

A large, vibrant sunflower in the foreground, with a field of smaller sunflowers in the background under a clear blue sky. The sunflower has bright yellow petals and a dark brown center. The background shows a field of similar sunflowers, some in bloom and some as buds, stretching towards the horizon.

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# Biofuel Technologies – Situation and Outlook in Europe

Production Technologies & Investment Opportunities

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European Energy Venture Fair 2006

Plenary Session IV: “2nd Generation Bioenergy & Biofuels”

Rueschlikon, September 12, 2006

**FESTEL**  
**CAPITAL**  
Creating a Better  
Future

## FESTEL CAPITAL

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- FESTEL CAPITAL is an advisory and investment firm focusing on the **commercialisation of technologies** and **optimisation of organisations** in the areas of energy, environment, health, infrastructures, materials and nutrition
- FESTEL CAPITAL supports **start-ups and spin-offs** from business planning over transactions up to business optimisation
- FESTEL CAPITAL **invests in selected companies** and supports companies based on **equity participation**
- FESTEL CAPITAL has special expertise and experience in business development and partnering in **China**

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- Before deducting individual conclusions, it is necessary to obtain additional data and conduct further analyses
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## Abbreviations

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### Abbreviations

- BTL      Biomass-to-Liquid
- CNG      Compressed Natural Gas
- CTL      Coal-to-Liquid
- DME      Dimethyl Ether
- FAME      Fatty Acid Methyl Ester
- FT      Fischer-Tropsch
- GHG      Greenhouse Gas
- GTL      Gas-to-Liquid
- H<sub>2</sub>      Hydrogen
- l      Litre
- kt      Kilotonne
- LNG      Liquefied Natural Gas
- LPG      Liquefied Petroleum Gas
- MeOH      Methanol
- RME      Rape Seed Methyl Ester
- SNG      Synthetic Natural Gas

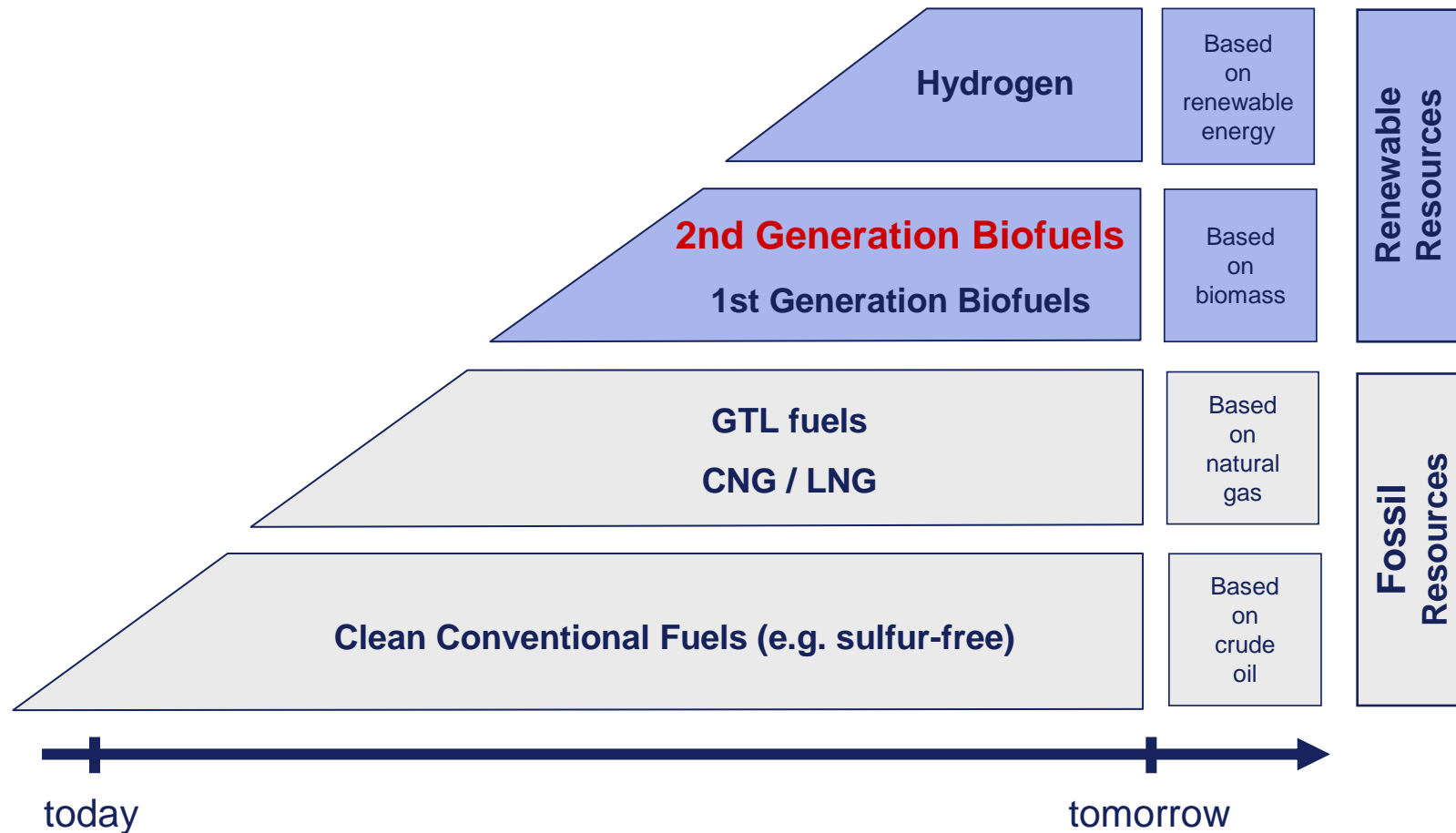
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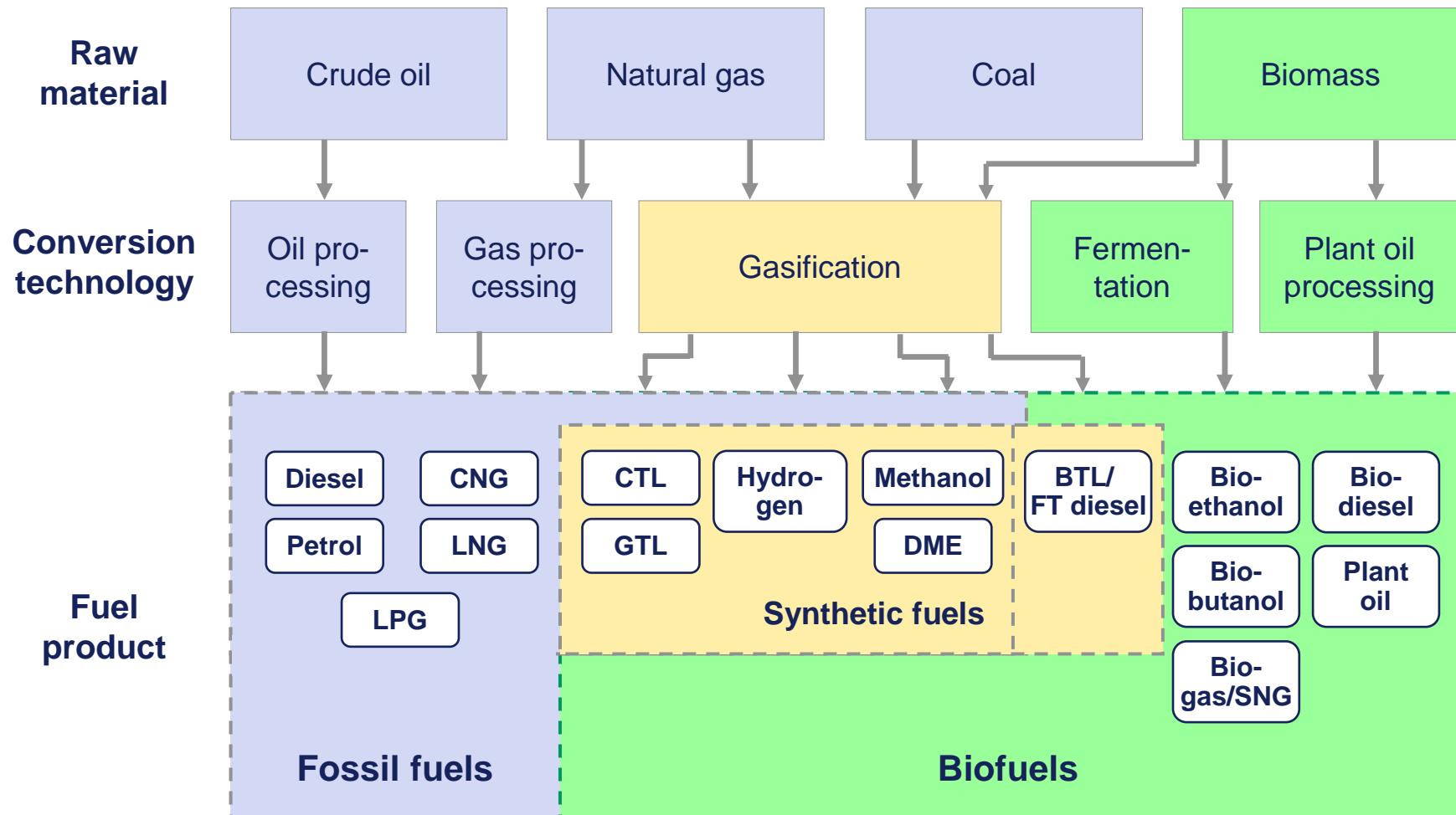
## Fuel Types and Criteria - Fuel Generations

Different generations of modern fuels deriving from fossil and renewable resources exist

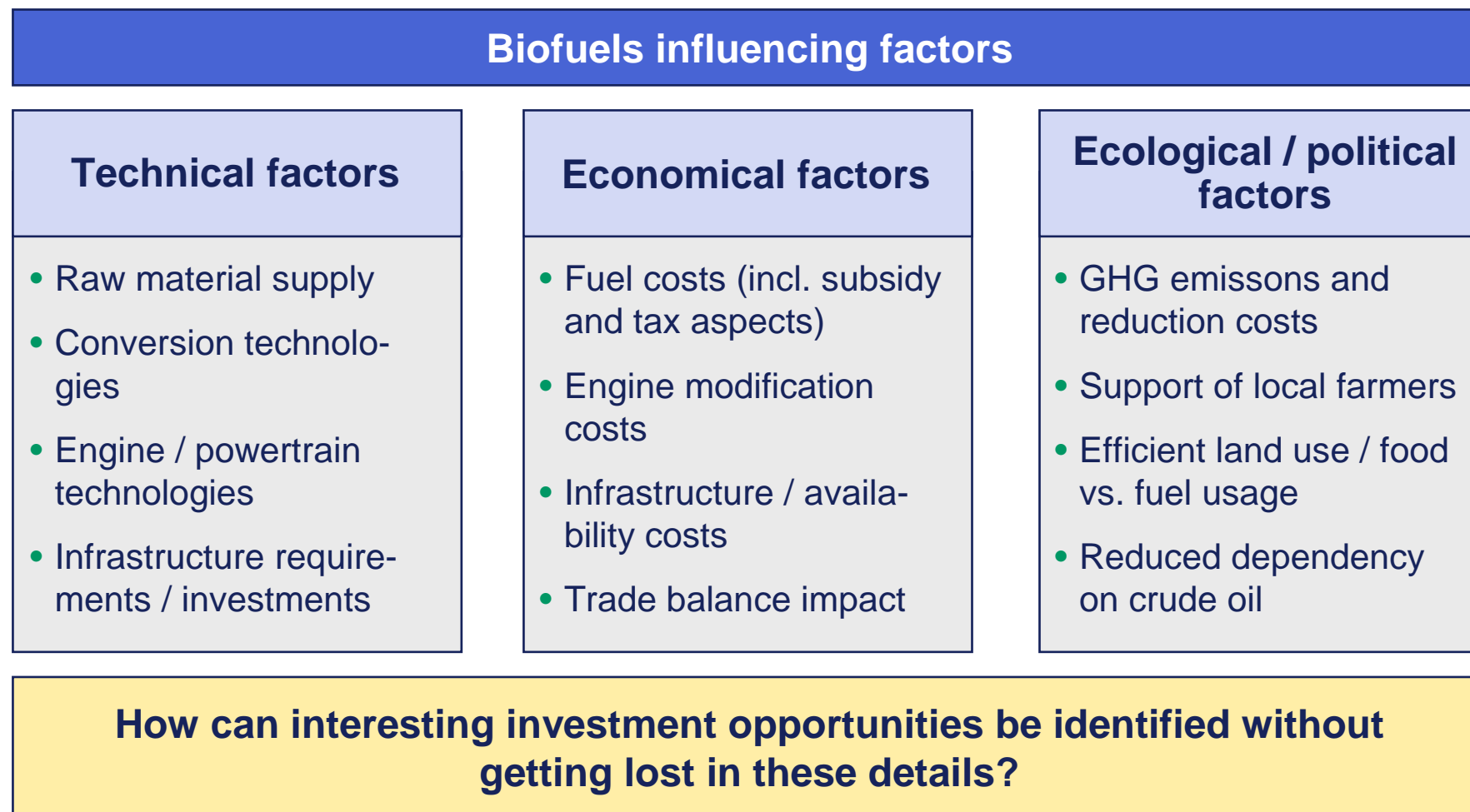


## Fuel Types and Criteria - Fuel Types

Fuel types can be categorized based on raw materials and main conversion technologies



**Biofuels are an extremely complex topic due to the high number of influencing factors**



**We have some fundamental hypotheses regarding biofuel usage over the next 10 to 15 years**

**Hypotheses regarding biofuel usage**

**Customer acceptance**

- Lower prices compared to fossil fuels (without tax subsidy!)
- Normal usage of existing cars
  - No loss of power and range
  - No modification costs
- High availability and easy handling (similar to existing fuels)



**Biofuel requirements**

- Low raw material and production costs
- No additional distribution / infrastructure costs
- Problem-free mixing with existing fuel types
- Same chemical/physical properties as existing fuels (e.g. energy content)

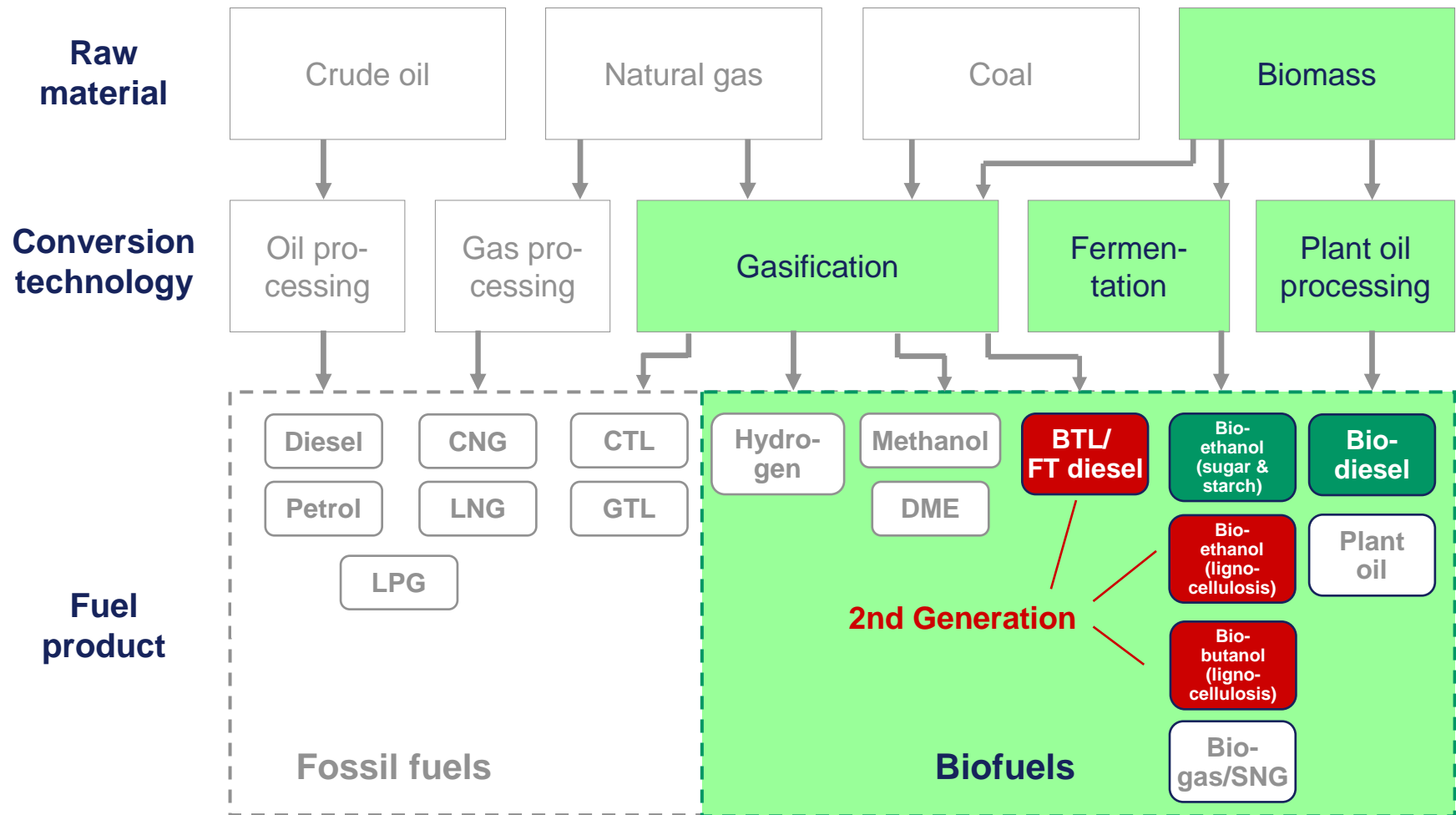
**Important are economical factors and not ecological aspects - the deciding factor for market success are the costs for the car owner at the filling stations**

The high complexity of biofuels can be reduced significantly for investors

Biofuels influencing factors		
Technical factors	Economical factors	Ecological / political factors
<ul style="list-style-type: none"> <li>• <b>Raw material supply</b></li> <li>• <b>Conversion technologies</b></li> <li>• Engine / powertrain technologies</li> <li>• Infrastructure requirements / investments</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Fuel costs</b> (incl. subsidy and tax aspects)</li> <li>• Engine modification costs</li> <li>• Infrastructure / availability costs</li> <li>• Trade balance impact</li> </ul>	<ul style="list-style-type: none"> <li>• GHG emissions and reduction costs</li> <li>• Support of local farmers</li> <li>• Efficient land use / food vs. fuel usage</li> <li>• Reduced dependency on crude oil</li> </ul>
<p><b>For investors only fuel costs based on raw material supply and conversion technologies are of importance</b></p>		

## Fuel Types and Criteria - Conclusion

### 2nd generation biofuels have very attractive long-term prospects



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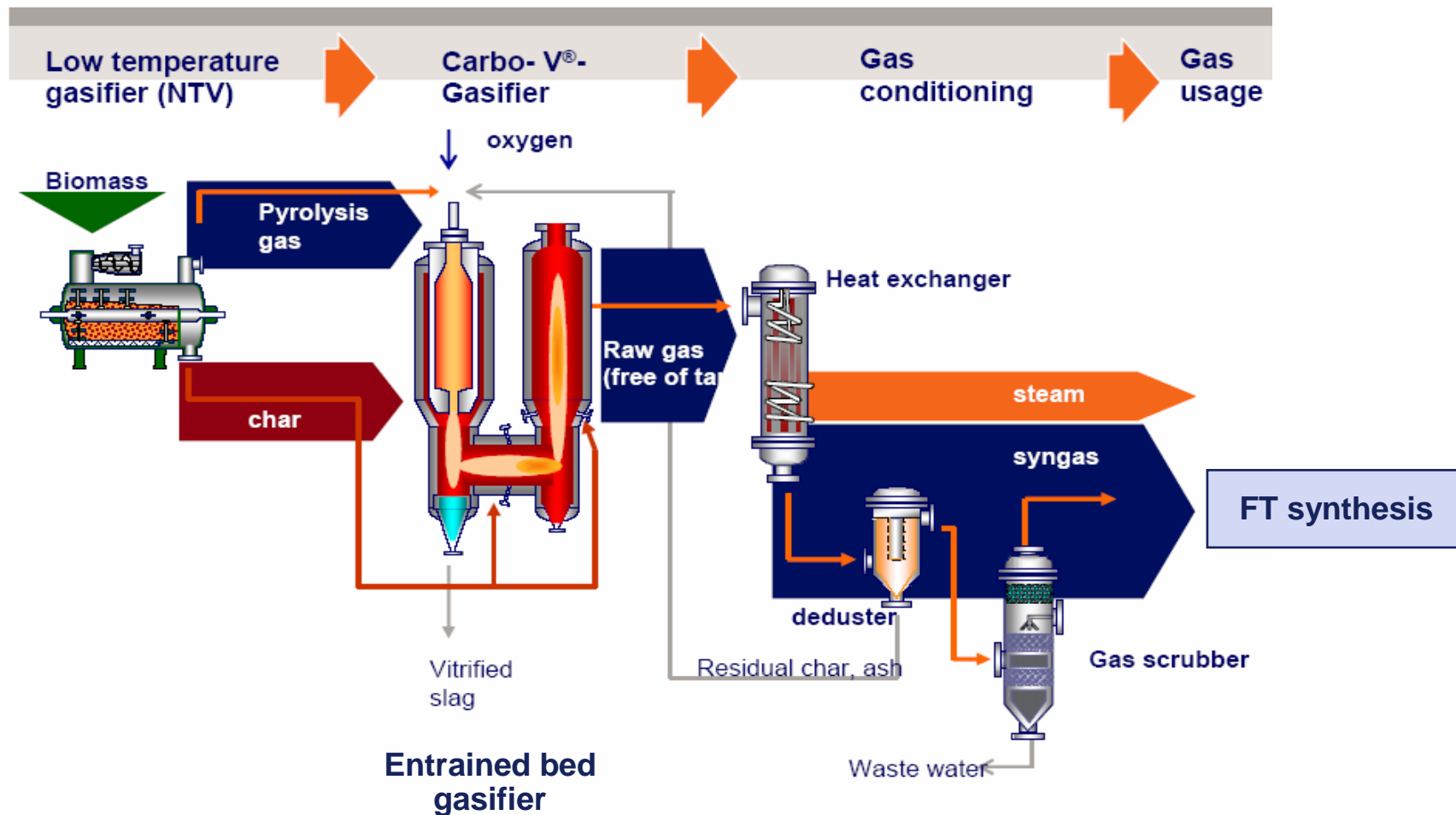
Investment Opportunities

A

Appendix: Information on FESTEL CAPITAL

Production Technologies - BTL Fuel

**Choren's Carbo-V Process is a 3-stage gasification process involving low and high temperature as well as endothermic entrained bed gasification**



Quelle: Choren

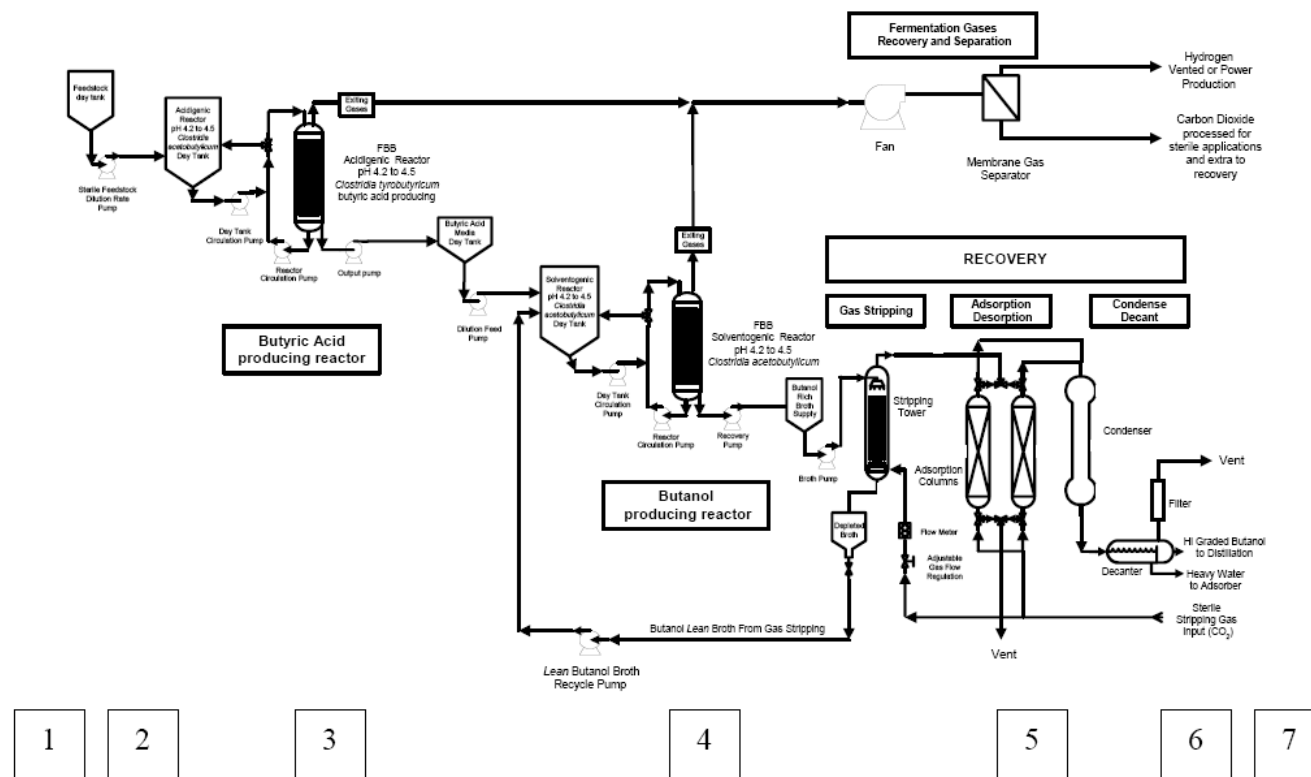
## Shell is cooperating with Choren to build the first commercial scale BTL production plant

- In August 2005, Shell bought a minority stake in Choren to build the world's first commercial scale facility with an annual capacity of **15,000 tonnes** of BTL fuel (SunDiesel)
  - The cooperation combines Choren's Carbo-V gasification process with Shell's further developed Fischer-Tropsch process
  - The plant is to be constructed by the end of 2006 and on stream in 2007 and production costs for the SunDiesel are estimated at Euro 1/l
- Choren is targeting to build other large-scale industrial production units in Germany, each with an annual production of **200,000 tonnes** (with the expected scale effects the cost to produce the biofuel would be Euro 0.6/l)
- The technical development of the BTL process is still at its beginnings, therefore **substantial improvement** is expected in the future
  - Currently, the conversion factor of biomass to BTL fuel is approx. 5 (5 t biomass for 1 t fuel) - it should be possible to optimise this value to 2.5 (**additional hydrogen**)
  - Improvement in the area of **logistics** is also necessary

Quelle: Choren

## Production Technologies - Biobutanol

### Environmental Energy Inc. (EEI) has developed dual immobilized reactors with continuous recovery (DIRCR™) process



1. Dry or wet milling
2. Conversion of biomass into usable sugars
3. **Butyric acid and hydrogen fermentation** (acidogenic)
4. **Butanol fermentation** (solventogenic)
5. High grading: gas-stripping/adsorption/desorption/condensing/decantation
6. Distillation: high purity
7. By-product recovery

Source: Environmental Energy Inc.





## Butanol is being seen as a more superior alternative fuel than ethanol due to its more favourable physical properties

- Butanol has a higher octane rating than ethanol; it has research and motor octane numbers of 113 and 94 compared to 111 and 92 for ethanol
- Butanol can replace fossil fuels up to 100% without modifying the engine whereby ethanol can only be blended up to 85% and here modifications to the engine are required
- Besides using butanol as a straight **substitute for petrol**, butanol can be blended with diesel or biodiesel and **burned in diesel engines**
- Butanol has a **high flashpoint** of 35°C compared to ethanol with 13°C (this is an advantage with regard to fire safety)
- Butanol is **far less corrosive and safer to handle** than ethanol and it can be shipped and distributed through existing pipelines and filling stations
- Butanol has a **lower vapour pressure** and is less miscible with water than ethanol

## Production Technologies - Cost Comparison

### The model calculation for Germany shows the competitiveness of the different biofuel types (1/2)

Numbers are based on a "bottom-up" calculation model







Biofuel	Raw Material	Region	Scenario	Plant Size (kt/year)	Plant Investment (mn Euro)	Production Costs (Euro/l fuel)	Profit Margin (Euro/l)	Price at Filling Station (Euro/l)
 Petrol	Crude oil	Europe	<b>60 USD/barrel</b>	10,000	2,600	0.37	<b>0.05</b>	1.30
Biobutanol	Corn	USA	Large scale 2008	200	240	0.33	<b>0.02</b>	1.30
Biobutanol	Straw	USA	Large scale 2008	200	240	0.30	<b>0.05</b>	1.30
 Biobutanol	Straw	Europe	<b>Large scale 2008</b>	200	240	0.35	<b>0.09</b>	1.30
Bioethanol	Straw	USA	Small scale 2008	50	60	0.45	<b>-0.13</b>	1.30
Bioethanol	Straw	USA	Large scale 2008	200	240	0.30	<b>0.02</b>	1.30
Bioethanol	Straw	USA	Large scale 2012	200	240	0.27	<b>0.05</b>	1.30
Bioethanol	Straw	Europe	Large scale 2008	200	240	0.36	<b>0.01</b>	1.30
 Bioethanol	Wheat	Europe	<b>With tax</b>	200	200	0.48	<b>-0.11</b>	1.30
 Bioethanol	Wheat	Europe	<b>Without tax</b>	200	200	0.48	<b>0.54</b>	1.30

Source: FESTEL CAPITAL analysis

## Production Technologies - Cost Comparison

### The model calculation for Germany shows the competitiveness of the different biofuel types (2/2)

Numbers are based on a "bottom-up" calculation model

Biofuel	Raw Material	Region	Scenario	Plant Size (kt/year)	Plant Investment (mn Euro)	Production Costs (Euro/l fuel)	Profit Margin (Euro/l)	Price at Filling Station (Euro/l)
 Diesel	Crude oil	Europe	<b>60 USD/barrel</b>	10,000	2,600	0.37	<b>0.06</b>	1.10
 Biodiesel	Rape seed	Europe	<b>With tax</b>	200	40 <sup>1)</sup>	0.54	<b>-0.13</b>	1.10
 Biodiesel	Rape seed	Europe	<b>Without tax</b>	200	40 <sup>1)</sup>	0.54	<b>0.34</b>	1.10
 BTL	Wood	Europe	Small scale with tax	120	180	1.02	<b>-0.61</b>	1.10
 BTL	Wood	Europe	<b>Large scale with tax</b>	1,200	1,800	0.82	<b>-0.41</b>	1.10
 BTL	Wood	Europe	<b>Large scale without tax</b>	1,200	1,800	0.82	<b>0.06</b>	1.10

1) Including oil mill

Source: FESTEL CAPITAL analysis

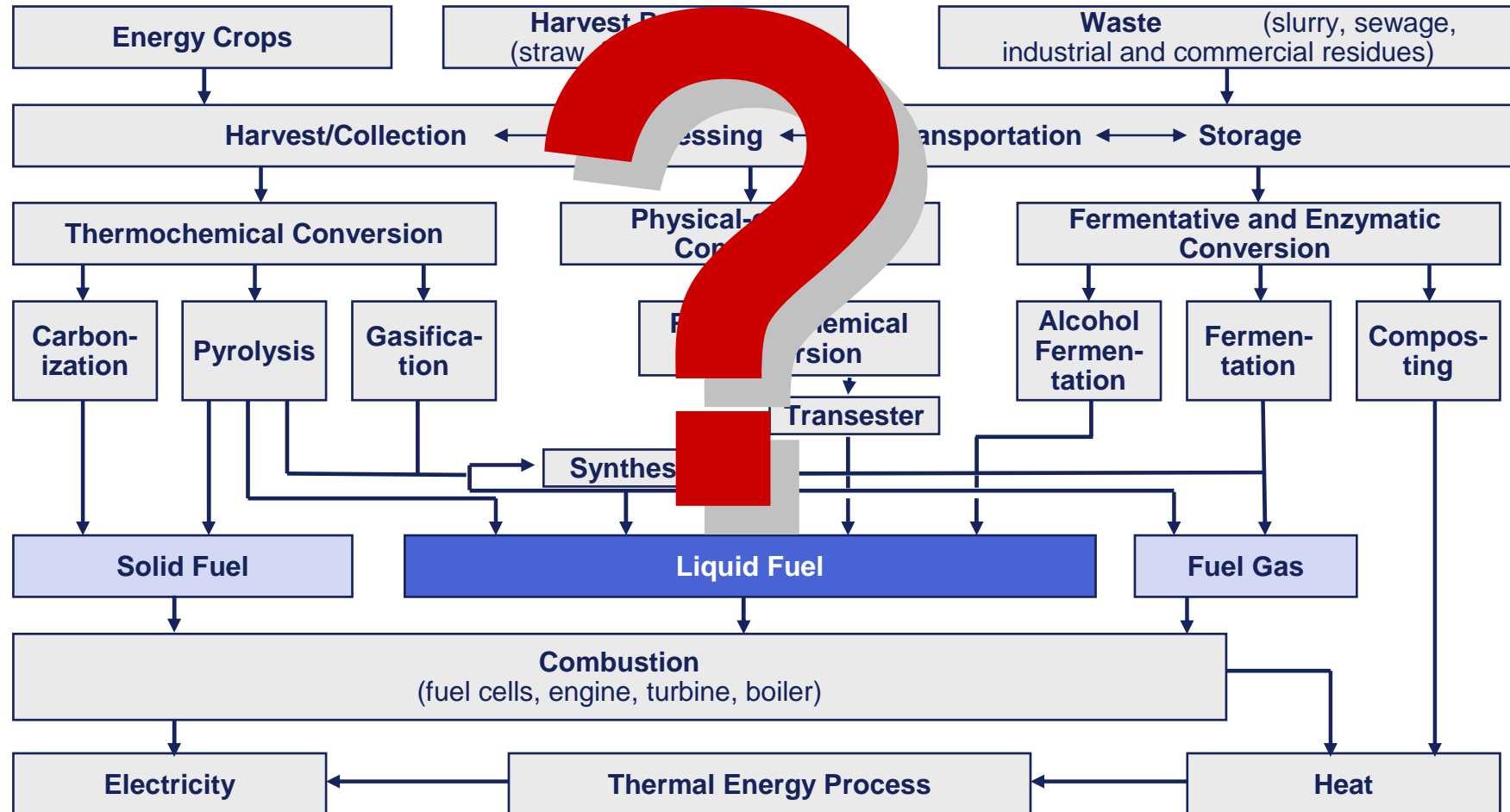
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## Investment Opportunities - Options

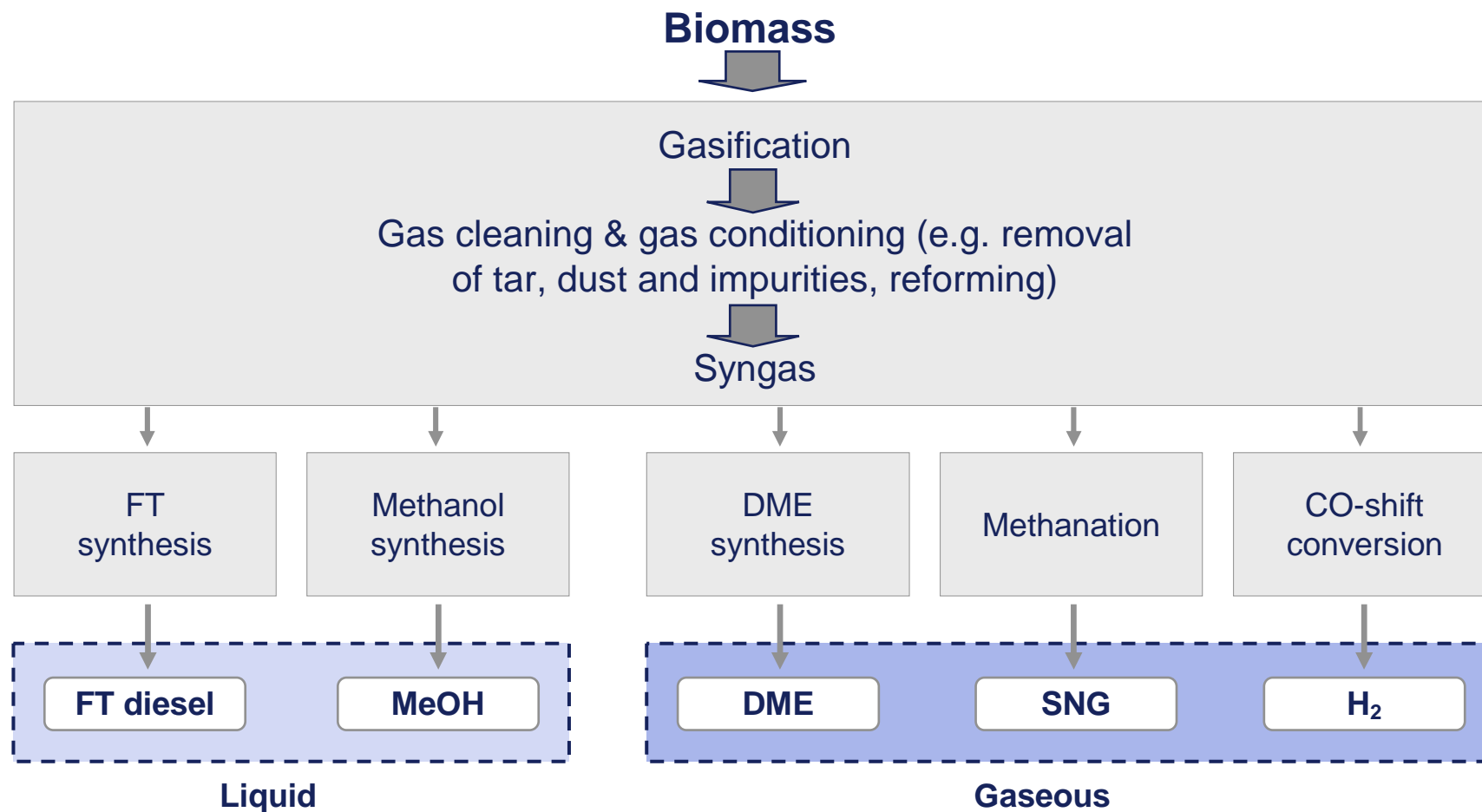
There are many pathways for the energetic utilisation of the different kinds of biomass



Source: Fraunhofer Institute for Environmental, Safety and Energy Technology

## Investment Opportunities - Gasification

**A wide range of synthetic biofuels and other products is accessible using gasification of biomass and following synthetic steps**



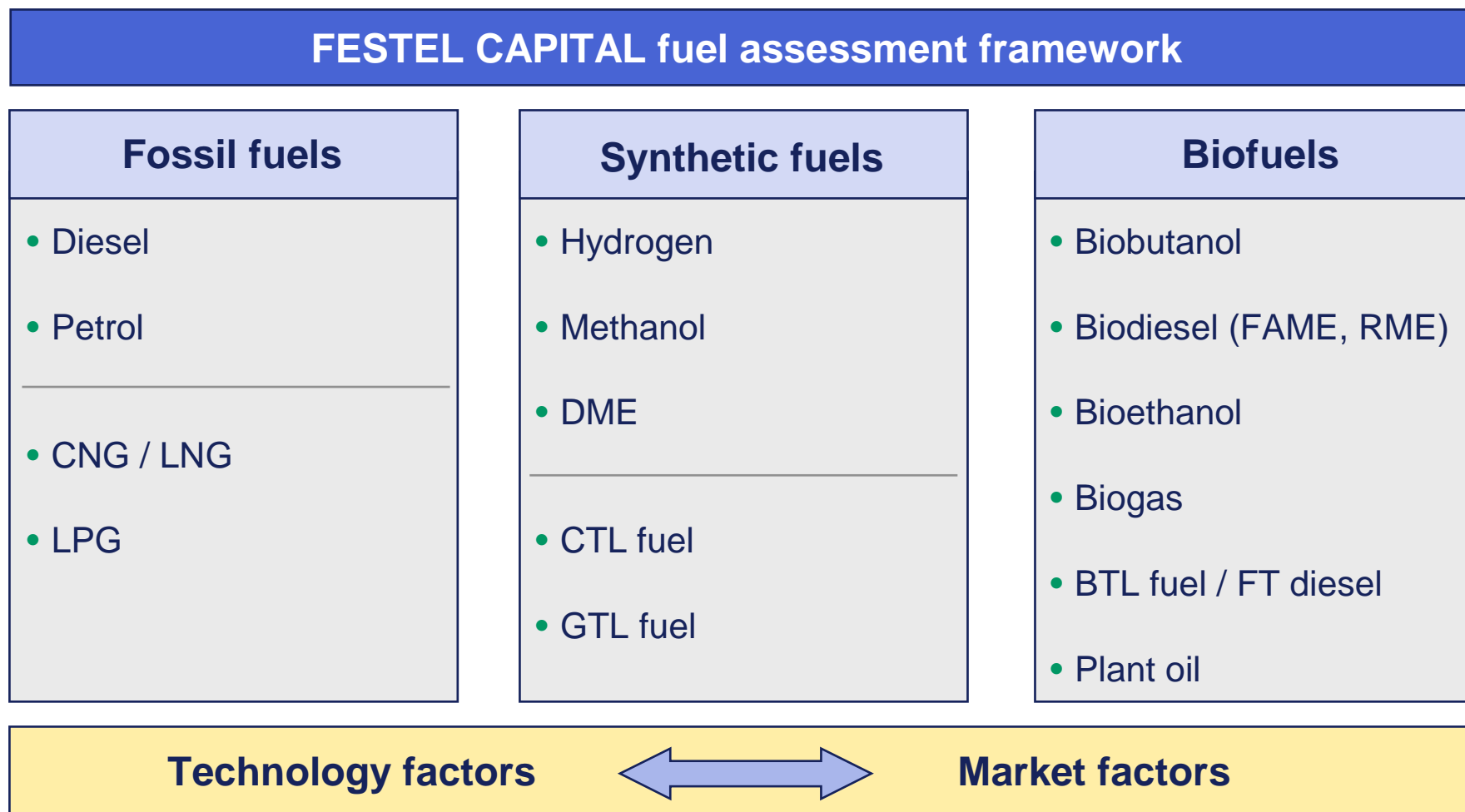
Source: Institute for Energy and Environment Leipzig, Future Energy

## 2nd generation biofuels provide very good investment opportunities for technology-oriented investors

- There are a high number of interesting **platform technologies** available and the selection process is crucial
- Investors should focus on 2nd generation biofuels based on an **in-depth understanding of ...**
  - long-term trends (e.g. fuel cells and hydrogen in transportation applications?)
  - biofuel technologies (e.g. sustainable raw material supply and conversion technologies?)
  - value chains and key players
- **Virtual development networks** with external financing could provide good investment opportunities (example biobutanol process)



**FESTEL CAPITAL has developed a framework to assess fossil, synthetic and bio-based fuels based on technology and market factors**



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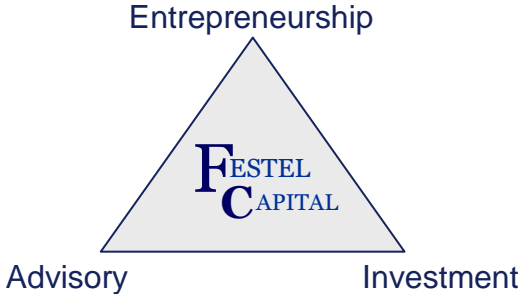
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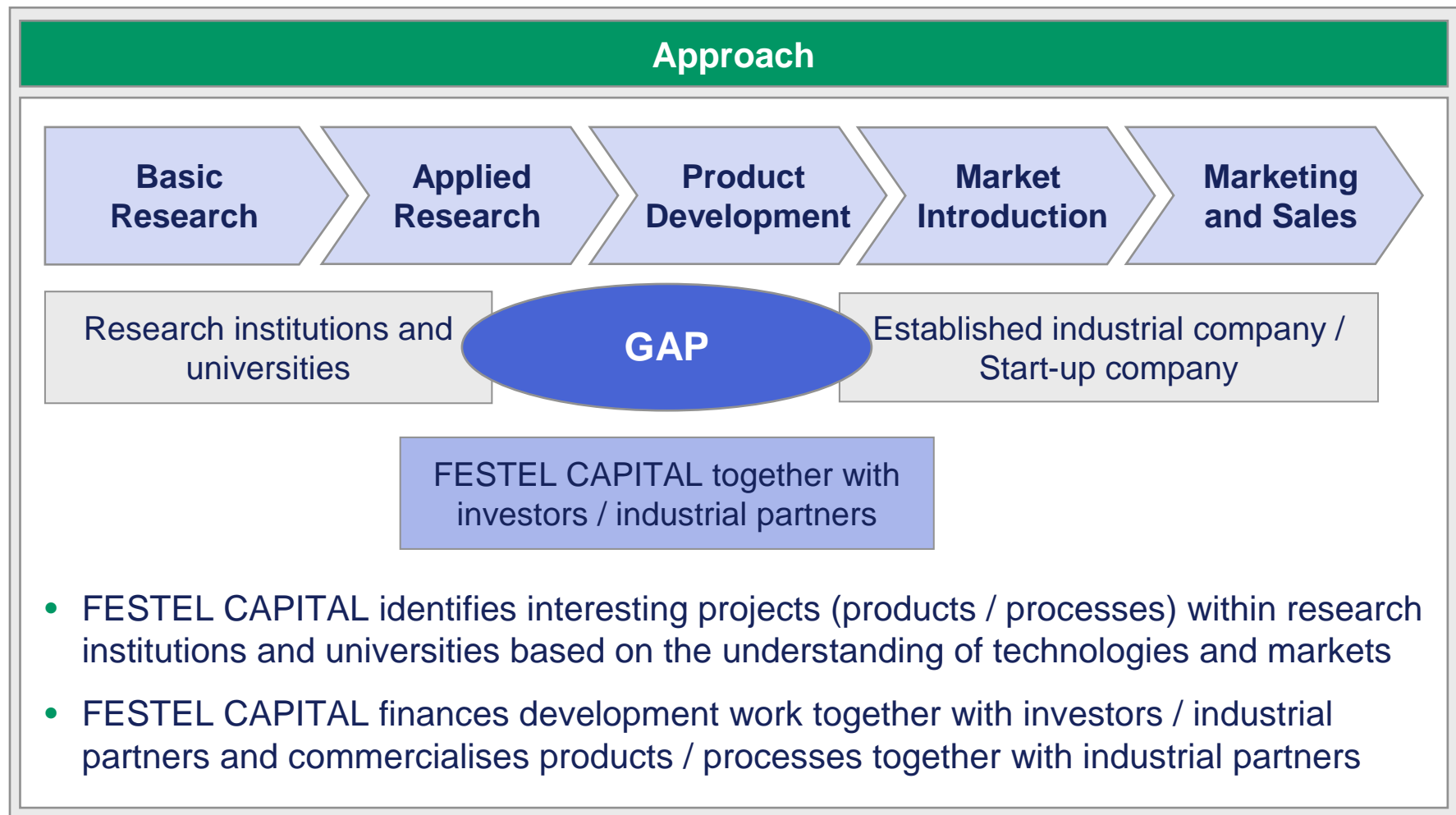
3 Investment Opportunities

**A Appendix: Information on FESTEL CAPITAL**

## FESTEL CAPITAL is an international advisory and investment firm focusing on the development / commercialisation of technologies

Profile	Activities (Examples)
<p>FESTEL CAPITAL is an advisory and investment firm focusing on the development / commercialisation of technologies in the areas of <b>energy, environment, health, infrastructures, materials and nutrition</b></p>	<p><b>FESTEL CAPITAL ...</b></p> <ul style="list-style-type: none"> <li>• supports companies, research institutions and universities to develop / commercialise innovative products and technologies</li> <li>• advises inventors as well as investors to successfully create and develop new businesses</li> <li>• finances development work together with external investors</li> <li>• invests in selected start-up and spin-off companies mainly in the seed phase</li> <li>• fosters the development of technology-related businesses and co-operations with China</li> </ul>
<p>FESTEL CAPITAL combines entrepreneurship, advisory and investment to create and develop <b>innovative businesses</b></p> 	

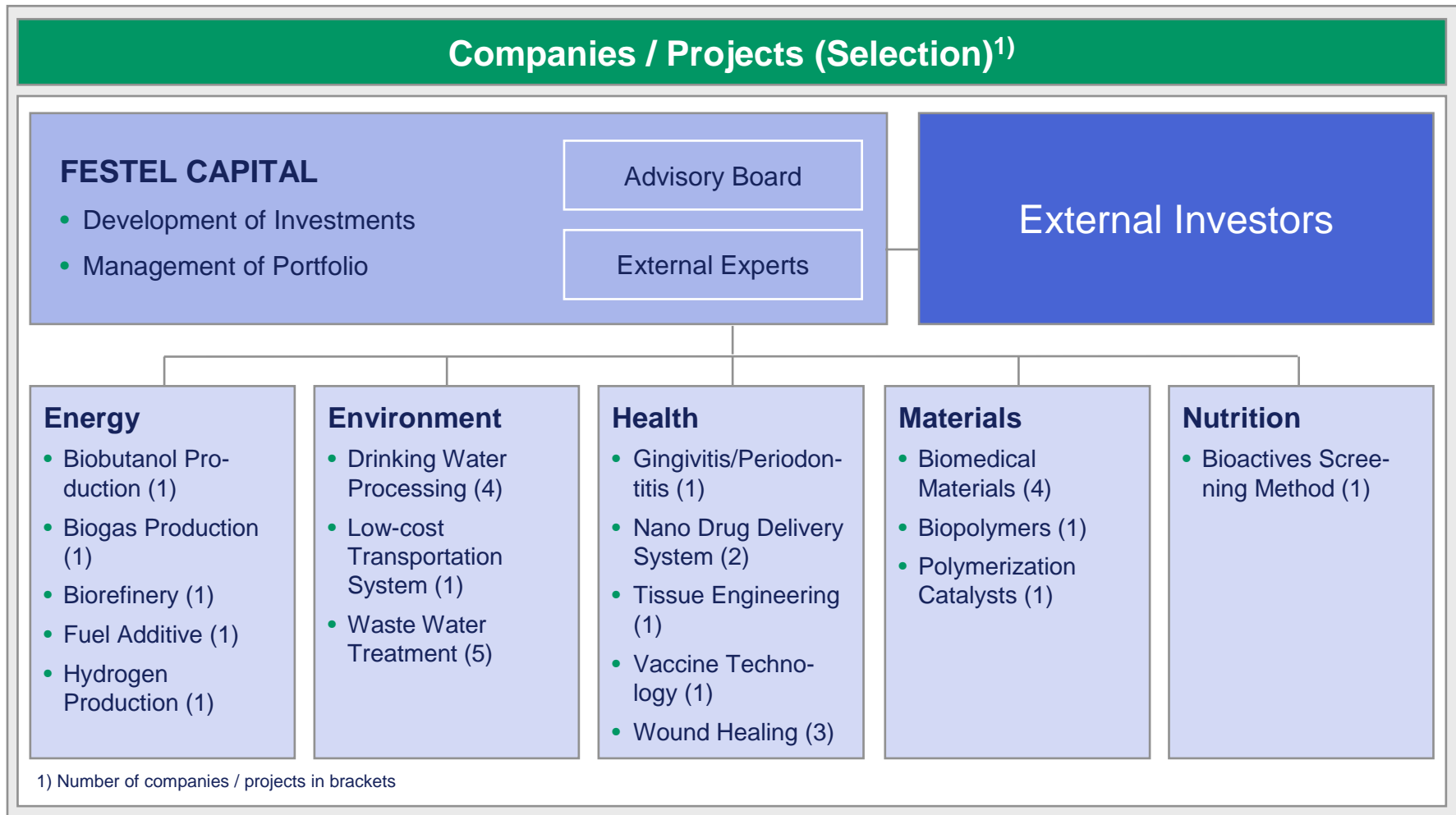
## FESTEL CAPITAL identifies high potential "not market-ready" projects and develops / commercialises them together with investors / industrial partners



## FESTEL CAPITAL has in-depth expertise in chemical / lifescience related technology fields, infrastructures and China

Area	Expertise (Examples)	
Energy	Drug Discovery & Development	<ul style="list-style-type: none"> <li>• Biological Targets</li> <li>• Active Substances</li> <li>• Synthesis &amp; Process Development</li> </ul>
Environment	Industrial Biotechnology	<ul style="list-style-type: none"> <li>• Bioconversion &amp; Biorefineries</li> <li>• Biopolymers</li> <li>• Enzyme Technology</li> </ul>
Health	Material Science	<ul style="list-style-type: none"> <li>• Biomedical Materials</li> <li>• Fuel Cell Components</li> <li>• Tissue Engineering</li> </ul>
Materials	Molecular Biology	<ul style="list-style-type: none"> <li>• Bioactives</li> <li>• Drug Delivery</li> <li>• Wound Healing</li> </ul>
Nutrition	Nanotechnology	<ul style="list-style-type: none"> <li>• Nanobiotech &amp; Nanomedical</li> <li>• Nanocomposites</li> <li>• Nanoelectronics</li> </ul>
Infrastructure	Production Technology	<ul style="list-style-type: none"> <li>• Biopharmaceuticals</li> <li>• Catalysis</li> <li>• Process Optimisation</li> </ul>
China	Renewable Energy	<ul style="list-style-type: none"> <li>• Bioenergy</li> <li>• Biofuels &amp; Synthetic Fuels</li> <li>• Solar Energy</li> </ul>
	Water Technology	<ul style="list-style-type: none"> <li>• Drinking Water Processing</li> <li>• Waste Water Treatment</li> <li>• Water Chemicals</li> </ul>

**FESTEL CAPITAL is building up a portfolio of companies / projects in the investment areas energy, environment, health, materials and nutrition**



FESTEL CAPITAL has worked together with leading technology-oriented companies

Partners (Selection)

