

## EYES ON THE TRACK, MIND ON THE HORIZON: THE REFUEL EU ROAD MAP FOR BIOFUELS

Marc Londo<sup>1\*</sup>, Sander Lensink<sup>1</sup>, André Wakker<sup>1</sup>, Günther Fischer<sup>2</sup>, Sylvia Prieler<sup>2</sup>, Harrij van Velthuis<sup>2</sup>, Marc de Wit<sup>3</sup>, André Faaij<sup>3</sup>, Martin Junginger<sup>3</sup>, Göran Berndes<sup>4</sup>, Julia Hansson<sup>4</sup>, Andrea Egeskog<sup>4</sup>, Henrik Duer<sup>5</sup>, Jeppe Lundbaek<sup>5</sup>, Grzegorz Wisniewski<sup>6</sup>, Adam Kupczyk<sup>6</sup>, Kurt Könighofer<sup>7</sup>

<sup>1</sup>: ECN Energy Research Centre of the Netherlands, PO Box 56890, NL-1040 AW Amsterdam, the Netherlands

<sup>2</sup>: IIASA, Austria

<sup>3</sup>: Copernicus Institute, Utrecht University, the Netherlands

<sup>4</sup>: Chalmers University of Technology, Sweden

<sup>5</sup>: COWI, Denmark

<sup>6</sup>: IEO EC BREC, Poland

<sup>7</sup>: Joanneum Research, Austria

**ABSTRACT:** The current hot debate on biofuels calls for a balanced and realistic long-term strategy for biofuels. The REFUEL project provides several ingredients for such a strategy. Analyses in this project indicate that domestically produced biofuels can cover a significant share of EU fuel demand in the coming decades, with the EU-12 new member states and Ukraine as most promising regions. This potential can be realised with residual streams and on existing agricultural land, without conversion of e.g. nature reserves. Second-generation biofuels are essential for the long-term success of biofuels due to their superior performance in many ways. But generally, the key challenge for the near future would be how to enhance the development of biofuels in a responsible way, i.e. stimulating the production chains with the best performance, and preventing negative impacts e.g., by paying careful attention to possible system impacts of biofuel production such as indirect land use changes and rising food prices. Finally, 2<sup>nd</sup> generation biofuels require specific policy: the precursor role of 1<sup>st</sup> generation is overrated, both in technical terms as well as in their role as market precursors. When it comes to synergies, 2<sup>nd</sup> generation biofuels might benefit more from other developments in the energy sector, such as initiatives in co-firing of biomass for (heat and) power, than from 1<sup>st</sup> generation biofuels, also because of the public resistance that the latter induce.

**Keywords:** biofuels, resource potentials, strategy

### 1 INTRODUCTION

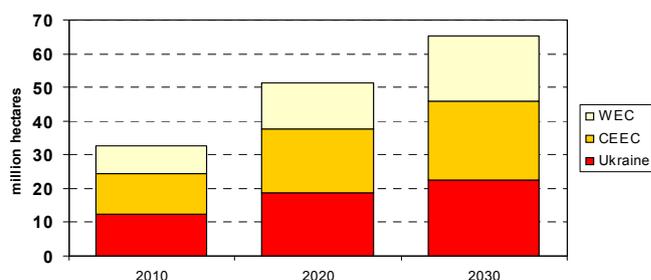
Biofuels production and consumption in the European Union are growing rapidly at the moment. With this tempestuous short-term development comes the need for an integrated long-term vision for biofuels. The REFUEL project contributes to this vision formation. In this project, funded by the Intelligent Energy Europe programme, seven EU institutes of different backgrounds have analysed the prospects for biofuels in terms of resource potential, costs and impacts of different biofuels, effects of different policy strategies, and broader system impacts of biofuels [1-6]. For this road map document, we applied our key tools and findings to the policy challenges of today. In this paper, we focus on three important elements in biofuels development:

- Potential availability of land and feedstock for biofuels; indicating that there is a vast potential in Europe, even sufficient to meet a 10% biofuels target by conventional 1<sup>st</sup> generation biofuels;
- The drawbacks of such a future, and the importance of 2<sup>nd</sup> generation biofuels in the light of the underlying drivers for biofuels;
- Policy strategies for the enhancement of 2<sup>nd</sup> generation biofuels

### 2 THE EU 2020 OBJECTIVE AND BIOFUEL POTENTIALS

The EU is in the process of setting out an ambitious development of biofuels until 2020. Key question is to what extent Europe can meet the proposed objective by

domestic production, and what would be the dominant biofuels. Within REFUEL, an extensive assessment of feedstock potentials in the EU27 and Ukraine showed that gradual yield increases in the coming decades can free up vast amounts of land for energy crop production against very low costs, particularly in the EU-12 new member states and in Ukraine [1, 4].



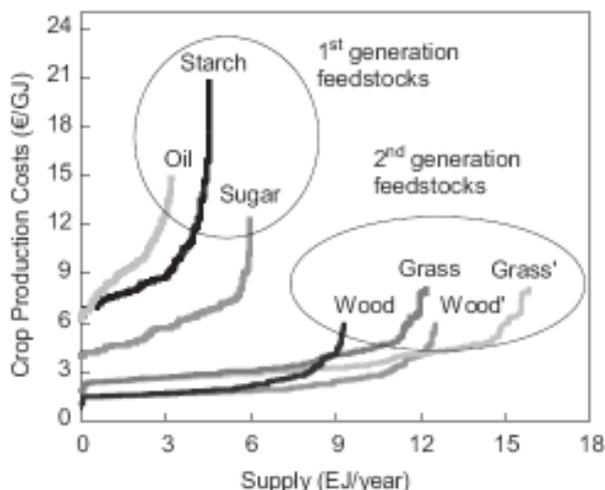
**Figure 1:** Agricultural land area potential for bio-energy feedstock production in Mha [4]. WEC: Western EU-15; CEEC: Eastern EU-12.

The resulting feedstock cost-supply curves (see

Figure 2) were applied in a full-chain cost optimisation model assessing the development of the least-cost biofuels mix over time [3]. Given the current shaping of the EU biofuels policy proposals, analyses in REFUEL indicate that a mix of conventional (1<sup>st</sup> generation) biofuels is probably the most cost-effective way to meet these ambitions. This provided that biomass for the stationary sector remains confined to existing woody resources, and ex-European imports make up 30% of total supply. Meeting the target would not need to

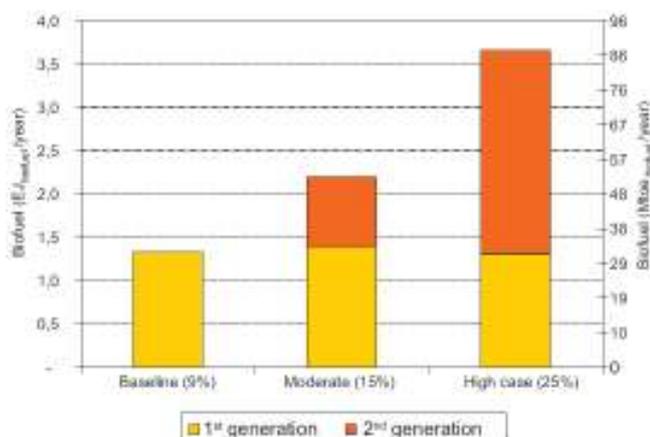
\*: Contacting author. t: 0031 224 568253; f: 0031 224 568339; e: [londo@ecn.nl](mailto:londo@ecn.nl); w: [www.refuel.eu](http://www.refuel.eu)

compromise EU food & feed production, and it would not require any conversion of EU nature reserves into agricultural land.



**Figure 2:** Biofuel feedstock cost-supply curves by 2030. Wood and Grass include use of pasture land not needed for animal husbandry [1].

Feedstock potentials seem sufficient to meet the proposed EU target of 10% in 2020 with conventional biofuels. However, when we reconsider the policy drivers for biofuels, it remains questionable whether a development solely based on 1<sup>st</sup> generation biofuels is the best answer to the underlying motivation for biofuels: such a mix leads to only modest reductions of greenhouse gases, creates minor opportunities for a competitive and innovative new industry, and requires extensive tracts of land. The latter issue becomes especially important if we need to go to higher biofuels shares by 2020 or later, or if biomass demand from other sectors increases substantially as well. This limitation is clearly shown when we evaluate higher targets (Figure 3): up to a certain level, 1<sup>st</sup> generation biofuels are most cost-effective, but at higher levels feedstock costs increase to levels at which 2<sup>nd</sup> generation biofuels take over the additional demand.



**Figure 3:** Split between 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels by 2030 at different levels of total production if the target is met by European biofuels only [3].

### 3 PERSPECTIVES ON BIOFUELS POLICY

A biofuels target share alone does not seem to induce the development of biofuels that best respond to the drivers for biofuels policy. Therefore, we defined and analysed several ‘policy packages’ that are built up on a specific policy perspective for biofuels, e.g. climate mitigation or energy security (see Table I). We analysed the impact of these packages on the development of the biofuels mix, the balance between 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels, and resulting GHG emissions, costs and socio-economic impacts with the tools developed in REFUEL ([7]).

**Table I:** Translation of different perspectives on biofuels into policy packages. For details see [7].

	Policy making priority		
<i>Policy measures:</i>	GHG	SES	Innov.
Biofuels target pathway	Mod.	High	High
Ambition levels RES-E/H	High	Mod.	Mod.
Assumed levels of import	High	None	None
CO <sub>2</sub> pricing	Yes	No	Yes
Energy crop premium	No	Yes	No
Investment subsidies	Diff	Yes	Yes
Specific targets 2 <sup>nd</sup> gen.	No	No	Yes

An evaluation of biofuels development subject to these policy packages shows substantially different results compared to the developments when only the 10% target is applied.

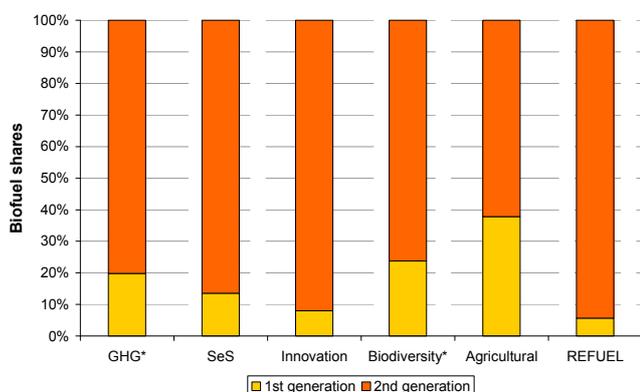
- First, there is an earlier introduction of 2<sup>nd</sup> generation biofuels in all perspectives. The introduction year varies between 2010 and 2015, which is ambitious but possible given the developments in the related technologies.
- By 2030, 2<sup>nd</sup> generation biofuels dominate in all perspectives (see Figure 4). The dominance is clearest in perspectives with high ambitions for biofuels, but also packages based on a strong environmental perspective induce a major development of 2<sup>nd</sup> generation biofuels.

In terms of feedstock use, 2<sup>nd</sup> generation biofuels first start applying residues, and only after this low-cost feedstock has run out of potential, dedicated crops are being introduced. By 2030, residues still make up roughly one-third of feedstock supply for 2<sup>nd</sup> generation biofuels (see Figure 5).

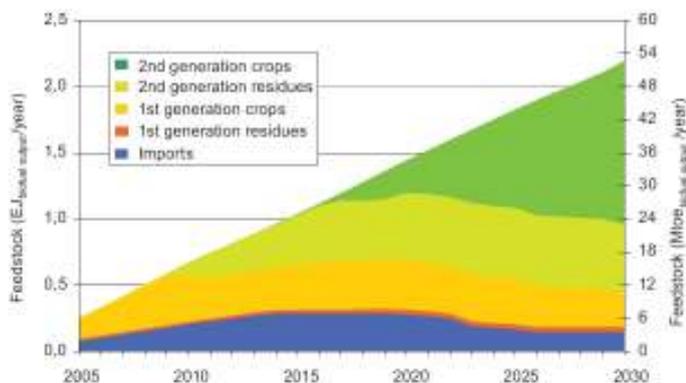
- Obviously, these perspectives show substantially better greenhouse gas emission reductions than the ‘base’ policy with a 10% target alone. For example, while a biofuels mix dominated by 1<sup>st</sup> generation biofuels reduces greenhouse gas emissions by roughly 40% compared to fossils, the innovation perspective increases this reduction to more than 90%.
- In terms of land efficiency, the strong role of 2<sup>nd</sup> generation biofuels leads to significantly higher average biofuel yields per ha than in the ‘base’

policy.

- In terms of costs, policy packages inducing higher shares of 2<sup>nd</sup> generation biofuels also lead to higher average costs per GJ biofuel. However, this cost increase lies in the order of 1 €/GJ (or several cents per litre), given the approach and limitations of this study.
- An early start with advanced biofuels leads to biofuels that better meet the drivers behind biofuels promotion than the conventional mix, and an early start also leads to an earlier cost reduction.
- There are several ways to increase the share of advanced biofuels, given these perspectives. Specific policy for 2<sup>nd</sup> generation may be the easiest, but other options are also possible.



**Figure 4:** The 2030 balance between 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels in the different perspectives, indicating the effect of the different policy packages. For complete packages listing see [7].



**Figure 5:** Development in net feedstock use in the GHG perspective policy package [7].

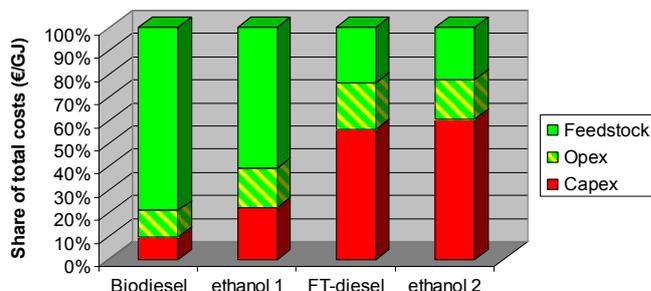
#### 4 STRATEGIES FOR 2<sup>ND</sup> GENERATION BIOFUELS

As shown, 2<sup>nd</sup> generation biofuels can be considered crucial for a responsible development of biofuels that significantly contribute to climate change mitigation and energy security. Their development however, requires actions from different stakeholders, varying over time and a manifold of measures can be conceived to support this process. Key REFUEL findings provide several contributions to this process, as summarised in this section.

#### 4.1 Current policies hardly pave the way for 2<sup>nd</sup> generation biofuels

In defence of current biofuels policies, it is often argued that 1<sup>st</sup> generation biofuels are essential for the development of their 2<sup>nd</sup> generation successors. We feel that this role is often overrated. In technical terms, the argument does apply to a certain extent to ethanol production, as a 2<sup>nd</sup> generation ethanol plant partly uses the same process steps (fermentation, distillation, etc.). Biodiesel production technology, however, is in no way relevant for the 2<sup>nd</sup> generation diesel substitutes such as FT-diesel.

Furthermore, the cost build-ups and related risk profiles of 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels differ greatly (see Figure 6): due to their high investment costs, 2<sup>nd</sup> generation biofuels require a more stable investment climate and related biofuel prices. As a consequence, current biofuels policy mechanisms that are effective in creating a market for 1<sup>st</sup> generation biofuels may not create a sufficiently stable environment for investments in 2<sup>nd</sup> generation options.



**Figure 6:** Cost build-up of key biofuel options.

Also in other issues, current policies may not prepare for the long-term perspective for biofuels. The current focus on low biofuel blends does not spur the introduction of higher blends needed in the long term, and the conventional feedstock may even create vested interests that may act as barriers to the required introduction of new cultivation of perennial crops. Finally, the public resistance that 1<sup>st</sup> generation biofuels induce (be it rightful or not) may also spill over to 2<sup>nd</sup> generation options.

#### 4.2 Development of lignocellulosic feedstock supply

The introduction of 2<sup>nd</sup> generation biofuels will require the establishment of new feedstock supply chains of lignocellulosic materials. This will require technical, institutional and even legal changes, which probably require supportive policy to be established in a consistent way. Key points of attention are

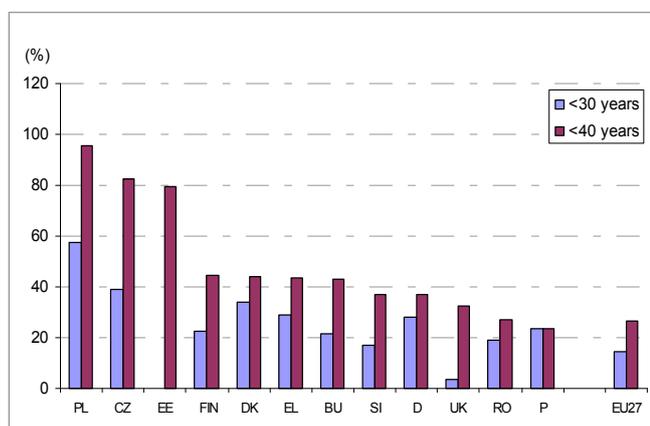
- The support for research on cultivation practices of perennial crops. As European experience with the production of lignocellulosic feedstocks is limited, additional research is required for optimizing management of lignocellulosic energy crops for the across Europe.
- Large scale production of lignocellulosic feedstocks implies a major land use conversion to crops with plantation cycles of 10 to 20 years. Such a development needs careful considerations beyond agronomic and economic factors. In particular, potential uses of some arable land for perennial

energy crops would have to be reflected in regulations and spatial policies both at the national level and in the Common Agricultural Policy (CAP).

- Furthermore, cross-sector policy harmonisation would be required to enhance these new supply chains, as well as the development of lignocellulosic markets able to absorb large-scale supply chains.

#### 4.3 Stepping stones for the introduction of 2<sup>nd</sup> generation technologies

In order to reduce the initial risks for 2<sup>nd</sup> generation production installations, stepping stones may be created by finding synergies with other parts of the energy sector. For example, initial establishment of biomass co-firing in existing coal-fired power plants would prepare stable feedstock supply that can later be used for 2<sup>nd</sup> generation biofuel production. The potential for biomass co-firing in existing power plants is sufficient to provide a significant start-up for these supplies (Figure 7). Also integration of gasification-based biofuels plants in district heating systems may lead to benefits (output diversification).



**Figure 7:** Current biomass co-firing potential in coal-fired power plants as a share of the amount of biomass needed to meet the 10% biofuels target in 2020. Top-12 EU member states and EU27 average, when power plants <30 years and <40 years old are assumed used for co-firing.

## 5 CONCLUSIONS

### *Domestically produced biofuels can cover a significant share of EU fuel demand*

Given the extensive resource potentials that gradually open up in the coming decades, particularly in the EU-12 new member states and Ukraine, Europe will be able to produce biofuels sufficient than 10% of EU gasoline and diesel demand by 2020 and beyond. This potential can be realised on existing agricultural land, without conversion of e.g. nature reserves.

### *Second-generation biofuels are essential, and biofuels development requires careful policy making*

In terms of biofuel chains, the development of 2<sup>nd</sup> generation biofuels seems to be essential for a long-term future of biofuels. Their environmental performance is superior to that of 1<sup>st</sup> generation biofuels, in terms of greenhouse gas emissions of the production chain, broadness of the feedstock base and biofuel yields per ha.

But generally, the key challenge for the near future would be how to enhance the development of biofuels in a responsible way, i.e. stimulating the production chains with the best performance, and preventing negative impacts e.g., by paying careful attention to possible system impacts of biofuel production such as indirect land use changes and rising food prices.

### *Second-generation biofuels require specific policy; the precursor role of 1<sup>st</sup> generation is overestimated*

In defence of current biofuels policies, it is often argued that 1<sup>st</sup> generation biofuels are essential for the development of their 2<sup>nd</sup> generation successors. We feel that this role is often overrated. In technical terms, the argument does apply to a certain extent to ethanol production, but biodiesel is in no way relevant for the 2<sup>nd</sup> generation diesel substitutes such as FT-diesel. Especially the risk profiles of 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels differ greatly: due to their high investment costs, 2<sup>nd</sup> generation biofuels require a more stable investment climate and related biofuel prices. Furthermore, current focus on low biofuel blends does not spur the introduction of higher blends needed in the long term, and the conventional feedstock may even create vested interests that may act as barriers to the required introduction of new cultivation of perennial crops. When it comes to synergies, 2<sup>nd</sup> generation biofuels might benefit more from current initiatives in co-firing of biomass for (heat and) power than from 1<sup>st</sup> generation biofuels, also because the public resistance that the latter induce may also spill over to 2<sup>nd</sup> generation options.

## 6 REFERENCES

1. M.P. de Wit, A.P.C. Faaij, G. Fischer, S. Prieler, and H. van Velthuisen (2007): *Biomass Resources Potential and Related Costs; The Cost-Supply Potential of Biomass Resources in the EU-27, Switzerland, Norway and Ukraine*. Utrecht: Copernicus Institute, Utrecht University.
2. G. Wisniewski, A. Kupczyk, and D. Rucinski (2008): *Policy measures for effective and efficient support of biofuels in EU 27. REFUEL, Work Package 7: Policy strategy, deliverable D17*. Warsaw: IEO EC-BREC.
3. H.M. Londo, S.M. Lensink, E.P. Deurwaarder, A. Wakker, M.P. de Wit, H.M. Junginger, K. Könighofer, and G. Jungmeier (2008): *Biofuels cost developments in the EU27+ until 2030; Full-chain cost assessment and implications of policy options. REFUEL WP4 final report*. Petten: ECN.
4. G. Fischer, E. Hizsnyik, S. Prieler, and H. van Velthuisen (2007): *Assessment of biomass potentials for biofuel feedstock production in Europe: Methodology and results. REFUEL deliverable D6*. Laxenburg: IIASA.
5. H. Duer, J. Lundbaek, and P.O. Christensen (2008): *REFUEL: Socio-economic and barrier assessment. WP 6 Final report*. Copenhagen: COWI.
6. G. Berndes, J. Hansson, A. Egeskog, and S. Werner (2007): *Bioenergy expansion strategies for Europe; Cost effective biomass allocation and biofuel stepping stones. REFUEL WP5 final report*. Göteborg: Chalmers University of Technology.

7. REFUEL-team (2008): *Eyes on the track, mind on the horizon; From inconvenient rapeseed to clean wood: A European road map for biofuels*. Petten: ECN.