



Biofuel Technologies – Situation and Outlook in Europe

Production Technologies & Investment Opportunities

European Energy Venture Fair 2006

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

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- FESTEL CAPITAL has special expertise and experience in business development and partnering in **China**

- **For queries, please contact**

Dr. Gunter Festel

Schuermattstr. 1, CH-6331 Huenenberg/Zug

E-Mail gunter.festel@festel.com

Internet www.festel.com

Phone/Fax +41 41 780 1643

Mobile Switzerland +41 79 6527 112

Mobile Germany +49 177 356 1837

Mobile China +86 1350 1880 189

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Abbreviations

Abbreviations

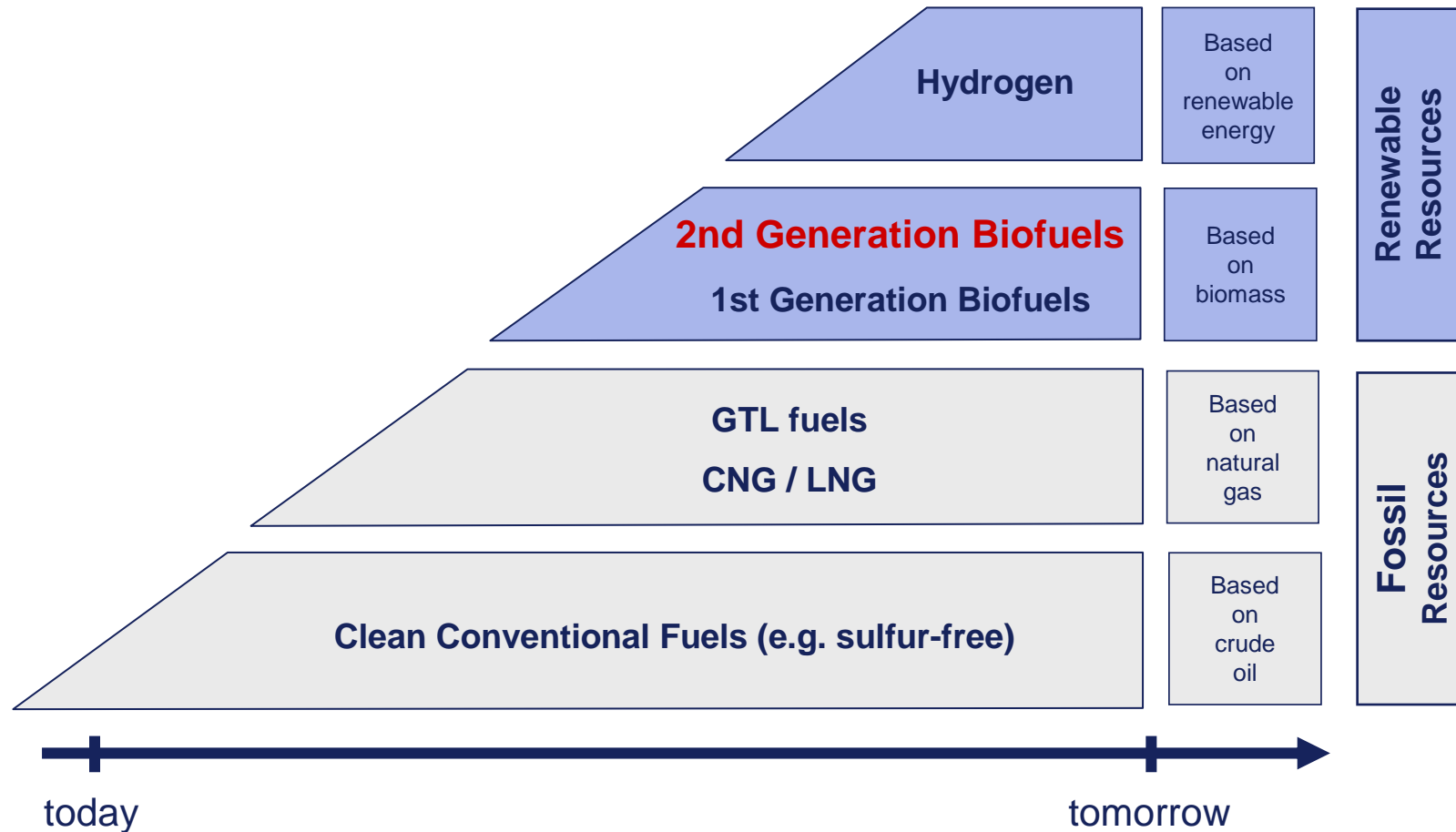
- BTL Biomass-to-Liquid
- CNG Compressed Natural Gas
- CTL Coal-to-Liquid
- DME Dimethyl Ether
- FAME Fatty Acid Methyl Ester
- FT Fischer-Tropsch
- GHG Greenhouse Gas
- GTL Gas-to-Liquid
- H₂ Hydrogen
- l Litre
- kt Kilotonne
- LNG Liquefied Natural Gas
- LPG Liquefied Petroleum Gas
- MeOH Methanol
- RME Rape Seed Methyl Ester
- SNG Synthetic Natural Gas

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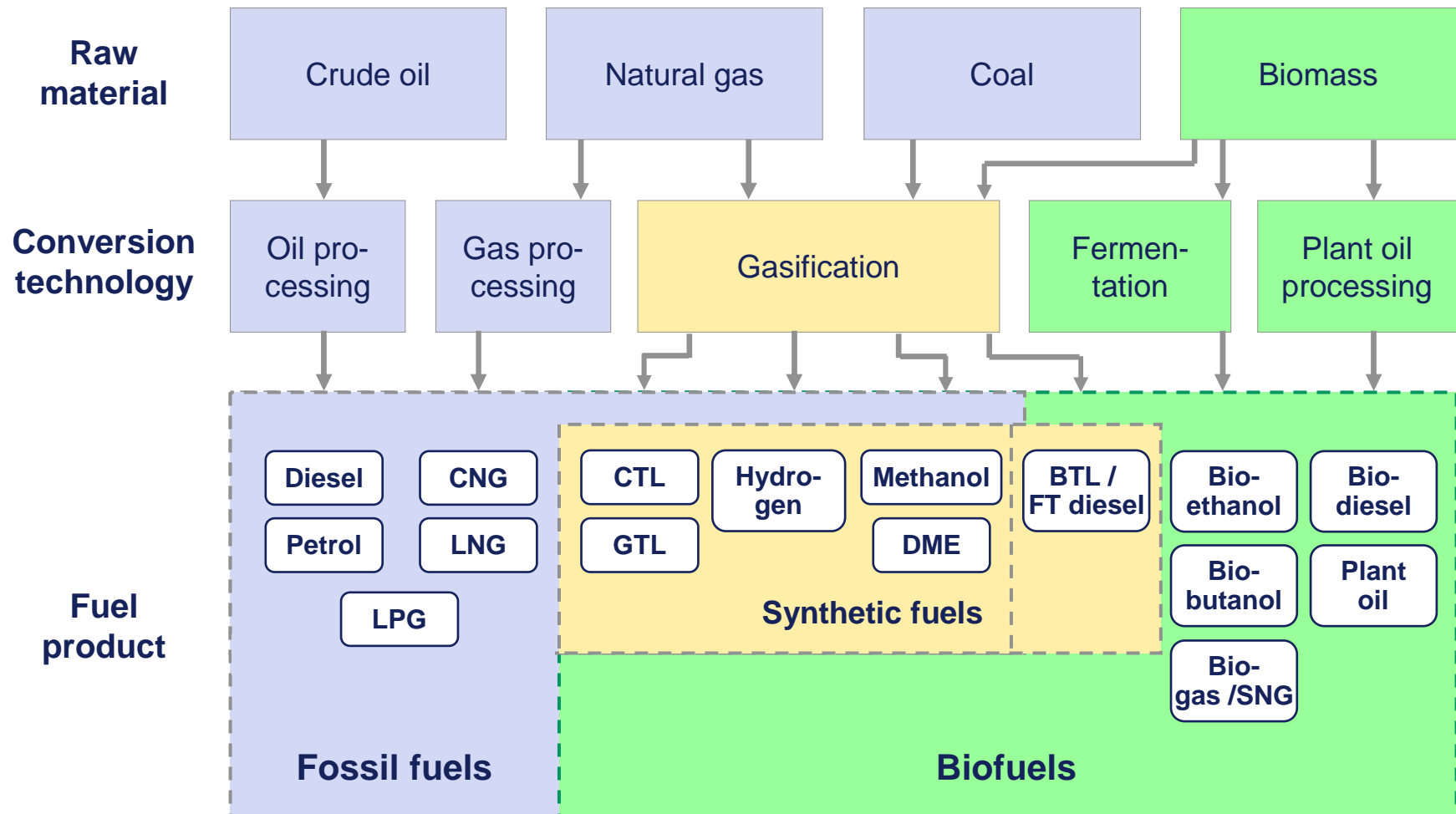
Fuel Types and Criteria - Fuel Generations

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

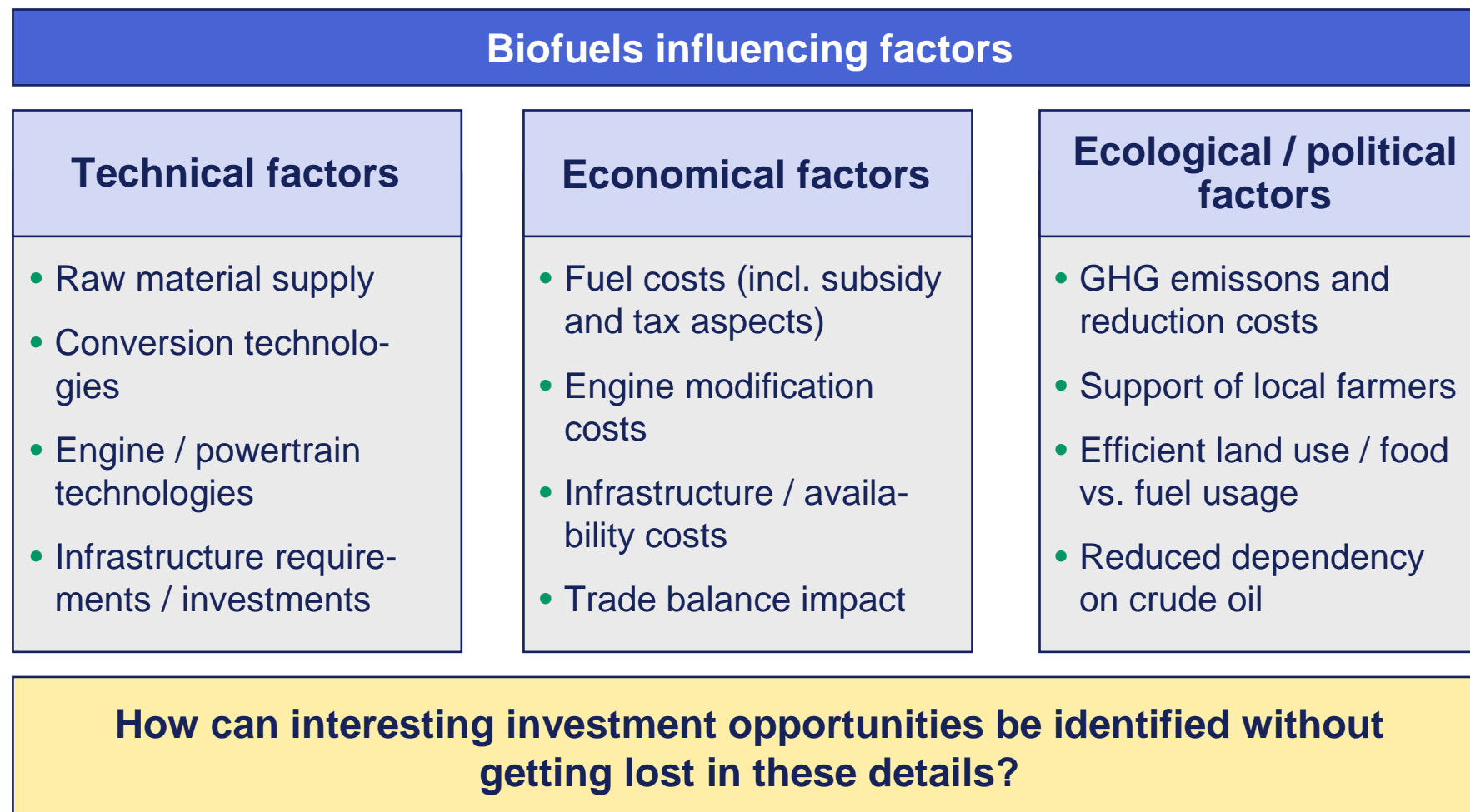


Fuel Types and Criteria - Fuel Types

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
- Some chemical/physical properties as existing fuels (e.g. energy content)

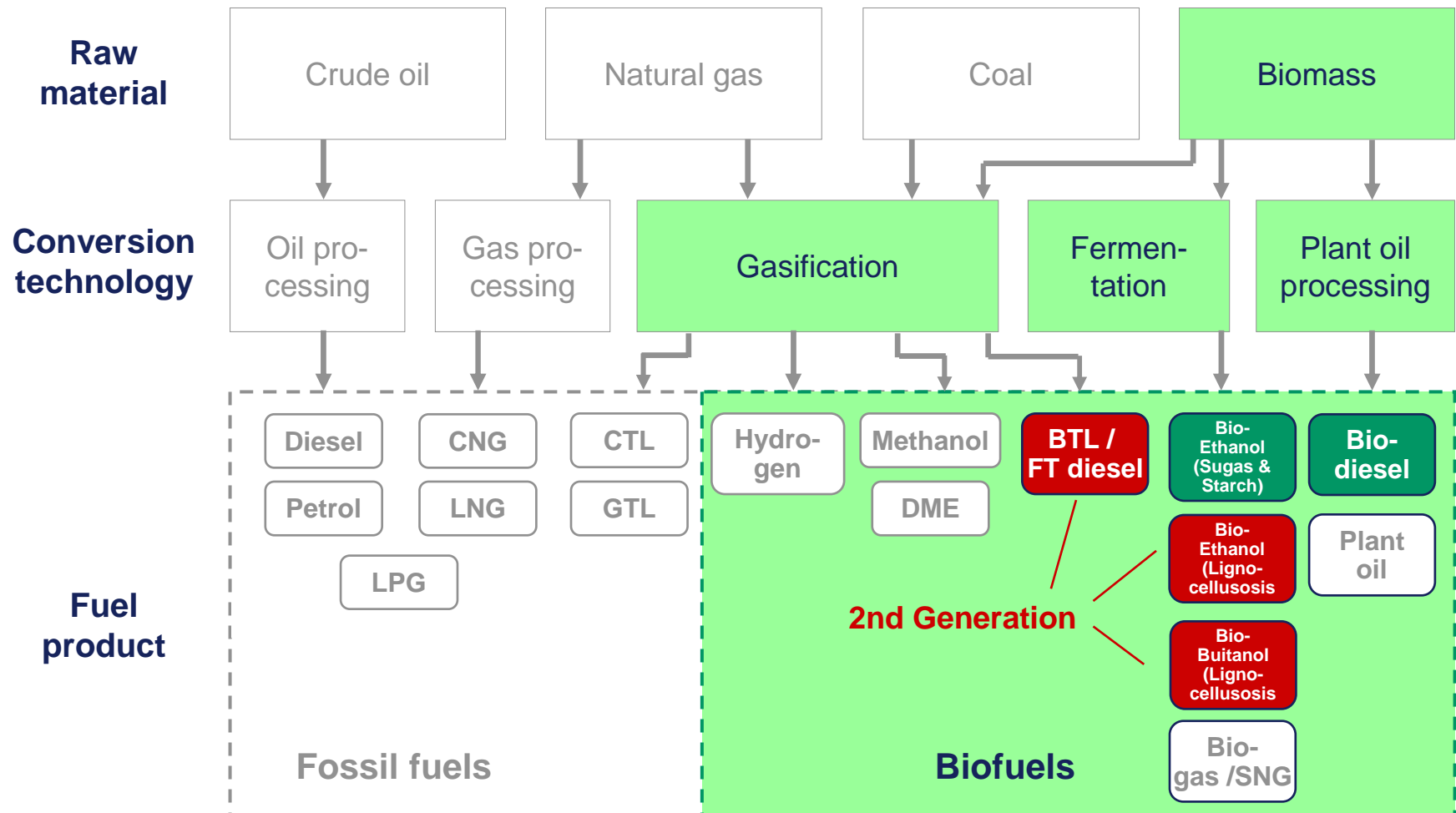
Important are economical factors and not ecological aspects - the deciding factor for market success are the costs for the car owner at the filling stations

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

Fuel Types and Criteria - Conclusion

2nd generation biofuels have very attractive long-term prospects



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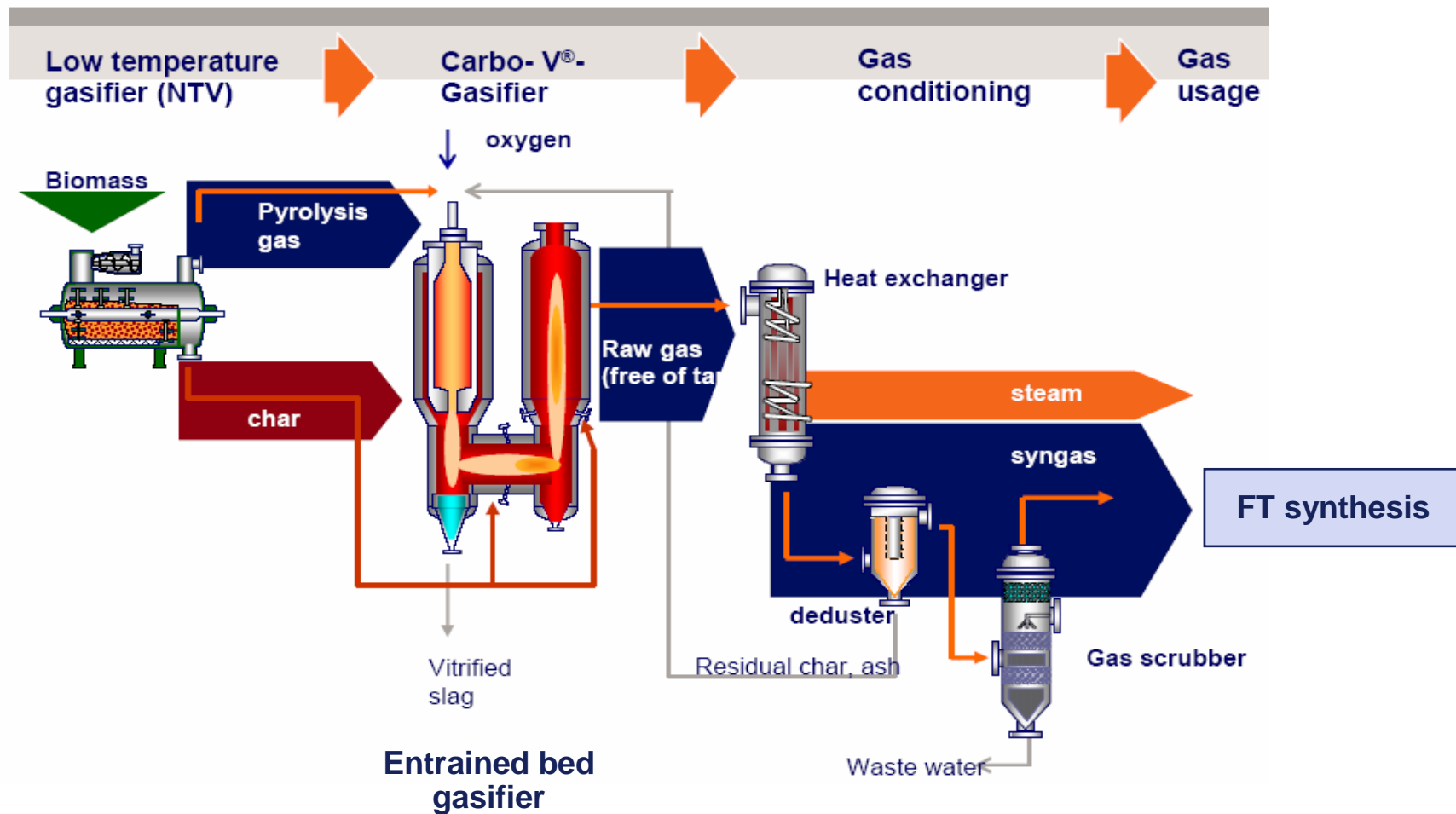
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Appendix: Information on FESTEL CAPITAL

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

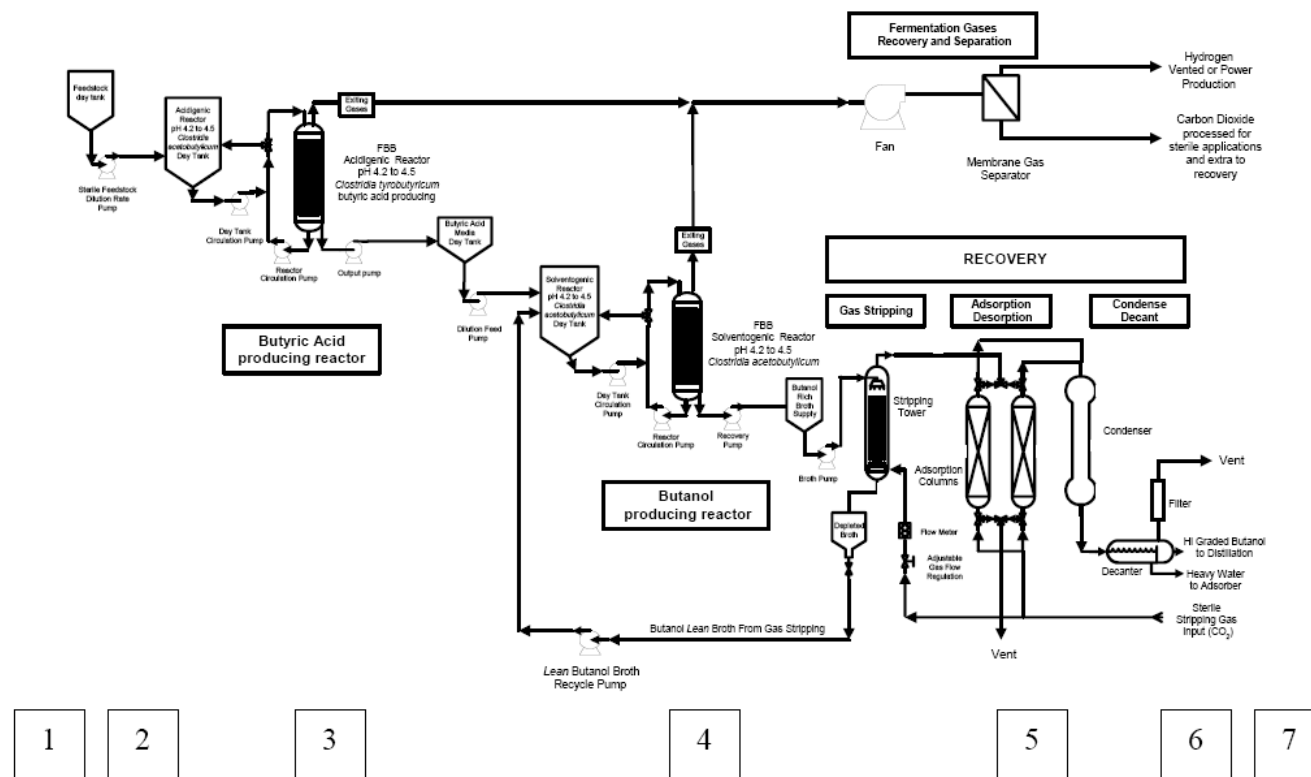
Shell is cooperating with Choren to build the first commercial scale BTL production plant

- 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** (acidigenic)
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	60 USD/barrel	10,000	2,600	0.37	0.05	1.30
Biobutanol	Corn	USA	Large scale 2008	200	240	0.33	0.02	1.30
Biobutanol	Straw	USA	Large scale 2008	200	240	0.30	0.05	1.30
 Biobutanol	Straw	Europe	Large scale 2008	200	240	0.35	0.09	1.30
Bioethanol	Straw	USA	Small scale 2008	50	60	0.45	-0.13	1.30
Bioethanol	Straw	USA	Large scale 2008	200	240	0.30	0.02	1.30
Bioethanol	Straw	USA	Large scale 2012	200	240	0.27	0.05	1.30
Bioethanol	Straw	Europe	Large scale 2008	200	240	0.36	0.01	1.30
 Bioethanol	Wheat	Europe	With tax	200	200	0.48	-0.11	1.30
 Bioethanol	Wheat	Europe	Without tax	200	200	0.48	0.54	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	60 USD/barrel	10,000	2,600	0.37	0.06	1.10
 Biodiesel	Rape seed	Europe	With tax	200	40 ¹⁾	0.54	-0.13	1.10
 Biodiesel	Rape seed	Europe	Without tax	200	40 ¹⁾	0.54	0.34	1.10
 BTL	Wood	Europe	Small scale with tax	120	180	1.02	-0.61	1.10
 BTL	Wood	Europe	Large scale with tax	1,200	1,800	0.82	-0.41	1.10
 BTL	Wood	Europe	Large scale without tax	1,200	1,800	0.82	0.06	1.10

1) Including oil mill

Source: FESTEL CAPITAL analysis

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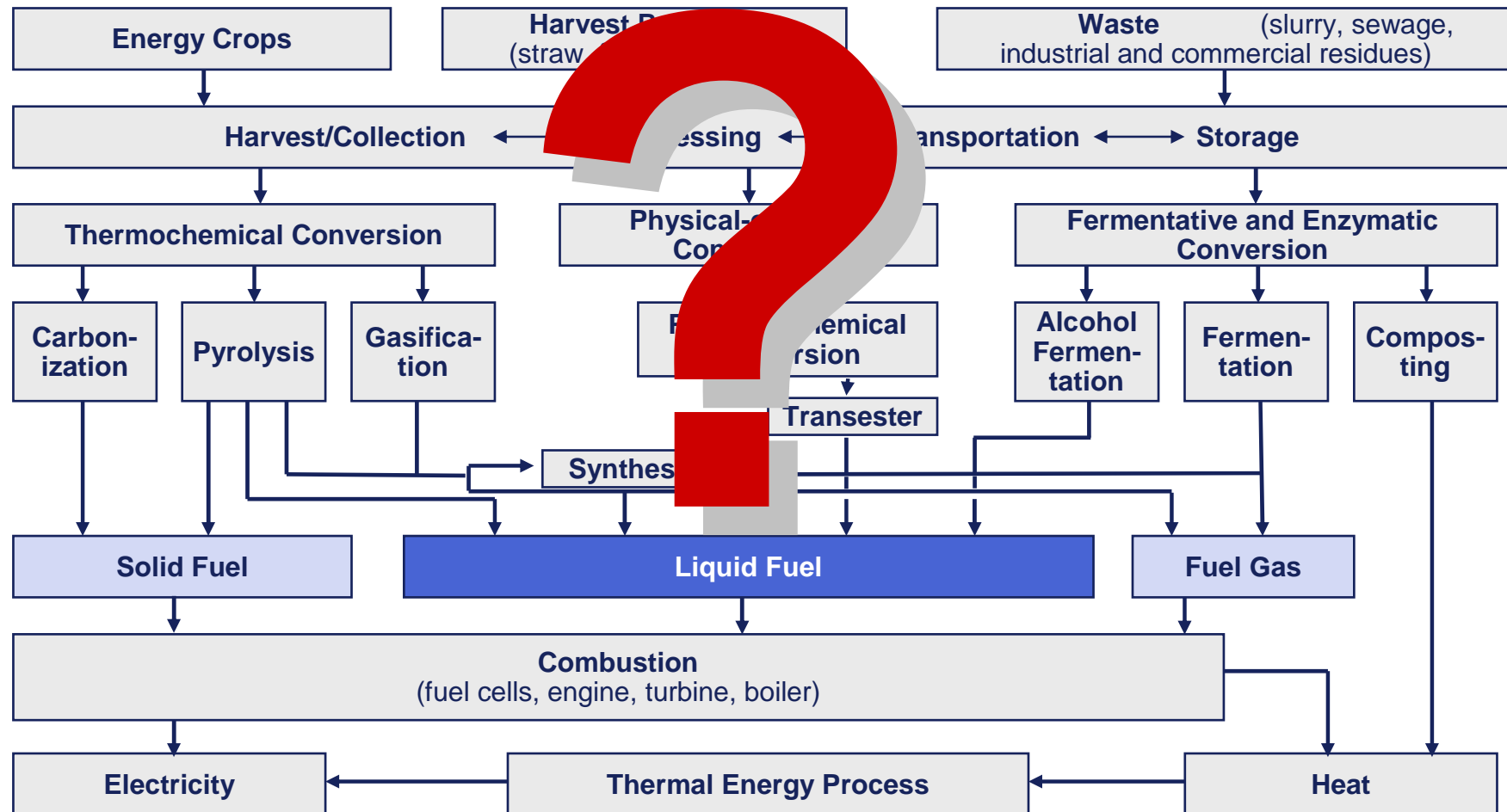
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Investment Opportunities - Options

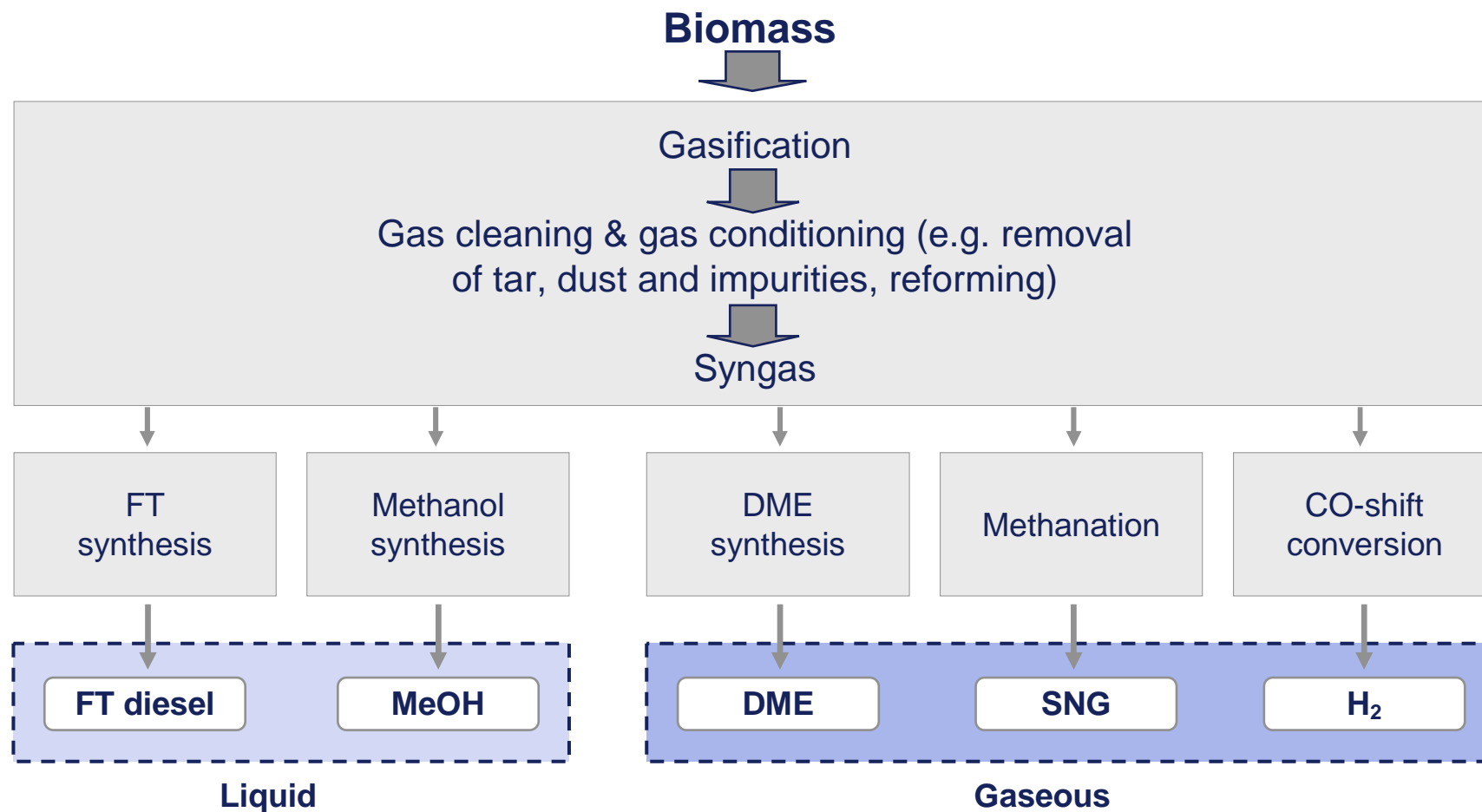
There are many pathways for the energetic utilisation of the different kinds of biomass



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



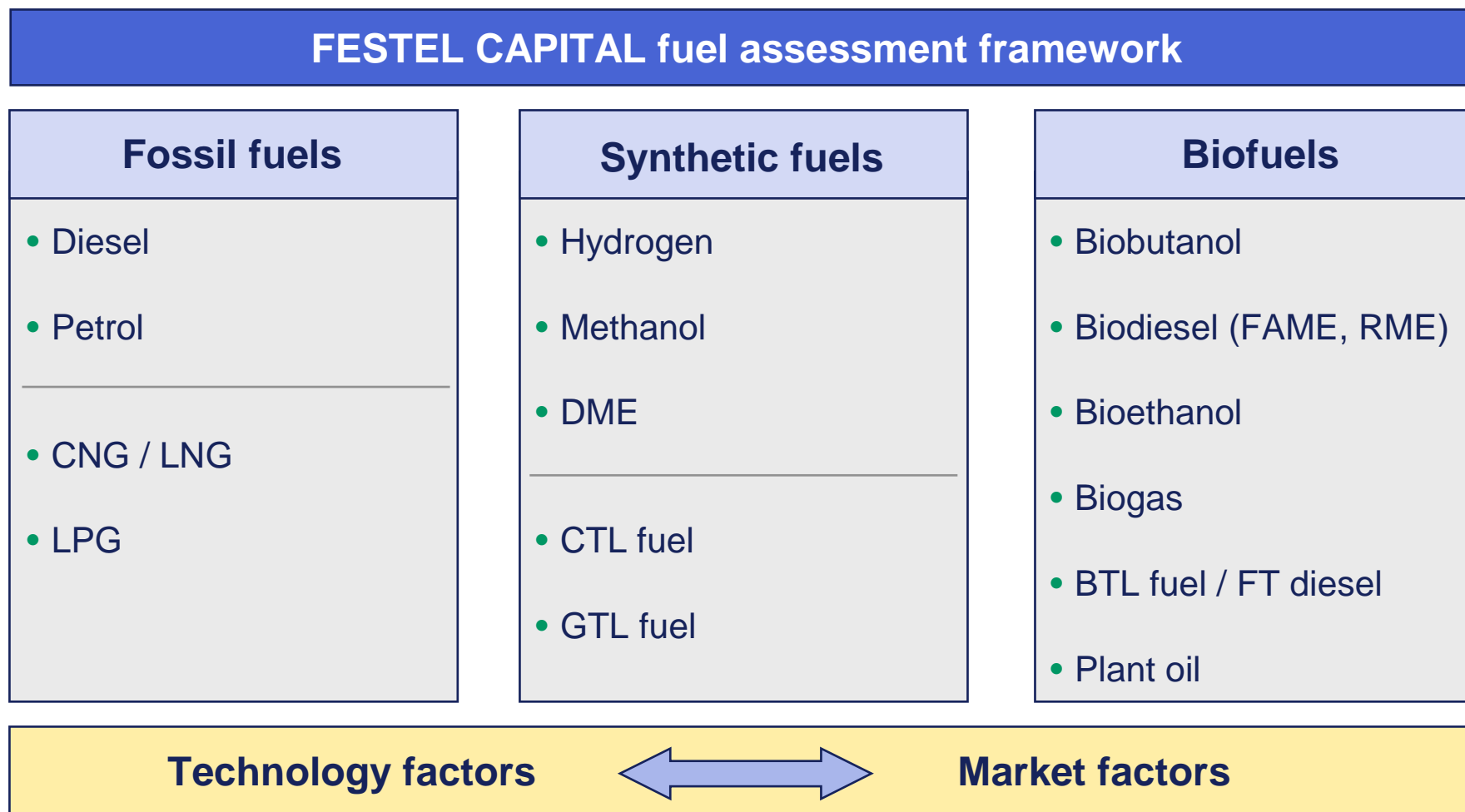
Source: Institute for Energy and Environment Leipzig, Future Energy

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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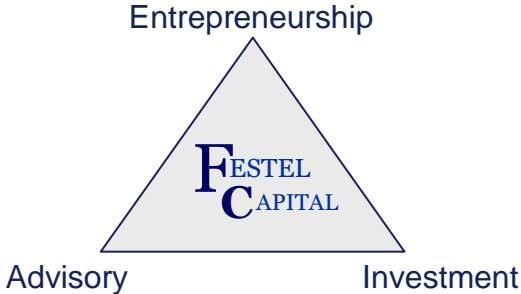
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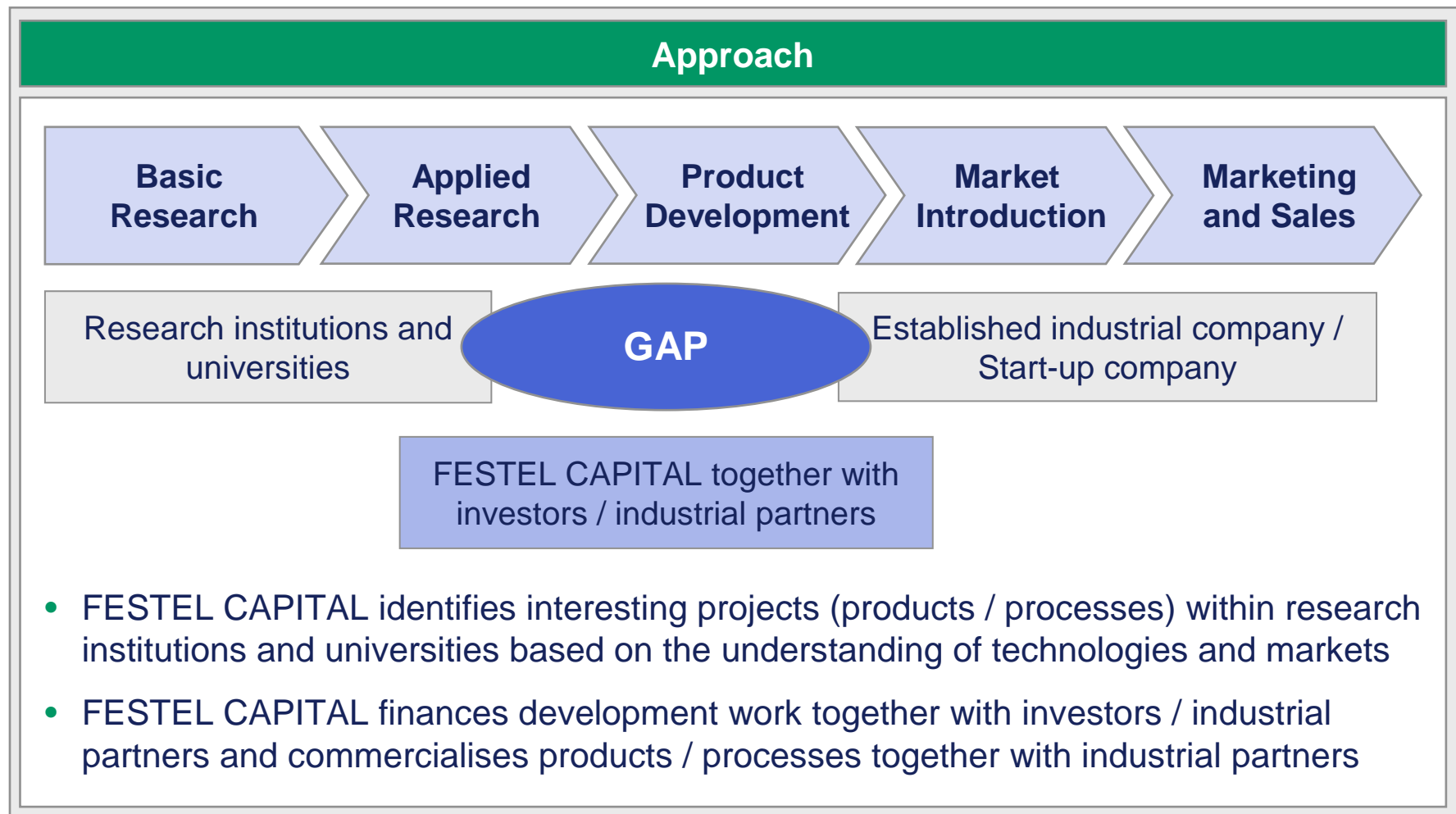
3 Investment Opportunities

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 energy, environment, health, infrastructures, materials and nutrition</p>	<p>FESTEL CAPITAL ...</p> <ul style="list-style-type: none"> • supports companies, research institutions and universities to develop / commercialise innovative products and technologies • advises inventors as well as investors to successfully create and develop new businesses • finances development work together with external investors • invests in selected start-up and spin-off companies mainly in the seed phase • fosters the development of technology-related businesses and co-operations with China
<p>FESTEL CAPITAL combines entrepreneurship, advisory and investment to create and develop innovative businesses</p> <div style="text-align: center;">  </div>	

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

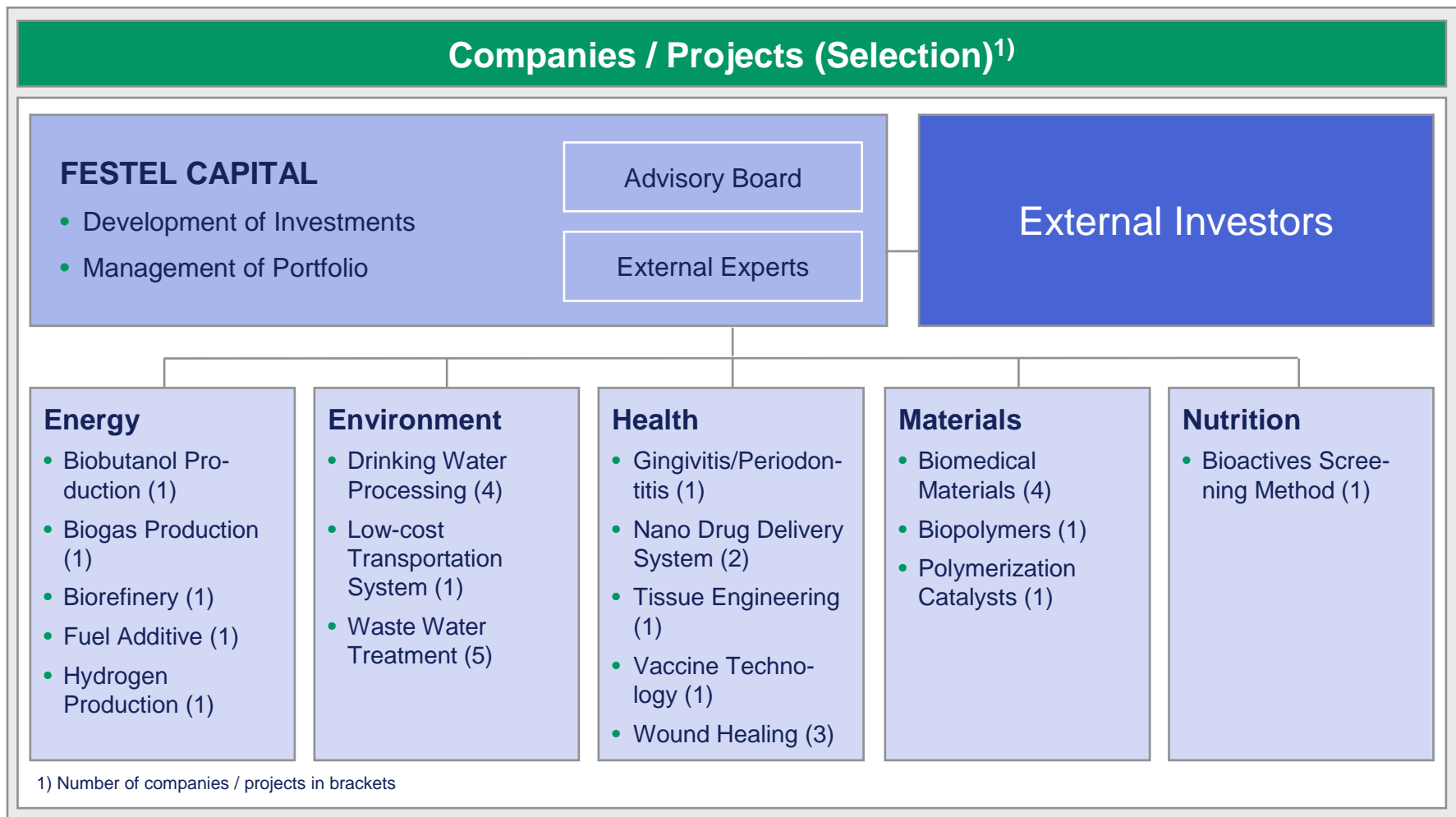


- FESTEL CAPITAL identifies interesting projects (products / processes) within research institutions and universities based on the understanding of technologies and markets
- FESTEL CAPITAL finances development work together with investors / industrial partners and commercialises products / processes together with 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"> • Biological Targets • Active Substances • Synthesis & Process Development
Environment	Industrial Biotechnology	<ul style="list-style-type: none"> • Bioconversion & Biorefineries • Biopolymers • Enzyme Technology
Health	Material Science	<ul style="list-style-type: none"> • Biomedical Materials • Fuel Cell Components • Tissue Engineering
Materials	Molecular Biology	<ul style="list-style-type: none"> • Bioactives • Drug Delivery • Wound Healing
Nutrition	Nanotechnology	<ul style="list-style-type: none"> • Nanobiotech & Nanomedical • Nanocomposites • Nanoelectronics
Infrastructure	Production Technology	<ul style="list-style-type: none"> • Biopharmaceuticals • Catalysis • Process Optimisation
China	Renewable Energy	<ul style="list-style-type: none"> • Bioenergy • Biofuels & Synthetic Fuels • Solar Energy
	Water Technology	<ul style="list-style-type: none"> • Drinking Water Processing • Waste Water Treatment • Water Chemicals

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)

