Advances in biochemical pathway
Main demo plants in Europe

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Disclaimer

- The presenter has gathered most of the informations from public announcements and websites.
- Some deviations from factual situation may be presented.
- The presentation does not claim to be exhaustive.
Biochemical Value Chains as defined in EIBI document

- Ethanol and other alcohols from ligno cellulose through chemical and biological pathway
- Hydrocarbons (fuels !) through biological and/or chemical synthesis from biomass containing carbohydrates
- *Bioenergy carriers produced by micro-organisms from CO2 and sunlight*
Ligno cellulose

Thermochemical pathway

Biochemical pathway
WOODY AND AGRICULTURAL BY-PRODUCTS RESIDUES ENERGY CROPS

PRETREATMENT

PRETREATED BIOMASS

ENZYMATIC or CHEMICAL HYDROLYSIS

FERMENTABLE SUBSTRATES

FERMENTATION

DISTILLATION

ETHANOL 

GASOLINE

BACTERIA 

FUNGUES 

ENZYMES

YEASTS

WWW.BIOFUELSTP.EU
Main issues

- EtOH cost
  - enzymes
  - pre-treatment
  - C5 conversion
  - ...
- Feedstock availability
- Biorefinery integration
- G1 unit revamp
- Butanol?
## Main EtOH G2 running demos (>1000t/y) in the EU

<table>
<thead>
<tr>
<th>Plant Owner</th>
<th>Location</th>
<th>Input capacity</th>
<th>Output capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abengoa Bioenergy, Biocarburantes Castilla y Leon, Ebro Puleva</strong></td>
<td>Babilafuente, Salamanca, Spain</td>
<td>25 000 t/year (lignocellulosics, steam explosion, wheat/wheat straw, corn stover)</td>
<td>4 000</td>
</tr>
<tr>
<td><strong>Inbicon (Dong Energy)</strong></td>
<td>Kalundborg, Denmark</td>
<td>30 000 t/year (lignocellulosics, wheat straw)</td>
<td>4 300</td>
</tr>
<tr>
<td><strong>Chempolis Oy</strong></td>
<td>Oulu (Chempolis Oy R&amp;D Center), Northern Finland</td>
<td>25 000 t/year (non-wood, non-food raw material formic acid pathway)</td>
<td>running ?</td>
</tr>
<tr>
<td><strong>SEKAB Industrial Development AB (IDU Project)</strong></td>
<td>Örnsköldsvik, Sweden</td>
<td>lignocellulosics, flexible for wood chips and sugar-cane bagasse</td>
<td>4 500 running ?</td>
</tr>
</tbody>
</table>
Abengoa facility

Start up september 2009
The production process involves:
Preparation of biomass
Thermochemical pretreatment
Enzymatic Hydrolysis
and fermentation with enzymes 
and yeast
Distillation to produce ethanol
and a solid co-product
Start up 2010
Straw as feedstock
Energy coproduction
External production of enzymes
Main announced EtOH G2 demos (>1000t/y) in the EU

<table>
<thead>
<tr>
<th>Plant Owner</th>
<th>Location</th>
<th>Input raw material</th>
<th>Output capacity (t/year)</th>
<th>Planned Start-up date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogasol (BornBio-Fuel 2)</td>
<td>Aakirkeby, Bornholm, Denmark</td>
<td>Lignocellulosics, various grasses, green waste, straw</td>
<td>4 000</td>
<td>2012</td>
</tr>
<tr>
<td>INEOS Bio</td>
<td>Seal Sands, Tees Valley, UK</td>
<td>Biodegradable household and commercial waste</td>
<td>24 000</td>
<td>2012</td>
</tr>
<tr>
<td>Mossi &amp; Ghisolfi</td>
<td>Tortona, Piedmont, Italy</td>
<td>Lignocellulosics</td>
<td>20 000</td>
<td>2012</td>
</tr>
<tr>
<td>Procethol 2G</td>
<td>Pomacle, France</td>
<td>Lignocellulosics</td>
<td>8000</td>
<td>2015</td>
</tr>
<tr>
<td>SEKAB</td>
<td>Örnsköldsvik, Sweden</td>
<td>Lignocellulosics</td>
<td>47 500</td>
<td>2014</td>
</tr>
<tr>
<td>SEKAB</td>
<td>Örnsköldsvik, Sweden</td>
<td>Lignocellulosics</td>
<td>120 000</td>
<td>2016</td>
</tr>
<tr>
<td>Sud Chemie</td>
<td>Straubing, Germany</td>
<td>Agriculture waste, wheat straw</td>
<td>2 000</td>
<td>2011</td>
</tr>
</tbody>
</table>
Main EtOH G2 running demos (>1000t/y) North America

<table>
<thead>
<tr>
<th>Plant Owner</th>
<th>Location</th>
<th>Input capacity (t/year)</th>
<th>Output capacity (t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOGEN Corporation</td>
<td>Ottawa, Ontario, Canada</td>
<td>30 t/d (lignocellulosics, wheat, barley and oat straw)</td>
<td>1 600</td>
</tr>
<tr>
<td>BP (Jennings Demo Facility)</td>
<td>Jennings, LA, US</td>
<td>Lignocellulosics, sugarcane bagasse, switchgrass, wood products</td>
<td>4 180</td>
</tr>
<tr>
<td>KL Energy Corporation</td>
<td>Upton, Wyoming, US</td>
<td>33 500 t/y (lignocellulosics, wood waste, waste pulp, cardboard, paper)</td>
<td>4 500</td>
</tr>
<tr>
<td>Western Biomass Energy</td>
<td>Upton, Wyoming, US</td>
<td>Wood waste, pine chips</td>
<td>4 000</td>
</tr>
</tbody>
</table>
Main EtOH G2 demo units outside EU

### Running
- BP/Verenium j-v – USA – 4180 t/y
- DuPont Danisco/UT-Genera Energy – USA – 1000 t/y
- KL Energy – USA – 4500 t/y
- Mascoma – USA – 1000 t/y
- Western Biomass Energy – USA – 4000 t/y
- Iogen – Canada – 1600 t/y
- Jilin Jiuxin Industry group – China – 30000 t/y
- Beijing Tiandi Riuyue Biomass technology – China – 8000 t/y
- Chinese Academy of Agricultural Engineering – China – 4000 t/y
- Henan fuel ethanol – China – 8000 t/y (2 units)
- CNPC – China – 30000 t/y (2 units)
- Shandong Longlive Bioenergy – China – 40000 t/y
- Shandong Wande – China – 8000 t/y
- Shandong Xueling Starch – China – 3000 t/y
- ZTE Energy – China – 30000 t/y
- Bioethanol – Japan – 1000 t/y
- Kirin Brewery -Japan – 8000 t/y
- Kirov Biochemical – Russia – 15000 t/y
- Thai Roong Ruang Energy – Thailand – 25000 t/y

### Announced
- Abengoa Bioenergy Biomass of Kansas – USA – 75000 t/y
- ADM - USA - 3000 t/y
- Allied Energy Services - USA - 60000 t/y
- BlueFire Ethanol - USA – 57000 t/y
- BP – USA – 100000 t/y
- Celunol - USA – 60000 t/y
- Colusa Biomass Energy – USA – 30000 t/y
- Fiberight – USA – 18000 t/y
- GulfEthanol – USA – 86000 t/y
- ICM – USA – 150000 t/y
- INEOS Bio - USA – 24000 t/y
- Mascoma – USA – 15000 t/y
- Novahol – USA – 75000 t/y
- Poet – USA – 93400 t/y
- University of Florida – USA – 55000 t/y
- IGEN – Canada – 68000 t/y
- Bio-Dynamic - China - 200000 t/y
- China Agri-Industries – China – 10000 t/y
- Shandong Wande – China – 30000 t/y
- Bioethanol – Japan – Planned expansion to 3000 t/y
- Thai Roong Ruang Energy – Thailand – 25000 t/y
- Chempolis – Vietnam – 48000 t/y
- Colbiocel – Colombia – 90000 t/y
- KL Energy – Brazil – 37000 t/y
- Petrobras – Brazil – 110000 t/y
Projects statistics

- 32 projects in the 0-1 ML (<800 t/a) category
- 13 projects in the 1-10 ML (0.8-8 kt/a) category
- 8 projects in the >10 ML (>8 kt/a) category
- 53 running projects
- 8 projects under construction
- 18 projects in the 1-10 ML (0.8-8 kt/a) category
- 72 total projects
Potential EtOH G2 announced capacities

Source: CEDIGAZ
Other alcohols / new fermentation pathways

- Eastern siberia – biobutanol – 30000t/y
- Lanzatech - EtOH waste gas fermentation – NZ -1000t/y
- Gevo – butanol – 3000t/y (project of revamp of Ethanol plant)

No demo running > 1000t/y
  - Coskata – cellulosic EtOH fermentation of syngas
  - Cobalt – butanol fermentation from sugar/cellulose
  - Butamax – butanol from sugar
  - Zeachem – hybrid process
Carbohydrates (sugar) to HC

- LS9 – fermentation pathway from sugar
- Amyris - fermentation pathway from sugar
- Virent - chemical pathway from sugar
Conclusions

• Many announced projects all over the world
• Still some technical and economic issues for EtOH G2
• Other pathways developing
• Biorefineries?