The projects have received funding from the European Union’s Seventh Programme for research, technological development and demonstration under grant agreement n° 282826 (SECTOR) and 282873 (BioBoost).
Global trade increase of bioenergy carriers

Wood pellets 2014

US 3.90 MT
Canada 1.26 MT
EU
Former USSR 2.10 MT
Korea
Canada 0.34 MT
SEA 1.09 MT
China 0.29 MT

For 2008 - 2009 data is taken from UN Comtrade under "440130"
For 2010 - 2012 data is taken from Lamers et al. 2013, except for Japan and S. Korea from UN Comtrade under "440130".
For 2013 data is taken from UN Comtrade under "440131"
For 2014 data is taken/derived from Jessica Dell (Argus Media). For ‘Others to EU’, and ‘World to Japan’, both are assumed to be same as 2013.

Base reference:

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Global trade increase of bioenergy carriers

Source: graph: IEA Bioenergy Task 40; data: EPA
Global trade increase of bioenergy carriers

Fuel ethanol production in US and Brazil

Source: F.O. Licht’s & EIA
Why advanced bioenergy carriers?

- Activation of a broader range of feedstock
- Enabling of long distance transport
- Advantages for storage
- Homogenous and high quality -> needed for high value applications
- Tailored properties to user demand
- Thermochemical processes ideal to achieve these advantages

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## Technology overview - process, products and TRL

<table>
<thead>
<tr>
<th></th>
<th>Torrefaction</th>
<th>Hydrothermal carbonization</th>
<th>Thermal fast pyrolysis</th>
<th>Catalytic fast pyrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditions</strong></td>
<td>200-320 °C ≈ 30 min</td>
<td>≈ 200 °C 10 bar, 6 h</td>
<td>500 °C sec.</td>
<td>500 °C sec.</td>
</tr>
<tr>
<td><strong>Feedstock</strong></td>
<td>Woody and non-woody biomass</td>
<td>„wet“ biomass and organic waste</td>
<td>Lignocellulosic biomass</td>
<td>Lignocellulosic biomass</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td>Pellets, briquettes</td>
<td>Biocoal dust, pellets and cakes</td>
<td>Catalytic pyrolysis oil (low O-content)</td>
<td>Biosyncrude (mix of pyrolysis oil and char)</td>
</tr>
<tr>
<td><strong>Heating value</strong></td>
<td>20-28 MJ/kg</td>
<td>≈ 30 MJ/kg</td>
<td>20-25 MJ/kg</td>
<td></td>
</tr>
<tr>
<td><strong>TRL-level achieved</strong></td>
<td>7</td>
<td>6-7</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
### Trend: Diversified and advanced demands

<table>
<thead>
<tr>
<th>Fields of demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In general</strong>: cost efficiency, low emissions, use of existing infrastructure, applicability small to large scale and varying end uses</td>
</tr>
<tr>
<td><strong>Logistics &amp; storage</strong>: small to big bags, bulks, tanks, grids, open storage, bunkers, pumps, belt conveyer</td>
</tr>
<tr>
<td><strong>Pretreatment/milling</strong>: hammer mill, roller mill, fan beater mill</td>
</tr>
<tr>
<td><strong>Conversion</strong>: pulverized fuel boiler, EF-gasifier, small/medium scale boilers, combustion engines, FLOX burner, refinery processes</td>
</tr>
<tr>
<td><strong>Final products</strong>: heat, power, chemicals, transportation fuels, oil, coal, slurry</td>
</tr>
</tbody>
</table>

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Requirements for advanced bioenergy carriers (examples)

**End user demand**

**Energy content:** as high as possible for transport and conversion efficiency

**Durability:** e.g. weather resistance, important for storage

**Grindability:** for optimal milling processes

**Water resistance:** optimisation for outdoor storage and handling

**Particle size:** optimal combustion efficiency
Promising advanced bioenergy carriers

BioBoost

Potential and cost studies for residual biomass feedstocks (e.g. straw, forest residues, organic waste...)

Conversion by thermal and catalytic pyrolysis, hydrothermal carbonization to produce biosyncrude, catalytic pyrolysis oil, and HTC char

Application test for gasification (synthetic fuels), upgrading in refineries, CHP. Feasibility of by-product and nutrient separation.

SECTOR

22 feedstocks → e.g. stem wood, logging residue, straw, poplar, prunings from olive trees, willow, bagasse, eucalyptus, ...

4 products → torrefied pellets, torrefied briquettes, torrefied chips, torgas

4 end use applications → cofiring, (co-)gasification, pellet boilers, production of chemicals

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Key factors for market implementation

1. **End user demands identification and reliability of large scale production (confidence)**
Key factors for market implementation

2. Proven sustainability

GHG-emissions from electricity production based on torrefied pellets from different feedstocks and locations. Source: SECTOR Project

GHG-emissions according to RED for fuel production via thermal and catalytic pyrolysis pathway. Source: BioBoost-Project

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Key factors for market implementation

3. describable, verifiable and tradable properties/quality

End user demands

- Property description
- Testing methods
- Logistics and handling guidelines

SECTOR: support of ISO 17225-8
BioBoost: identification of energy carrier properties and fuel requirements, application specific product optimization
Main achievements in the last 3 years

1. Up-scaling and increase of technology readiness level

**SECTOR**

→ Demonstration of torrefaction technology at commercial scale
→ Optimisation of torrefaction system and densification
→ Demo-Scale (Topell) Toroidal bed reactor technology

**Bioboost**

→ Increase in TRL for thermal/catalytic pyrolysis and HTC technologies
→ Customizing products towards CHP, gasification or upgrading for refinery integration
Main achievements in the last 3 years

2. Intensified market activities

- Torrefaction Plants:

- HTC Plants:
Main achievements in the last 3 years

3. Enhanced market strategies

- Approach of different sectors:
  - Small to medium scale appliances
  - Development of bioeconomy products
  - Designer fuels for transport sector

- Approach of different regions:
  - Supply: USA Southeast & Northwest Russia, Canada and Brazil with further biomass potential
  - Demand: Asia Pacific, South Africa, US, some parts of Europe, mostly in UK
The way ahead - pending issues

- **Research demand and market readiness**
  - Fast and catalytic pyrolysis as well as HTC have entered demonstration state
  - Torrefaction of woody biomass is ready to market - non woody biomass follows behind

- **Market Barriers to tackle:**
  - Low price for coal and CO₂-emission allowances - no biomass price parity
  - Competition to established technologies - confidence needs to be established
  - Lock-in into other solutions - once invested, change is unlikely
  - Sheer size of needed investment to supply relevant amount to potential customers
  - Policy coherence and stability for reliable European market conditions
Basic considerations for market development

- Biomass only source of carbon in the long run
- Stepwise implementation of advanced utilisation of biomass from
  - Short term: heat and power via mainly combustion to
  - Mid term: Transportation fuels and chemicals
  - Long term: Added value by nutrient and by-product recovery
thank you very much!

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