Overcoming the initial investment hurdle for advanced biofuels:

An analysis of biofuel-related risks and their impact on project financing

Report D7.1 of ELOBIO subtask 7

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Authors

Tjaša Bole
Marc Londo
Joost van Stralen
Ayla Uslu

Partner / Institute

Energy Research Centre of the Netherlands
P.O. Box 56890
Radarweg 60
1043 NT AMSTERDAM SLOTERDIJK

Contacts main author:

Tel. +31.224.564833
Fax +31.224.568339
bole@ecn.nl

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Executive summary

Study aim

Advanced or “second generation” biofuels are expected to have an important role in mitigating potential negative impacts of expanded biofuel production and use. However, despite important technological advances of the past few years, second generation biofuels are largely still at a demonstration stage and seem to be lacking investment to move toward full commercialization. One of the main barriers hampering a more significant market share for advanced biofuels are perceived risks of second generation biofuel projects. First and second generation technologies have very different risk profiles, which translate to different costs of capital for biofuel projects employing more established or newer technologies. Higher perceived risks will result in higher cost of capital. This influences the rate of market deployment and consequently affects their technological learning curve and further cost reductions.

The main objective of Elobio’s WP7 was to:
1. Understand the risks related to first and second generation biofuel projects.
2. Evaluate their impact on the cost of capital.
3. Assess what policy options can overcome the initial investment hurdle for advanced biofuels, lower their cost of capital and achieve wider market deployment.

Methodology

To answer these questions, a combination of qualitative and quantitative methods was employed. The basic methodological steps undertaken within this study were:
1. Define risk-profiles for first and second generation biofuels and the related financial parameters based on input obtained through interviews and a survey of biofuel financing experts.
2. With a newly developed cash-flow model, calculate baseline weighted average cost of capital (WACCs) using the financial parameters obtained in the survey and price data for feedstock, biofuels and by-products.
3. Define a number of policy cases outlining biofuel support measures.
4. Analyse potential future biofuel development pathways, using the WACCs calculated in step 2 and policy measures defined in step 3 in Biotrans, a techno-economic model which optimizes the biofuel mix for a given set of input parameters, including biophysical feedstock supply and cost and a selected set of policy measures.
5. Assess the effectiveness and efficiency of different policy measures to achieve higher market deployment of second generation biofuels.

Results

The risk profile analysis indicates that technology risk is the main hurdle towards wider market deployment of advanced biofuels. Lack of sufficient technological track record makes conventional finance sources wary of funding biofuel production installations employing second generation technology. Until the perceived technology risk is overcome, second generation biofuel projects can only obtain financing through grants or from venture capital, which has a much higher risk-tolerance than other forms of equity (and debt) but also requires a much higher return on investment. Compared to first generation, the cost of capital for second generation biofuel projects is in the range of three to five times as much. Without additional support, the biofuel market does not allow second generation installations to generate sufficient returns to be of serious interest to any form of private capital supplying project finance.

Therefore, policy instruments will need to play an important role in supporting (at least initial) market deployment of advanced biofuels.

When planning policy support, we should distinguish between a “pre-commercial” phase, when both the cost of capital and cost of technology are very high and a “market-expansion” phase, where a proven technological track record has made conventional project finance sources (including debt) available thus significantly lowering the cost of capital, while at the same time technological learning effects have started lowering the cost of this capital intensive technology.

Bringing some initial capacities on the market can be achieved with different support measures at very different policy cost. Policy options tested for effectiveness in bringing the necessary initial capacity of advanced biofuels on the market include project investment subsidies of different levels, excise tax breaks and the ‘double counting’ as included in the EU renewable energy directive. Of these, only a substantial direct investment subsidy of over 50% of capital investment seems to be able to bridge the initial investment gap.

Such high subsidies are of course not sustainable in the long term. However, a discontinuation of all support after initial market introduction could result in advanced biofuels remaining a niche player in the middle term. This is because up to 2020 there may be sufficient potential supply of cheap first generation feedstock, which continues making conventional biofuel installations more competitive and attractive to investors. Thus, if there is an aspiration for advanced biofuels to move from a niche market to a more substantial supplier of transport fuel (around 20% by 2020 and over 30% by 2030 of the of the total biofuel market) in the middle term, some sort of policy support is likely to be necessary even after the initial investment hurdle has been surmounted.

Of the policy combinations tested in this study, the most favourable one to achieve a higher market share for advanced biofuels is high initial investment subsidies (discontinued after commercialization is reached) coupled with double-counting, which is also terminated after a certain period of time; in our case, by 2020. To fulfil its purpose best, this support measure should be discontinued as soon as learning effects have lowered the cost of the technology enough to make it more competitive with conventional biofuels. Otherwise, double counting can reduce the overall size of the biofuel market while substituting hardly any production of conventional biofuels with advanced ones. Model runs show that if the aim is to have advanced biofuels contribute roughly 20% of all biofuels 2020, the budget for support will need to run in the order of several hundred million €.

While promoting market expansion for advanced biofuels we must also keep in mind potential future risks related to significantly increased demand for lignocellulosic feedstock. To profit from economies of scale, advanced biofuel production plants will need to be very large (requiring around a million tonnes of dry biomass a year) and will represent another significant demand source for woody feedstock. Market risk might become a real issue for second generation as capacity expands and feedstock demand increases for already supply-constrained woody residues & crops.

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1. Introduction

The ELOBIO research project aims to develop policies that will help achieve a higher share of biofuels in total transport fuel in a low-disturbing and sustainable way. The results from WP5 on the relationship between biofuels and markets for food and feed show that to minimize potential negative impacts of biofuels, advanced or second generation biofuels that convert lignocellulosic biomass into e.g. ethanol or FT-diesel will need to play a much more important role than at present. These biofuel routes generally show significantly better greenhouse gas performances than first-generation biofuels, and have less impacts on agricultural commodity prices, also because their feedstock base includes a wide variety of residues. The potential role of second generation biofuels in reducing the environmental and economic pressures linked to increased biofuel production and consumption has been recognized by governments worldwide, who are starting to offer specific incentives for advanced biofuels[1].

However, second generation technology is largely still at a demonstration stage. One of the determining factors for its successful commercialization is a conducive investment climate, which allows for an acceptable cost of capital. This, in turn, to a large extent depends on the perceived risks related to investment in biofuel projects. First and second generation technologies have very different risk profiles, which translate to different costs of capital for biofuel projects employing first or second generation technology. Higher perceived risks will result in higher cost of capital. This influences the rate of market deployment and consequently affects their technological learning curve and further cost reductions.

WP 7 aims at addressing the Elobio objective of providing a reliable estimate of the potential and costs of biofuels, given the application of low-disturbing policy measures. More specifically, we seek to evaluate the impact of these biofuel policy measures on the investment climate for second-generation technologies.
To this end, we try to answer several sub-questions in a following logical sequence:

1. What are the different factors that contribute to investment risk in biofuels and what are their relative contributions to overall biofuel project risk as perceived by finance providers?
2. How do these risks translate into cost of capital for different biofuel technologies?
3. How does cost of capital influence market penetration rates for the different technologies?
4. What is the best policy (or policy mix) to overcome the initial investment hurdle for advanced biofuels, thus lowering their cost of capital and achieve wider market deployment?

To answer the first question we make an initial attempt at defining the risk profiles of first and second generation biofuel projects, based on literature and input from experts in the field of biofuel financing. We then analyze the nexus between risks related to biofuel projects and their cost of capital and based on finance experts judgments we translate the risk factors into financial parameters determining biofuel projects' cost of capital (more specifically, the weighted average cost of capital, WACC). As first and second generation technologies have a different risk profile, this will be reflected in their respective WACCs. We then analyze the

[1] Please see Elobio report D2.1 for a comprehensive overview of biofuel support policies in a number of countries http://www.elobio.eu/fileadmin/elobio/user/docs/WP2-PolicyAnalysis_v20080912.pdf

impact of the latter on market penetration rates for first and second generation technologies. By using Biotrans, an ECN-developed least-cost biofuels optimization model, we show how different WACCs affect the relative competitiveness of second-generation biofuels vis-à-vis their first generation counterparts. And finally, we can explore the effect of specific support policies on reducing the risk for advanced biofuels and hence on their market deployment.
This report presents the results of the work carried in the Elobio work package seven, which originally concentrated on "biofuels potentials, costs and other aspects of the biofuels market", including the investment climate. However, the focus of the WP evolved during the course of the project from a pure potential assessment to an assessment of a more "realistic potential" or "how to bring the potential of lignocellulosic biofuels to the market" and what are the related policy costs[2].

The report is structured as follows: section 2 introduces the topic of risk and finance of biofuel projects. Section 3 describes the methodology used in this study, including a short description of the two models used to generate the results. Section 4 discusses the main risks related to biofuel projects as perceived by investors and lenders in the sector and in section 5 we present the financial parameters reflecting different risk profiles of first and second generation biofuels. Section 6 presents the policy options and combinations tested for overcoming the initial investment hurdle for advanced biofuels and support their wider market deployment. The model results are also presented here. Sections 7 and 8 present an important potential opportunity for second generation production plants in the form of heat sales, and a potential market risk due to feedstock competition with other wood-based industries. The conclusions and recommendations are given in section 8. Section 9 discusses the limitations of the analysis that need to be kept in mind when interpreting the results.

[2] Biofuel production potentials and the related implications for agricultural commodities have been addressed by other Elobio partners, please see deliverables of WP5 for details.

2. Financing biofuel projects and the related risks

2.1 Corporate vs. project finance

The two main options for financing new installations are corporate and project finance. Corporate financing (sometimes also refereed to as internal or equity financing) can be basis for credit and collateral. Unlike project-specific financing, it is not tied to any specific projects (Short et al., 1995) but is financed directly off the corporate balance sheets of the mother company. Project-specific financing, on the other hand, can be defined as the arrangement of debt, equity, and credit enhancement for the construction or refinancing of a particular facility in a capital-intensive industry where lenders base credit appraisals on the projected revenues from the facility rather than on the assets or credit of the promoter of the facility (Simpson, 1992).

There are several considerations in a decision whether to take the corporate or project finance route. Although there are some biofuel projects known to be funded through corporate finance, especially some second generation demonstration plants, project finance is the route used by most innovators to bring new technologies into the market, which is why it is also the focus of this analysis.

When analyzing risks related to a biofuel investment undertaken through project finance, it is important to take note that debt lenders and equity investors have a very different risk tolerance, which is reflected in the financial parameters they apply as conditions to a project seeking finance. What is discussed next, are the characteristics of the two main sources of capital in project finance and the terms and conditions they apply to projects they fund.

2.2 Equity

Equity investors are residual stakeholders with rights to profits but only in the case of timely debt servicing (Einowski et al., 2008). This means that equity investors can only share a venture's profit after debt lenders have been repaid. The risk for equity providers is thus much higher than for lenders, which is expressed in higher required return on equity (RoE), compared to the interest rate asked by lenders (Jager & Rathmann, 2008).

There are different types of equity investors: individual private equity, institutional private equity (which includes technology-focused private equity or venture capital funds) and corporate investors. A good overview of equity investors is provided by Einowski et al. (2008). Different types of equity invest in technologies in different stages of the commercialization process. Generally, technology oriented private equity (venture capital funds) are those most willing to invest in new technologies and represent a potentially important source of capital for projects using second generation biofuel production technology. However, at the moment, even venture capital funds rarely invest in the biofuel sector (rather, they are looking to invest in rapid growth businesses based on a new technology or business model). In 2003, the whole sustainable energy sector accounted for only 2% of the global overall venture capital investments in that year (with biofuels accounting for just a fraction of those). However, this share has been continuously rising since 2000, with a particularly significant increase in Europe (Wustehagen & Teppo, 2006). For the case of biofuels, globally, first generation still attracts almost twice as much venture capital investment than second generation biofuels, although investment in the latter has been increasing at a much faster rate, as seen from figure 1.

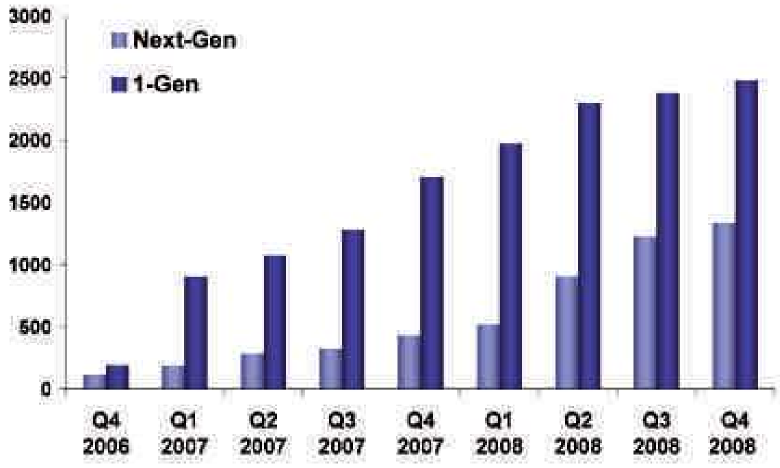

Figure 1: Venture capital and private equity investment in first and second generation biofuels (in Million US$)
Source: New Energy Finance, 2008

What is important to note here, is that equity invested in first generation projects is matched at least in equal, and more often, higher amounts by debt finance, while this is not the case for second generation projects, which are mainly funded by venture capital (and some grants). In other words, the total capital flow into first generation projects is three to five times the amount that is available to second generation projects.

2.3 Debt

The essence of obtaining debt financing for a biofuel project is the search for credit and the fashioning of a loan package that provides adequate assurance to a lender that the borrower is creditworthy so that the loan will be repaid in a timely manner. Alternatively stated, it is the fashioning of a loan package such that the risk of default is reduced or mitigated to bring the risk within levels acceptable to the lender (Einowski et al., 2008).

While an investor may be willing to take some risk related to a project, (debt) lenders are much more risk averse and will demand for several securities that ensure timely debt servicing. This is being translated in the financial parameters that lenders apply, such as debt term, interest rate (i), and debt service coverage ratio (DSCR), which calculates the amount of cash the project is required to generate to meet its debt obligations (debt servicing to interest, principal and lease payments). A DSCR of 1 is the minimum required to ensure the investment (or in our case the biofuel project) generates sufficient income to cover its debt. Based on expected cash-flows, banks normally set a minimum DSCR requirement that includes some cushion and demand a DSCR higher than one. A DSCR of 1.5 means the investment (or project) can obtain debt finance on the amount desired only if it can generate a cash flow 50% higher than its debt servicing. Or, if considered from the other way around, a project with a given cash flow and a required DSCR of 1.5 can only obtain debt financing worth two-thirds of its cash flow, the rest will have to be filled by equity.

In principle, the riskier the project, the quicker the lender will want to be repaid, the higher the interest rate applied to the loan will be and the higher the buffer incorporated in the DSCR.

2.4 The debt-equity ratio and the Weighted Average Cost of Capital (WACC) as measure of risk

In the end, most biofuel projects will have arranged for a combination of debt and equity financing. In fact, sufficient equity capital is usually a prerequisite to obtaining debt financing, and will have to close the gap between the total investment required by the project and the maximum obtainable debt. The mix of equity and debt determines both the funding costs to the business and the risk exposure for the investors; therefore it should reflect the risk associated with the project.

The resulting debt-equity-ratio of a typical project employing well-established technology is usually between 50/50 to 80/20 or even higher. Together with the debt interest rate and the RoE, the debt-equity ratio determines a project's cost of capital. The higher the risk, the less debt will be available to the project and the more equity it will have to raise. Because equity is generally more expensive than debt, consequently a riskier project will have a higher cost of capital than a less risky one.

It is important to distinguish between the ex-ante and the ex-post WACC, which can differ quite substantially. An ex-ante WACC represents the minimum financial requirements that lenders and investors expect a project to meet to qualify for their support. The ex-post WACC can be lower or higher than the ex-ante expected WACC. If the project eventually generated a higher profit than initially expected, it will reward its equity investors with a return on equity (RoE) higher than the minimum required, which will in turn increase its ex-post WACC. This however, does not mean, the cost of capital of this project has increased. It is important to make this distinction here because all the latter reference to WACC in this report refers to the ex-ante variant, which aims at capturing the risk level of a project rather than its actual returns.

3. Methodology

3.1 Methodology overview

To answer the question how do biofuel-related risks affect the market deployment of second generation biofuels and what policy measures can mitigate those risks and support faster intake of new technologies, a combination of qualitative and quantitative methods were employed. The basic methodological steps undertaken within this study were:

1. Define risk-profiles for first and second generation biofuels and the related financial parameters based on expert input obtained through interviews and a survey.
2. With a newly developed cash-flow model calculate baseline WACCs based on the financial parameters obtained in the survey and market prices for feedstock, biofuel and by-products.
3. Define a number of policy cases outlining biofuel support measures.
4. Insert the WACCs calculated in step 2 and policy measures defined in step 3 into Biotrans, a techno-economic model which optimizes the biofuel mix for a given set of input parameters, including biophysical feedstock supply and cost and a selected set of policy measures.
5. Assess the effectiveness and efficiency of different policy measures to achieve higher market deployment of second generation biofuels.

An overview of the methodology is presented in Figure 2 while the next sections explain each step in more detail.

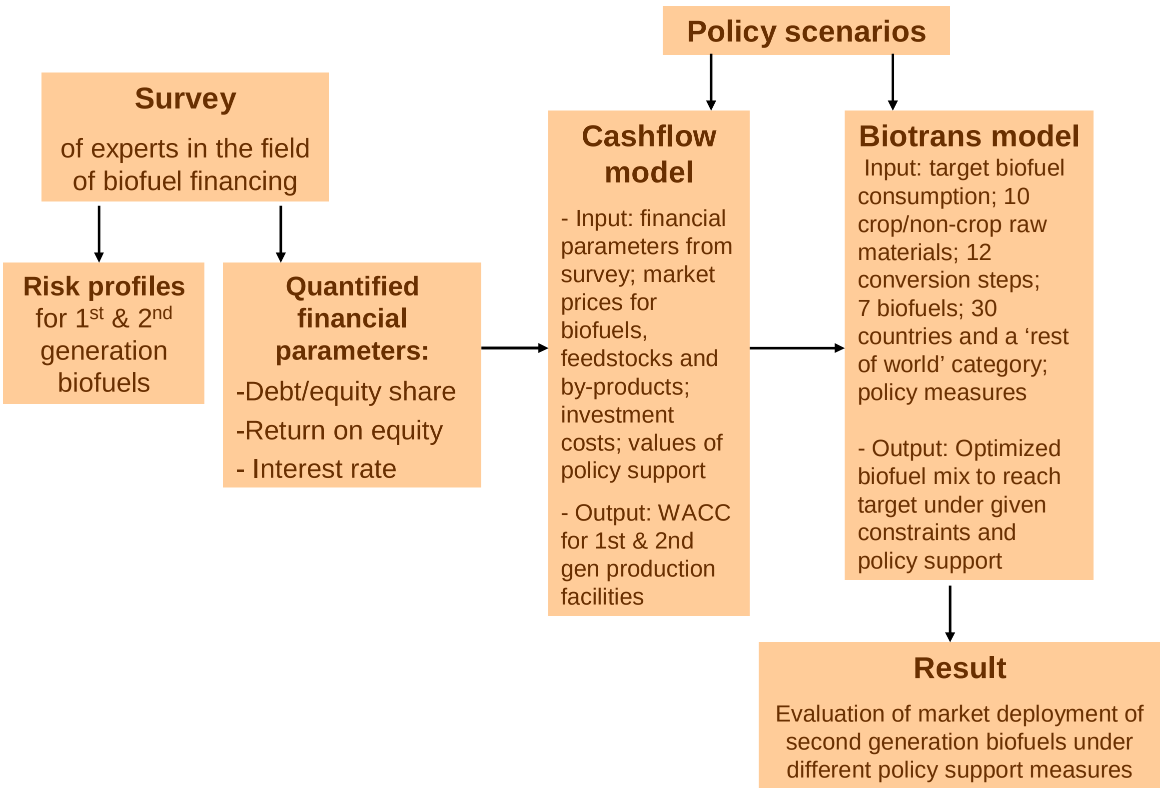

Figure 2: Methodology overview

3.2 Risk profiling survey and quantification of financial parameters

A number of semi-structured interviews with experts in the field of biofuel financing were conducted to gain an insider's understanding of which risks are most commonly associated to biofuel projects and how they affect the projects' cost of capital. One of the important points that emerged from these talks was that an investment into a biofuel producing facility is, to a significant extent, a qualitative decision. The projected cash flow of a particular project of course plays an important role; though the perceived risks and mitigation measures available to investors have an even bigger one. Based on these initial discussions, we developed a questionnaire to achieve a more systematic risk profiling of first and second generation biofuels.

The aim of the questionnaire was thus to provide a systematic framework of risk perception of debt and equity finance providers regarding investment into biofuels and what are the differences between first and second generation projects and how are they reflected in their respective financial parameters (interest rate, DSCR, RoE etc).

The questionnaire was structured in two parts: in the first one, a biofuel-risk matrix listed the most important risks associated with biofuel projects, which were derived from literature and expert interviews. In the matrix, the perceived level of risk (none, low, medium or high) is assigned to different types of biofuels to derive information on which types of risks are most relevant for first and second generation, since this determines where risk-mitigating policies should focus on. The outcome of the first part of the questionnaire is presented in section 4 in the discussion of the main risks associated to investment in biofuels projects.

Table 1: The biofuel-risk matrix

Risk type	1st generation biofuels		2nd generation biofuels	
	Biodiesel from vegetable oil	Bioethanol from cereals	Bioethanol from straw	FT-diesel from wood processing residues
Project level risk				
o Technology risk				
o Other				
Market (Trading) risk				
o Variations in biofuel prices				
o Variation in feedstock prices				
o Variation in prices of by-products				
o Other				
Regulatory risk				
o Changes of policy support schemes)				
o Sustainability criteria				
o Other				
Geopolitical risk				
o Changes feedstock supply conditions (regime or policy change in supplying country)				
o Other				
Marketing (PR) risk				
o Adverse public perceptions of biofuels				
o Other				

The second part of the questionnaire asked the experts to quantify short and long-term financial parameters for biofuel investment, based on their experience and expectations. This period-distinction was made for two reasons: on one hand, to overcome the current effects of the economic crisis on the cost of capital in general and on the other hand because long-term financial parameters, although hypothetical, reflect anticipations on the full commercialization of second generation biofuels.

The questionnaire was sent to a number of experts in the field of biofuel project financing (banks, equity companies and also public funding agencies) in various European countries[3].

In the questionnaire, we distinguished four most representative types of biofuels, two first generation options (bioethanol from cereals and biodiesel from vegetable oil) and two second generation ones (lignocellulosic ethanol and FT-diesel). However, the answers received provided only marginal differences for the types within the groups, hence the answers were generalized for these two main types of biofuels and are also presented in this manner in section 5. The answers from the questionnaire were then averaged out to provide the most

[3] We would like to acknowledge the help and thank for valuable input the experts consulted at Fortis Bank, Waterland Private Equity and Kempen & Co. in the Netherlands, Alternative Energy Finance in the UK, IDEA in Spain, the European Investment Bank and the rest of the organizations that preferred to remain unnamed. Despite significant attempts to engage finance providers from Eastern Europe, we unfortunately did not manage to receive any feedback from the region, making the original plan to calculate geographically-differentiated WACCs unfeasible.

common financial parameters applied to biofuel projects and these were then used as input into the cash flow model, which is presented next.

Table 2: Financial parameters table

	1st generation biofuels		2nd generation biofuels	
	Biodiesel from rape seed oil	Bioethanol from wheat	Bioethanol from straw	FT-diesel from wood processing residues
Level of debt financing (in %)				
Level of equity financing (in %)				
Debt-service coverage ratio				
Interest rate (%)				
Required return on equity (%)				
Debt-term (no. of years of debt financing)				
No. of years after which initial equity exits the project				

3.3 The cash flow model

This cash flow model has been developed specifically for the Elobio project. It is a simple excel-based model, which is used to determine the cost of capital for biofuel projects given a number of data sets (e.g. market prices of feedstocks, biofuels and by-products) and constraints (the DSCR must equal a minimum pre-determined amount, the interest rate is fixed and the RoE generated by the project must meet a required minimum). It computes the minimum project return necessary to satisfy the predetermined conditions (a minimum value) for the financial parameters: DSCR, return on debt *(i)* and return on equity *(RoE)*. The model is thus used to calculate the debt-equity ratio of a biofuel project. In case where the input data (prices) does not allow meeting the minimum pre-set financial parameters, the model calculates the price increase necessary by which both DSCR and RoE criteria are just met.

Inputs of the model are:
- Technical parameters, such as production capacity in tons per year, operational time, technical lifetime if the installation, energy content of the feedstock and conversion efficiency;
- Cost and revenue parameters, including capital costs, operation and maintenance costs, feedstock costs, revenues from sales of biofuels and by-products;
- Finance parameters, which were quantified in the survey of biofuel finance experts and include the DSCR, loan interest rate (i) and required return on equity (RoE).

It is important to note the discrepancy in the type of feedstock cost data: first generation feedstock is based on market price data projections, while second generation feedstock cost are based on cost curve estimates, which calls for caution in interpreting the WACCs resulting from the cash flow model. The fact that we use ***market prices*** for first generation processes and ***cost estimates*** for second generation means that the latter's production costs might be underestimated, which will increasingly be the case for future predictions when a larger demand for second generation feedstock might increase their price. If all else remains equal, the resulting WACC for second generation might thus be an underestimation.

The technical parameters used in the model are described in detail in Annex 1, while figure 3 shows the calculation steps in the model.

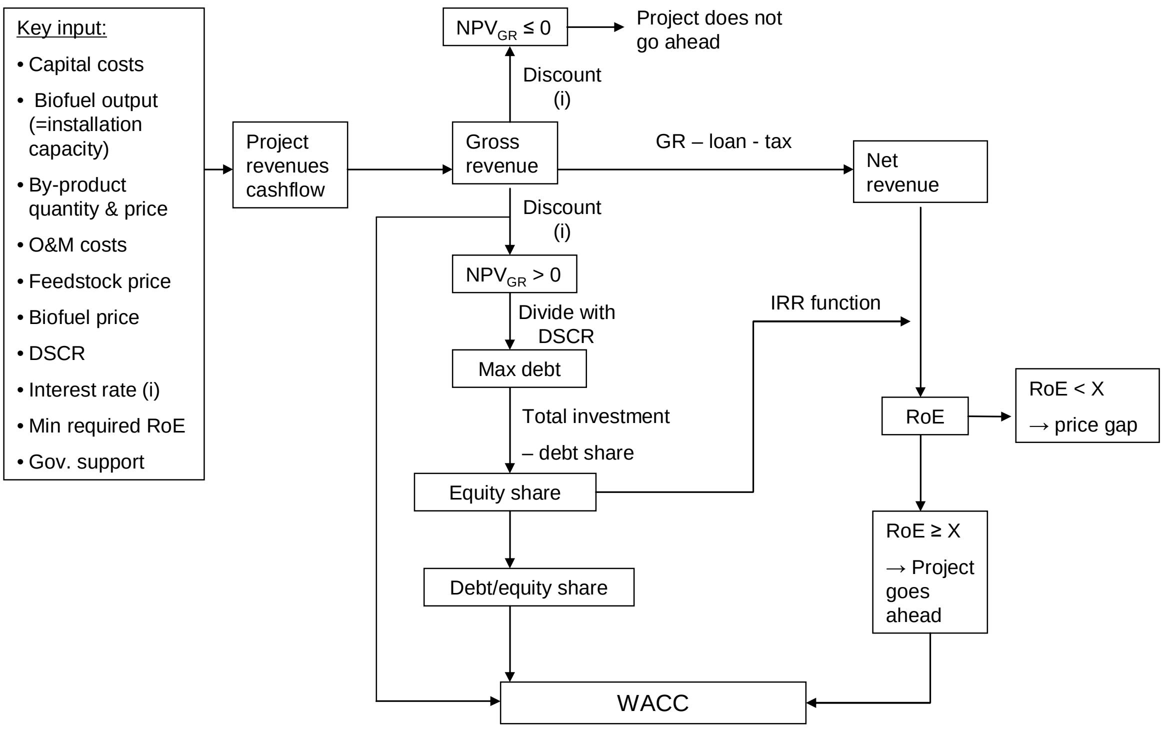

Figure 3: Cash flow model calculation steps

As shown in figure 3, the final outcome of the cash flow model is a WACC, for the given set of input parameters. By varying these parameters we can assess their influence on the cost of capital.

As mentioned before, the Elobio cash flow model calculates an ex-ante WACC, including the maximum debt share that a project may obtain and a minimum required RoE. The actual (ex-post) RoE might be lower or higher than the one calculated by the model, however the investment decision is mostly based on the expected RoE.

The ultimate aim is of course to explore how the cost of capital influences the market penetration rates for the considered first and second generation technologies. To this end, we use the WACCs calculated by the cash flow model as input into the Biotrans model, which is explained next.

3.4 The Biotrans model

3.4.1 Model description

Biotrans is a techno-economic market model, which selects the most cost-effective biofuel production chain given projections of demand (e.g. based on biofuel policy targets) and a pre-determined set of constraints (on potentials and technological progress). The model optimizes the full supply chain allocation from biofuel raw material production, processing, transport and distribution to end use. Inputs to BIOTRANS are detailed country level biomass potentials and their costs, technology parameters and their cost (including capital cost), and support policies while outputs are biofuel costs, biomass and biofuel traded volumes, and trade flows between countries.

For the analysis presented in this study, we assume that the demand for biofuel in Europe equals to the 10% of transport fuel by 2020 target for renewable fuels set by the EU Renewables Directive[4] and 15% by 2030. The target is then treated as an obligation that has to be achieved by a certain biofuels mix. There is no specific sub-target for second generation.

Along the different steps in the supply chain, trade is possible between the different member states. The model uses as input a wide range of (mainly techno-economic) parameters regarding the current European biofuel situation, as well as macro-economic and technological projections. These projections result in both a variant for the target year and a set of constraints for the development towards this target year, by restricting year-to-year variations. The output of the BioTrans model includes detailed allocations of production, processing, transport and distribution of energy crops and biofuels. Output also indicates the extent to which member states trade between different steps in the production chain.

The current model configuration uses:
10 crop/non-crop raw materials;
12 conversion steps with 2 intermediate products, 1 auxiliary and 6 byproducts;
7 biofuels and associated distribution technologies;
30 countries and a 'rest of world' category: EU27, Switzerland, Norway, Ukraine; Brazil and Malaysia represent 'rest of world' for ethanol and palm oil imports, respectively.

This model can support policy makers in the development of a cost efficient biofuel strategy for Europe in terms of biofuel production, cost and trade, and in an assessment of its larger impact on bioenergy markets and trade up to 2030. A more detailed description of the model can be found in Lensink et al. (2007).

3.4.2 Biotrans adaptations for Elobio

For the purpose of the analysis in this project several adaptations have been made to the Biotrans model that were not yet available in the version described in Lensink et al. (2007). These adaptations include:

WACC: In the previous version of Biotrans the WACC was 6% for all conversion processes, for the whole time horizon. It was useful for this project to allow for WACC values that are differentiated per process type and per year. This adaptation made it possible to have different

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[4] Although the directive requires 10% of transport fuel to be renewable (not just biomass—based), it is most probable that the bulk of the 10% target for renewables in transport will still have to come from biofuels, the main uncertainty being mid-term developments in electric propulsion (Londo, 2009).

WACC values for first and second generation biofuels and different values for technologies in the pre-commercial and commercial stages.

Double counting: Double counting of second generation biofuels for the target, as described in the EU renewable directive, has been included in the model. Since one GJ of second generation biofuel plus one GJ of fossil fuel can be counted as two GJ of biofuel for reaching the renewable fuels target, it means that also the fossil fuel price has to be included to calculate the costs of these two GJ.

It has also been possible to switch the double counting off at a particular year, once the amount of second generation has reached a certain share in the biofuel mix.

Investment subsidies: Have been made year dependent as well to allow investigation into what level of investment subsidy is needed to get second generation biofuels introduced and when the investment subsidy can be phased out.

Heat: Some process chains for second generation biofuels have electricity as a by product. To make further use of the excess heat, the heat fraction that can be sold as a byproduct has also been included in these process chains. We have worked with an efficiency of 10% (with respect to the energy contents of the feedstocks).

Taxation: Taxation of biofuels can be included in an optimization. This allows studying the effect of taxation of first generation biofuels versus non-taxation for second generation biofuels and what effect it has on the penetration year and level of second generation biofuel. The taxation level can also be varied per calculation year.

4. Main perceived risks of biofuel projects

4.1 Basic risk categories

As with all investments, investing in biofuel production is not without risk. There is a large body of literature exploring various risks related to investments in renewable energy technology employing a range of risk-categorizations. Jager and Rathmann (2008) for example explain risks in a project cycle, starting with project development and financial closure risks, such as delays in obtaining the necessary licenses and permits and continuing through construction, operation and decommissioning risks. Some classifications are based on inner or outer project environment, while others distinguish risk based on the actors carrying it, e.g. project sponsor risk, regulator's risk, competitors' risk etc. In this study, we narrowed our focus on risks that are as specific to biofuels projects as much as possible, hence leaving out general project development risks, which are shared by any projects competing for funding.

Another point worth mentioning is that the perception of risks differ depending on the point of view; project developers (especially if they are not also the main investors), tend to have different views related to the risk related to their project, than do finance providers. In this study, we focused on the views of the latter, as for biofuel installations financed under a project finance framework; the perception of the finance providers is of crucial importance.

We therefore focused on the following five risk categories:

- Technology risk: includes performance level, unexpected maintenance, necessary upgrades etc. Technology risk is especially relevant for new technologies which have a short or even no track-record in large-scale production installations producing a product of consistent quality for longer period of time.
- Market risk: mainly refers to fluctuations of the feedstock and biofuel prices and the correlation between the two or lack of it.
- Regulatory risk: as most biofuel production still requires policy support it is important whether investors and lenders consider this support as adequate and stable, or insufficient and unreliable.
- Geopolitical risk: is mainly relevant for production based on feedstock from regions with an unstable political environment where export taxes or bans can be adopted without sufficient prior notice.
- Stakeholder acceptance risk: refers to the negative publicity received by biofuels during the food crisis of 2007/2008, which was seen as real threat to the reputation of finance providers who could be associated to biofuel production and has caused some lenders to categorically deny funding to any kind of biofuel projects.

The above risks were qualitatively assessed by a number of biofuel finance experts through our questionnaire. The aim of this exercise was to determine which specific risks (other than general project risks) are most commonly associated with biofuel projects and whether they differ for first and second generation installations. The below table summarizes the most frequent values assigned to the different risk types and it has to be noted, that the answers received were very consistent across the respondents, e.g. no one thought that technology risk is low for second generation or that stakeholder acceptance is not at all an issue for first generation biofuels.

Table 3: Risk profile of first and second generation biofuels

Risk Type	*1st generation*	*2nd generation*
Technology risk	Low-medium	High
Market risk	High	Medium
Regulatory/Policy risk	High	Medium
Geopolitical risk	Medium	Low
Stakeholder acceptance	High[5]	Low

N=7

The answers received from the surveyed experts show that first and second generation biofuels clearly exhibit very different risk profiles – although similar risks play a role for each, their perceived influence (or weight) is very different. What follows is a short explanation of each risk type together with some suggestions for mitigation.

4.2 Technology risk

Technologies employed to produce first generation biofuels, such as the biological fermentation process used to produce ethanol from sugars extracted from sugar and starch crops and the production of biodiesel from vegetable oil and animal fats through transesetrification are technically mature and commercially available, thus related technological risks are low. However, technical improvements can still be made to commercial ethanol production routes, e.g. improved enzymes to convert starch to sugars (hydrolysis), improved bacteria (fermentation), water separation methods, process and plant optimization, greater value-added co-products, which can improve the efficiency of the process but also initially raise the technology-related risks (IEA Bioenergy, 2009). Thus, there is still some level of technological risks involved even in first generation technologies, which might explain the generally "low-medium" level of perceived risks (although one participant in the survey even identified them as "high").

The situation is opposite for second generation biofuels. The most advanced second generation route is the one for lignocellulosic ethanol and even this one is still at the demonstration stage. Although some of the individual stages involved in the process are already commercial (e.g. dilute acid pre-treatment, acid hydrolysis, fermentation and distillation), technological advances still need to be made in several process steps (e.g. enzymatic hydrolysis, fermentation of C5 sugars). At the same time, gasification-based routes and the Fischer-Tropsch processes involve mature technologies, already used at commercial scale. However, there is very limited experience in integrating biomass gasification with downstream processes for the production of liquid or gaseous transport fuels. Also, each individual system is generally designed to work on a particular feedstock with narrow physical and chemical property ranges. Further R&D is needed to determine and optimize plant configurations that will be technically and economically viable based on a variety of feedstocks. Technologies for the production of methanol from gasified mixed feedstock and for the production of green diesel, as well as ethanol production via gasification are in the demonstration stage (IEA Bioenergy, 2009). Consequently, although parts of the technologies employed for the production of second generation biofuels have been used for other purposes for some time now, the entire production chain remains unproven on a large, commercial

[5] Note that "high" in this case refers to "high risk of stakeholders acceptance" or in other words "high likelihood of stakeholders un-acceptance". The converse is true for second generation.

scale, thus remaining highly risky from the point of view of investors, as it is still often unknown in advance whether or not these technologies will ultimately allow the production of a transport fuel of consistent quality.

Because of all of the above mentioned technical reasons and because of a lack of sufficient successful demonstration projects so far, capital providers see technology risks related to investments in second generation production facilities as "high," which completely alienates risk-averse banks but even most private equity. As Zider (1998) points out, "betting on a technology risk in an unproven market segment is something even venture capital would avoid."

Technology risk is particularly important for second generation because the technologies are capital intensive and have long lead times. Capital intensity of energy technologies (as opposed to, for example, internet companies) is one of the main investment barriers mentioned by several venture capitalists. Some suggestions on how to deal with the challenge of capital intensity include partnerships in licensing, manufacturing, franchising and distribution, early exit and pursuing multiple target markets (Wüstenhagen & Teppo, 2006).

From an investor's point of view, there is not much that can be done to mitigate technology risk. To some extent it can be managed by requiring a working prototype before the investment is made, and by staging investments, so that later financing rounds are tied to the achievement of certain milestones in technology development (Wüstenhagen & Teppo, 2006). However, while this will provide a certain level of security for the investors, it might further extend the project timeline and further delay large-scale implementation.

4.3 Market risk

Market risk refers to the variability of feedstock, biofuel and by-products prices or rather to the lack of correlation between input (feedstock) and output (biofuel) prices, thus making the profit margin rather unpredictable. Even for the case of US corn-based ethanol, which consumes about one quarter of the country's corn production, the correlation coefficient between US ethanol and corn futures for the period mid 2005 to beginning 2008 had an absolute value of only 0.4 (CBOT, 2008). The price correlations for other feedstocks, such as wheat and some oilseeds, is even weaker.

This is of course much more the case for first generation biofuels, because they use foodstuffs as their main feedstock, which can have high price volatility. This type of risk became very pronounced after the food price shock of 2008, when several biofuel producers had to drastically cut down production or even shut down their operation completely, because the feedstock has become so expensive and the price of biofuel did not always follow the rise of production costs, making it uneconomical.

The market risk related to second generation biofuels has less to do with prices and more to do with quantities (at least initially). Possible feedstocks cover a wide range of cheap non-food crops, residues and waste products, often with a negative price. Nevertheless, there are risks associated with provision of sufficient feedstock quantities. With current technologies, it is expected that economical second generation biomass-to-liquid (BTL) plants will need to be very large (requiring around a million tonnes of dry biomass a year) to be economically viable (IEA Bioenergy, 2009). Furthermore, with increased demand the price for biomass is likely to start rising, too. Logistical difficulties and possible future increases in feedstock price reflect in market risk for second generation biofuels being perceived as "medium" rather than low with the majority of investors.

The value of chemical co-products must not be underestimated in providing stable revenues, as they can be a primary financial motivator in the development of certain technologies. The pyrolysis process, for example, produces bioliquid with over 200 chemicals that could have a considerable combined value (some pharmaceuticals produced through pyrolysis are valued at over $3,000/kg). Consequently, the successful inclusion of co-product value could be a turning point in investment decisions (SDTC, 2006). Nevertheless, co-products can also suffer from quick price swings – the price of glycerine, the main by-product of the transesterification process plunged with the surge in global biodiesel production, something that happened to a lesser extent also to distilled dry grains (DDGs), the main by-product of first generation bioethanol.

An important difference between technology and market risk is that there are ways of mitigating the latter. Investing in a multi-feedstock plant, hedging and securing long-term contracts can increase price predictability, at least for the short to middle term. The biorefinery concept maximizes the use of the biomass resource and brings revenue from different markets, lowering the risk of a slump in one of them. Although market risk remains high, these mitigation options make it less uncontrollable and thus a lesser issue compared to technology risk.

4.4 Regulatory risk

Because most of the demand for biofuels is policy-induced, regulatory (or policy) risk plays in important role in making an investment decision into biofuels. The main source of regulatory risk is government regulation of the end (biofuel) market. Regulatory risk refers to possible changes in targets for biofuels, discontinuation of support programs, additional requirements, such as sustainability criteria etc. Interestingly, regulatory risk is perceived as a bigger issue for first than second generation biofuels, although the latter are even more dependant on government support than their first generation counterparts. The main reason for this is the expectation among capital providers that sustainability criteria will play an increasing role in governmental support for biofuels and in this respect, second generation technologies are widely known to perform better than first generation.

As an example of regulatory risk on an EU-level, the EU Renewables Directive, whose main purpose is to support the production and use of renewable energy sources including biofuels, has introduced some additional uncertainties, especially for first generation, with its provision for a review of the impact of the implementation of the target on the availability of foodstuffs at affordable prices by 2014 at the latest, which can result in a significant change of policy environment for traditional biofuels. From an investor's perspective, this introduces a potential discrepancy between the technical and economic lifetime of his investment, which is a major deterrent.

Regarding second generation, the directive introduces a system of double counting any contribution from biofuels produced from wastes, residues, non-food cellulosic material, and lignocellulosic material, providing a specific incentive for second generation biofuels. When this applies to a quota system for fuel distributors, second generation biofuels become competitive if their additional price compared to fossils is less than twice the price difference between 1st generation biofuels and fossils. So, quite counter-intuitively, an increasing fossil fuel price decreases the competitiveness of second generation biofuels (assuming constant prices of biofuels themselves). This effect may be dampened by first generation biofuels being more dependent on fossil inputs than second generation biofuels, their prices therefore also increasing with higher fossil oil prices, but at least this mechanism complicates an assessment of the impacts of the double-counting measure (Londo, 2009).

Another important aspect of regulatory risk is sustainability requirements, from minimal GHG reductions to impact on food prices. In this respect, first generation biofuels are widely known to perform much worse and the expectation among capital providers seems to be that these criteria will play an increasing role in governmental support for biofuels, by and large favoring second generation technologies. Together with the possible 2014 target revision, these are likely to be the main reasons for regulatory risks seen to be higher for first than second generation biofuels.

Among venture capitalists investing in the sustainable energy sector, political risk is seen as very high and is particularly disliked by investors because it seems harder to manage or even outside their area of influence (Wüstenhagen & Teppo, 2006).

4.5 Geopolitical risk

Geopolitical risk partially overlaps with regulatory risks but refers more specifically to biofuels that largely rely on imported feedstock, which makes them subject to political measures in the feedstock exporting countries. This is especially relevant for first generation biofuels from cereals or vegetable oils, as the feedstock they require can be subject to export bans in periods of higher food prices, as during the food price shocks in 2008. Nevertheless, this is only perceived as a “medium” risk for traditional biofuels.

Mitigation measures for geopolitical risk would be similar to those for market risk: securing long-term contracts with suppliers, securing feedstock from a number of sources, although this can increase input costs.

4.6 Stakeholder acceptance

Stakeholders (mainly public) acceptance has proven to be a very serious issue for investment into biofuels, mainly first generation. Because of the negative publicity around possible impacts of biofuels on food prices and deforestation, many banks decided to categorically deny funding to biofuel installations. Those that continue to do so, are often heavily engaged in marketing activities to improve the “green image” of biofuels, which add to the costs of capital for biofuel projects. The public seems to have a much more favorable view of second generation biofuels, something that came out very strongly also during the first EloBio stakeholder consultation (Lundbæk & Londo, 2008).

While public opinion can have a very strong influence on lenders and investors’ decisions, it is not the only one. The auto industry and farmers are also important stakeholders to consider when making an investment decision into biofuels, as they will dictate whether biofuels can be produced and used in the first place. While farmers welcome the increased demand for their produce, there has been mixed response from the auto industry, especially before biofuel obligation schemes. However, this risk only becomes more relevant with higher blends, which are not yet widely promoted in Europe.

Stakeholders acceptance thus seems to be focused mainly on short-to-medium term sustainability issues, which penalize (sometimes unfairly so) the whole spectrum of first generation biofuels, translating into high acceptance risk. And while this appears to be low for second generation at the moment, it will be interesting to see whether this will change in the future with large scale deployment and particularly when significant vehicle adaptation might be required to accommodate the higher blends.

Mitigating the risk of stakeholder un-acceptance is a public relations exercise few banks and investors are willing to engage in. It involves disseminating significant amount of information over a complicated topic, on which even the scientific community is not completely aligned. Since the demand for biofuels is mostly policy induced, the role of governments in increasing public acceptance for biofuels should be much more significant. A credible and consistent sustainability certification scheme can go a long way in lowering this barrier.

5. Biofuel projects' cost of capital

5.1 Biofuel project's financial parameters

The risks examined in the previous section, together with some more general project-related risks, have a significant influence on the cost of capital for biofuel projects, which was addressed in the second part of the questionnaire. Here, we present the average figures for the financial parameters obtained from the survey and it is again worth noting that there was little variance across individual answers, except for the DSCR, which varied between 1.2 and 2.

The short-term figures present in table 4 represent the current status of biofuels project financing, while the long-term figures are of course assumptions.

Table 4: Short and long-term financial parameters for investment in first and second generation biofuels

FINANCIAL PARAMETERS	*1st gen*	*2nd gen*
Short term		
Level of debt financing	50-80%	0%
Interest rate	6.5-9%	n.a.
DSCR	1.2-2.0	n.a.
Level of equity financing	20-50%	100%
Required return on equity	15-20%	20-30%
WACC	**6.6-13.2%**	**20-30%**
Long term		
Level of debt financing	50-80%	50-80%
Interest rate	6-8%	6-8%
DSCR	1.2-2.0	1.2-2.0
Level of equity financing	20-50%	20-50%
Required return on equity	15-20%	15-20%
WACC	**6.3-12.8%**	**6.3-12.8%**

Source: Expert input
N=7

Depending on its cash-flow, a first generation biofuel project can obtain 50% to 80% of its investment needs from a bank at an interest rate of 6.5 to 9%, while the rest has to be filled by equity, which for these kind of investments will typically require a return of between 15 and 20%. This leads to a WACC of 6% to 13%. For first generation biofuels it is likely there will not be major differences between short and long term financial parameters, except for the possible discontinuation of the liquidity surcharge that is currently applied by banks in view of the credit crunch, which will somewhat lower the interest rate.

Due to its high technology risk, second generation biofuel projects are not yet eligible for bank loans and need to be financed almost exclusively by equity capital (in absence of grants), which will require a higher return than in the case of first generation, typically between 20 and 30%. Because equity is the only finance source (except for any grants or direct government subsidies), the WACC equals the RoE at levels of 20 to 30%. While the high cost of capital is clearly a barrier for increased deployment of second generation, the general expectation is that once the technology does reach commercialization, second generation projects should become eligible for a similar financing structure as first generation, which means lowering the cost of capital by half or even more.

The crucial question is of course when second generation will reach full commercialization, and this is also where the views of the surveyed experts diverged most. Some expect this might be the case within 2 years, others see another decade passing before second generation technologies are just as established as first generation ones.

Technological risk thus proves to have the highest weight on the cost of capital compared to other risk factors, which were also rated as "high" (market and stakeholder acceptance for first generation) and again this has to do with the limited or no options for mitigation of this kind of risk as opposed to the several options available to mitigate market risk.

The figures provided by the biofuel finance experts consulted within Elobio are largely confirmed by the financial structure of some biofuel producing installations (as an example, Bioenergi Tønder's target WACC for their new first generation plant was 10%) and literature. Jager & Rathmann (2008) for instance, decompose the return on equity for renewable energy projects into the following components:

- a risk-free rate (e.g. 3-5% for 10 year government bonds);
- an equity risk premium related to the performance of similar listed asset classes (e.g. a premium of 4-5% to compare with the typical IRR of similar listed asset classes of 7-9%);
- in case the equity is provided via a fund, management fees add 2% or more to the equity rate, and an illiquidity premium of about 3% may be incorporated by the investor for the fact that the shares can not be sold as easily as stock exchange listed funds;
- a technology or "esoteric asset class" premium for new and unproven technologies or institutional situations (e.g. 3-15%); and
- a regulatory risk premium reflecting the risks of the energy markets and renewable energy support schemes (e.g. a -3% reduction for low-risk to +3% extra for schemes with higher risk).

This adds up to a required RoE between 15% and 30%, the main factor for the large range being the maturity of the technology. This assessment was done for renewable technologies in general and also holds for the case of biofuels.

The main objective of WP7 within the Elobio project was to identify and define support policies which are able to mitigate risk related to investing in advanced biofuels thus lowering the WACC for projects employing second generation technology. Before proceeding with policy support and their impact on WACCs, a short discussion on the selection of biofuel chains for the WACC analysis is required. Ideally, we would have calculated WACCs for each biofuel chain included in Biotrans. However, as the risk questionnaire already pointed out, there is little difference within the first and second generation biofuel groups in terms of risks, which should be reflected in their similar WACCs. However, to take into consideration basic differences in feedstock costs as well, we decided to take into consideration the following biofuels value chains:

- sugar-based bioethanol from sugarbeet
- starch-based bioethanol form wheat
- oilseed-based biodiesel from rapeseed
- lignocellulosic bioethanol

- FT-diesel

The WACCs for the above biofuel chians, considered the most representative, were generalized for the other technologies included in Biotrans.

5.2 Basic WACCs

The first step in the analysis was to calculate the WACCs for the most representative biofuel value chains, by including the financial parameters as defined by expert input into the cash flow model. For our calculations we took a middle estimate of the financial parameters and the input cost and biofuel prices explained in section 4.2.2 and we calculated for each of the five biofuel value chains the ex-ante WACC and the price gap necessary to reach the minimum financial requirements for the cases where they were not immediately met.

For second generation biofuels we also distinguished a pre-commercial phase, where we assumed no debt finance to be possible and a commercial phase where a similar financing structure as for first generation would be possible but with a somewhat higher DSCR, to remain on the conservative side. An overview of the financial parameters applied, the resulting WACCs and price gaps can be found in the Table 5 below:

Table 5: Cash flow model input and output

Biofuel type	Financial parameters	Finan. param. met	Price gap (€/t)	Price gap (in %)	WACC (after price gap)
sugar-based bioethanol from sugarbeet	DSCR = 1.5 Interest rate = 7% Required RoE = 15%	Yes	- 379	-57	7.17% (d/e=80/20)
starch-based bioethanol from wheat	DSCR = 1.5 Interest rate = 7% Required RoE = 15%	No	37	5.6	7.17% (d/e=80/20)
vegetable oil-based biodiesel	DSCR = 1.5 Interest rate = 7% Required RoE = 15%	Yes	- 534	- 52.9	7.17% (d/e=80/20)
lignocelluslosic bioethanol pre-commercial phase	DSCR = not relevant Required RoE = 30%	No	577	87.3	30% (d/e=0/100)
lignocelluslosic bioethanol commercial phase	DSCR = 1.8 Interest rate = 7% Required RoE = 15%	No	9	1.4	7.84% (d/e=73/27)
FT-diesel Pre-commercial phase	DSCR = not relevant Required RoE = 30%	No	105	10.4	30% (d/e=0/100)
FT diesel Commercial phase	DSCR = 1.8 Interest rate = 7% Required RoE = 15%	Yes	- 428	42.4	7.17% (d/e=80/20)

The WACC figures in table 5 represent the minimum financial requirements for each biofuel chain. They show that in the case of a biofuel obligation, some chains (sugar-based bioethanol and vegetable-oil based biodiesel) meet the requirements of debt providers and equity investors without needing any government support, and would do so even if the average market price for biofuels was almost half lower than what is projected by OECD-FAO, all else equal (see appendix 1 for feedstock price projections). Agricultural price shocks of the type witnessed during the 2007-2008 food crises could of course turn the situation around.

At the same time, it shows that under the predicted market conditions, the other biofuel chains are not very attractive to the average investor. Wheat-based bioethanol for example needs a small support to generate sufficient returns to attract private capital, whereas both second generation chains will need very significant levels of support to attract the venture capital required to help it cross the bridge to a fully commercial phase (the equivalent of roughly a 10% price increase for FT diesel and almost 90% for the case of lignocellulosic ethanol). The bigger the price gap, the more support is needed.

What the above table also illustrates is that once FT diesel production reaches full commercialization, it is likely to become almost as attractive to investors as the first generation biofules offering the best returns at the moment.

As discussed in the previous chapter, technology risk is the biggest hurdle to overcome before conventional (and cheaper) finance sources become available to second generation biofuel projects. Overcoming technology risk (as perceived by finance providers) means nothing more than a proven technological track-record, or in other words, sufficient installed production capacity on a commercial scale operating steadily over a certain period of time. The main aim of second generation policy support should therefore be to bring some initial quantities to the market. The following chapter discusses what would be the best policy combination to achieve this.

6. Policy support to second generation

6.1 Overcoming technology risk to full commercialization

The WACCs calculated by the cash flow model above were inserted into Biotrans to add the cost of capital to the investment costs in the model. As discussed above, given the current cost of the technology and the predicted biofuel price, there will be hardly any private capital willing to invest in a second generation biofuel venture. This is confirmed by a Biotrans run where all first generation biofuel chains are subject to a WACC of 7.17% and second generation technologies are facing the current reality of a 30% pre-commercial WACC until 2015 and 7.17% thereafter[6], which is a rather arbitrary period-distinction based on the mid-point expectations of the surveyed finance experts on the commercialization of 2nd generation. As can be seen in figure 4, without any supporting measure there will hardly be any second generation technologies by 2030, if current market and financing conditions persist, because first generation biofuels, especially biodiesel, will simply be cheaper to produce and much more attractive to investors (those not concerned with stakeholder acceptance).

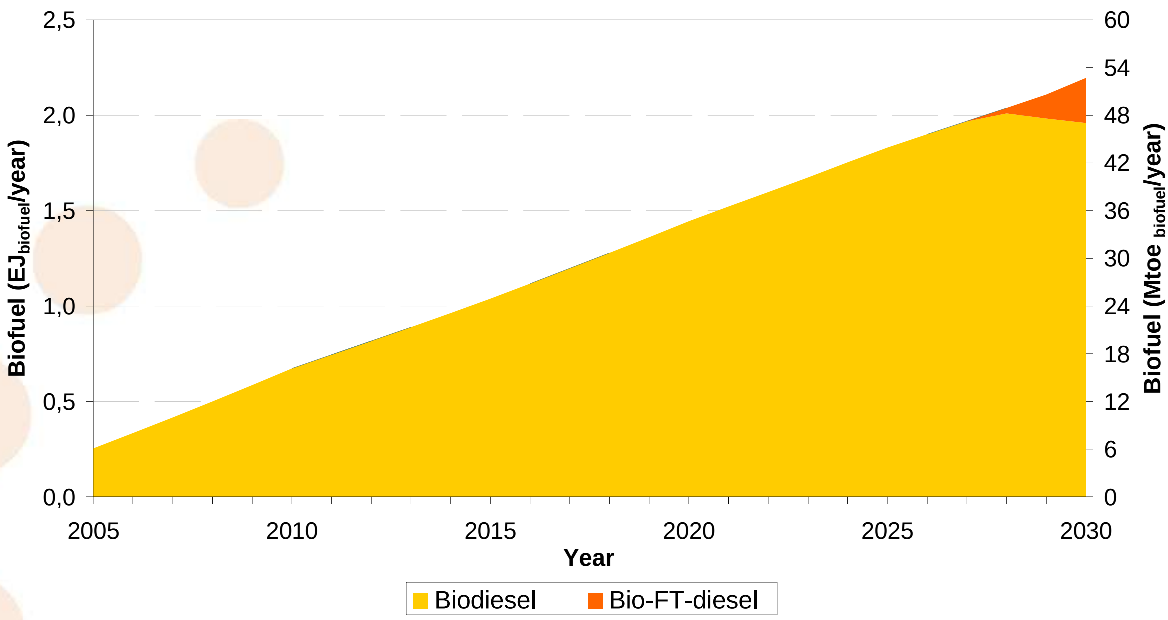

Figure 4: Biofuel mix under WACC = 7.17% for first generation technologies and 30% for second generation until 2015 and 7.17% thereafter

The first question to be answered was therefore when can we reasonably assume that second generation technologies will have reached full commercialization (from the point of view of finance providers) and what kind of policy support is best suited to achieve it? As mentioned before, the expectations of finance experts vary widely in this regard, from 2 to 10 years. The cash flow model runs have shown that private capital alone is unlikely to flow into second generation production capacities in sufficient levels under the current and predicted market conditions, hence some sort of policy support will be needed at first to bring some level of installed capacity on the market. Once that is achieved, two cost-reducing effects should take place:

[6] Assuming they will be eligible for the same financing structure as 1st generation once they reach full commercialization.

a) reduced technology risk making it eligible for debt finance and equity other than venture capital, leading to a considerably reduced cost of capital and
b) learning effects reducing the cost of the technology.

The very high WACC of 30% will then be replaced with the 7.84% and 7.17% WACC for lignocellulosic bioethanol and FT diesel, respectively, and it will be calculated over a smaller base, because the cost of technology will have been brought down by learning effects, thus significantly increasing the competitiveness of second generation technologies.

Three policy options were tested for their ability to introduce into the market a level of second generation that would allow for learning effects to start taking place and the technology to be considered sufficiently proven. The “sufficient” level of market introduction for second generation to be considered commercial has been somewhat arbitrarily set to cca 10% of the biofuel market. The policy options tested were the following:

1. <u>Investment subsidy of different levels (50%, 60% and 70% of total project costs)</u>

Investment grants or direct subsidies are an important support measure for technologies not yet interesting for conventional finance sources. By subsidizing a part of the investment costs, governments shoulder part of the risk by lowering the total amount which needs to be provided by investors. For installations employing second generation technologies this can have a very high impact on the final cost of the product, since capital costs (into the production facility) represent a very high proportion of total project costs (as opposed to the case of first generation, where capital costs account for only up to one third of total production costs).

We tested a situation where all second generation installations could be granted a direct subsidy covering 50%, 60% or 70% of their total investment costs. The subsidy would be available as long as it takes 2nd generation installations to overcome the technology risk barrier and reach a lower WACC typical for mature technologies.

2. <u>Tax break for second generation biofuels</u>

For this case we take the fuel taxation in Germany as a benchmark and assume that all first generation biofuels (used in low blends) are subject to the same tax levels as fossil fuels (that is 47 €ct per liter for the case of first generation biodiesel and 66 €ct per liter for first generation bioethanol), while second generation biofuels are completely exempt from taxes.

We examined two different possible impacts of taxation and tax exemptions:
a) An interesting, though highly hypothetical case, would be one under conditions of an obligation and no imports. In this case, the tax proportion that could not be absorbed by the margin of the lowest-cost first generation biofuel chain would be transmitted to consumers as a biofuel price increase. As sugar-based ethanol is the lowest cost production chain for ethanol, we assume that in absence of low-cost import competition, sugar-based ethanol producers would be setting the price of ethanol in Europe. Their price gap would be able to absorb 379 of the 836 €/ton assumed tax on ethanol (a complete reversal of the tax break enjoyed until recently in Germany, for example). The difference, in this case 457.5 €/ton, would be transferred to consumers in the form of a biofuel price increase, which could be exploited by producers of second generation bioethanol on which a tax is not imposed.

For the case of biodiesel, a full tax of 534 €/ton (consistent with a full phase-out of Germany's 0.47 €/l former tax break), just equals the average margin of vegetable-oil based biodiesel, making a tax-induced price increase potentially exploitable by FT-diesel producers unlikely.

b) A more realistic scenario, where a certain degree of imports from outside the EU are possible and hence there is no tax-induced price increase of biofuels.

3. <u>Double counting</u>

The double counting mechanism allows second generation biofuels to count twice as much as first generation towards biofuels targets. This means, there can also be price differentiation between the two biofuels generations. The price for second generation biofuels can now equal the oil price plus twice the difference between first generation biofuels and the oil price. (At the moment, the price for all biofuels is determined by the cheaper first generation biofuels.)

2^{nd} generation price = fossil oil price + 2 x (1st generation biofuels price – fossil oil price)

<u>Results</u>

The conclusion from those model runs was that neither full tax differentiation (with or without a tax-induced biofuel price increase) nor double counting is alone sufficient to overcome the significant investment barrier that second generation technologies are currently facing due to insufficient technological track-record[7]. Only a very high investment subsidy level of 70% of total investment costs seems to be able to overcome this and introduce some second generation capacity into the market. Even such a high subsidy seems to only become interesting to biofuel producers by 2016, when the demand for biofuels is too high to be covered by the cheapest first generation options, which are starting to run out. Clearly, such a high level of support is not sustainable in the long run, from a budget point of view, and is mainly meant to achieve the introduction of second generation technologies, after which it has to be discontinued or replaced by less capital intensive support options.

For example, if the 70% subsidy is maintained for another 2 years after the first appearance of second generation on the market, by approximately 2018 they could reach some 10% of the biofuel market share, at which point it would be reasonable to assume (although as mentioned before, completely arbitrary) that there would be sufficient proof of technological performance to eliminate or significantly lower the technology risk, thus opening to second generation biofuel projects the possibility of obtaining other finance options than venture capital and in turn significantly lowering their WACC. At the same time, the learning effects would start lowering the cost of the technology making it more competitive compared to first generation installations.

[7] Graphically, the results of these runs and the runs for subsidy levels of 50% and 60% of investment costs look exactly like figure 4.

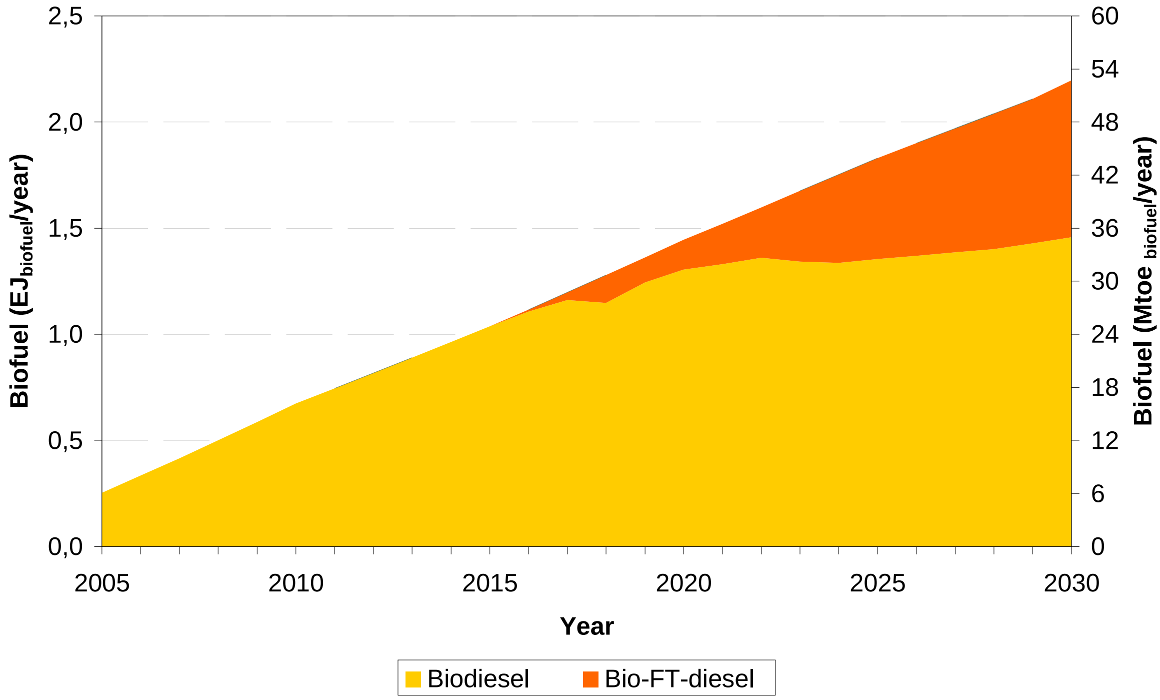

Figure 5: Biofuel mix under a 70% investment subsidy for second generation biofuels until 2018, first generation WACC of 7.17%, second generation WACC of 30% until 2018 and 7.84% and 7.17% thereafter for lignocellulosic bioethanol and FT diesel, respectively

As can be clearly seen from figure 5, FT-diesel is the dominating second generation biofuel on the market. This is due to the already mentioned lower production costs compared to lignocellulosic bioethanol, which will make it more attractive to finance providers once the initial investment hurdle is overcome[8]. Even so, the FT-diesel share drops after 2018 when the investment subsidy is discontinued. However, at that point learning effects have already started reducing the cost of the technology and since demand for biofuels is growing in the scenario runs, they are becoming increasingly attractive, resulting in a steady growth from 2020 (10% market share) towards 2030 (34% market share). Learning effects also explain the difference with the scenario represented earlier in figure 4, where just an arbitrary drop in WACC did not result in any deployment of second generation biofuels and therefore did not give the opportunity to reduce their cost due to learning.

Significant investment support thus seems to be necessary to achieve the introduction of some noteworthy quantities of second generation biofuels onto the market. However, the above case still does not reach the 30% market share for advanced biofuels by 2020, as advocated by the European Commission, because the total production costs are mostly still higher than for first generation biofuel chians. To achieve a higher market share for second generation, a combination of policy support options will be needed (for a limited time period at least) also

[8] However, Biotrans cost supply curves for lignocellulosic ethanol might need to be revised soon, if the recently announced technological advances prove to be correct; the Danish company Novozymes plans to launch a new enzyme sometime this year, which should allow cellulose ethanol to be produced for less than 2 dollars per gallon, which is about 37 eurocents per litre (Gave newsletter, 17-02-2010). At the same time Cellulose Sciences International (CSI) have developed a new pre-treatment process to ensure more efficient conversion of cellulose-based biomass into sugars, which will reduce the amount of enzymes required resulting in direct cost savings (Gave newsletter, 29-03-2010).

after they have been fully commercialized. In the next section, we evaluate the effectiveness and efficiency of a number of policy scenarios aiming to reach an approximately 30% share of second generation biofuels on the market by 2020.

6.2 Towards a 30% biofuel market share for second generation technologies

After having established how much support might be needed to achieve full commercialization of second generation biofuels, the aim is to find the policy mix that will achieve their higher market share at the least policy cost. We composed and tested a number of policy cases with different combinations of policy support options during the pre-commercial and commercial phases of second generation production chains. Table 6 presets the six most interesting of the nine policy combinations we tested (the full overview table and the graphs and explanations of the remaining three cases are available in Annex 2).

Table 6: Overview of selected policy cases

	Pre-commercial phase	Commercial phase
1	***Investment subsidy***	
a	Investment subsidy 70% for the year of introduction + 2 years thereafter	Continuous investment subsidy of 30%
b	Investment subsidy 70% for the year of introduction + 2 years after	Gradual subsidy phase out: 30% first 4 years after full commercialization, 15% subsequent 4 years, 0% thereafter
2	***Tax break (+investment subsidy)***	
	Full taxation of all biofuel (836.5 €/t for bioethanol & 534.1 €/t for biodiesel) + 70% investment subsidy until year of introduction + 2 years after	Full taxation of 1st gen and partial taxation of 2nd gen (418 €/t for 2nd gen bioethanol and 267 €/t for FT diesel)
3	***Soft loan (+investment subsidy)***	
	Investment subsidy 70% for the year of introduction + 2 years after	Soft loan 1%
4	***Double counting (+investment subsidy)***	
a	Investment subsidy 70% for the year of introduction + 2 years after + double counting	Double counting
b	Investment subsidy 70% for the year of introduction + 2 years after + double counting	Double counting discontinued after 2020

1. Investment subsidies

As we saw in the previous section, investment subsidies are an effective way of bridging the gap to commercialization of second generation biofuels thus reducing the cost of capital from few tens of percent typical for venture capital to a few percent characteristic of a project developed with conventional finance.

Investment subsidies are equally effective in helping second generation technologies achieving a higher market share. Clearly, the higher the investment subsidy, the more second generation production capacity we will see on the market. As mentioned before, however, investment subsidies are a very costly policy measure which cannot be maintained forever. In cases 1a and 1b, we therefore compare the effect of a continuous investment subsidy of 30% (after full commercialization for second generation is reached) and a gradual phase out of this support measure (30% subsidy for the first 4 years after commercialization, 15% for the following 4 years and no more thereafter). The impacts on second generation penetration under these two options can be seen in figures 6a and 6b.

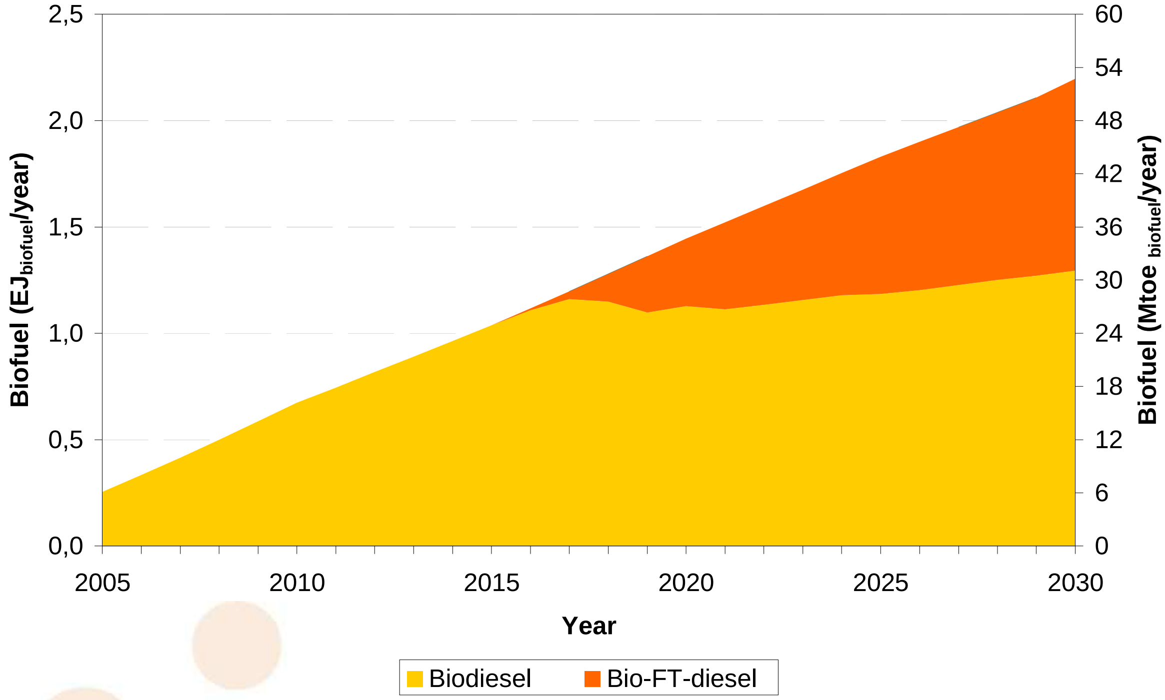

Figure 6a: Case 1a - biofuel mix for the case of 70% investment subsidy until commercialization is reached and 30% thereafter (first generation WACC of 7.17%, second generation WACC of 30% until 2019 and 7.84% and 7.17% thereafter for lignocellulosic bioethanol and FT diesel, respectively)

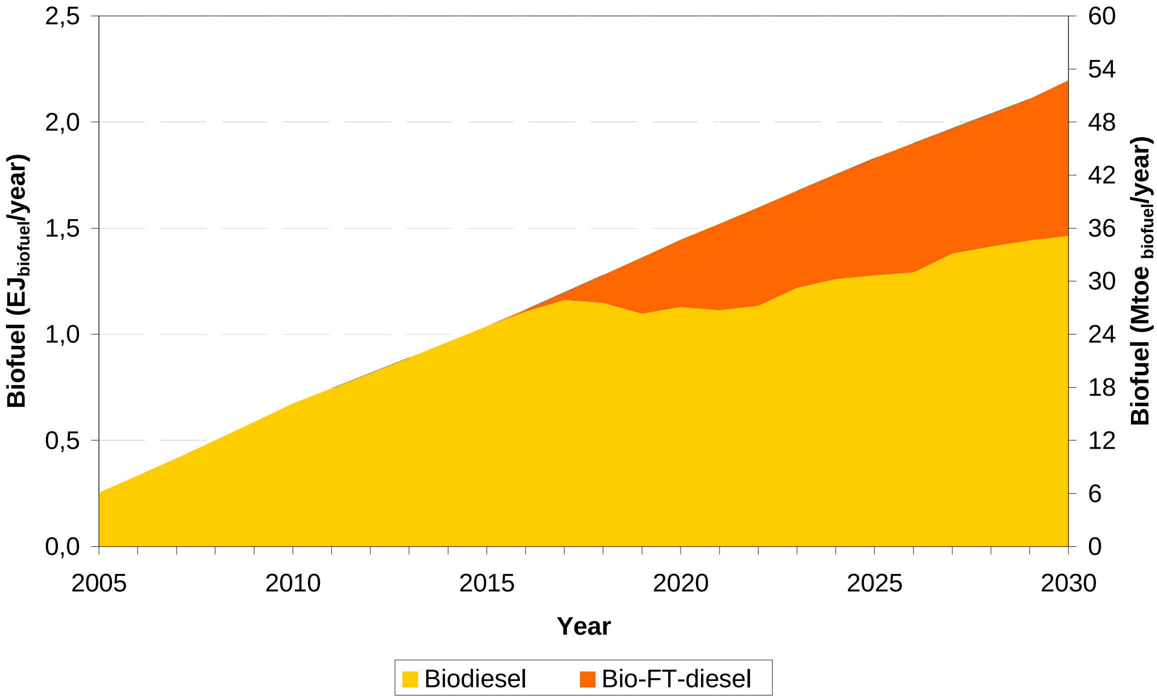

Figure 6b: Case 1b - biofuel mix for the case of 70% investment subsidy until commercialization is reached, 30% for the first 4 years thereafter, 15% for the following 4 years and a complete discontinuation by 2027 (WACCs same as in case 1a)

Both cases achieve of the same deployment of second generation biofuel (FT diesel) by 2020, some 22%, since the subsidy levels are the same until that date. More interesting is the development thereafter. By 2030, a continuous subsidy of 30% of investment costs helps second generation biofuels reaching approximately 41% market share (or 901 TJ) at a total cost of approximately 14.5 billion €, compared to 33% (or 732 TJ) in the case of a gradual subsidy phase-out, at a cost of around 7 billion €, which is 19% less second generation biofuel on the market at half a policy cost compared to a continuous subsidy. Again, the main reason for the difference is learning effects.

2. Tax break

Tax exemptions for biofuels have played an important role in promoting the use of first generation biofuels in many countries, albeit at the cost of large tax revenue losses for governments. However, as initial runs have shown, such a strategy is not sufficient to overcome the initial investment barrier for second generation technologies. Nevertheless, in combination with an initial period of investment subsidies, tax differentiation between first and second generation biofuels could be warranted as a support option.

In all cases first generation biofuels were fully and consistently taxed across Europe according to the German tax levels of 836.5 €/t for ethanol and 534.1 €/t for biodiesel[9]. In addition, investment subsidies of different levels were added until second generation biofuels became noticeable in the biofuel mix.

[9] This is of course not a realistic scenario, as excise taxes differ significantly across Europe, nevertheless it gives an indication on the level of cost of such support policy.

We tested combinations of different tax exemption levels for 2nd generation (full and partial), timing of tax reduction introduction (pre-commercial or commercial phase) and levels of complementary investment subsidy and found that a partial tax exemption of second generation is best introduced after commercialization has been achieved through a 70% investment subsidy (as in case 1), which is discontinued after second generation biofuels reach approximately 10% of market share. (The results of the other runs are presented in Annex 2.)

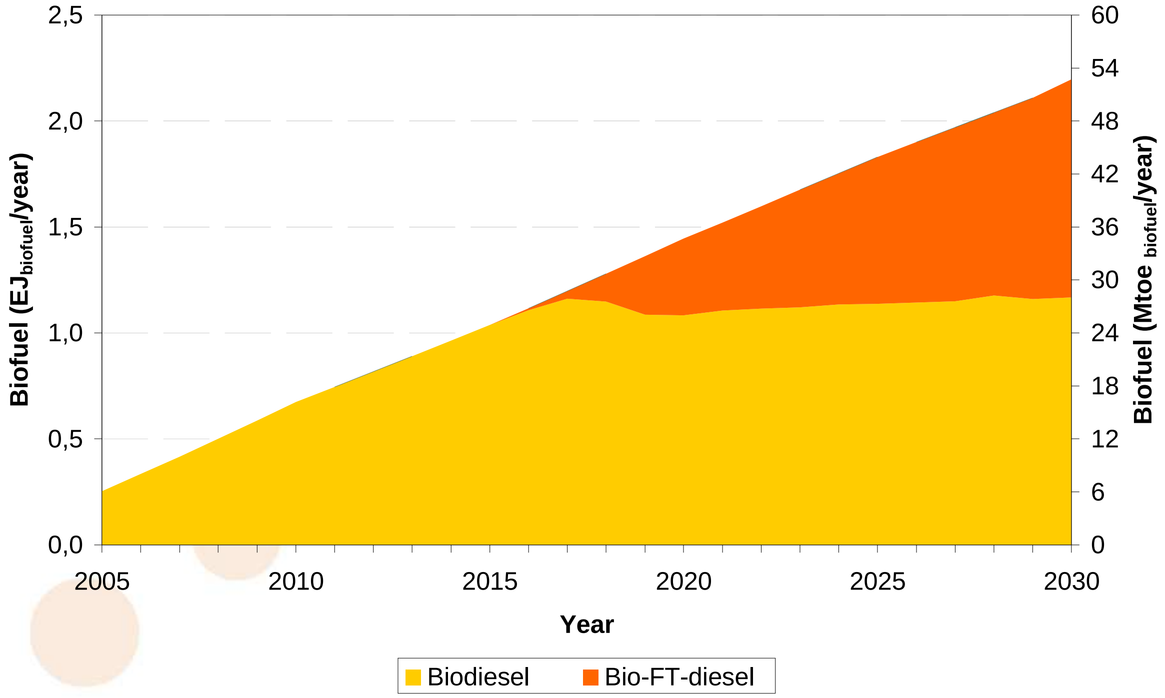

Figure 7: Case 2 - biofuel mix for the case of a 70% investment subsidy in the pre-commercial phase and reduced taxation (50%) of second generation biofuels for the commercial phase

This kind of policy combination achieves a market share of about 25% for second generation biofuels and an almost 47% share in 2030. The total policy cost comprised 2.7 billion € of investment subsidies and over 19 billion € of cumulative tax revenue loss, due to reduced tax income from sales of second generation biofuel. Compared to other combinations of lower investment subsidy (50%) and continuous tax exemptions (both full and partial) through both the pre-commercial and commercial phases (see Annex 2), this is the cheapest policy option.

3. Soft loan

After second generation technologies become eligible for debt financing, subsidizing the interest rate of the bank loan also becomes a possible support option, which directly lowers the projects' cost of capital. Biotrans runs have shown that on its own, soft-loans subsidizing 1 or 2 percentage points of the bank loan are alone not sufficient to achieve high market share for second generation biofuels. However, this instrument can be used in combination with other support options, reducing the need for direct investment subsidies and representing a potentially cost-efficient complementary option.

Figure 8 presents a situation in which a 70% investment subsidy is employed to bring second generation biofuels to the market (as in cases 1 and 2), then discontinued two years after the initial investment barrier is overcome, after which a soft loan of 1% is introduced as the only support option.

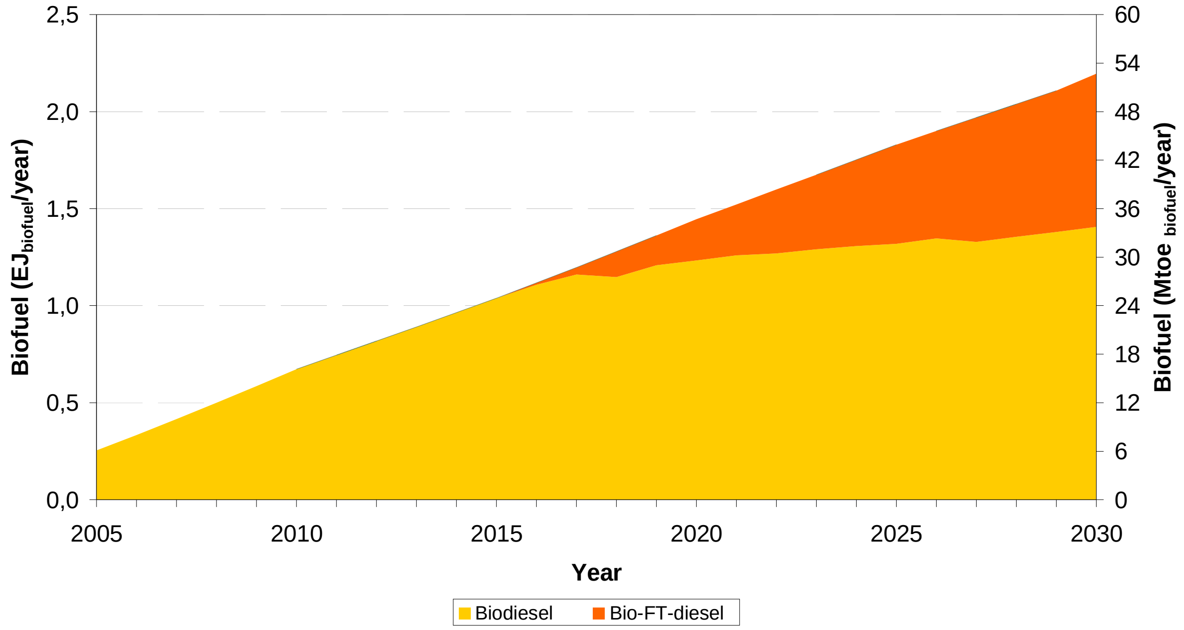

Figure 8: Case 3 - biofuel mix for the case of a 70% investment subsidy in the pre-commercial phase and soft loan of 1% for second generation biofuels thereafter

This policy combination achieves a second generation market share of 14,7% in 2020 and almost 36% by 2030. The total policy costs are the 2.7 billion € initial investment subsidy and just under 1 billion € of loan subsidization costs.

If a continuous 10% investment subsidy (throughout second generations' commercial period) is added to the soft loan, a market share of 16.7% in reached by 2020 and almost 37% by 2030, at a total cost of almost 7 billion € investment subsidies (2.7 of which in the pre-commercial period) and almost 1 billion € of loan subsidization costs. An almost double policy cost for a marginally larger market share (see Annex 2).

4. Double counting

Double counting was introduced by the new Renewable Energy Directive in 2009 and currently represents the main supporting option for second generation biofuels in Europe. Its effectiveness is still not entirely clear. While increasing the competitiveness of second generation compared to the first, this advantage varies with fossil fuel price, adding an element of uncertainty for investors and lenders.[10] This is difficult to quantify but it will most likely be reflected at least in a higher DSCR requirement by banks for second generation installations[11].

Double counting also means that the proportion of second generation biofuels entering the market for transport fuels, can be matched by an equivalent amount (based on energy content) of fossil fuel. This reduces the total size of the biofuel market, potentially challenging the very drivers for biofuel policy support.

[10] See Londo (2009) for a detailed explanation.
[11] Note that this possible effect on the WACC hasn't been included in the double counting runs with Biotrans.

As the initial runs have shown, double counting on its own does not represent a sufficient incentive to bring significant amount of second generation biofuels to the market. However, coupled with a high investment subsidy, even if the latter is discontinued shortly after the initial investment barrier is overcome, it can achieve high market share for second generation biofuels at low policy cost. As can be seen from figure 9a below, a combination of double counting together with a 70% investment subsidy until the year of second generation introduction and two years thereafter, yields a market share of 18% in 2020 and almost 31.5% by 2030 at a total policy cost of only around 860 million €. This is significantly lower than any other policy combination assessed so far. However, it must be noted, that under this scenario, the total amount in absolute terms of both biofuels in general and second generation in particular, are smaller than under any other case analyzed so far, the difference being almost twice as much compared to the tax break case.

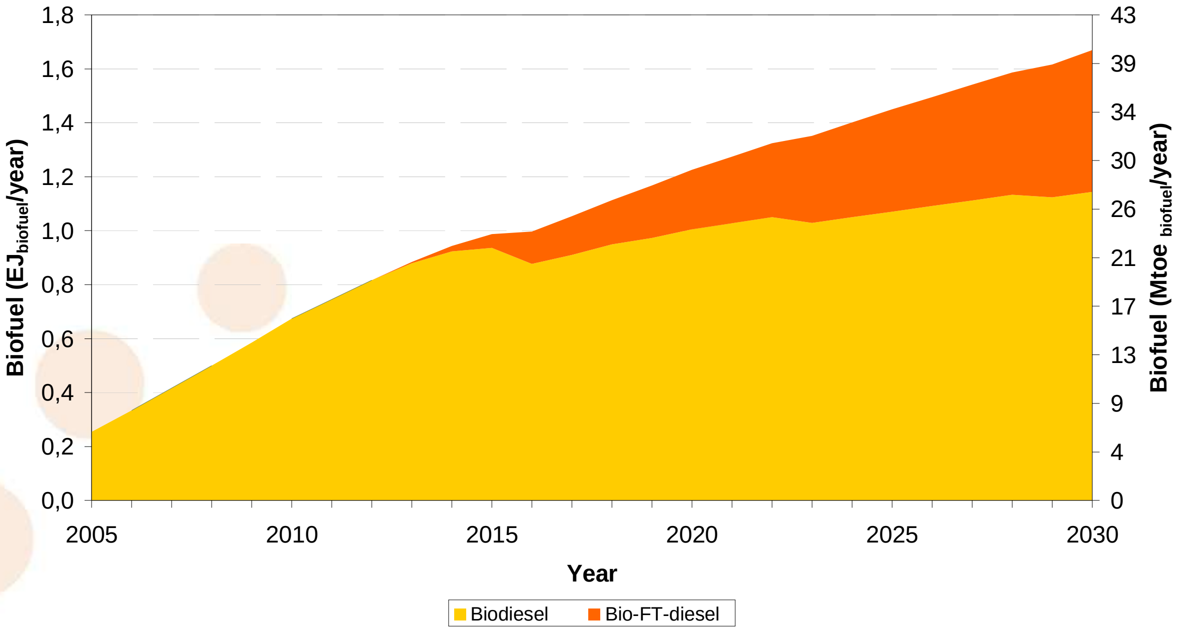

Figure 9a: Case 4a - biofuel mix for the case of double counting of second generation biofuels and a 70% investment subsidy in the pre-commercial phase and only double counting thereafter

The reason lies in the already mentioned possibility to match any amount of second generation biofuels by equal amount (in energy content terms) with fossil fuels, allowing them to fill part of the biofuel obligation quota. At the same time, by comparing the volumes of first generation biofuels for the various scenarios so far, we see that double counting of second generation hardly displaces any significant amount of first generation production. However, what double counting does achieve is an earlier market introduction of second generation biofuels compared to all other cases described so far.

It thus appears that double-counting can be a very cost-efficient way of speeding up the introduction of second generation into the biofuel market, but less effective in significantly expanding its production capacities in the longer run, although it does support a fair relative market share for advanced biofuels. This is to large extent because double counting diminishes the total size of the biofuel market, rather than significantly increasing production

volumes of second generation biofuels. Because of this, it is not an instrument that should be used for a prolonged period of time; otherwise biofuels might remain a niche market, representing less than 10% of the transport fuel market by even 2030.
Double counting should, similarly to expensive investment subsidies, be seen as a means to bridge the technology risk barrier to full commercialization of biofuels and support initial capacity levels until learning effects start decreasing the cost of the technology.

Such a case is presented by figure 9b below, which shows the biofuel mix under a situation where initial second generation production capacity is supported by both double counting and a 70% investment subsidy. The latter is discontinued two years after first market introduction of second generation biofuels, while double-counting is abolished in 2020.

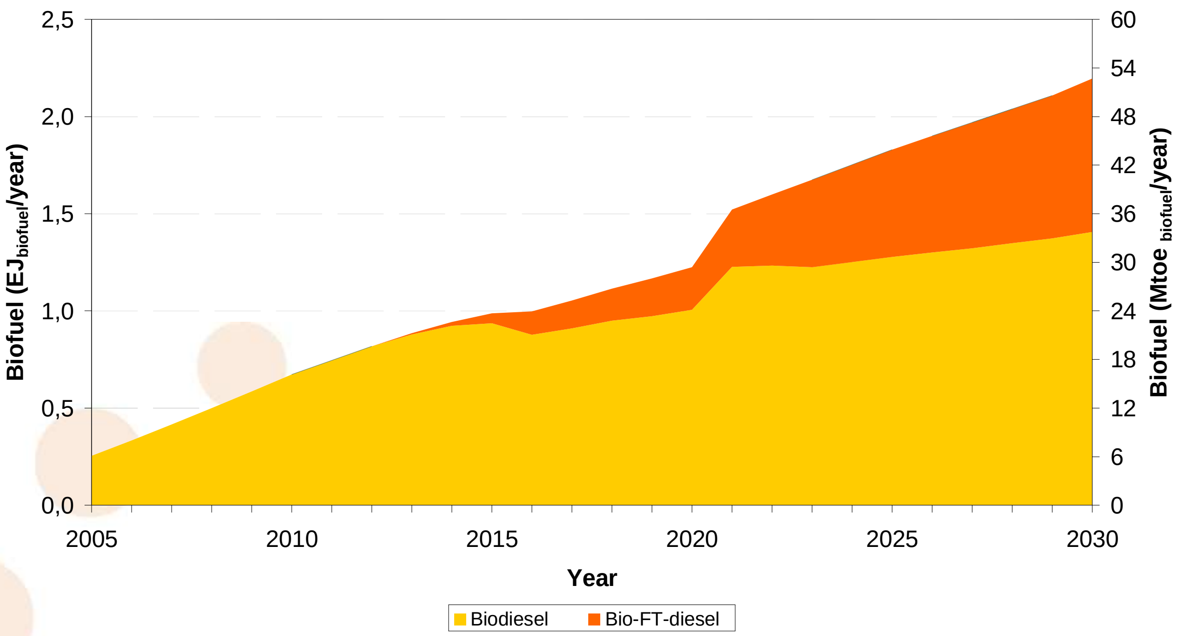

Figure 9b: Case 4b - biofuel mix for the case of double counting of second generation biofuels and a 70% investment subsidy in the pre-commercial phase and only double counting until 2020

Unsurprisingly, the two scenarios lead to the same relative and absolute amount of second generation biofuels until 2020 (ca. 18% of all biofuels), while the developments thereafter are much more interesting. When double counting is discontinued, there is a sharp increase in biofuel production, both first and second generation which now needs to fill the gap created by fossil fuels not used anymore to cover part of the biofuel obligation. This indicates that second generation technologies will at that point have reached sufficient technology cost reduction to become attractive competitors to first generation installations, even without any other significant support. Under this scenario, by 2030, second generation represents 36% of the biofuel market share (compared to 31.5% with continuous double-counting) and 50% higher volumes in absolute terms. In both cases the policy costs do not reach 1 billion €.

The main reason for second generation being able to achieve a significant market share in this case even without any additional support measures, is again learning effects. Double counting has, in combination with a high investment subsidy level, brought second generation into the market a few years earlier than any other policy combination analyzed so far. Earlier market introduction means that by 2020 learning effects would have reduced the cost of the technology more, than if they only started by 2016 (as in most other cases). The conclusion is that double counting is a very cost-efficient complementary measure to achieve market introduction of second generation biofuels into the market but needs to be discontinued after a while to fulfill its purpose best.

It is worth noting that the results presented here together with the related policy costs, strongly depend on technology learning rates. If learning does not go as well as expected, penetration rates for second generation would falter without some continuing support and for such support additional funding would be required.

7. Potential opportunity: heat sales

Synthetic biofuels- BTL technologies - generate surplus heat, which is lost. When the technology risks are overcome and those gasification technologies comprise a larger market share the amount of surplus heat will be significant. This surplus heat, however, can be utilized. For instance, it can be sold to the heat market, particularly, to the district heating systems.

The total amount of heat delivered to the EU Member States district heating (DH) systems in 2003 was 2034 PJ (see Elobio D6.1 and 6.2) and the potential for DH to grow is large in most member states. Werner (2006) estimates a doubling of the present total DH deliveries in the specified region in total up to 2020. However, assuming, e.g., that biofuel/heat co-generation needs to deliver heat to the DH system a certain amount of hours of the year to be introduced, it will not be possible to use the entire heat sink.

The diversified and local character of DH systems is not captured when assessing national data instead of systems level data. Hence, the actual impact of introducing biofuel/heat co-generation is somewhat different than presented in this paper. First, we overestimate the possibility for biofuel/heat co-generation since we assume that it is possible to implement it in all individual DH systems independent of their size. Second, performing the analysis with information at the individual DH systems level (concerning e.g., load curve and heat supply options) would also influence the outcome to some extent. The impact of introducing a new technology, when using an aggregated description of the national DH systems, will be sensitive to the slope of the national load curve for the affected heat supply options. The impact will thus vary between countries and scenarios. For a discussion of the impact of introducing a new technology on the use of a certain heat supply option, when using an aggregated description of the national DH systems, see Knutsson et al. (2006).

Assuming a different annual load curve influences the outcome, depending on how large a difference is assumed. In countries with less constant heat demand during the year than given by the annual heat load curve used, the possibilities for biofuel/heat co-generation to be introduced in the existing DH system might be smaller than found in this study. In countries with a more constant heat demand during the year the opposite is true.

In reality, an individual DH system is not always completely connected, i.e., there may be limitations in the transfer capacity within the system. Thus, it might not be possible to replace several heat supply capacities at different locations with one biofuel/heat co-generation plant. However, a comparison of the size of DH production from biofuel/heat co-generation and the size of individual DH systems will indicate the importance of the size issue.

Policies intended to promote biofuels for transport may also improve the interest for biofuel/heat co-generation. Other policies will directly and/or indirectly influence the prospects for biofuel/heat co-generation, with uncertain net effects. Policies intended to promote heat from renewable energy sources might stimulate biofuel/heat co-generation but will also stimulate biomass-based combined heat and power (CHP) and heat-only boilers (HOB). Similarly, policies promoting renewable electricity might stimulate biofuel/heat co-generation plants that also generate electricity, but they will also stimulate biomass-based CHP plants and biomass co-firing in coal-fired CHP plants.

Heat sales are a revenue stream available only to second generation installation, and can potentially affect their profitability, or, at least initially, decrease the need for policy support. To establish the magnitude of heat sales impact we re-performed all policy cases including the heat sales. In table 7 we present some of the most interesting results.

Table 7: Overview of second generation biofuel production volumes, market share and policy costs with and without heat sales

Case	Year of 2nd gen introduct.	[TJ] 2nd gen 2020	relative [%] 2020	[TJ] 2nd gen 2030	relative [%] 2030	Invest. subs. costs [M€]	Tax losses [M€]	Soft loan costs [M€]	Total policy costs [M€]
1a	2016	317,565	22.0%	901,139	41.0%	14,624	-	-	14,624
1a heat	2012	556,743	38.5%	1,232,444	56.1%	20,815	-	-	20,815
1b	2016	317,565	22.0%	732,381	33.3%	7,342	-	-	7,342
1b heat	2012	407,839	28.2%	913,479	41.6%	6,609	-	-	6,609
2	2016	361,130	25.0%	1,028,806	46.8%	2,716	19,326	-	22,042
2 heat	2012	676,172	46.8%	1,835,424	83.6%	2,614	39,365	-	41,979
3a	2016	212,468	14.7%	789,775	35.96%	2,716	-	998	3,713
3a heat	2012	377,334	26.1%	933,012	42.49%	2,614	-	1,471	4,085
5a	2013	219,954	18.0%	526,190	31.5%	861	-	-	861
5a heat	2011	297,816	26.0%	610,320	38.5%	889	-	-	889
5b	2013	219,954	18.0%	790,205	36.0%	861	-	-	861
5b heat	2011	297,816	26.0%	928,113	42.3%	889	-	-	889

As can be seen from table 7, heat sales can potentially have two positive impacts on the development of second generation biofuels:

a) They may increase the speed of introduction of second generation by a couple of years (more or less depending under which support scheme the installation would operate). An earlier introduction rate also means the technology moving towards competitiveness sooner.
b) Increasing market share. In all presented cases, the difference is quite substantial, ranging from 30% to 80% more second generation biofuels produced in absolute terms.

The most important message from table 7 is, however, that heat sales can support a continuing expansion of second generation production while policy support is gradually phased out, as is demonstrated in case 1b (where investment subsidy is gradually reduced and finally discontinued), thus reducing the total cost of the policy. By contrast, where policy support is continuously provided per unit of capacity installed or biofuel produced (and sold), as is the case with continuous investment subsidies and tax exemptions, the policy costs can escalate very fast.

Present and prospective future DH systems in the individual EU countries show that it can offer a substantial heat sink for surplus heat from biofuels production using the biomass gasification route. The linking with district heating can serve the purpose of improving cost competitiveness of this biofuel option. However, the implementation potential depends on the cost-competitiveness of this heat supply option compared to, in particular, fossil-fuel-based CHP but also the future use of industrial surplus heat and heat from waste incineration. Further, there are some serious logistical issues that might prevent second generation installations to exploit the benefits of heat sales. BtL plants will most likely have a large capacity, and will be located in a harbour area. As such, even if there is a district heating system available, it is questionable whether the heating system has sufficient capacity to absorb the large amount of excess heat produced by BtL plants.

8. Potential risk: competition with other ligno-cellulose-based industries

Although market risk is not yet seen as a significant issue for second generation biofuel production, continuous provision of cheap and abundant lignocellulosic feedstock is likely to become a challenge. Wood, in all its forms, has a very large number of applications and many forestry based industries are already competing for wood resources in their many forms.

Because the market for wood residues is very intransparent, it is rather difficult to make a precise estimate of the flows of wood residues to its different applications. According to a UNECE/FAO study on wood resources availability and demand (UNECE/FAO, 2007) there are data weaknesses on both the supply side (in particular on woody biomass outside the forest, post consumer recovered wood and logging residues) and on the consumption side (especially on wood use for energy and on conversion factors calculating wood raw material equivalent from units of products). The UNECE/FAO's 2005 wood resource balance for EU/EFTA shows that material use (sawnwood, pulp and paper, wood-based panels and other products) account for about 58% of total wood use in the region (821 million m3) and energy use accounts for the remaining 42% (mainly private household use, internal industrial use, power and heat production, and a substantial share 'undifferentiated). Statistics for energy applications, however, are known not to include all flows. Particularly trade flows of wood pellets used for co-firing are difficult to determine, partly because of missing or vague trade definitions (UNECE/FAO, 2007). Nevertheless, the wood balance clearly shows that energy and material uses are of the same order of magnitude.

Future assessments of wood uses predict a faster increase of energy use compared to material uses. The amount of demand from the energy sector will depend on bioenergy targets and the level of support they will receive from governments but also on the relative competitiveness of bioenergy options with other renewables. On the basis of this data it can be calculated that by 2020 the combined shortfall of wood supply in Europe could reach 300 million m^3, which does not even include any potential demand for the production of second generation biofuels.

Figure 10 shows the resource base of a middle case of possible developments for second generation, for example case 5b described in the previous section. We can see that wood processing residues are the most important feedstock source, followed by agricultural residues and woody crops.

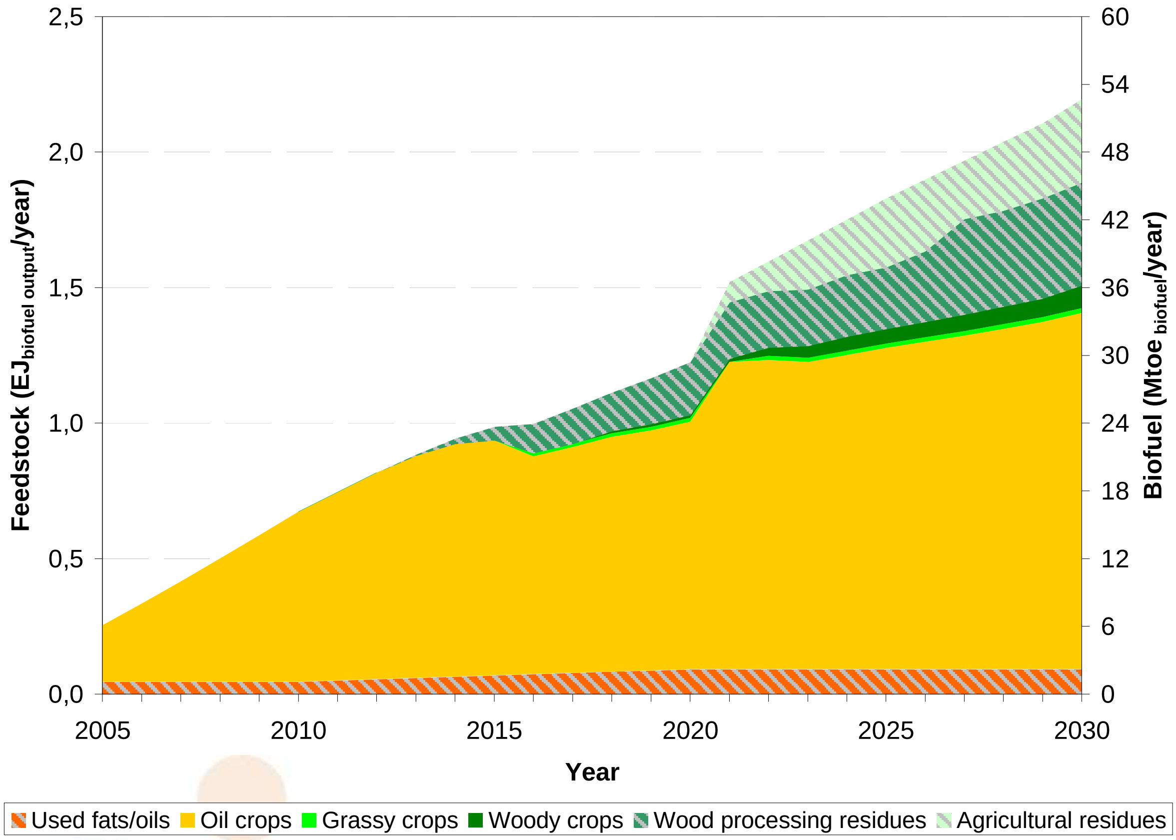

Figure 10: Resource base of biofuel mix achieved under policy case 5b

Wood residues and woody crops would in this case represent almost 0.5 EJ of biofuel feedstock by 2030. Assuming that 1 metric tonne wood equals about 1.4 cubic meters (solid wood) and the energy content of wood fuel is about 18-22 GJ/t, a simple back-of-the-envelope calculation shows that if second generation biofuels would reach a 30% market share over the next two decades, it would add an additional 80 to 100 million m3 of demand for forest wood, woody crops and residues, increasing the gap between supply and demand and competition among all forestry-based sectors[12].

Unless more wood resources in Europe are mobilized, the deficit will have to be imported or shared by all industries and will likely result in higher wood prices and lower growth for all forestry-based sectors.

Unfortunately, price changes of wood residues, a prime feedstock for BtL plants, are very difficult to estimate because they are not traded on established trading platforms. Lack of consistent price data could also be one of the reasons why feedstock provision is not yet seen as an issue for second generation plants. However, with increased BtL capacities and the corresponding increased demand for lignocellulosic feedstock, market risk could very likely become a reality for second generation plants as well.

[12] In terms of competition with the stationery sector, the utilities' demand for biomass feedstock for heat & power production depends a lot on CCS developments, see Elobio deliverable D6.

9. Conclusions and recommendations

Second generation biofuels have an important role to play in a more sustainable transport system. They are generally more acceptable to most stakeholders (as discovered during stakeholder consultations in WP4) and can alleviate potential environmental and social pressures caused by increasing biofuel demand worldwide (as described in WP5). However, while desirable for many reasons, they are not yet economically attractive enough to draw the type and amount of capital necessary to meet all that is expected of them.

The aim of Elobio WP7 was to assess the main investment hurdle preventing advanced biofuels from becoming a competitive player on the biofuel market. An analysis of risk profiles of first and second generation biofuels according to finance experts revealed that the biggest hurdle for second generation is technology risk, which cannot be reasonably mitigated by a contractual arrangement of a project seeking finance, but requires a steady technological track-record. This can be achieved by bringing a critical amount of second generation production technology on the market. Until then, the only finance sources for advanced biofuel projects are grants and venture capital, which implies very high cost of capital, even three to five times the cost of capital for first generation projects. The current biofuel market situation does not support returns of the type required by venture capital, making advanced biofuels an unattractive investment option.

To overcome this initial investment hurdle, a significant level of support is likely to be necessary. The effect of risk mitigation policies on the cost of capital is difficult to model explicitly on a macro level. However, since technology risk is best mitigated by increasing the amount of installed capacity until there is sufficient proof of the technology's performance, we can reasonably assume that after such point is reached, conventional finance sources will consider financing projects employing second generation technology, thus significantly lowering the projects' cost of capital. Different policy options or combinations can help second generation achieve the necessary market penetration to be considered "a fully commercialized technology" at different policy costs.

When searching for the optimal solution, we should distinguish two "phases" of support for advanced biofuels: the "pre-commercial phase", where the aim is to bring some initial quantities to the market so that investors can become familiar with the technology and the "market expansion phase" where the aim is supply quantities sufficient to meet a significant share of the demand for biofuels.

Model runs with Biotrans show that the most effective option to overcome the initial investment barrier are high investment subsidies, in excess of 50% of total investment costs; they are a relatively costly option but it is important to note they do not need to be in place for a long time. Tax breaks and double counting on its own do not appear to be sufficient to overcome the initial investment barrier.

Once the initial investment hurdle is overcome, learning effects and lower cost of capital should make second generation biofuel projects more interesting for investors. However, model runs show that until 2020 there could be sufficient supply of cheaper first generation feedstock to keep the still more expensive advanced biofuel chains a niche market. To expand their market share beyond 10%, some sort of policy support will remain necessary beyond successful commercialization of the technology.

Table 8 presents a summary of the effectiveness and efficiency of achieving a higher market share for advanced biofuels for some promising policy options. The number of plus (+) and minus (-) signs indicates the strengths of a policy option/combination in achieving a high share of second generation biofuels (effectiveness) at a low policy cost (efficiency). Thus, *more* pluses indicate a higher market share, while *fewer* minuses (or even a plus) indicate lower policy costs.

Table 8: Effectiveness and efficiency of advanced biofuel support options

Policy option(s)	Effectiveness (market share of 2nd gen by 2030)	Efficiency (total policy cost in €$_{2005}$/GJ biofuel)
1a: Continuous investment subsidy (>50% of investment costs)	+++ (~40%)	-- (~15)
1b: Investment subsidy gradually phased-out	++ (~35%)	-- (~10)
2: Initial investment subsidy + subsequent partial tax break	+++ (~45%)	--- (~20)
3: Initial investment subsidy + subsequent soft loan	++ (~35%)	- (~5)
4a: Initial investment subsidy + continuous double counting	++ (~30%)	+ (~2)
4b: Initial investment subsidy + double counting discontinued after 2020	++ (~35%)	+ (~1)

Of the policy combinations tested in this study, the most favourable one is high initial investment subsidies (discontinued after commercialization is reached) coupled with double-counting, which is also discontinued after an initial period. To fulfil its purpose best, this support measure should be discontinued as soon as learning effects have lowered the cost of the technology enough to make it more competitive with conventional biofuels. Otherwise, double counting can reduce the overall size of the biofuel market while substituting hardly any production of conventional biofuels with advanced ones. Again, we made an arbitrary decision to discontinue double counting less than ten years after market introduction of second generation biofuels although some more research would be needed to establish more precisely when the cut-off date should be.

Tax incentives similar to those used to promote first generation biofuels would also be a very effective mean to increase market share of advanced biofuels, however their high cost (in the form of tax revenue loss) does not make it a sustainable incentive, even for the medium term. A more general conclusion is that to avoid policy costs escalating beyond maintainable levels, any support measures given per unit of capacity installed or biofuel produced (and sold), should gradually be discontinued. An added benefit of a support measure “with a deadline” is that it might also increase the sense of urgency with project developers and investors eager to cash in on the limited amount of incentives, thus speeding up development of first capacities.

It is important to note again that both the effectiveness and the efficiency of the above policy measures depend considerably on the following two factors:

- what market share exactly would need to be reached by second generation technology to be considered sufficiently proven and,

- how fast would technological learning lower the cost of the production technology?

Regarding the former, the roughly 10% market share assumed to be sufficient in this study can be considered a realistic amount, making our policy costs results an upper-side estimate. On the other hand, the technological learning curve included Biotrans is a fairly optimistic one, which could lead to a faster lowering of production costs for second generation biofuels and consequently to lower subsidy levels. We did not attempt to quantify the net result of these two opposite effects. It is nevertheless clear, that if the aim is to have advanced biofuels contribute a noteworthy amount of transport fuels by 2020, the budget for support will need to run in the order of several hundred million €.

There are other important developments that can speed up or slow down market deployment of advanced biofuels. Heat sales can support introduction of second generation biofuel/heat cogeneration and most importantly support market expansion while policy support is gradually phased out. However, the size, proximity and seasonal character of the heat sink are significant issues to be resolved before this synergy can be exploited.

While promoting market expansion for advanced biofuels we must also keep in mind potential future risks related to significantly increased demand for lignocellulosic feedstock. To be economical, advanced biofuel production plants will need to be very large and will represent another significant demand source for woody feedstock. Market risk might become a real issue for second generation as capacity expands and feedstock demand increases for already supply-constrained woody residues & woody crops.

There are other risks to second generation biofuel chains which, although less prominent than technology risk, are nevertheless important for their steady development and increased use. Government risk, for example, can be mitigated by transparent, clear and long-term policies, which give the right signal to business developers and finance providers. This does not necessarily mean heavy long-term subsidization of second generation installations but rather a policy environment allowing a high degree of certainty in the evaluation of long-term investment decisions.

Finally, it is worthwhile to contrast our findings with the views of stakeholders on biofuel support options collected during consultation in WP4 (see Lundbæk & Londo, 2008 and Duer et al., 2009 for more details):

- *Farmers seem to prefer a mandatory target for biofuels and no specific support for second generation*. This can imply that opportunities from growing and providing lignocellulosic crops are not yet fully recognized. At the same time there is a growing market with fairly high prices for biomass from e.g. willow in Sweden. However, farmers seem reluctant to adopt this crop in their cropping strategies – presumably because the crop is a perennial crop and thus more prone to risks in shifting prices over the years, but perhaps also out of lack of knowledge on yields and of how to manage this crop. More information dissemination on potential income from supplying feedstock to advanced biofuel producers among farmers' organizations and support for introduction of new crops might be beneficial.
- *Vegetable oil producers want any tax exemptions to be consistent across countries*. This would be difficult to achieve as excise taxes or tax breaks are decided on a member state level. However, homogeneity might come from the fact that due to its high policy cost tax exemptions are being replaced by obligations.

- *A suggestion from academia included an advise against blending mandates and in favour of counter-cyclical mandates* (e.g. a blending target that is high when feedstock prices are low and vice versa) however this would significantly increase the investment risk into biofuel plants, specially because market fluctuations would now mean not only high input costs but a potential shut-down of production. Although this remark was primarily intended for first generation biofuels, it could become relevant for second generation as well, if other forestry-based industries (e.g. pulp & paper, fibre-boards) start suffering from high input prices.

10. Analysis limitations

Significant data and methodological challenges were encountered in the course of the study and not all were fully resolved. Hence, some caution is required when interpreting some of the results.

The implications of investment risks on a macro level are significantly more difficult to assess than on a project level (where Monte Carlo analysis is often successfully applied). The aim of this study was to analyze the implications of project-level risk on the biofuel sector's developments. For this, we needed to rely on a number of assumptions and expert opinions, often based on qualitative assessments.

The data sample on financial parameters for biofuel projects provided by biofuel finance experts is rather small and mainly based on input by experts from Western Europe, thus does not sufficiently account for possible geographical differences. If the cost of financing a biofuel project in Eastern Europe is significantly higher, this might negatively affect productive utilization of the large biomass supply of that region. (E.g. if the money to finance the production capacity is in Western Europe but the cheapest feedstock is in East Europe, in reality, those two might not come together, which is not considered as a possible limitation here.)

The model further assumes unlimited supply of capital to projects meeting the WACC criteria. However, in reality several reasons contribute to limiting the flow of capital to biofuel projects. The potential negative impact on agricultural prices and biodiversity has prompted several banks from categorically denying financing to first generation biofuel projects. The financial crisis and the resulting reduced lending capacity of several banks are another strong reason for the short term. In this respect, the analysis presented here should be interpreted as a rather optimistic case, especially for first generation production.

Because we use market price data for first generation feedstock and cost-data for second generation feedstock we might be underestimating the production costs of second generation biofuels. In turns, their casflow might be overestimated and the WACC underestimated. As mentioned before, this is probably less of an issue for the first quantities of advanced biofuels coming onto the market, but it is a bias that could increase proportionally with competition for second generation feedstock.

The modelling of biofuels is based on optimisation to a least-cost fuel mix meeting a given demand for biofuels. This leads to quite radical choices between biofuel chains, also when the cost differences between the chains are relatively minor (this is why none of the graphs shows any bioethanol, for instance). In reality there will always be niche situations, in which costs differ from the average, and investors will have imperfect information, so biofuels with slightly higher production costs may be introduced anyway (Refuel, 2008).

And finally, we do not take into consideration the effects of corporate finance investment on second generation technological learning – because of this our input data on costs of advanced biofuel production chains might be on the conservative side.

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12. Annex 1: Cash flow model technical parameters and calculation steps

Technical parameters

Production capacity (Q)
The production capacity is the maximum biofuel output possibly produced by the biofuel installation and is expressed in tons of biofuel per year (tons/y).

Operational time
The operational time of the biofuel installation is assumed to be constant over the year and allow for an even monthly distribution of the total yearly biofuel production capacity. The total operational time is assumed to be 8000 hours/year which equals to a 91% availability.

Technical lifetime
The economic life of the biofuel installation is the number of years the installation can operate with just regular maintenance and is the same as assumed in Biotrans (20 years).

Energy content and conversion efficiency
Both these parameters conform to those in the Biotrans model and can be found in Deurwaarder et al. (2007).

Cost and revenue parameters

Production costs are the costs incurred in all steps of the project leading to the production and distribution of the product (biofuel in this case). The main cost categories are:

Capital costs (C_c)
The capital costs equal to the investment required to build the biofuel production plant or in other words the investment into fixed assets. They include the development cost of the production facility site (building, road etc) and the technology costs: the installation that is used for the conversion processes, the storage facilities for the feedstock and biofuels until they are transported to the blending point (or point of distribution).

There is a considerable difference in the technology investment costs between first and second generation biofuels – the latter being significantly higher.

Operation and maintenance costs ($O\&M_c$)
Three types of operation and maintenance costs can be defined: variable costs ($O\&M_{c-v}$) that depend on the production (€/ton), annual fixed costs ($O\&M_{c-f}$ in €/yr) and miscellaneous costs (€/ton). As far as costs for insurances or warranties are concerned, they are assumed to be paid for in the purchase price of the equipment, so their costs can be included in the capital costs. Typical O&M costs are costs for scheduled and unscheduled technical maintenance (often based on maintenance contracts), insurance, land rent, taxes (excluding corporate tax) and management costs.

Both capital and all O&M costs included in the cash flow model refer to the cost estimates gathered for the Refuel project and can be found in Deurwaarder et al. (2007).

Feedstock costs (F_c)
Feedstock costs are the costs incurred to secure the biomass that is converted to biofuel and includes the market price paid for crops and their transport to the biofuel plant or the price and collection costs associated with the residues that would be used to produce the biofuel.

Most crops used in the production of first generation biofuels are traded on the global agro-commodities markets, and their prices are easily accessible and published by a number of organizations tracking development on the global agricultural markets. The market price projections for starch crops and vegetable oils used in the cash flow model are derived from the OECD-FAO Agricultural Outlook 2009-2018 dataset (2009) for the period until 2018 and assumed constant thereafter. The original prices for the agricultural crops were world purchase prices originally published as real prices in 2007 USD, which we converted to EUR based on an average exchange rate as published by the European Central Bank (2010) for the years 2008, 2009 and 2010 (until February) and assumed constant thereafter. Finally, we deflated both feedstock and biofuel prices to 2005 levels (the price level used in Biotrans) with IMF’s world inflation figures from the World Economic Outlook (October 2008).

Second generation feedstocks require a completely different approach. Unfortunately, there is little or no published evidence on trade transactions with lignocellulosic crops or residues. What trade is there in these commodities is usually bilaterally agreed upon and prices are rarely disclosed, making their systematic tracing virtually impossible. Hence, for the case of second-generation feedstocks we relied upon their cost estimates as published by the Refuel project (Deurwaarder et al., 2007).

This discrepancy in the type of feedstock cost data calls for caution in interpreting the WACCs resulting from the cash flow model. The fact that we use ***market prices*** for first generation processes and ***cost estimates*** for second generation means that the latter’s production costs might be underestimated, which will increasingly be the case for future predictions when a larger demand for second generation feedstock might increase their price. If all else remains equal, the resulting WACC for second generation might thus be an underestimation.

Revenues
A biofuel project can have several revenue streams:

- biofuel sales
- by-product sales
- government incentives

The prices used for the calculation of revenues from biofuel sales were also taken from the OECD-FAO Agricultural Outlook 2009-2018 dataset (2009), which similarly as the feedstock prices were assumed constant after 2018. As those prices were published in EUR, no currency conversion was necessary, only deflation from constant 2007 to 2005 price levels was again performed by using IMF’s world inflation figures from the World Economic Outlook (October 2008).

We take account of different by-products into the cash flow model. For first generation production chains we include animal feed products such as rape meal and dry distillers grain. Unfortunately, we could not find price forecasts for those by-products, therefore we used F.O.

Lichts' World Ethanol and biofuels reports between Sept 2008 and May 2009 to derive average rape meal and DDG prices for 2008 and 2009 and assumed them constant thereafter.

For second generation production chains the co-production of electricity and heat are accounted for. The prices of electricity are the same as used in Biotrans, see Deurwaarder et al. (2007). The prices for heat included in the model are based on expert judgments[13].

Although mentioned here, government incentives of different forms are less of a direct income stream and rather a way to lower production costs; as discussed in section 6 under policy scenarios.

Finance parameters

Weighted Average Cost of Capital
As discussed in section 2, the financing sources for a biofuel installation (referred henceforth as a biofuel "project") broadly fall into two categories: equity and debt. Although other forms of capital exist and could be employed to finance a biofuel project as well (e.g. mezzanine), the cash flow model focuses on these two.

The return on debt (or the bank interest rate) (i), the return on equity (RoE), the debt/equity ratio (d/e), together determine the weighted average costs of capital (WACC), which is calculated as: $WACC = e * RoE + d * i * (1\text{-corporate tax})$ and $e + d = 1$.

An important feature of this particular cash flow model is that it explicitly takes into account the debt service coverage ratio (DSCR). The DSCR determines the amount of debt a project can obtain given its projected cash flow, thus directly dictating the debt equity ratio, which is a key variable in determining the weighted average costs of capital (WACC).

All the values of the financial parameters used in the cash flow model are based on expert input obtained through the questionnaire.

Taxes, write-offs and time periods
The cash flow model should take all applicable taxes into account, whether on federal, national, state or local level. All taxes, write-offs and interest payments are deducted from the fiscal profit. There is no tax on negative profit. An average corporate tax rate of 25.5% is assumed for all biofuel projects.

The write-off period ($Ta=Tp$) is typically 20 years.
The cash flow model distinguishes the following periods (typical values):
- Technical life of the project: $Tb=20$ yr
- Policy period: *Tp* varies for different measures, see section 4.5 for individual measures
- Duration of bank loan: $Tr=20$[14] yr
- Depreciation period: $Td=20$ yr

[13] Price for surplus low-temp heat will depend on what fuel is substituted. This study considered 8.42 €/GJ.
[14] At the time this study has been conducted, the loan periods granted by banks were generally much shorter than 20 years due to the financial crisis. However, because the time horizon of the models is 20 years, we are looking at the average longer term loan term, which are likely to go back to the longer, pre-crisis period.

Cash flow calculations

The biofuel cash-flow model differs from the conventional cash-flow models. The latter normally compute the project return, whereas the biofuel cash flow goes a step further and uses project returns projections to determine its cost of capital.

This is achieved through the following calculation steps:

1. Define the ***initial investment*** or the amount that needs to be financed (in our case these are capital costs as defined in the Biotrans model (Deurwaarder et al., 2007).

2. Calculate the ***gross revenue (GR)***:

   The gross revenue is calculated as:

   $GR(t) = (S(t) + p_b(t)+\sum B_p(t)\bullet\eta_p - F_c(t)\text{-}O\&M_{c\text{-}v}(t)) \bullet Q(t) - O\&M_{c\text{-}f}(t)$

   t year of project operation, $0 \leq t \leq T$

   $GR(t)$ gross income at year t *in* €
   $S(t)$ subsidy per ton of biofuel produced in €/ton , if applicable, otherwise 0
   $pb(t)$ biofuel price in year t *in* €/ton
   $B_p(t)$ value of by product p in €/ton biofuel
   η_p conversion factor from ton biofuel to ton byproduct p
   $Fc(t)$ feedstock cost in year t *in* €/ton
   $O\&M_{c\text{-}v}(t)$ the variable fraction of O&M costs in year t *in* €/ton
   $Q(t)$ production capacity in tons/year
   $O\&M_{c\text{-}f}(t)$ the fixed fraction of O&M costs in year t *in €/ton*

3. Calculate the project's ***GR's net present value*** (NPV_{GR}) by using the pre-determined return on debt (i) as the discount rate.

4. Define the DSCR (based on expert input).

5. If the NPV_{GR} is bigger than 0, then divide it with the DSCR to obtain the maximum amount of debt the project can obtain. The gap to the total initial investment amount that needs to be financed should be covered by equity. We now have the ***debt/equity ratio*** of the project.

   Reality check: for first generation biofuels, the debt financing should range between 50 and 80%. If the project cannot obtain 50% debt, it will also not be attractive enough for equity providers and will not go ahead. On the other hand, due to optimization of finance, it cannot have more than 80% debt, even if the cash flow allows it. The model gives a warning when the calculated debt share is not between the required bounds.

   For second generation projects, the debt share should be allowed to increase from 0% (in the initial study period) to 50-80% after full commercialization.

6. Subtract amortization and interest amount from the gross revenue to obtain the taxable revenue and from that subtract the (corporate) tax to arrive at the ***net revenue after tax.***

7. Using the calculated equity amount from step 5 and the net revenue after tax the ***return on equity RoE*** can easily be calculated. This “calculated” RoE will be contrasted to a predetermined RoE value (X) based on expert consultations. If:
    - the calculated RoE is lower than X, then the project does not go ahead;
    - the calculated RoE is equal to X, then the project does go ahead;
    - the calculated RoE is bigger than X, then the model changes one of the key parameters (either lowers the biofuel price or increases the feedstock price) until the calculated RoE is exactly equal to X.

13. Annex 2: Overview of all policy cases

Table A2.1: Overview of all policy cases tested in Elobio WP7:

	Pre-commercial phase	Commercial phase
1	***Investment subsidy***	
a	Investment subsidy 70% for the year of introduction + 2 years thereafter	Continuous investment subsidy of 30%
b	Investment subsidy 70% for the year of introduction + 2 years after	Gradual subsidy phase out: 30% first 4 years after full commercialization, 15% subsequent 4 years, 0% thereafter
2	***Tax break (+investment subsidy)***	
a	Full taxation of 1st gen (836.5 €/t for bioethanol & 534.1 €/t for biodiesel) + 50% investment subsidy until year of introduction + 2 years after	Full taxation of 1st gen and full tax exemption for 2nd gen,
b	Full taxation of 1st gen (836.5 €/t for bioethanol & 534.1 €/t for biodiesel) + 50% investment subsidy until year of introduction + 2 years after	Full taxation of 1st gen and partial taxation of 2nd gen (418 €/t for 2nd gen bioethanol and 267 €/t for FT diesel)
c	Full taxation of all biofuel (836.5 €/t for bioethanol & 534.1 €/t for biodiesel) + 70% investment subsidy until year of introduction + 2 years after	Full taxation of 1st gen and partial taxation of 2nd gen (418 €/t for 2nd gen bioethanol and 267 €/t for FT diesel)
3	***Soft loan (+investment subsidy)***	
a	Investment subsidy 70% for the year of introduction + 2 years after	Soft loan 1%
b	Investment subsidy 70% for the year of introduction + 2 years after	Investment subsidy of 10% + soft loan of 1%
4	***Double counting (+investment subsidy)***	
a	Investment subsidy 70% for the year of introduction + 2 years after + double counting	Double counting
b	Investment subsidy 70% for the year of introduction + 2 years after + double counting	Double counting discontinued after 2020

Runs results

Case 2a: A continuous full tax exemption of second generation does increase their market share to 45% by 2020 and over 90% by 2030, as seen in figure 7a. However, the tax revenue losses for this case amount to a cumulative figure of 77.5 billion €, adding the total investment subsidy of 2.5 billion € makes such a scenario unrealistically costly.

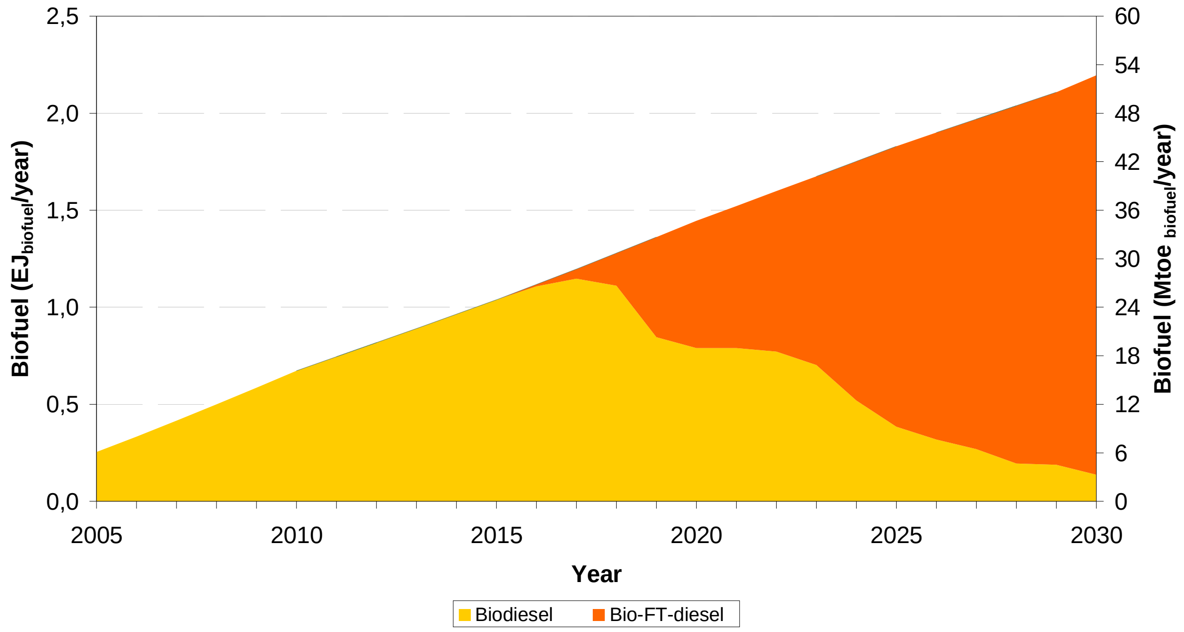

Figure A.2a: Case 2a - biofuel mix for the case of continuous full taxation of first and no taxation of second generation biofuels and a 50% investment subsidy to second generation in until market introduction and 2 years thereafter (WACCs same as in case 1a)

Case 2b: Second generation biofuels are granted a full tax exemption in the pre-commercial phase and only a 50% tax reduction in the commercial phase (meaning that cellulosic ethanol would be taxed at 418.25 €/t and FT diesel at 267 €/t). Under such a scenario, the biofuel mix on the market would be as shown in figure A2.b below.

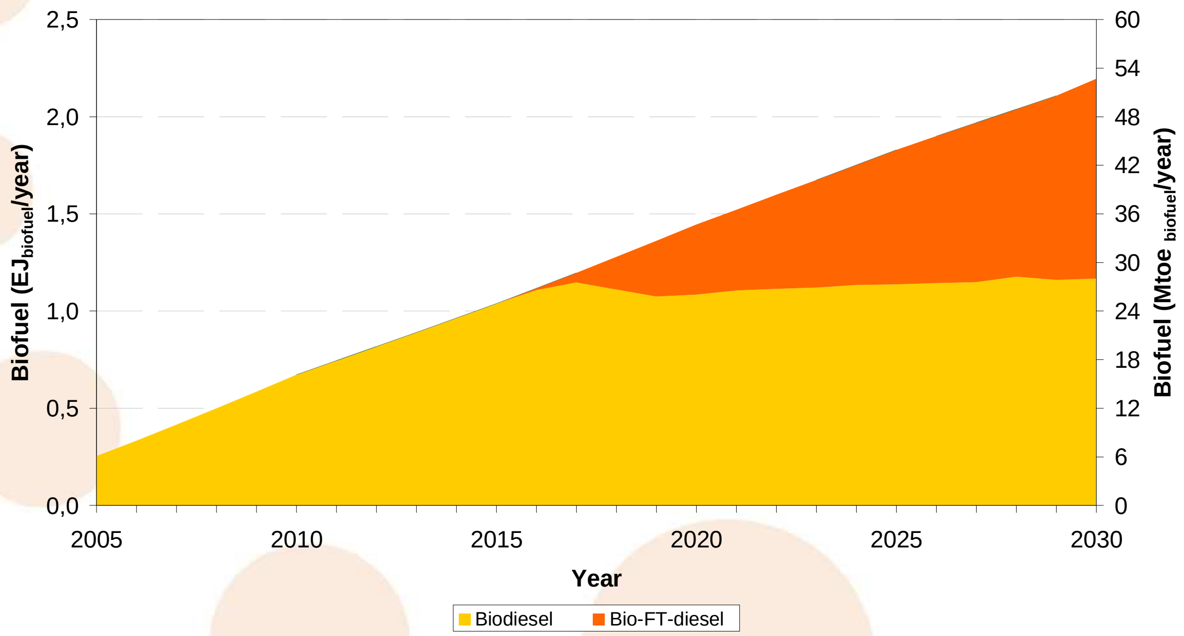

Figure A.2b: Case 2b - biofuel mix for the case of continuous full taxation of first and partial (50%) taxation of second generation biofuels and a 50% investment subsidy to second generation in until market introduction and 2 years thereafter (WACCs same as in case 1a)

Under this scenario, second generation still increases its market share to 25% by 2020 and over 47% by 2030, also at the still high cost of almost 20.5 billion € in tax revenue loss and investments subsidy costs of 2.5 billion €. Compared to the first case analyzing the impact of investment subsidues (70% in the pre-commercial and 30% during the commercial phase), which also achieved a second generation market share of over 40%, the policy cost of a partial tax break is much higher (by almost 10 billion €).

Case 3b:

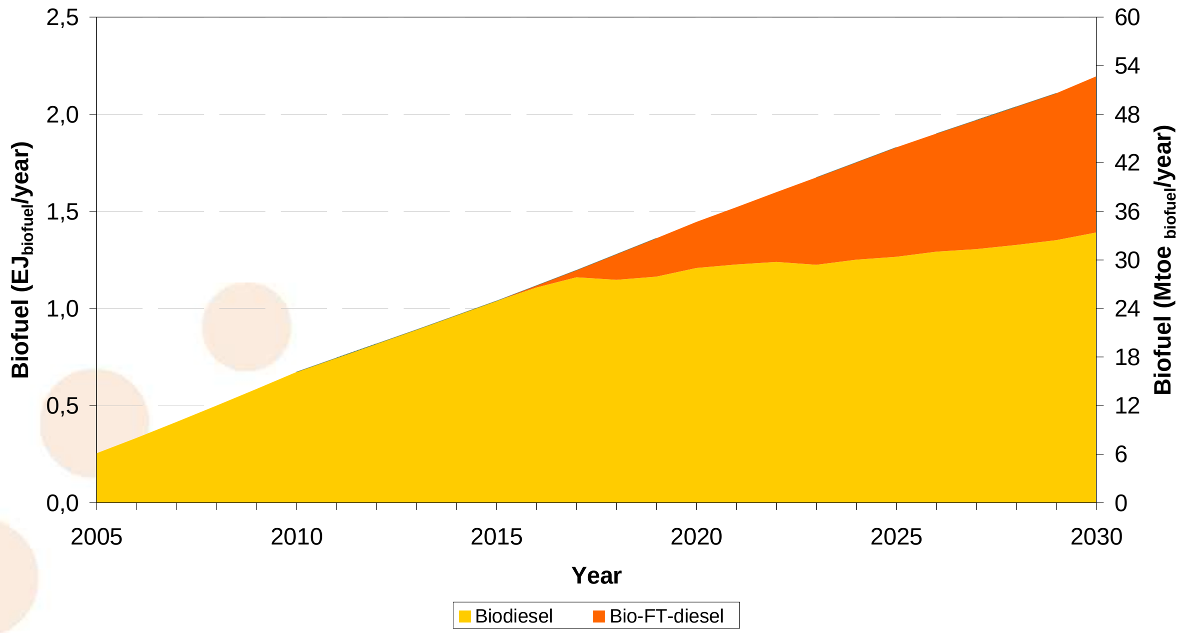

Figure A.2c: Case 3b - biofuel mix for the case of a 70% investment subsidy in the pre-commercial phase, continuous 10% investment subsidy and soft loan of 1% for second generation biofuels thereafter

Biofuel policies for dynamic markets

Contact Elobio

Energy research Centre of the Netherlands (ECN)
P.O. Box 1
1755 ZG Petten
The Netherlands
info@elobio.eu
http://www.elobio.eu

Intelligent Energy Europe

elobio
Biofuel policies for dynamic markets