poplar might reach heights of about 8 metres while it may result in significant changes in land use as well.

Cross border regional development

According to the permit application, the VIB will transport wood from the field trial with GM poplar WT/52-3 in the Netherlands to Ghent in Belgium, where it will be processed into bio-ethanol in the laboratory and a pilot plant for 2nd generation bio-fuels. The building of this pilot plant for 2nd generation bio-fuels was announced by the Ghent port administration in September 2008.³³ At that occasion, its spokesperson claimed that 'Ghent' in Belgium and 'Terneuzen' in the Netherlands with a total joint annual production of 1.2 million tons of bio-fuels are together the European market-leader in bio-fuels, followed by 'Rotterdam' with an annual production of 0.9 million tons.

³² In Friesland, a northern province in the Netherlands, the provincial administration recently contributed € 260,000 to a project for the adoption by farmers of so-called 'landscape maize'; a dwarf cultivar developed by a small breeding firm Nordic Maize Breeding together with Wageningen University. Large firms, like Monsanto, Syngenta and KWS, were not interested. One of the reasons for provincial financial support is that citizens started complaining about the landscape impacts of conventional maize cultivation in Friesland. Other reasons include biodiversity and traffic safety and because "*dwarf maize could even strongly simplify navigating sailing yachts and skûtjes*". (Agrarisch Dagblad, 06.02.2009)

³³ See <http://www.zita.be/>

The pilot plant meant to bridge the gap between theoretical knowledge and industrial production is one of the core initiatives of Bio Base Europe, which in turn is the result of an alliance between Ghent Bio-Energy Valley, Vlaanderen, in Belgium, Biopark Terneuzen, Zeeland, in the Netherlands and their respective partners (see Table 2).³⁴

Table 2: Parties involved in Ghent Bio-Energy Valley and Biopark Terneuzen

Ghent Bio-Energy Valley	
Name of entity	Core activity
Ghent University	Science and education
The city of Ghent	Administration
The port of Ghent	Administration
POM Oost-Vlaanderen	Provincial development agency
Alco-Bio Fuel	Bio-ethanol production
BIORO	Bio-diesel production
Electrabel	Energy company, member of the Suez group
SPE	Energy production and supply
Organic Waste Systems	Treatment of municipal solid waste and industrial organic waste
Oleon Biodiesel	Production of biodegradable components from renewable resources
Oiltanking	Handling, storage and distribution of petroleum and bulk chemicals
Sea-Invest	Port handling of various dry bulk, liquid bulk and fruit terminals
Desmet Ballestra	Solutions for seed crushing, oleochemical, biodiesel, detergent markets
Genencor International	Enzymes/biochemicals for industrial and agri-processing markets
Capricorn	Venture capital
Geodetics Construction	Construction for the bulk and processing industries and waste handling
Lalemant	Transport and shipping
Cargill	Import, storage, processing and distribution of agribulk and vegetable oils
Fabricom	Technical installations and services for industrial and infrastructure markets
Ernst & Young	Services in assurance, tax, transaction and consultancy
BnS Engineering	Engineering and project management of industrial projects
Biopark Terneuzen	
Name of entity	Core activity
Royal Nedalco	Production of bio-ethanol from plant materials
Yara Sluiskil	Supplier of artificial fertilisers
Rosendaal Energy	Production of bio-diesel
Cargill	Import, processing, trade and storage of agricultural commodities
Ecoservices Europe	Processing and sales of dry and liquid organic waste material
ESV Group	Storage and distribution of bio-fuels
Heros	Recycling of waste and rest-products; transport,
Biomass Unie	Joint venture between Heros Group and ESV Sluiskil
Valuepark Terneuzen	Partnership between Zeeland Seaports and Dow Benelux
Glastuinbouw	Greenhouse horticulture

Sources: Bio Base Europe, Ghent Bio-Energy Valley, Biopark Terneuzen

On 18th December 2008, Bio Base Europe received € 21 million from the European Regional Development Fund set up by the European Commission to foster cross border co-operation and to stimulate sustainable socio-economic development in European border regions. Bio Base Europe has the objective to “transform the region into the main a bio-economy gateway

³⁴ See <http://www.biobaseurope.eu/Bio%20Base%20Europe%20press%20release%20E%20final.doc>

in Europe” and “to accelerate the development of a sustainable bio-based economy in Europe”.³⁵ It is expected “to boost the current drive towards sustainable production processes and to reduce the emissions of greenhouse gases” and “it will develop a unique platform for the advancement of sustainable bio-based processes that aid the development of bio-energy and bio-products from renewable biomass resources and cut reliance on non-replaceable fossil fuels”.

The Bio Base Europe Pilot Plant will mainly focus on “second generation technologies to convert agricultural waste products and non-food crops, such as wheat straw, corn cobs, *Jatropha* and algae oils in bio-fuels, bio-plastics and bio-products (...) Whereas the potential of these technologies has already been demonstrated in laboratory trials, the difficulty lies in taking these processes to the production scale. Currently, many new processes are held up or even abandoned because of these difficulties. The Bio Base Europe Pilot Plant is set up to eliminate this obstacle, by providing pilot facilities that permit scaling up of new bio-processes to an industrial level”.

The new € 13 million pilot plant is scheduled to become operational in the fourth quarter of 2009. The second core activity of Bio Base Europe is a state-of-the-art training centre to address the industry-wide shortage of skilled processors and technical maintenance personnel, especially for the bio-based economy, operating according to an open educational model. It will also encourage networking, technological innovation, entrepreneurship and develop a public information and communication programme. The € 8 million training centre will be located at Terneuzen and become operational in 2010.

In conclusion, the field trial with GM poplar WT/52-3 in the Netherlands can be regarded as one (little) step in a cross border regional development process with the objective to transform Vlaanderen in Belgium and Zeeland in the Netherlands into a main sustainable bio-economy gateway of Europe. Parties with direct political, socio-economic and/or commercial interests that are shaping this cross border regional development process are public administrations, research institutions and private companies active in markets, like import, storage, processing and/or distribution of petro- and agro-bulk commodities, bio-fuels, biochemicals, municipal and industrial waste handling and recycling, engineering and construction, shipping and transport, finances and consultancy.

Summary of the field trial’s wider context

The field trial’s purpose to study the GM poplar’s response to biotic stress by a few pathogens and abiotic stress by frost and wind mainly serves the technological objective of developing novel ways of producing bio-fuels because of the aim to develop GM poplar that is ‘productive’ under field conditions. The investigations foreseen by the VIB can hardly be qualified as ‘environmental risk research’, while physical containment measures imposed by the Dutch CA *might* limit potential environmental risks of the field trial to the trial site. The field trial will therefore not lead to an adequate scientific understanding of the potential risks of the GM poplar in scaled up releases or commercially worthwhile short rotation coppices. In case of an application for a scaled up field trial with the GM poplar in the Netherlands, a lack of scientific understanding of the potential environmental risks may well result in a denial by

³⁵ See previous footnote.

the CA to grant a permit, given its regulatory policy objective of 'safe' releases of GMOs into the environment.

The field trial with GM poplar WT/52-3 is one step in a technological route for a novel way of producing bio-ethanol with a series of intricately linked scientific, technological and societal objectives and interests, ranging from understanding and engineering lignin biosynthesis in model plants and new energy crops and developing novel ways of producing bio-fuels to mitigation of climate change, reduction of dependency of fossil oils imported from politically unstable regions and promotion of rural development. While these are all global issues that are to be tackled from the local to the international level, the field trials can be regarded as one (little) step in a cross border regional development process with the objective to transform Vlaanderen in Belgium and Zeeland in the Netherlands into a main sustainable bio-economy gateway of Europe. Parties with direct political, socio-economic and/or commercial interests that are shaping this cross border regional development process are public administrations, research institutions and private companies active in markets, like import, storage, processing and/or distribution of petro- and agro-bulk commodities, bio-fuels, biochemicals, municipal and industrial waste handling and recycling, engineering and construction, shipping and transport, finances and consultancy.

Whether the field trial with GM poplar WT/52-3 - as a step in a specific technological route for 2nd generation bio-ethanol - could lead to commercially worthwhile operations, depends on bio-fuel market developments, European government policies and societal discussions on 1st and 2nd generation bio-fuels, which are at an early stage. With the exception of Brazilian sugar cane bio-ethanol, none of the 1st and 2nd generation bio-fuels is or will be able - without government interventions - to compete with fossil fuels. Governments in Europe are now also negotiating legislation on how to produce biomass for bio-fuels in a sustainable way. Notably, woody biomass for electricity and heat generation is likely to remain more cost-effective than using it to produce 2nd generation bio-fuels. Moreover, there might be other technological routes for production 2nd generation bio-ethanol from woody biomass that probably do not require genetic modification of the wood composition of poplar. In addition, commercially worthwhile production of bio-ethanol from GM poplar requires the introduction of Short Rotation Coppice (SRC), which is a (agro-forestry) practice novel in the Netherlands with profound consequences for the environment, biodiversity and, in particular, the Dutch landscape currently dominated by farmland crops and grasslands, as SRC poplar might reach heights of about 8 metres, while it may result in significant changes in land use as well..

USEFULNESS/NEED OF THE FIELD TRIAL WITH GM POPLAR WT/52-3

Approach to usefulness/need analysis

For the sake of the usefulness/need analysis of the field trial with GM poplar WT/52-3 in the Netherlands, it is proposed to distinguish between ‘GMO-related aspects’ and ‘Sustainable biomass-related aspects’. By doing so, the usefulness/need analysis can make usage of the current state of affairs concerning societal discussions and policy debates on ‘GMOs’ and ‘sustainable biomass-energy’ in the Netherlands.

It should thereby be noted that these two issues have so far mostly been discussed in two separate societal and policy arenas in the Netherlands. However, for the usefulness/need analysis of this field trial, it is required to link them. The outcome of the societal discussions and policy debates on these two issues so far will therefore be reviewed and, subsequently, integrated into an appraisal framework. The appraisal framework will then be applied to the field trial with GM poplar WT/52-3 and its wider context, in order to analyse the potential usefulness or need for the Netherlands.

GMO-related aspects

Since the first field trials with GM plants in the Netherlands in the beginning of the 1990s, potential risks to the environment and human health were and have remained a source of divergent views among regulators, innovators and public interest organisations. For almost every permit for field trials with GM crops, the government faced appeals at the highest administrative court, the Council of State (Raad van State). In its decision-making on permits for field trials, the Dutch CA has generally always sought to make a sharp distinction between societal-ethical and scientific-technical aspects of regulating releases of GM crops.³⁶

In 1996 mainstream political parties became interested in GMOs as a result of mass-media attention to the societal controversy over the first imports of GM soy from North-America. In 1999, this interest resulted in two parliamentary resolutions asking the government to declare its policy on biotechnology and to organise a broad public debate. This led the government to issue a White Paper on biotechnology in 2000. The government also announced the installation of the Commission on Biotechnology for the supervision of a broad public debate in 2001. After a year of intense public and political discussion, the main result of the parliamentary debate on the White Paper in 2002 was a resolution urging the government to develop an integral societal-ethical evaluation framework (ISEEF) for biotechnology.

A few months later this was followed by a discussion paper for an ISEEF commissioned by the COGEM.³⁷ The COGEM subsequently recommended that the CA make it mandatory for applicants of large-scale and commercial releases of GM crops to complete a ‘risk/usefulness’ form to facilitate a dialogue among interested parties. However, both the CA and innovators immediately objected, since the European regulations did not allow for societal-ethical aspects, such as usefulness/need or sustainability, to be taken into account. One year later, the

³⁶ Schenkelaars, P. (2005) Regulating GM crops in the Netherlands: precaution as societal-ethical evaluation, *Science and Public Policy*, 32(4): 309-316.

³⁷ COGEM (2003) Naar een integraal ethisch-maatschappelijk toetsingskader voor moderne biotechnologie: discussienota ter voorbereiding van een tweede signalering van de COGEM gericht aan de Staatssecretaris van VROM, CGM/020628.

discussion paper was followed by the COGEM's societal-ethical signal on an ISEEF, which was sent to Parliament in November 2003, where it did not raise any comments. Parliament thus simply endorsed the COGEM's ISEEF or took it for granted, probably because the mainstream media were then devoting hardly any attention to controversies of GM foods and GM crops. Neither the ISEEF nor the risk/usefulness form have so far been used in regulatory practice.

Five years after the publication of the ISEEF, the European Council of Ministers at its meeting of 4 December 2008 started seeking to strengthen environmental risk assessments and monitoring arrangements and to appraise socio-economic benefits and risks and agronomic sustainability of deliberate releases of GMOs, because "*GMOs, in particular cultivation of genetically modified plants, give rise to discussion and questions, within the scientific community and society at large regarding their impact on health, environment and ecosystems*".³⁸ At this moment, it is difficult to foresee whether, and if so, how this eventually might affect the distinction made by the Dutch CA between societal-ethical and scientific-technical aspects of regulating releases of GM crops.

In essence, the ISEEF consists of a five-step process with a series of evaluation criteria concerning matters of content and procedural aspects:

- Step 1: Mapping the space for the consideration and creating conditions for a righteous consideration through engaging and soliciting views from interested parties and individual citizens.
- Step 2: Determining whether the permit application complies with criteria that are considered threshold values in the corresponding sector (agriculture, health care, etc.), and whether the case has already been subjected to a similar societal-ethical evaluation. An example of threshold values to be checked is the following list: a) Has the applicant complied with criteria foreseen by the CA, e.g. sound scientific substantiation, sound risk analysis, adequate safety and emergency measures, monitoring plan and equality before the law, and; b) Compliance with international, European and Dutch treaties and legislation concerning human rights, the principle of freedom of choice and autonomy, the principle of transparent governance, the right of access to information and the precautionary principle, and; c) Has the case already been subjected to a similar societal-ethical evaluation. The next step can only be made if the permit application complies with all these criteria.
- Step 3: Describing the values that can be affected, which might be counterbalanced by certain benefits and expected objectives, whereby negative aspects that not immediately lead to disapproval are mapped.
- Step 4: Making the aimed objectives explicit; in step 3 and 4, which precede the consideration of values that can be affected and aimed objectives, use is made of a checklist of values, objectives and interests that are involved and, dependent of the situation, are weighed differently (see Table 3 for a checklist with possibly affected values and aimed objectives). The more a value can be seriously affected, the more should be known about the nature of the aimed objectives. Moreover, in certain cases

³⁸ See footnote 3.

it might be relevant for the consideration to identify alternative possibilities, each with its potential negative effects to reach the aimed objectives.

- Step 5: Consideration of the identified values that could be affected versus the aimed objectives by a politically responsible authority.

Finally, one of the COGEM's recommendations is not to limit an integral societal-ethical evaluation to a consideration of economic benefits versus techno-scientifically assessed risks, but to broaden the category 'risk' to deterioration of values, and to consider societal usefulness of the aimed objectives.

Table 3: Checklist of possibly affected values and aimed objectives

POSSIBLY AFFECTED VALUES AND AIMED OBJECTIVES*		
Biodiversity	Do good	Social (in)dependency
Communication	Integrity of humans, animals, plants, ecosystems	Social (dis)advantages
Cultural diversity	Quality of life for humans and animals	Conflict with outlooks on life
Cultural appraisal of food	Quality of environment; less environmental burden	Technological innovation
Cultural appraisal of food production	Unintended consequences for third parties: industry, farmers, producers, alternative production methods, consumers, freedom of choice, animals, etc.	Tradition
Sustainability	Solution of global food issue	Safety for humans and animals
Economic (in)dependency	Pluralism	Accountability of involved actors
Economic benefits	Product innovation	Advancing knowledge and technological co-operation
Economic disadvantages	Justice	Freedom
Genetic diversity	Respect for life	Wellbeing of humans, animals and plants
Health of humans, animals, plants	Respect for humans, animals, plants and the environment	Employment opportunities

* In the Dutch COGEM report of 2003 the listing of key words and key phrases is in alphabetical order; there is no ranking or distinction between 'affected values' and 'aimed objectives'.

Source: COGEM (2003)

Sustainable biomass-energy related aspects

Perhaps needless to say, but since a few years global issues like climate change and energy supply have attracted considerable attention and debate from mainstream politics, policy making, media and the general public as well as a wide range of commercial and non-commercial parties. Not surprisingly, numerous scientific articles, technical studies, policy documents, position papers, legislative proposals, research grants and news items are now being issued on a daily basis. Also not surprisingly, interests and views widely diverge on the urgency of these issues and how to tackle these issues, also because they are intricately linked to a whole set of other issues, like trade, transport, agriculture, economy, international development co-operation, science & technology, environment, nature, biodiversity, etc.

In this context the governments of all major trading blocs, including the European Commission and EU member states, have implemented a series of own policy instruments to promote the production and use of bio-fuels in order to mitigate climate change, reduce dependency of fossil oils imported from unstable regions and foster rural development. Whether these policy instruments are adequate for reaching the aimed objectives, and whether there are (radically) alternative solutions for reaching the same objectives, are legitimate questions but beyond the scope of this paper.

Because 1st generation bio-ethanol and biodiesel are not undisputed from societal and environmental perspectives, policy and societal discussions have in the mean time started focusing on the development of legally binding or guiding principles for 'sustainable' biomass production for renewable energy, including (liquid transportation) bio-fuels. In this area there many initiatives. In the Netherlands for example, these discussions led the government to install the project group "Sustainable production of biomass" chaired by Jacqueline Cramer (currently Minister of VROM) and composed by representatives of the Ministries of Economic Affairs, Development Co-operation, the Environment and Foreign Affairs, research institutions, power and heat suppliers, an energy company, an agri-bulk processor, a bank and environmental and development non-governmental organisations. In February 2007 the project group published its evaluation framework, including a set of criteria and indicators.³⁹ The project group defines the sustainability of large-scale production of biomass on the basis of six relevant themes, which are for the greater part linked to the 'Triple P' of sustainable development: People, Planet and Profit, supplemented with specific themes for biomass. The six relevant themes are:

1. Greenhouse gas emissions: How much emission reduction does the biomass yield for a specific producer, calculated from its source up to its use, and compared with the average use of fossil fuel?
2. Competition with food and other local applications: Does the large-scale production of biomass for energy supply supplant other use of the land, for example for the cultivation of food or wood as building materials, and what are the consequences?
3. Biodiversity: Does the local natural ecological system of land and water lose any variation in forms of life because of the large-scale cultivation of energy crops?
4. Environment: Are there any effects of the use of pesticides and fertilisers, or are there other local effects on soil, water and air because of the large-scale production of biomass?
5. Prosperity: Does the production of biomass contribute towards the local economy?
6. Social Well-being: Does the production improve the local living conditions of the local populations and employees?

For each theme, the project group has determined as clearly as possible the sustainability criteria and indicators, which form the heart of its advice to the Dutch government.

³⁹ Accessed at http://www.mvo.nl/biobrandstoffen/download/070427-Cramer-FinalReport_EN.pdf

Framework for analysis of the usefulness/need of GM poplar WT/52-3 in the Netherlands

Based on the present state of affairs of societal and policy discussions in the Netherlands on GMOs and sustainable biomass-energy, it is reasonable to combine the recommendations from the COGEM's for an integral societal-ethical evaluation framework (ISEEF) and the sustainability themes (criteria and indicators) into a framework for the usefulness/need analysis of the field trial with GM poplar WT/52-3 in the Netherlands.

With a view to Step 2 of the COGEM's ISEEF, it is assumed that a permit will be granted for the field trial. But given the history of legal appeals from public interest organisations and individual citizens against regulatory decision-making by the CA in the Netherlands, it can be expected that the soundness of the risk analysis, the safety and emergency measures and monitoring plan foreseen in the permit will be questioned, which will eventually lead to a ruling by the Court of Law (Raad van State). At this moment, it is impossible to predict the nature of such a ruling.

Further, for the purpose of the usefulness/need analysis in this case, the field trial with GM poplar WT/52-3 in the Netherlands is regarded as:

- 1) One step in a scientific research programme within the context of a technological route with the objective of developing a novel way of producing 2nd generation bio-ethanol, as well as;
- 2) One step in a cross border regional development process within the context of a transformation of that cross border region into a bio-based economy with the objective to develop sustainable production processes for bio-energy and bio-products from renewable biomass resources and to cut reliance on non-replaceable fossil fuels.

Finally, the framework for the usefulness/need analysis as such will not further be elaborated here immediately applied to the field trial.

Usefulness/need analysis of the field trial with GM poplar in the Netherlands

The results of application of the framework for the usefulness/need analysis to the field trial with GM poplar WT/52-3 in the Netherlands are be represented through a matrix (See Table 4).

Aspects, like 'interfering with nature' and 'crossing of species boundaries'⁴⁰ and associated notions, such as 'respect for life', 'outlooks on life', etc. have not been analysed in this matrix. Though, it is well known that the European public bases its support for a biotechnological innovation on weighing its perceived risks, usefulness and moral acceptability.⁴¹

⁴⁰ The *ccr* gene in GM poplar WT/52-3 is a species-own gene, but it stands under the control of a CaMV 35S promoter that has been isolated from cauliflower mosaic virus and two regulatory DNA sequences isolated from *Agrobacterium tumefaciens*.

⁴¹ Gaskell, G., et al. (2000) Biotechnology and the European public, *Nature Biotechnology* 18: 935 – 938.

Table 4: Matrix of affected values, aimed objectives and comments

Affected value and/or aimed objective	Comments
Advancing knowledge	Scientific understanding of lignin biosynthesis is directly linked to engineering of trees for more efficient bio-ethanol production. In addition, the field trial serves to understand whether GM poplar WT/52-3 will be productive under field conditions. The field trial will however not advance knowledge of the potential environmental risks of large-scale or commercial GM poplar releases in the Netherlands.
Technological innovation	Genetic modification of poplar for a more efficient production of a 2 nd generation bio-fuel could result in a technological innovation. But there are several other technologies under development that do not require genetic modification of poplar but could also result in innovations for more efficient production of that 2 nd generation bio-fuel.
Product innovation	The technological innovation of a GM poplar could result in a product innovation. Whether the novel product will be adopted by end-users is highly dependent on bio-fuel market developments, government policies and public acceptance.
Employment opportunities	The cross border regional development into a bio-based economy will probably offer better employment opportunities mainly for highly educated and well trained personnel.
Socio-economic (dis)advantages	A transformation of the cross border region into a bio-based economy will also have impacts on the structure of its agricultural sector. At this stage, it is hard to predict who will lose and who will gain. The same goes for the cross border region as a whole. Yet, it is hardly likely that abandoning the specific GM poplar dependent route for bio-ethanol production for other technologies under development for woody biomass-energy production would seriously disrupt the transformation of the cross border region into a bio-based economy.
Economic (in)dependence	<p>On the one hand, a bio-based economy might increase the economic independence of the cross border region. But given the projected high share of fossil transportation fuels in the next decades, it is not reasonable to expect that the cross border region's reliance on imports of fossil fuels will significantly decrease, irrespective of which novel production technologies for bio-fuels will eventually appear to be commercially worthwhile.</p> <p>Intellectual Property Rights (IPR) regimes differ for low-lignin trees developed by conventional breeding, respectively GM low-lignin trees. If government funding of conventional and GM breeding of low-lignin trees is not conditional on a fair distribution of IPRs on R&D findings among public and private partners, this could negatively affect public tree breeding programmes and the eventual use thereof by farmers/foresters.</p>
Communication	The VIB communicates about the field trial through press releases, interviews, participation at public meetings. On its website, under the heading "The Poplar Files", it makes its views and information on the issue publicly available. However, with communication, there is always the question whether it is one-way and meant to educate and persuade the other, or two-way and meant to share knowledge and views and reconsider previous positions and (dis)continuation or adaptation of certain actions or practices.

Table 4 (continued)

Affected value and/or aimed objective	Comments and/or remarks
Sustainable energy Reduction greenhouse gas emissions	The VIB claims that GM poplar-derived 2 nd generation bio-ethanol is sustainable and carbon-neutral. However, the methodology and data used to arrive at this claim are not disclosed. In addition, woody biomass for electricity and heat generation, without the need to release GM trees, is likely to remain more cost-effective than using it to produce 2 nd generation bio-fuels.
Nature and biodiversity	Commercially worthwhile production of 2 nd generation cellulosic-bio-ethanol requires cultivation of the GM poplar in short rotation coppice, which leads to other wild life habitats than farmlands and grasslands. This could in turn result in different positive and negative impacts on biodiversity.
Landscape / tradition	Commercially worthwhile production of 2 nd generation cellulosic-bio-ethanol requires cultivation of the GM poplar in short rotation coppice that could reach a height of 8 metres. In the Netherlands this is a novel practice, which will impact the landscape traditionally dominated by farmlands with 'low' crops, such as maize and wheat, and grasslands.
Land use	Large-scale adoption of short rotation (GM) poplar coppice plantations might lead to conflicts with land use for arable crop production, recreational purposes and nature conservation.
Environment	The establishment of short rotation coppice plantations has more in common with agricultural or horticultural crops than forestry. Large-scale short rotation poplar coppice plantations require inputs, like pesticides and fertilisers, that may or may not, also depending on management, have environmental effects. Additionally, physical containment measures imposed by the CA in its permit might limit potential risks to the site of the field trial. But large-scale or commercial release of GM poplar WT/52-3 in short rotation coppice plantations will in practice not allow to implement physical containment measures, like removal of flower buds before flowering or seed set. As a consequence, it can then be expected that GM poplar WT/52-3 will hybridise with related poplar species in the Netherlands, while the ecological risks thereof are (at least at this stage) not known.

Given the matrix, the following main conclusions can be drawn about the usefulness/need of the field trial with GM poplar WT/52-3 in the Netherlands:

- It is needed for the scientific-technological objective of a novel way of producing bio-ethanol from poplar. But there are other technologies for 2nd generation biofuels under development that do not necessarily require environmental releases of GM trees, like GM poplar WT/52-3. It is therefore not indispensable for the societal objective of transforming the cross border region into a bio-based economy.
- It is not useful for the regulatory and societal objective of 'safe' large-scale or commercial releases of GM poplar in the Netherlands.

- It is not needed for the societal objectives of mitigating climate change or reducing dependency on fossil oil imports from unstable regions. On the one hand, because it is likely that the use of (non-genetically modified) woody biomass for power and heat generation will remain more cost-effective than for bio-fuels production. On the other hand, it is not reasonable to expect that the cross border region's reliance on imports of fossil fuels will significantly decrease, irrespective of which novel production technologies for bio-fuels will eventually appear to be commercially worthwhile.

Evidently, the nature of these conclusions is subjective but certainly not definitive, as other views, data, information and arguments may or may not lead to their reconsideration. One may therefore disagree with these conclusions and one may well have criticism on (the quality of) the information, data and analysis presented so far. But in the end every conclusion will be subjective, depending on perceptions of usefulness and risks and moral values. And, additionally, conclusions drawn by individuals and parties with different interests and (world) views will always be pluralistic.

Multi-Criteria Mapping as a way forward

Yet, decisions have to be made by us, that is 'society' as represented by many different stakeholder groups. In this case of GM poplar WT/52-3 some of the questions are: Should we support or oppose this specific technological route for 2nd generation bio-ethanol? Should we grant a permit for field trials with GM trees or not? Should we invest or disinvest in alternative, competing technological routes? Moreover, each of these questions is associated with another set of questions concerning the political, socio-economic and environmental pros and cons of each option.

Notably, in both Dutch policy contexts of GMOs and biomass-energy, the widespread recognition emerged among many stakeholder parties over the last years has led to several government initiatives to develop evaluation frameworks, not only from a techno-scientific risk management point of view but also from societal-ethical perspectives or based on Triple P (people, planet, profit) sustainability criteria. However, application of these 'broader' evaluation frameworks is far from common practice in governmental policy formulation and decision-making on technological risks. On the other hand, conventional risk assessment policy, particular in the case of GMOs, has so far largely failed, partly because it seeks to provide a single and 'sound scientific' answer to only one question: *Is it safe or unsafe?*

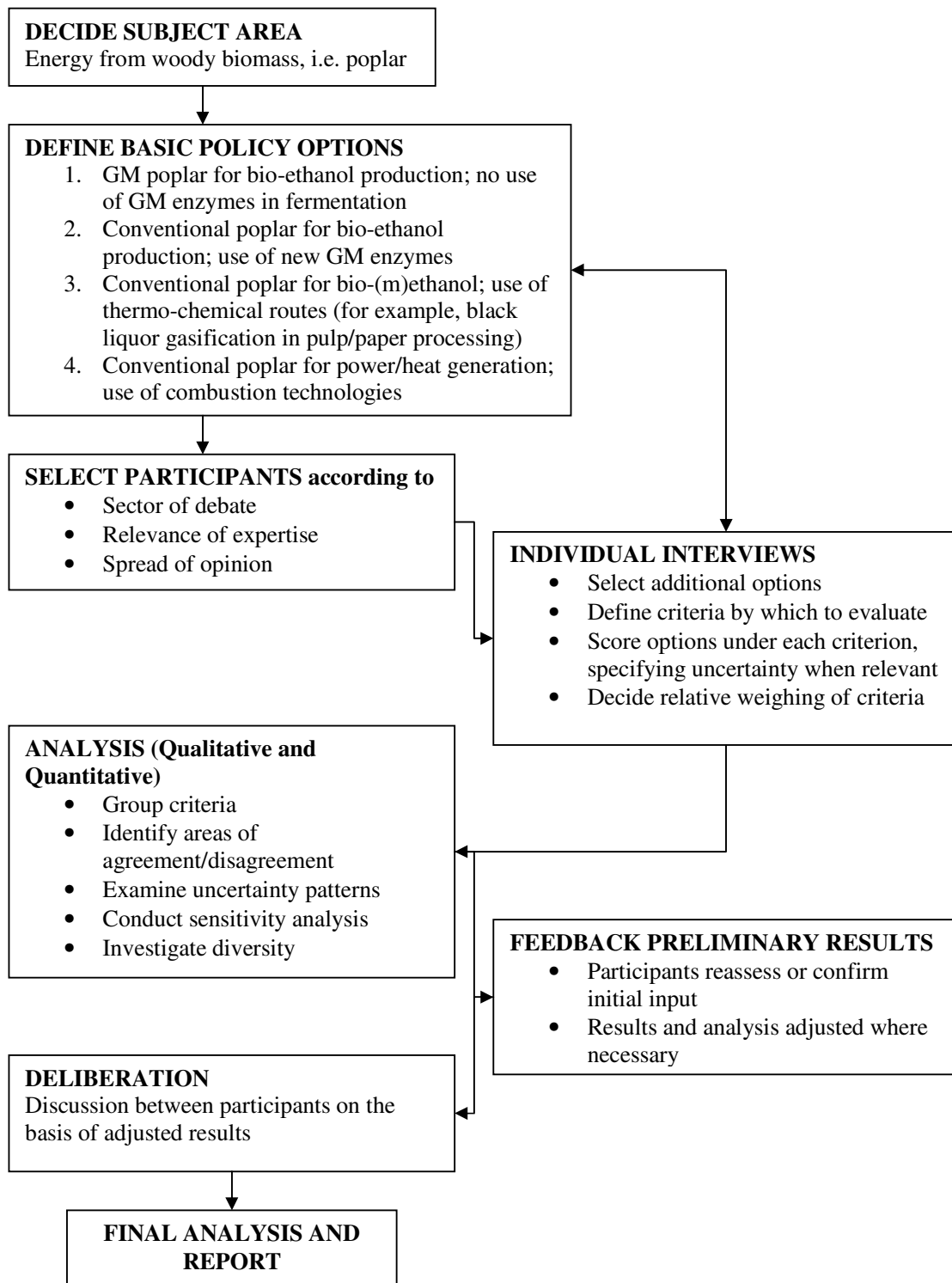
If the Dutch government wishes to pursue other and 'broader' risk policy approaches, it will need to apply risk appraisal tools that are: flexible and broad in scope; open to divergent interests and values; able to acknowledge uncertainty; whilst being systematic, transparent, verifiable and accessible as well as practically feasible and efficient. So-called Multi-Criteria Mapping (MCM) techniques might provide one potential approach. MCM is able to provide a reliable 'map' of the key technological and social issues from which policy makers can make more transparent, socially robust and readily accountable decisions.⁴²

In case of application of MCM to the case of GM poplar WT/52-3, its design could benefit from the 'broader' evaluation frameworks developed by the Dutch government for GMOs and

⁴² Stirling, A. & Mayer, S. (1999) Rethinking Risk: a pilot Multi-Criteria Mapping of a genetically modified crop in agricultural systems in the UK. A report by SPRU, Science and Technology Policy Research, in association with GeneWatch, funded by Unilever in consultation with Green Alliance and a variety of other environmental and consumer organisations, ISBN 0/903622/86/6.

biomass-energy so far. Figure 2 represent a flow chart for how MCM could be applied in this case.

Figure 2: Flow chart of MCM and how to apply to GM poplar WT/52-3



Source: Stirling & Mayer (1999), except for the suggested basic policy options; their source is this report.

Following a MCM approach, it is up to the participants to agree with the decision of ‘woody biomass-energy’ as subject area as well as to define basic policy options and evaluation criteria. However, at this stage, given the Dutch policy debates on GMOs and biomass-energy, it can be expected that participants will define criteria for evaluating each basic policy option concerning the following themes:

1. Technological feasibility: all production routes for 2nd generation bio-fuels are subject to intensive public and private R&D efforts; likelihood of technological success; time and capital required for commercial production, etc.
2. Greenhouse gas emissions reduction: net energy balance; economic costs per unit carbon dioxide emissions reduced and acreage used, etc.
3. Competition with food and other local applications, like timber, pulp and paper, etc.
4. Environment: effects of the use of pesticides and fertilisers and other local effects on soil, water and air because of Short Rotation Coppice (SRC) poplar plantations; ecological effects of SRC GM poplar plantations, etc.
5. Biodiversity: effects on landscape, effects on protected or endangered species, etc.
6. Prosperity: contributions towards cross-border regional development, employment opportunities, new prospects for farmers, etc.
7. Social well-being: effects on the local living conditions of the local populations and employees, etc.
8. Ethical aspects and moral values: effects on species’ integrity; respect for life, etc.

As the MCM flowchart in Figure 2 suggests, participants will subsequently be asked to score each policy option under each criterion. They will also be asked to justify their scores by reference to what might be called ‘technical’ considerations, drawing on their own knowledge and expertise as established professionals in the policy fields of GMOs and biomass-energy and as representatives of stakeholder parties in the wider social debate over GMOs and biomass-energy.

For a detailed description of the methodologies driving the next steps in the MCM process see Stirling & Mayer (1999), who have used the MCM process in the wider social debate on GM crops in the UK. For the sake of this paper their main conclusions should suffice: “*the MCM process allowed constituencies with starkly divergent interests and values to fully engage in the appraisal process. This was possible because MCM provides an approach which is at the same time relatively pluralistic, systematic and transparent. Indeed, for these reasons it may be that MCM offers a means to help avoid the dangers of (on the one hand) spurious attempts to impose ‘consensus’ and (on the other hand) opaque, distrustful and corrosive social conflict over technological risks.*”

Thus, if the Dutch government wishes to apply both ‘broader’ evaluation frameworks for GMOs and biomass-energy, the subject of GM poplar for bio-ethanol production offers a unique opportunity for engaging stakeholder parties in a MCM-like appraisal process.