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High integrative, CO_2 negative, high efficient power generation from ash rich biomass coupled with production of algae based bio oils as well as black earth avoiding effluents at Hainhaus/Odenwald using the BtVB process

Prof. Dr. Andreas Hornung, Dr. Andreas Apfelbacher, Sudhakar Sagi
European Bioenergy Research Institute EBRI
Aston University, UK

Conception, Chile
04.05.09

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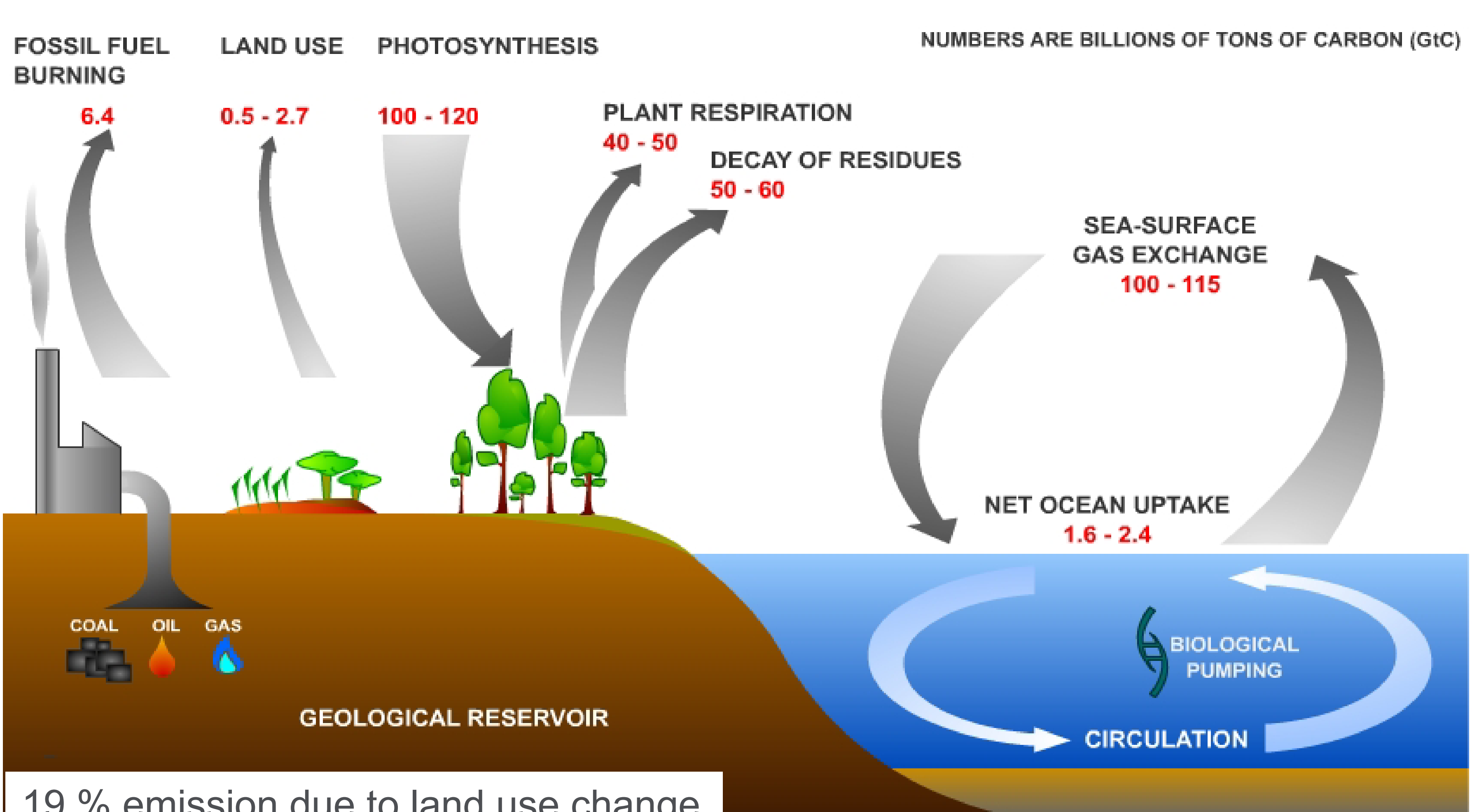
THE GLOBAL CARBON CYCLE



19 % emission due to land use change

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Global impacts resulting from climate change!

- Switzerland – Wallis valley
- India China – 25 % water by galciers
- Andes – ?

- All measures given or proposed will not stop the development or even turn it! - They will slow down the development

- Mankind need to introduce an “active” carbon sequestration instead of carbon dioxide sequestration only

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Intermediate Pyrolysis

Pyrolysis

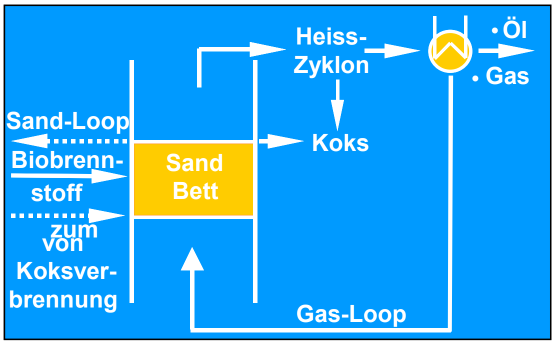
- Various reactors and three main pyrolysis procedures in practice

- Fast pyrolysis
- Intermediate pyrolysis
- Slow pyrolysis

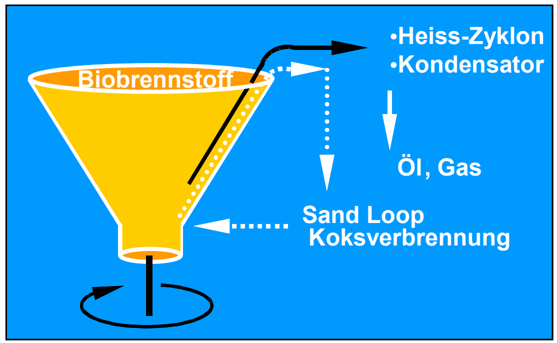
- Most significant difference is the residence time of the solid phase within the reactor – seconds, minutes, up to hours and correlated energy transfer and temperature distribution
- Gas phase residence times for fast and intermediate pyrolysis are usually below 2s

Fast Pyrolysis Reactors

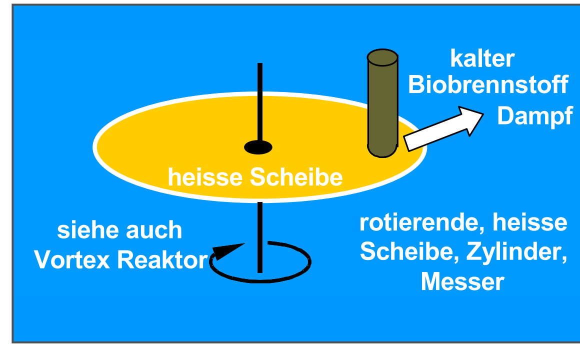
Fluidised bed



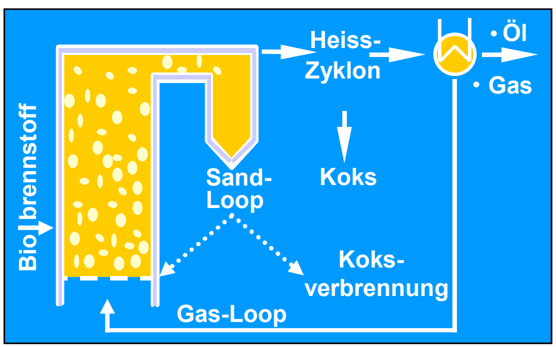
Rotating cone



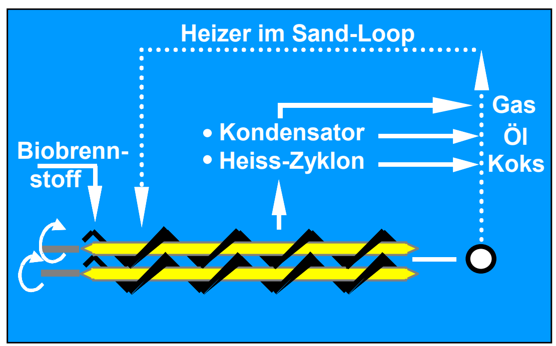
ablative reactor



Circulated fluidised bed



Twin screw



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	Fast pyrolysis 500°C	Slow pyrolysis 420°C	Slow pyrolysis 500°C	Slow pyrolysis 600°C
Total liquid, wt% on dry feed	75.0	51.9	52.8	51.9
Char yield, wt% on dry feed	8.5	33.6	31.9	32.0
Gas yield, wt% on dry feed	10.9	13.4	11.3	11.4
Closure, wt% on dry feed	94.4	98.9	96.0	95.3
Heating rate, °C/min	–	14.5	13.7	12.6
		(Slow pyrolysis liquid from dry ice and acetone condenser – water and light ends)		
Water content (%)	20.8	45.9	48.2	43.8
Char content (%)	0.04	0.02	0.03	0.03
Viscosity, cP	53.8	1.4	1.1	1.8
PH	2.4	2.3	2.5	2.4
Elemental analysis (%)				
C	43.9	28.13	28.00	27.39
H	7.4	9.38	9.38	9.55
N	0.07	0.03	–	–
O by difference	48.6	62.5	62.7	63.1
HHV (wet), MJ/kg	14.4	6.8	6.4	7.1
		(Slow pyrolysis liquid from EP – heavy organic fraction)		
Water content (%)	–	8.6	11.3	7.8
PH	–	2.8	2.6	2.6
Elemental analysis (%)				
C	–	54.8	53.75	55.30
H	–	7.14	7.41	7.23
N	–	0.10	0.13	0.16
O by difference	–	38.0	38.72	37.32
HHV (wet), MJ/kg	–	21.3	20.4	21.8

A.V. Bridgwater*, P. Carson and M. Coulson
A comparison of fast and slow pyrolysis liquids from mallee
Int. J. Global Energy Issues, Vol. 27, No. 2, 2007

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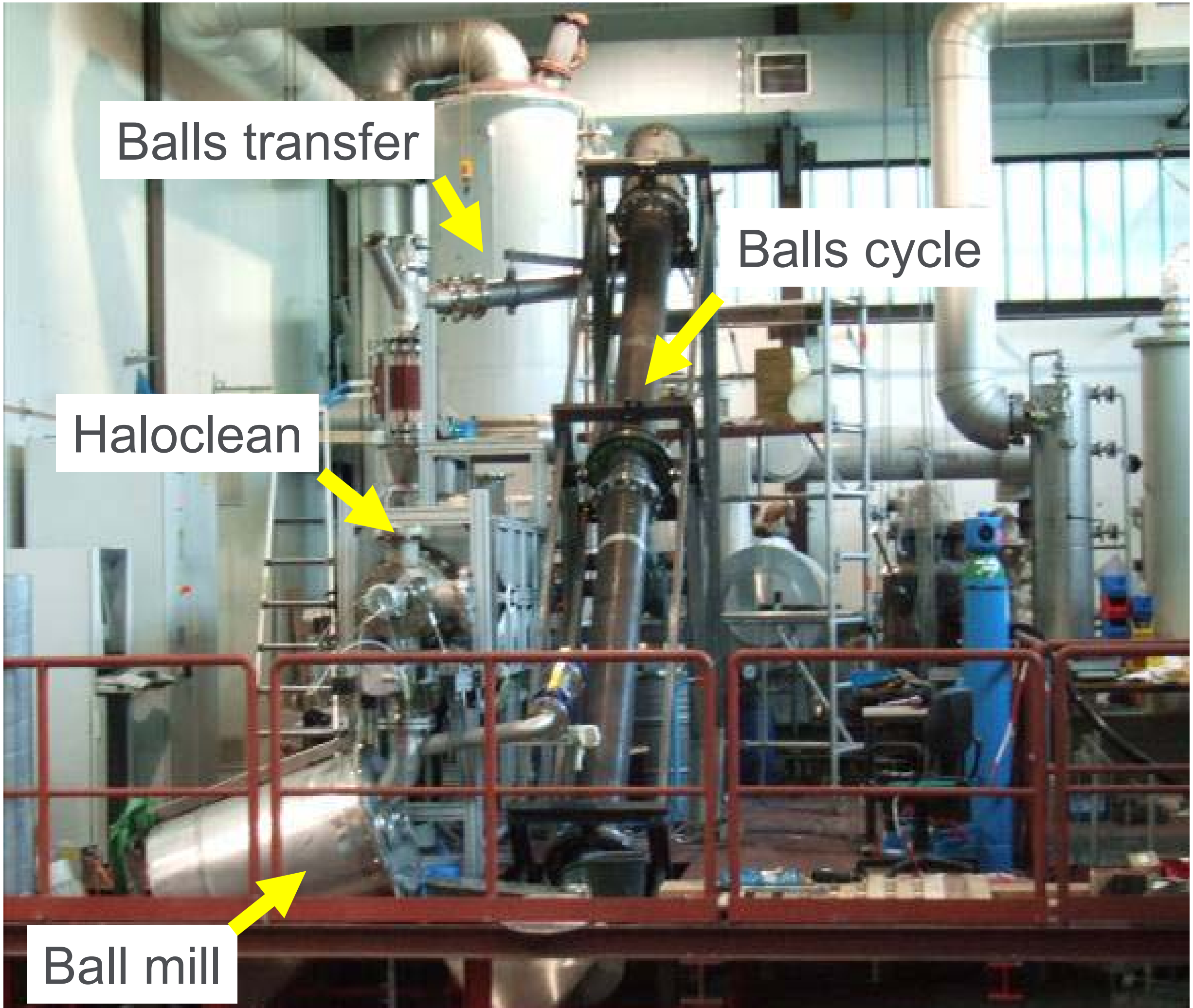
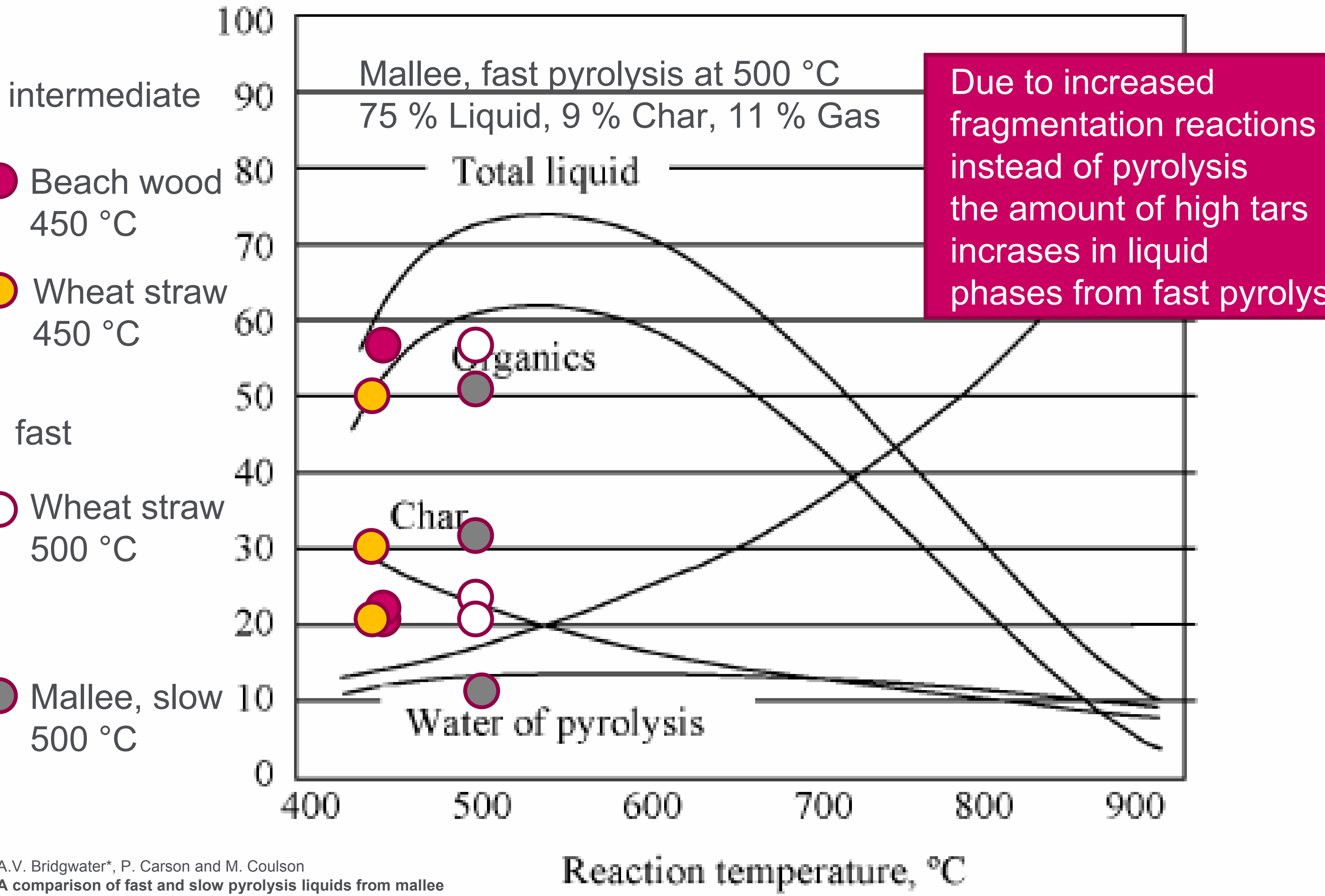
Intermediate Pyrolysis – Haloclean ®

- Flexible feed stock (different biomass, shapes and mixtures of those
- High quality pyrolysis products and variable yields of products
- Economic plant size at 12,000 t/a – 20,000 t/a



Feed		Yield			Energy (MJ/kg)		
Amount	Tempera ture	Coke	Liquids	Gas	Coke	Liquid	RawMat
Olive stones 169,3 kg	450°C	30%	47%	23%	30	Oil: 30 Water: 10	
Rice husk 86,3 kg	450°C	41%	41%	18%	21	Oil: 27 Water: 10	15
Rape seeds 611,15 kg	450°C	33%	57%	10%	30	Oil: 34 Water: 2	26
	500°C	15%	52%	33%	26	Oil: 35 Water: 2,5	26
Rape residues 1292 kg	450°C	38%	45%	17%	24	Oil: 16 Water: 2,5	19
	550°C	25%	50%	25%	24		19
Beechwood 148,7 kg	450°C	23%	56%	21%			
	500°C	21%	57%	22%			
Coco nut 13 kg	450°C	34%	52%	14%			22
Rice bran 3 kg	500°C	20%	38%	42%			
Brewers grain 2 kg	450°C	23%	51%	26%			
Wheat straw >15t (2005)	450°C	30%	50%	20%	25	Oil: 21 Water: 6	16

Typical liquid, char and gas yields for fast pyrolysis vs. temperature



A.V. Bridgwater*, P. Carson and M. Coulson
A comparison of fast and slow pyrolysis liquids from mallee
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Bio-thermal Valorisation of biomass (BtVB) for CO_2 negative power generation

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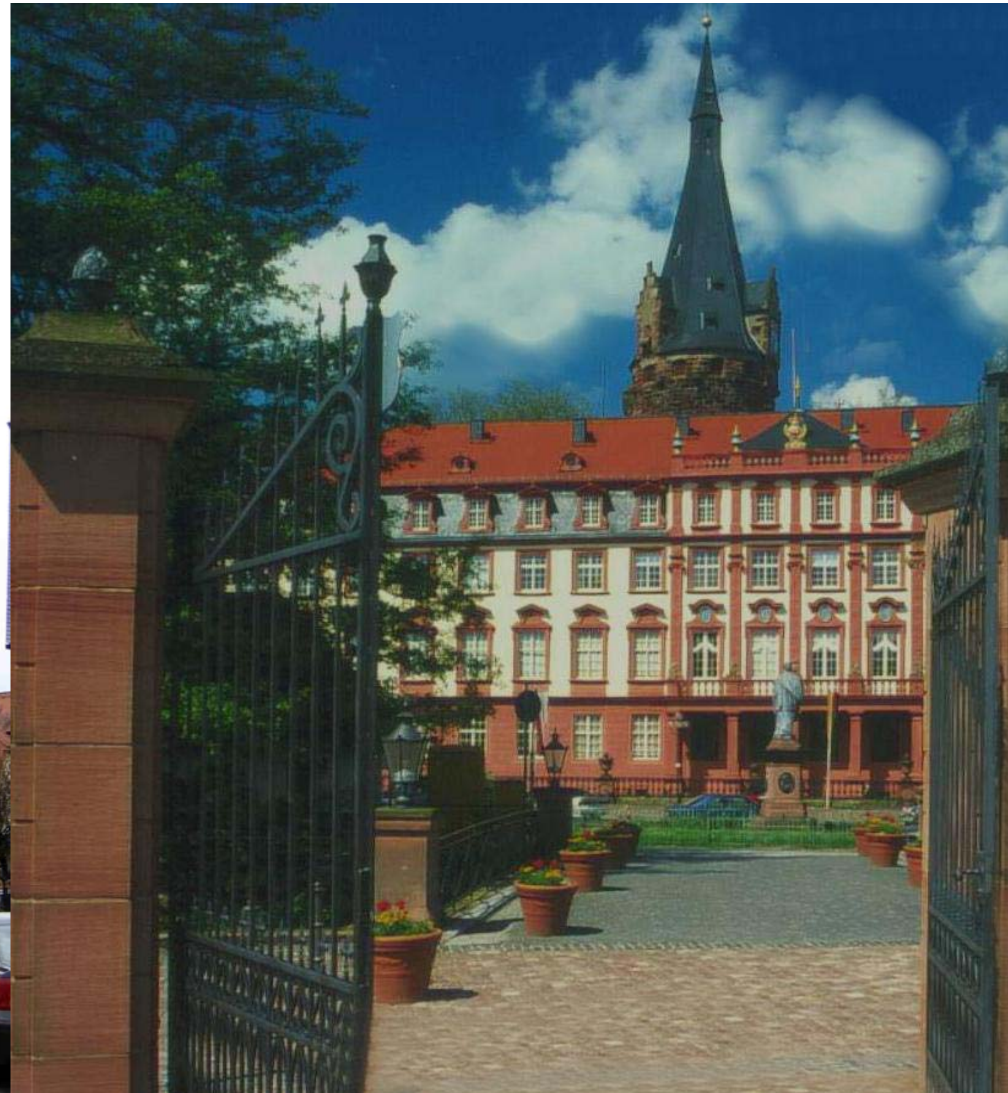

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Odenwald, Germany

- Ash rich and high moisture feedstock: energy grass, residue wood, algae, biogas residue
- Integrated production of fertilizer (Black Earth)
- Immediate pyrolysis gasification without filtration or condensation

- 10 MW power plant based on Güssing type gasifier and CHP; 3,5 MWel, 4,5 MWth
- Ashes remain in char and are used on 1,5 ha test field as fertiliser
- CO_2 reduction by carbon sequestration
- Realisation: approx. 2011
- Investment: > 20 Mio. EUR

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The future, more than a commercial site

Energy Park

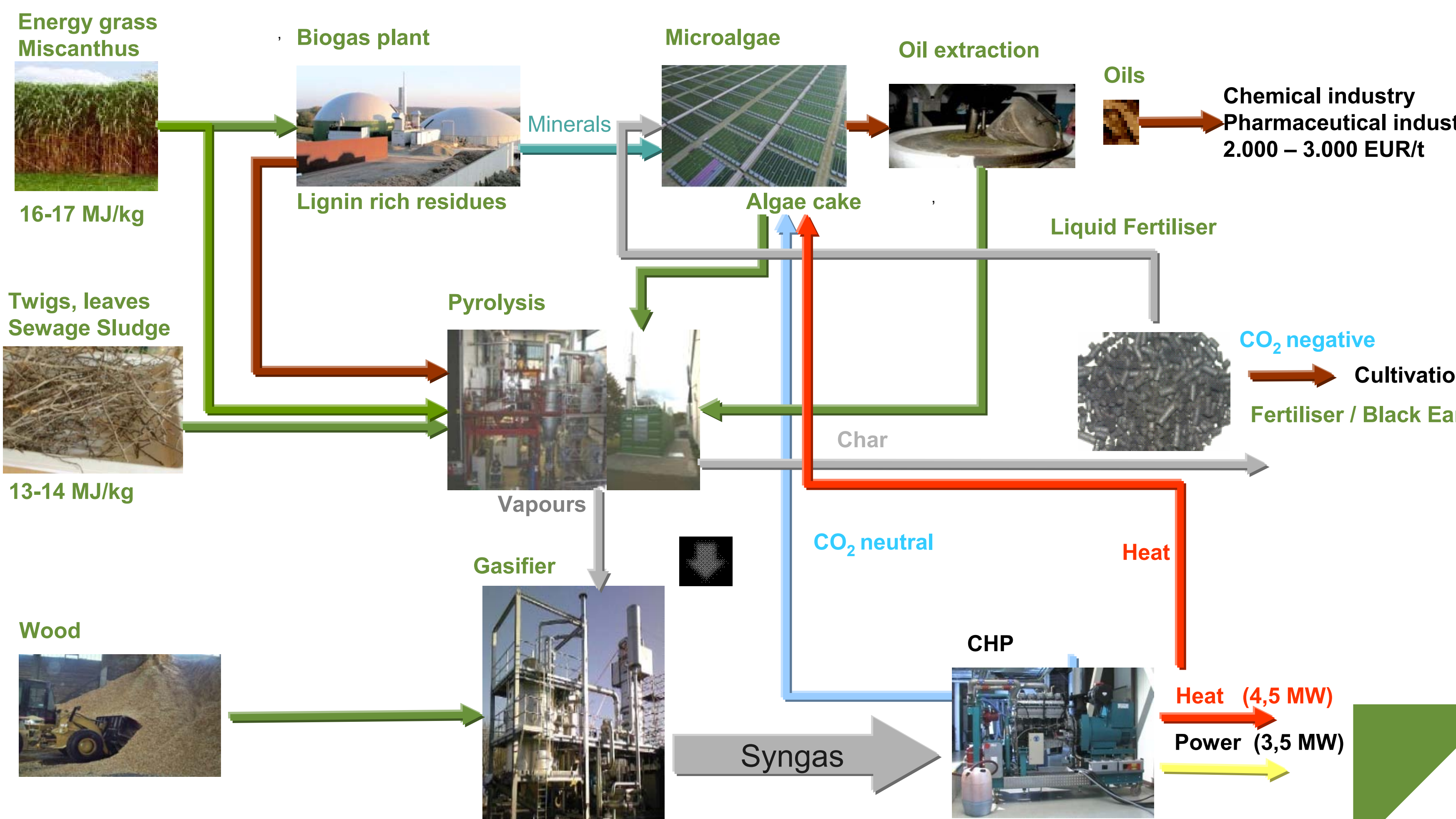
αΩ

Aston

Odenwald

Energy partnership in application, research and education

Bio-thermal valorisation of biomass - BtVB Process



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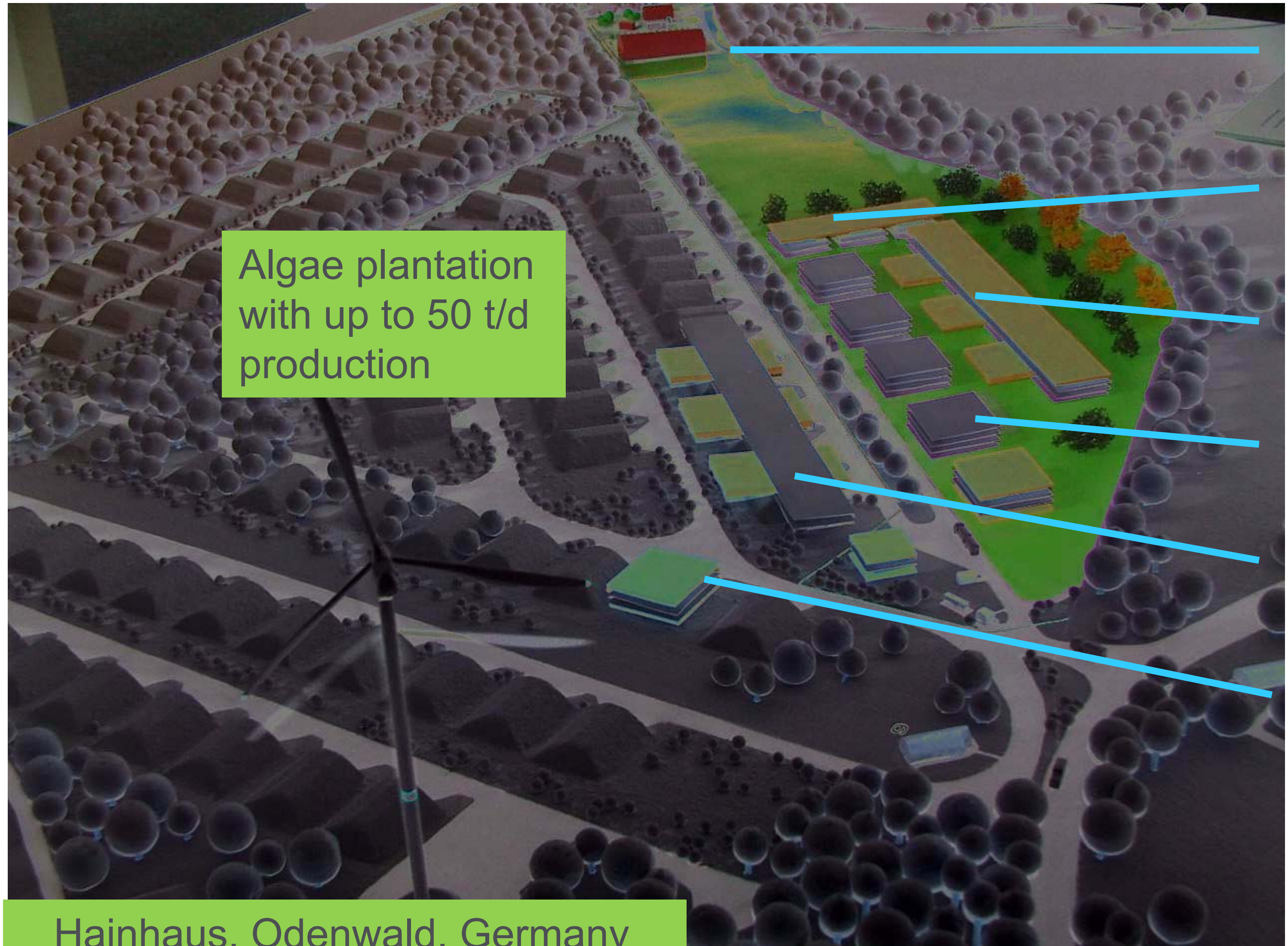

Hainhaus, Odenwald, Germany

Are we dreaming?
Or at least dreaming together with others? NO!

- **Boeing Executive on Biofuel Future 04/09**

  From Smart Brief: In **an interview with Germany's Spiegel Online** (in English), Billy Glover, Boeing's chief environmental strategist, said, "The biofuels that can be available in the next few years will have a 60 percent lower carbon footprint than fossil fuel," adding that carbon trading schemes will help drive prices down. And while he is not sure about some estimates that the entire global aviation industry could be fueled by an algae culture the size of Belgium, he told Spiegel, "we are very pleasantly surprised by the innovation and the progress," in algae research.

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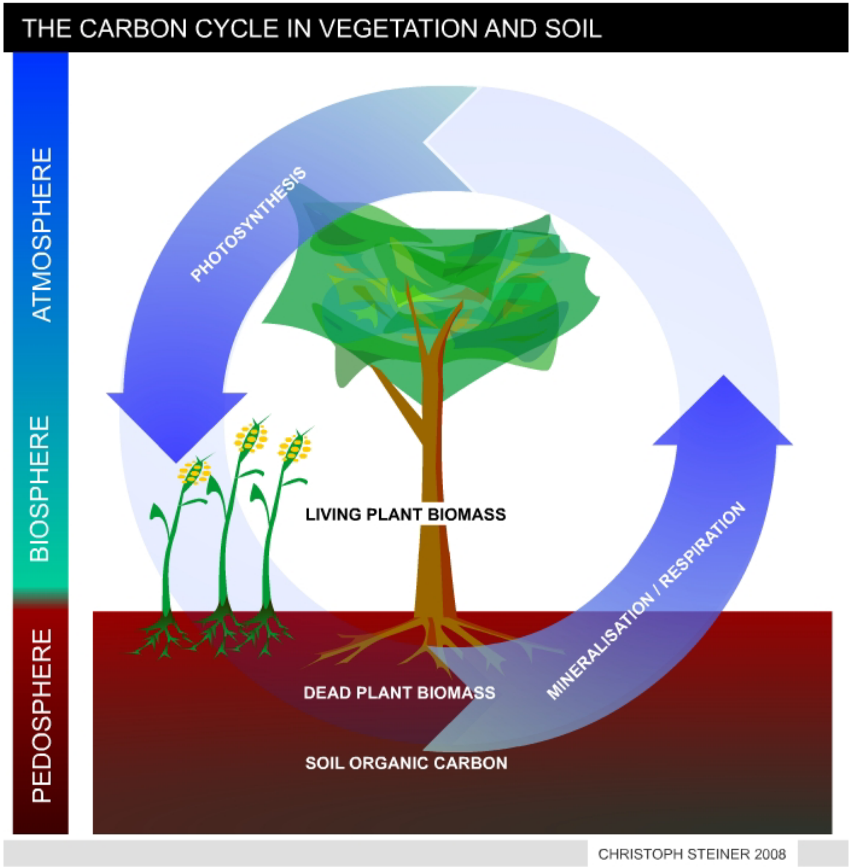
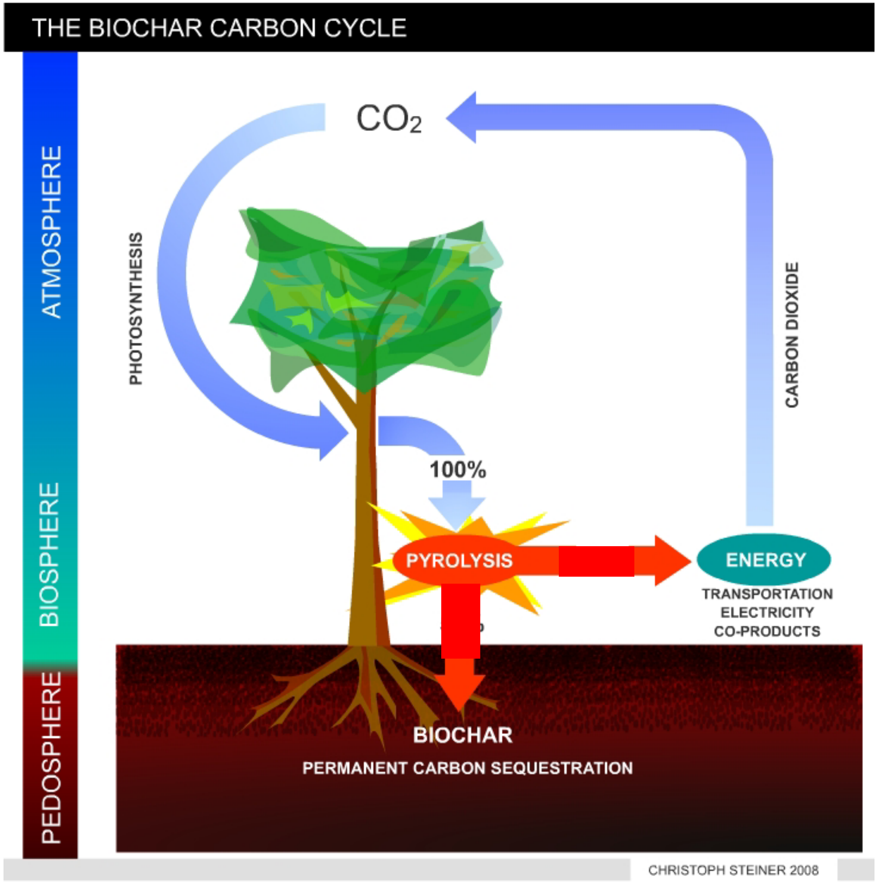




It is not enough to use biomass instead of fossil fuels

Biochar application – Brazil (11 tons per ha).
Embrapa Research Station, Manaus, Brazil, Photo C. Steiner

The classical way is biochar from wood – we are looking for alternatives

Hydrogen, heat and power as well as fuels from biomass
How does the state of the art fit?
Do we have the right set of industrial partners?

Johnson Matthey – Brewers grain, reforming catalysts
Oxford Catalyst – Small scale FT
Severn Trent Water – Energy from Sewage Sludge
Tenmat - Hot gas filtration
Kebelmann – Analytics
VariconAqua – Algae Photobioreactor
Repotec (Güssing) and CET – Gasification
Carborobot - Rotating Grate Combustion
Schnell - Dual Fuel Engines
Hangya Futura – Energy Grass
Utilicom – CHP systems
Veolia ....

Power Generation from Sewage Sludge

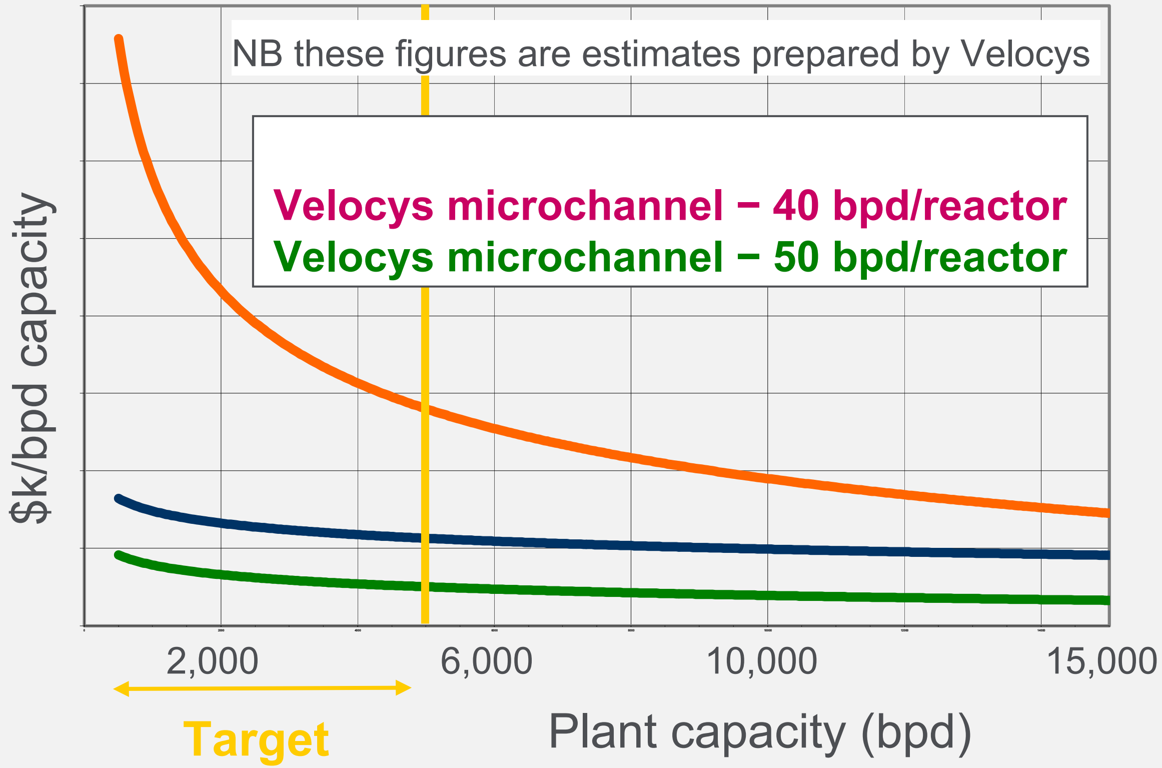
Intermediate Pyrolysis of sewage sludge

The research aim of this project is to develop efficient methods to turn sewage sludge into heat and electricity.

Pyrolysis

EBRI and STW

Velocys FT Reactor Cost Advantage – Oxford Catalyst



Sasol's FT Reactor

"Velocys' technology is expected to facilitate the production of synthetic fuels **economically on a small scale** in many sites and situations", Nexant

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Heat and power, dual fuel engines for pyrolysis gases and liquids

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Birmingham – Revolution on steam, Evolution in Green

“Post Carbon Era City”

Reduce CO_2 emissions by 60 % by 2026!
From 6.6 tonnes/capita to 2.8 tonnes/capita

Adapting the City to Climate Change impacts

Measurable Behavioural Change

Green Innovation

Energie Imports

Birmingham imports 16,000 GWh of energy. A leakage of over £ 1bn from city economy (excludes transport fuel)

The City Council consumes 580 GWh energy - £ 25m

Source: Sandy Taylor

asifier

Syngas → Heat and power,

Hydrogen → Transportation, Living

FT → Transportation, Aviation

SNG → Substitution in Transportation and Living

+

Biochar for brownfield treatment

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Storage ← **Application** ← **Distribution** ← **Production**

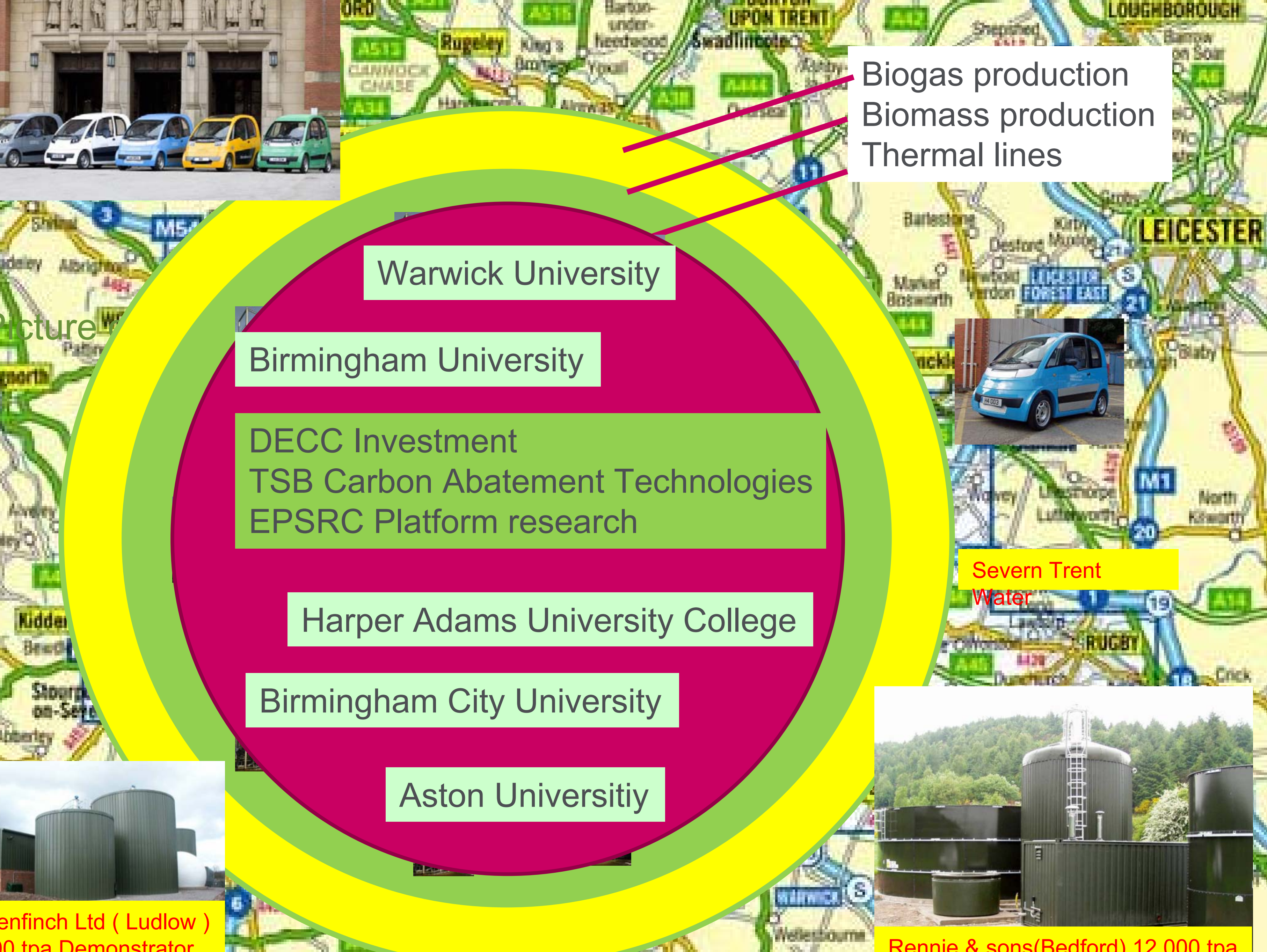
- Existing gas storage units

- Heating
- Power
- SNG as substitute to natural gas
- Hydrogen powered cars

- Canals
- Streets
- Thermal lines

- Biogas
- Biomass
- Biochar

- Heat & Power
- Fertiliser
- SNG
- H_2


Biogas production
Biomass production
Thermal lines
Warwick University
Birmingham University
DECC Investment
TSB Carbon Abatement Technologies
EPSRC Platform research
Harper Adams University College
Birmingham City University
Aston Universitiy
Severn Trent Water
enfinch Ltd (Ludlow)
00 tpa Demonstrator
Rennie & sons(Bedford) 12,000 tpa

Science City – Innovation for Birmingham 2026

- **EBRI Site**
  - Demonstration application at EBRI site (Aston University) with power and heat for EBRI (max. 1 MWh_{el}, mixed feedstocks) live 2010
- **Innovation for Birmingham 2026**
  - This scheme is consuming 300.000 t/a of biogenic waste and residue material realised within Birmingham
  - It delivers 580 GWh (CHP) with 15 applications required to make the council green
  - It offers a **hydrogen grid with up to 60 tonnes per day** and biochar for fertilization
    as well as carbon sequestration (equiv. to approx **270.000 t/a CO_2**)
  - It also offers a mid and long term research and development platform to shape the new strength of Birmingham, being the development and application centre of green technologies

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Birmingham

All the work shown is embedded in EBRI the European Bioenergy Research Institute

EBRI stands for an example within a city developing and demonstrating green energy technologies!

EBRI stand for a University research unit and for EBRI UK Ltd., founded last week

EBRI stands for a unique applied research and engineering platform within Europe

The European Bioenergy Research Institute - EBRI

Completion planned for 10/2010

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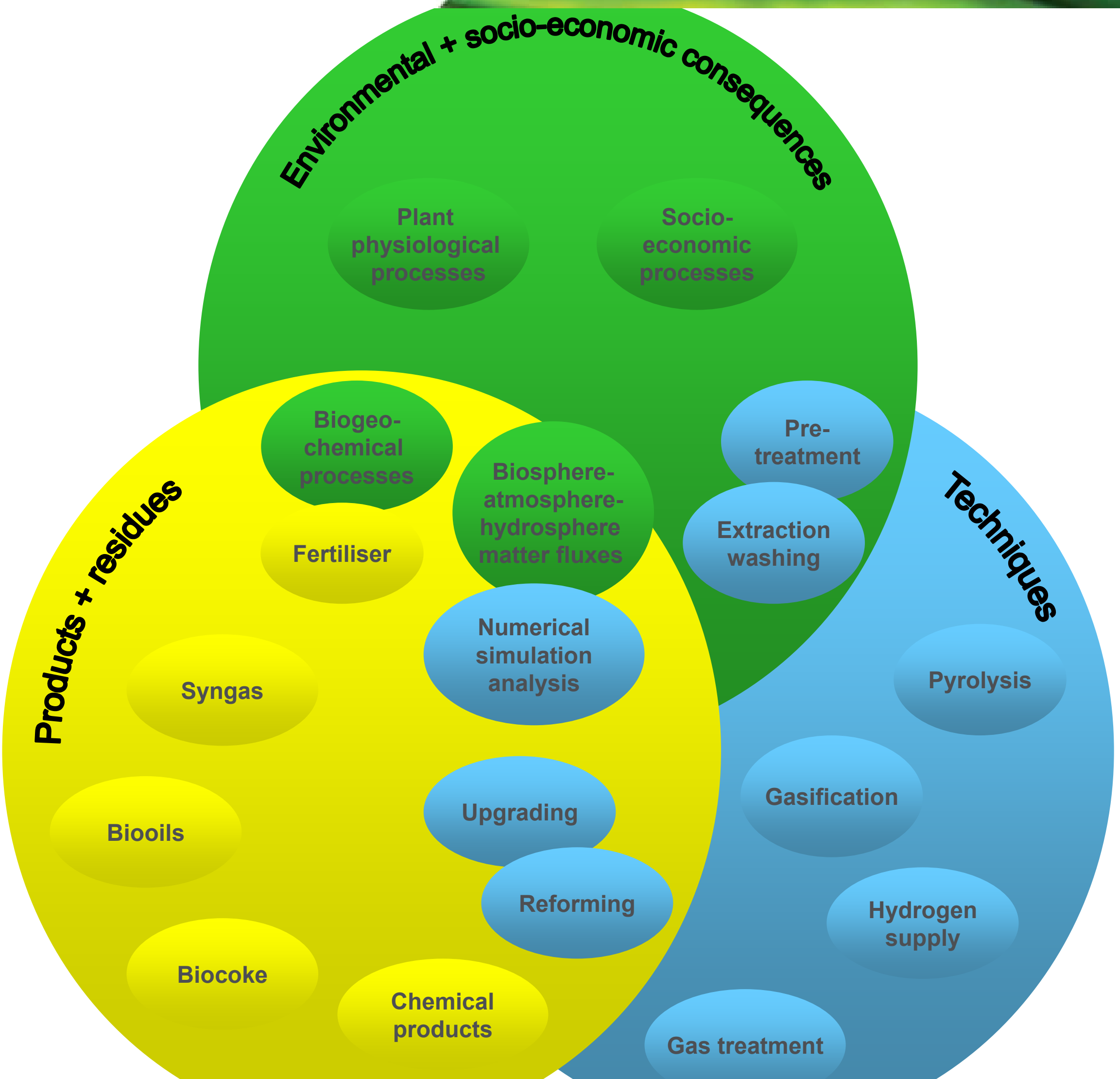
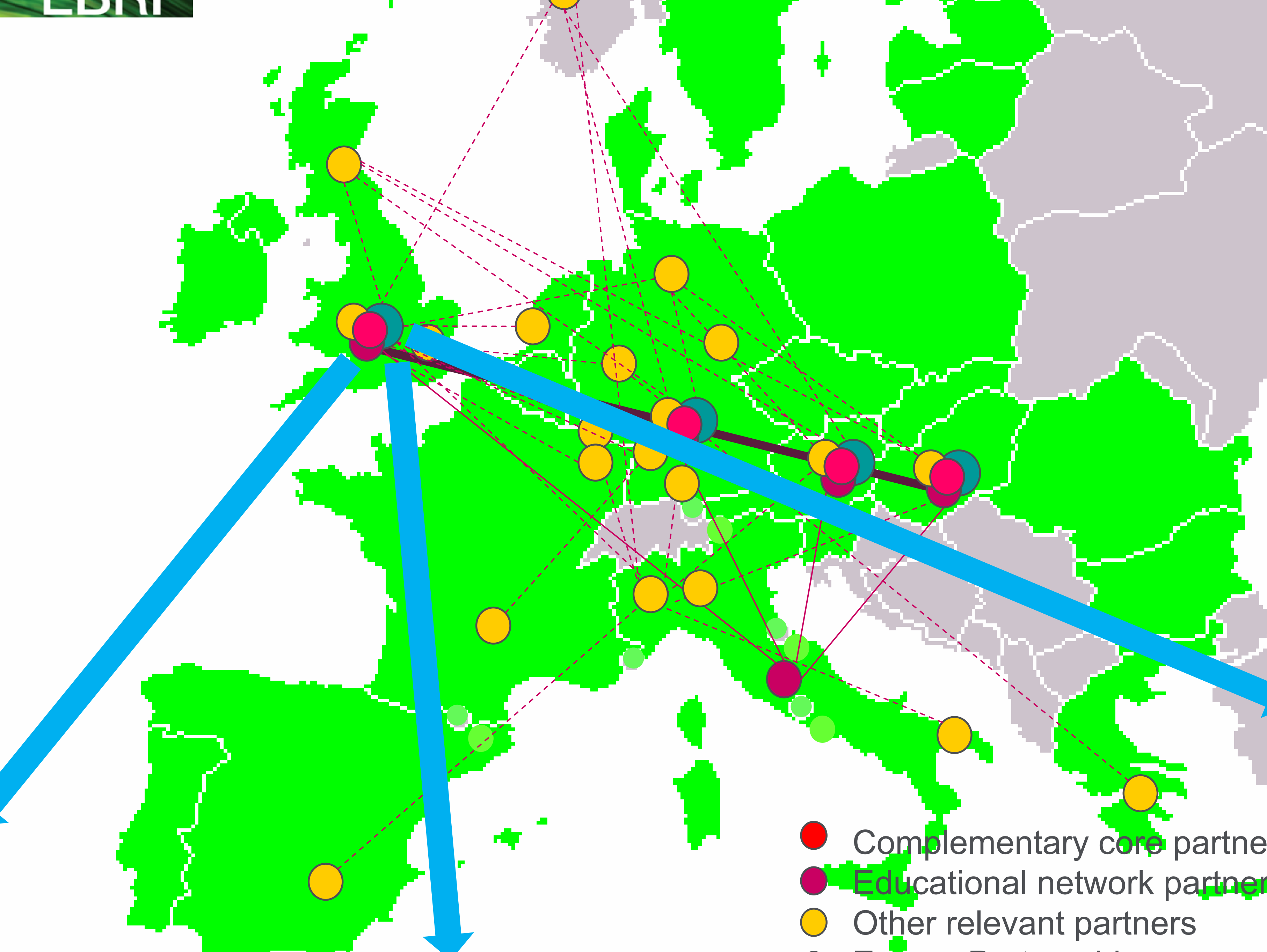


Establish global projects and collaboration

- India – Ongoing negotiations with IIT Delhi (Indian Institute of Technology), IIP Dehradun, (Indian Institute of Petroleum) and Anna University, Chennai for the application of pyrolysis technologies to establish a "Science Bridge"
- Africa – Strategies of partner companies to establish feedstock resources and bioenergy technologies
- South America – European technology transfer ambitions with Chile, Peru, Brazil and Argentina
- USA – interest in demonstrator and testing facilities for pyrolysis
- Canada – cooperation in pyrolysis technologies for distinct market needs


Complementary core partne
Educational network partner
Other relevant partners

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India and China

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The Indian Science Bridge Project

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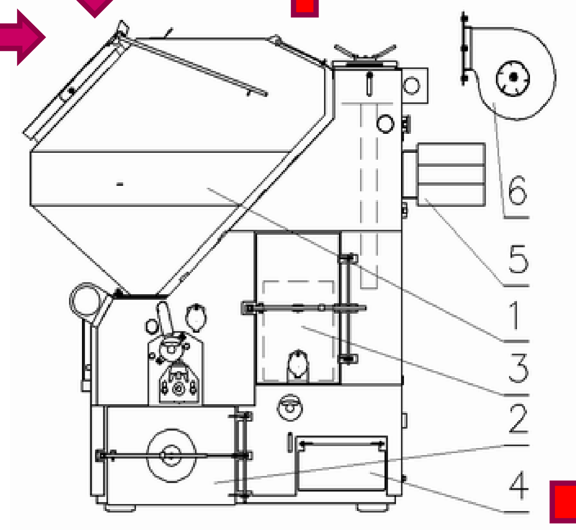
Feed:
Wood
Agricult.
Residues
Coal and
Mixtures

Pyroformer

Engine
(from 7,4
kW)

Power

Char



Heat

Lister cold
start engine

Target price
12.000 £

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Twinning cities
Birmingham-Guangzhou

ames Bryce (Deputy Consul General)
ames Mc Guire (Consul Trade and Investment)
/ayne Ives (Deputy Head Climate Change & Energy – South China)
hine Xiao (Climate Change Assistant)
iang Jin Quan (Chief Engineer, Bureau of Environmental Protection of GZ)
lfi Chen (International relations foreign affairs office – deputy director)
imin You (International relations foreign affairs office)
like Smith (Commercial director Utilicom)
ames Chen (Senior Engineer – Ove Arup & Partners HK)
elly Wu (International officer, Birmingham City Council)
andy Taylor

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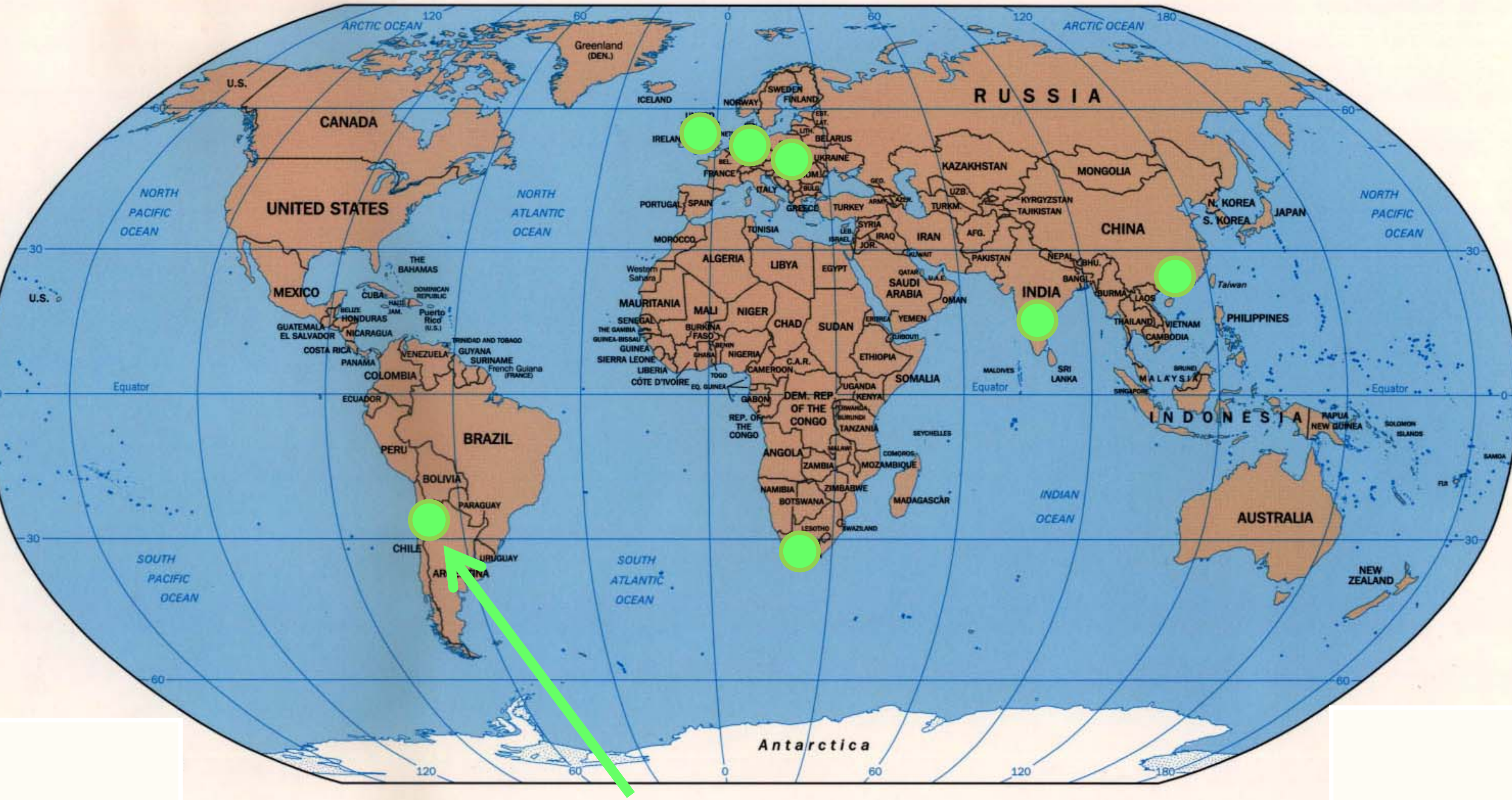

BRI a global development

I will be on an invited new mission from 2nd of May

- Internet presentation

  EBRI.ORG.UK

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Katharina

Carlo

Janath

The team