RoadToBio
Roadmap for the chemical industry towards a bioeconomy

Duration time: 24 Month; May 2017 – April 2019
Budget: 996.000 €

Consortium:

Bio-based sweet spots for the chemical industry – A conclusion and discussion after the second stakeholder workshop
11 July 2018
Lea König (DECHEMA), Mladen Crnomarkovic (E4tech)
Agenda of the webinar

• Welcome and Introduction of the project
  – Introduction of the business cases
  – Conclusion of the workshop

• Workshop results: Focus on polymer-based dedicated chemicals
  – Lactic acid
  – PHA
  – PEF
  – Barriers to increase the bio-based share of chemical products in the EU
  – Outlook: Implementation of the results in the Roadmap

• Q & A session
RoadToBio: The road into a bio-based future

Components of the roadmap
- Analysis
  - Hurdles
  - Opportunities
  - Enablers
- Roadmap
- Strategy
- Action plan
- Engagement guide
- Action plan

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- Analysis
  - Hurdles
  - Opportunities
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Stakeholder participation in creating the roadmap:
- Chemical Industry
- NGOs
- Administrative Bodies
- Governments

Key challenge
How can the European chemical industry remain competitive and at the same time become more sustainable?

2016
- 88% Fossil-based Chemicals
- 12% Bio-based Chemicals

2030
- 25% Bio-based Chemicals
Business case of RoadToBio

Aim

- Attractive opportunity for the chemical industry to enlarge the bio-based portfolio
- From 9 business cases key learnings about actions needed to overcome barriers and realise business cases

What do the business cases show?

- Addressed societal needs
- Product markets
- Actors and their potential benefits as well as for the society
- Technical and commercial barriers
- Conditions of the value chains to provide viable business cases

How do they fit into the roadmap?

Combine the various studies and use specific examples to show
- How the bio-based share of the production portfolio can be increased
- Advantages exist for the respective producer
Roadmap content and learnings

From 9 business cases key learnings about actions needed to overcome barriers and realise business cases

- **Key actors**: Identified key actors involved in achieving 25% by 2030 goal.
- **Barriers**: Summarised key barriers specific to industry sector or business case. Characterisation of barriers in terms of time horizon impact (e.g. immediate/mid/long-term), impact on different actors, opportunity to overcome them, etc.
- **Action plan**: List of actions, applicable to wider sector, which need to be taken in order to achieve the goal of 25% by 2030. Identified time-scale of each action and actor who will carry out these activities.
- **Benefits**: Benefits from the level of deployment assessed in terms of: market uptake/shares, GHG reduction, job creation
## Structure of the business cases

### Value chain summary
- Value chain description for bio-based chemical and its fossil counterpart
- Feedstock type
- Key derivatives and applications (sectors)
- Customers/consumers

### Supply
- EU industry structure & integration
- Key players (producers/developers)
- Competing technologies (bio-based and fossil) – key characteristics and development status
- Production costs (bio-based & fossil)

### Demand
- Market characteristics (volume, growth, prices)
- Market drivers & trends (economic, societal, policy, etc.)
- Sustainability requirements for downstream application (or per sector)

### Opportunities
- From commercial businesses stand point (EU’s industry and SMEs)
- Conditions under which value chains provide valuable business proposition (techno-economic assessment)

### Barriers
- Commercial (product prices)
- Technical (technology development, feedstock availability, product performance)
- Political
- Standard/labelling

### Success factors
- Investments requirements
- Regulatory framework
- Compatibility with existing value chains (up and downstream integration, feedstock availability)
- Skills, competences, infrastructure

### Benefits
- From the standpoint of EU as a whole
- Societal (job creation)
- Economic (export, growth)
- Environmental (GHG and waste reduction)
- Resource resilience (imports dependency, circular economy)
Methodology of business case selection

**Identification of the sweet spots**

Analysis of the bio-based opportunities for the chemical industry

Ranking for ‘market potential’ and ‘ease of implementation’

Creating and ranking long list

For each kind of chemical group → Sweet spots

**Priorities of the chemical industry for selection of business cases**

Workshop 02.07.17

Phone interviews

9 business cases

Workshop 19.06.18

**Criteria**

<table>
<thead>
<tr>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement in resource efficiency</td>
</tr>
<tr>
<td>Bio-based product has improved functionality</td>
</tr>
<tr>
<td>High margin can be obtained</td>
</tr>
<tr>
<td>Low risk for political or ethical disputes</td>
</tr>
<tr>
<td>Savings in GHG emissions</td>
</tr>
<tr>
<td>Availability of biomass in the EU</td>
</tr>
<tr>
<td>Decrease in use of toxic/harmful substances</td>
</tr>
<tr>
<td>Potential for green premium</td>
</tr>
<tr>
<td>EU has competitive advantages</td>
</tr>
</tbody>
</table>

**Analysis of the biobased opportunities for the chemical industry**

**Ranking for 'market potential' and 'ease of implementation'**

**Creating and ranking long list**

For each kind of chemical group → Sweet spots
### Bio-based chemical groups of RoadToBio

<table>
<thead>
<tr>
<th>Group</th>
<th>Drop-In chemicals</th>
<th>Smart Drop-In chemicals</th>
<th>Dedicated chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>• Chemically identical to fossil based chemicals</td>
<td>• Subgroup of drop-ins</td>
<td>• Dedicated production pathway</td>
</tr>
<tr>
<td></td>
<td>• High volume</td>
<td>• Bio-based pathway provide advantages</td>
<td>• No identical fossil-based chemical</td>
</tr>
<tr>
<td></td>
<td>• No additional production costs for chemical industry</td>
<td>• Provide advances in production pathway</td>
<td>• Additional properties</td>
</tr>
</tbody>
</table>

### Pathways to different kinds of bio-based chemicals

![Pathways diagram](image)

**Figure 1:** Schematic differentiation of pathways of drop-in, smart drop-in and dedicated bio-based chemicals.

Source: Carus et al. 2017 Bio-based drop-in, smart drop-in and dedicated chemicals, nova-Institut
## Business cases of RoadToBio

<table>
<thead>
<tr>
<th>Product group</th>
<th>Feedstock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sugar/Starch</td>
</tr>
<tr>
<td>Platform chemical</td>
<td>Lactic acid</td>
</tr>
<tr>
<td></td>
<td>1,4-Butanediol</td>
</tr>
<tr>
<td>Solvent</td>
<td></td>
</tr>
<tr>
<td>Adhesive</td>
<td></td>
</tr>
<tr>
<td>Agrochemical</td>
<td></td>
</tr>
<tr>
<td>Lubricant</td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td>PEF</td>
</tr>
<tr>
<td>Man-made fiber</td>
<td></td>
</tr>
<tr>
<td>Coatings</td>
<td></td>
</tr>
<tr>
<td>Surfactant</td>
<td></td>
</tr>
</tbody>
</table>

*Drop-in, Smart drop-in, Dedicated*
Stakeholder workshop of RoadToBio on 19.06.18 in Brussels

Aim of this workshop
• Introduce business cases to stakeholders
• Validate data
• Collect insights of stakeholder to set the Roadmap on the right path

Date
• 19 June in Brussels

Participants:
• 20 participants
  – Industry
  – Associations
  – Academics
  – NGOs

Thank you for your participation
Stakeholder workshop: Approach

Divide the chemicals in four groups

**Drop-In chemicals**
- Ethylene
- Methanol

**Smart Drop-In chemicals**
- 1,4-Butanediol
- Dodecanedioic Acid

**Dedicated chemicals**
- Furfural
- Glycerol

**Polymer-based dedicated chemicals**
- Lactic Acid
- PEF
- PHA

Fact sheets for introducing chemicals to stakeholders

Analysis of the weaknesses, strengths, opportunities and threats via SWOT analysis with the experts

Polymer-based dedicated chemicals
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Consortium:

Workshop results: Focus on polymer-based dedicated chemicals
11 July 2018
Mladen Crnomarkovic (E4tech), Lea König (DECHEMA)
### Key feedback received from the stakeholder workshop

<table>
<thead>
<tr>
<th>Necessary stakeholder input</th>
<th>Key feedback received from stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Approach to development of business cases</td>
<td>• Validation by chemicals industry stakeholder</td>
</tr>
<tr>
<td>• Data quality</td>
<td>• Review data given in case studies</td>
</tr>
<tr>
<td>• Data gap</td>
<td>• Provide missing data</td>
</tr>
<tr>
<td>• SWOT analysis</td>
<td>• Assessment of case studies</td>
</tr>
<tr>
<td>• Barriers</td>
<td>• Key barriers for EU bio-based industry</td>
</tr>
<tr>
<td>• Roadmap</td>
<td>• Provide views on the roadmap</td>
</tr>
</tbody>
</table>

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*Bio-based Industries Consortium*
High-level stakeholder feedback: **New materials with improved functionality represent the largest opportunity for EU bio-based industry**

- Dedicated chemicals and polymer-based dedicated chemicals get most of attention - offer new and improve functionality in end products

- Production of bulk chemicals is not cost competitive in Europe – feedstock cost and availability in other regions

- Some of the smart drop-ins have small EU production volumes or small downstream markets in the EU – this may be a weakness
Lactic Acid (PLA) Case study

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total: 120</td>
<td>Total: 1,200</td>
<td>Given for PLA – key derivative of lactic acid 2,600</td>
<td>15.5</td>
</tr>
<tr>
<td>Bio-based: 120</td>
<td>Bio-based: 1,200</td>
<td>2,600</td>
<td>Source: 2016, CNBC &amp; Grand View Research</td>
</tr>
</tbody>
</table>

Value chain: today all lactic acid is bio-based

Top suppliers (global)

- Corbion
- Natureworks
- Hebei Jindan
- Shenzhen...
- Chongqing Bofei
- Wuhan Sanjiang

Production costs (2017) €/tonne*

- Fossil Lactic acid
- Bio-based Lactic acid

Demand

- Europe: 48%
- Asia: 29%
- Americas: 29%
- China: 13%

*Estimated Year: 2016

Source: 2016, CNBC & Grand View Research
# Lactic acid: SWOT analysis

## Strengths
- Several market opportunities
- Nontoxic and biodegradable as a solvent
- Lower price than other biodegradable polymers

## Weaknesses
- Brittle polymer
- Additives/plasticizers for improved performance often not biodegradable or bio-based
- No higher volumes to applications other than plastics
- No established recycling stream

## Opportunities
- Chemical recycling
- Development of full recycling process

## Threats
- No advanced functionalities compared to other plastics

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Cheapest among biodegradable bio-based polymers ➔ to grow volumes new applications are needed and/or improved recycling characteristics
**PHA Case study**

**Market Volume EU:**
- Total: 7 (ktonne/yr)
- Bio-based: 7

**Market Volume Global:**
- Total: 110 (ktonne/yr)
- Bio-based: 110

**Price:**
- (€/tonne): 4,000 – 5,000

**Market growth rate:**
- (%)/yr: 4.9

**Value chain**

**Feedstock**
- Glucose
- Agricultural residues

**Production costs (2014)**
- €/tonne*

**Potential EU Demand**
- (per application)

**Top suppliers (global)**
- ADM: 46%
- Merck: 9%
- Tianjin B. Materials: 9%
- Tianjin G. Bioscience: 9%
- Shenzhen E.B.: 5%
- Kaizhao: 3%

**Key Products**
- PHA
- PHA blends
- PHA granulate

**Application**
- Biodegradable packaging, disposable products, health care applications
- Blown films, fibres, foams, injection moulding
- Cosmetics – biodegradable microbeads

**Production costs (2014)**

- Sugar based
- Waste water based
- Biogas based

**Potential EU Demand**

- Packaging
- Fertiliser coating
- Medical implants
- Microbeads
PHA: SWOT analysis

**Strengths**
- Best bio-based bio-degradable polymer
- Good barrier properties

**Weaknesses**
- Only quality is biodegradability (no other special qualities showing)
- Downstream processing expensive – very diluted product
- Not suitable for long-time use (because it is biodegradable)

**Opportunities**
- Fertilizers application (slow releasing)
- Development of full recycling process
- New applications: filler or rheology modifier for home and personal care products/cosmetics

**Threats**
- Competes with cheaper fossil and bio-based polymers (PEF)

Possibly the best biodegradable polymer ➔ reducing production costs and developing new applications are likely to create market opportunities.
PEF (PET) Case study

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-based (est.): 3</td>
<td>Bio-based (est.): 12</td>
<td>PET price represents the market price</td>
<td>6 – 8.8</td>
</tr>
</tbody>
</table>

Source: Grand View Research (2016)

Value chain: Compared to its fossil counterpart: PET

Feedstock

- Sugar (Fructose)
- Alkoxyethyl-Furfural (RMF)
- 2,5-Furandicarboxylic acid (FDCA)
- Monochloroethylene glycol (MEG)
- PTA
- MEG
- Cr
- DMT

Key Derivatives

- Polyethylene furanate (PEF)
- Polyethylene terephthalate (PET)

Application

- Water and beverage bottles
- Food packaging
- Carpet facing, textiles
- Resin
- Film
- Fiber

Production costs (2018)

- PET: 1,100 €/tonne
- PEF: ?

Source: ICIS

Estimated regional demand of PEF (2016)

- Asia: 25%
- Europe: 15%
- N. America: 12%
- Other regions: 48%

Potential demand (global) (2016)

- Film (e.g. packaging)
- Resin (e.g. bottles)
- Fibre (e.g. textiles)

Source 2016: Grand View Research

Source 2016: Grand View Research (2016)
PEF: SWOT analysis

**Strengths**
- Improved functionality e.g. mechanical strength and better barrier properties

**Weaknesses**
- Not easily recyclable
- Production costs are high

**Opportunities**
- Development of full recycling process
- Easily used in higher volume applications
- Could be used in lesser amount than PET for same application

**Threats**
- Competition with PET, bio-PET, PTF
- Big focus on recyclability in Europe – circular economy

Enhanced functionality in packaging applications → competes with cheaper fossil and bio-based drop-in plastics
Lessons learned for dedicated polymers

Circular economy: Strong demand for recyclable bio-based polymers

Challenges & opportunities:
- Find way to separate from mixed plastics
- Establish dedicated recycling streams

Look for applications other than packaging ➔ biodegradable films for farming, fillers or microbeads for cosmetics, biomedical materials, automotive, electronics and other fields

Make dedicated chemicals cost competitive:
- Lower production costs - technology development
- Switch to cheaper feedstock - waste streams vs. sugars
# Results of the survey on key barriers for bio-based products

## Key barriers according to bio-based industry stakeholders

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Action</th>
<th>Time frame</th>
<th>Actor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil benchmark / Low price fossil resources</td>
<td>Carbon tax</td>
<td>Short-term</td>
<td>Government</td>
</tr>
<tr>
<td>High CAPEX</td>
<td>Invest in R&amp;D/ Subsidise FOK plant</td>
<td>Mid-term</td>
<td>Industry/SME/ Government</td>
</tr>
<tr>
<td>REACH/ health &amp; safety</td>
<td>Simpler procedures for obviously non-toxic components/ SME funds for REACH registration</td>
<td>Short-term</td>
<td>Government/ Industry</td>
</tr>
</tbody>
</table>

## Key actors

<table>
<thead>
<tr>
<th>Key actors</th>
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</thead>
<tbody>
<tr>
<td>Government/ Policy makers/NGOs</td>
</tr>
<tr>
<td>Scientific and Educational institutions (e.g. Universities)</td>
</tr>
<tr>
<td>Industry/SMEs</td>
</tr>
<tr>
<td>Society and media</td>
</tr>
</tbody>
</table>

## Time horizon

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate action needed</td>
</tr>
<tr>
<td>Action needed in the next 2 – 5 years</td>
</tr>
<tr>
<td>Action needed in</td>
</tr>
</tbody>
</table>

## What

<table>
<thead>
<tr>
<th>What is the action that needs to be taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest in R&amp;D and innovation</td>
</tr>
</tbody>
</table>

## Who

<table>
<thead>
<tr>
<th>Who is the key actor to address this barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry / SME &amp; Universities</td>
</tr>
</tbody>
</table>

## When

<table>
<thead>
<tr>
<th>What is the time horizon to take the action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term/Mid-term</td>
</tr>
</tbody>
</table>

## Description

<table>
<thead>
<tr>
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<tr>
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</tr>
</tbody>
</table>
## Concept of the Roadmap: Barriers, actors and actions

<table>
<thead>
<tr>
<th>Potential barrier</th>
<th>Overcoming strategy/activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Government/ policy makers &amp; NGOs/activity</td>
</tr>
<tr>
<td>Barrier 1</td>
<td>Action actor 1</td>
</tr>
<tr>
<td>Barrier 2</td>
<td>Action actor 1</td>
</tr>
<tr>
<td>Barrier 3</td>
<td>Action actor 1</td>
</tr>
<tr>
<td>Barrier 4</td>
<td>Action actor 1</td>
</tr>
</tbody>
</table>

**Barrier characteristic:**
- Short-term
- Mid-term
- Long-term
Concept of the Roadmap: Action plan

- **2018**: Identify area of innovation
- **2020**: Research and development activities
  - Regulatory framework
  - Public funding program innovation
- **2024**: Research and development activities
  - Capacity building: skills and expertise
- **2026**: Secure investments
- **2030**: Changing public perception

- **Industry & SMEs**
- **Government/Policy makers & NGOs**
- **Scientific & Education institutions**
- **Society & media**
This project has received funding from the Bio-Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 745623.

Q & A
Thank you for your attention.

For Further information:
Visit our website www.roadtobio.eu
Subscribe to our monthly newsletter
Contact: lea.koenig@dechema.de

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