PYREG GmbH

A new value chain system - P rich biochars from different feedstocks

ECOFRIENDLY RECYCLING TECHNOLOGY

PYREG GMBH - MILESTONES

Thanks to permanent innovation and continuous progress in further developments, our company has gained an excellent reputation as a pioneer & market leader in our branch.

1999 -2009

Development of the PYREG technology at Technical University of Bingen by Dipl.-Ing. Helmut Gerber & Prof. Dr.-Ing. Winfried Sehn.

2009 -2010

Helmut Gerber founds PYREG GmbH. The company headquaters is Dörth, close to Koblenz, Germany.

2011 -2016

Entry of renowned investors, participation on numerous research projects, successful further development of the carbonization process.

2017 - today

Bodo-Joachim Wendenburg joins management board; PYREG develops and manufactures - with around 30 employees - standardized carbonization units in Dörth, Germany.

Motivation: University research projects 1999-2010
Technische Hochschule Bingen, Thermodynamics department

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PYREG approach

Thermal, climate-friendly upcycling of a multitude of unused waste biomasses.

Market and biomass disposability analysis

- Biomass has low energy density, transportation over longer distances causes problems (cost, emission, traffic,..)
- Biomass users (farmers, municipalities, green waste companies, waste water treatment plants, …) are distributed over the area. (>10.000. WWTP in Germany, >15.000 green waste collection sites, >50.000 farmers)

→ Decentralized approach → → rethinking common technologies

Main development tasks

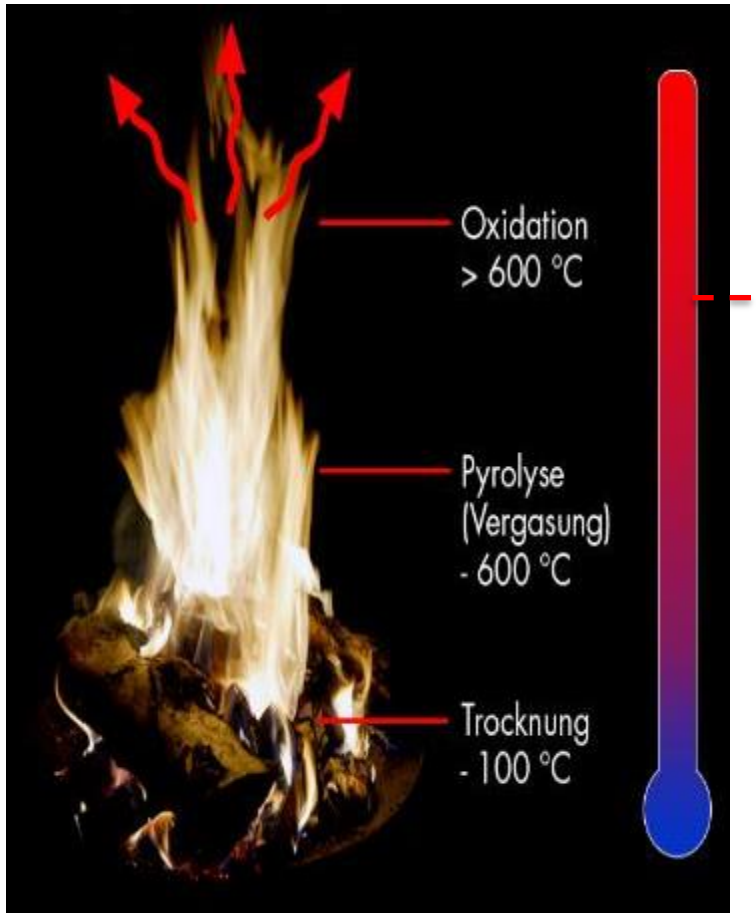
i. Waste biomass contains **10-100x more problematic substances** for thermal use (nitrogen, ash, sulphur, heavy metals,..) than common woody material, and has a lower ash melting temperature. **Fulfil european waste incineration directive**.

ii. Use of **common** large scale **technologies** might **not** be **possible** (cost, complexity,..) and has to be reassessed.

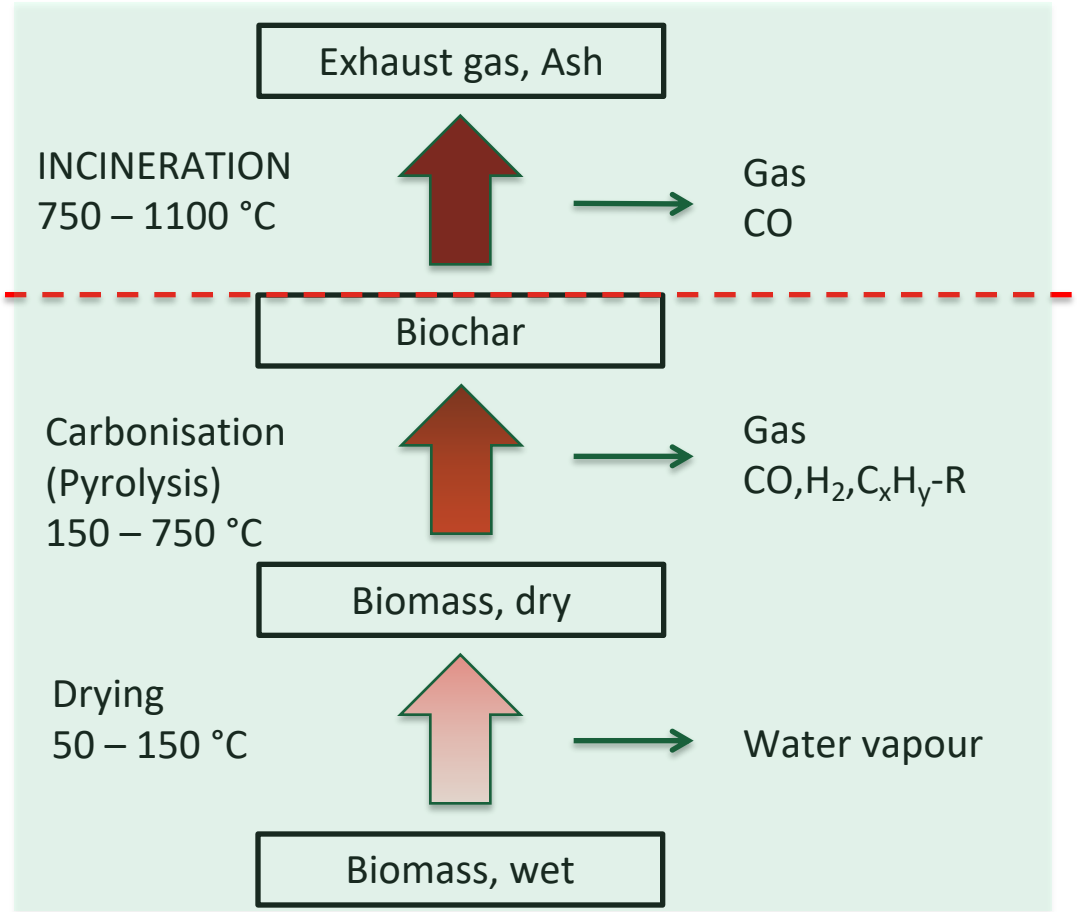
iii. Decentralized approach needs easy to operate technologies **with less complexity** and investment cost than common.

PYREG process design

Process principle



Thermochemical description



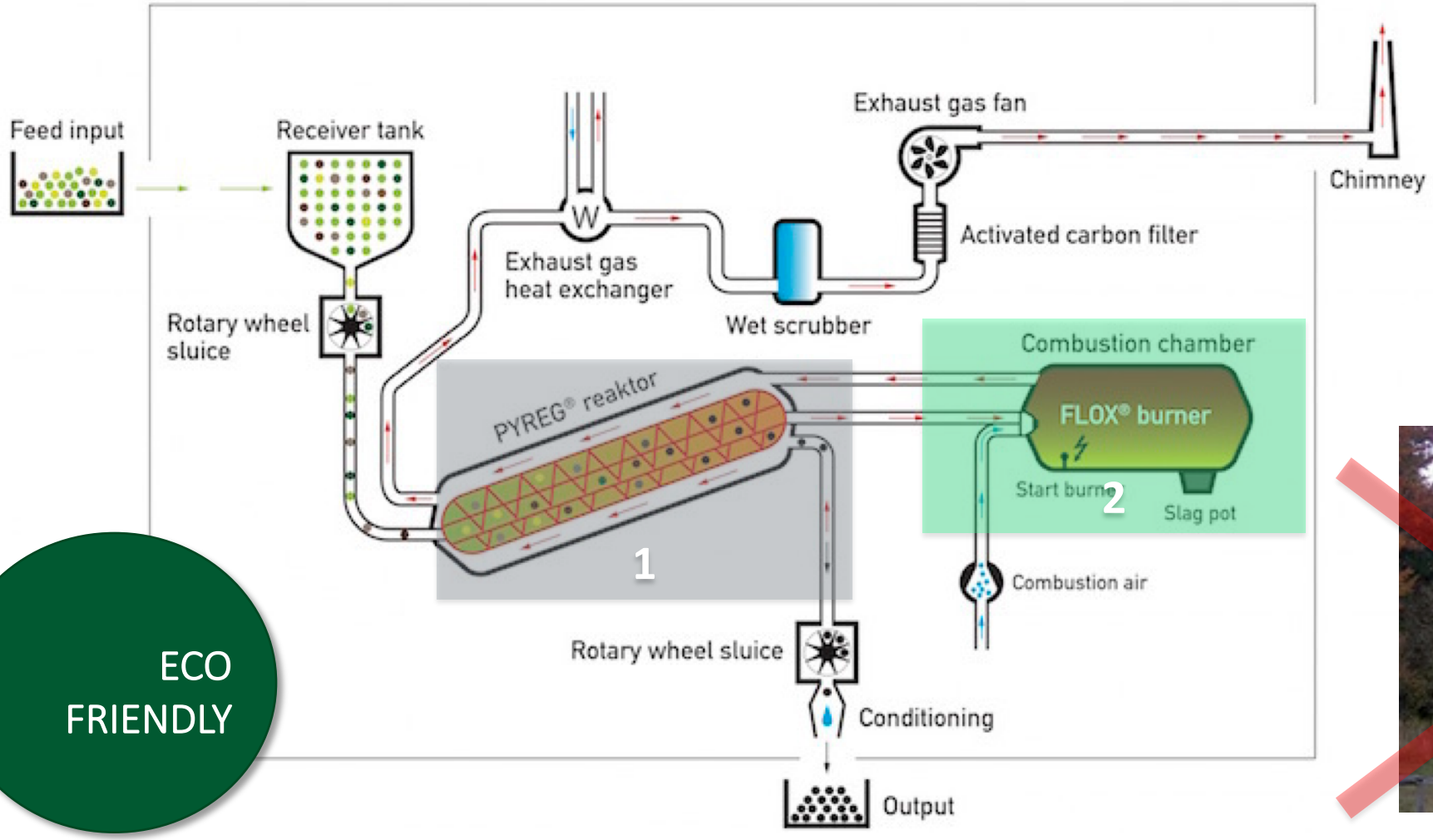
Abstraction

Step 2

Ash melting temperature

Step 1

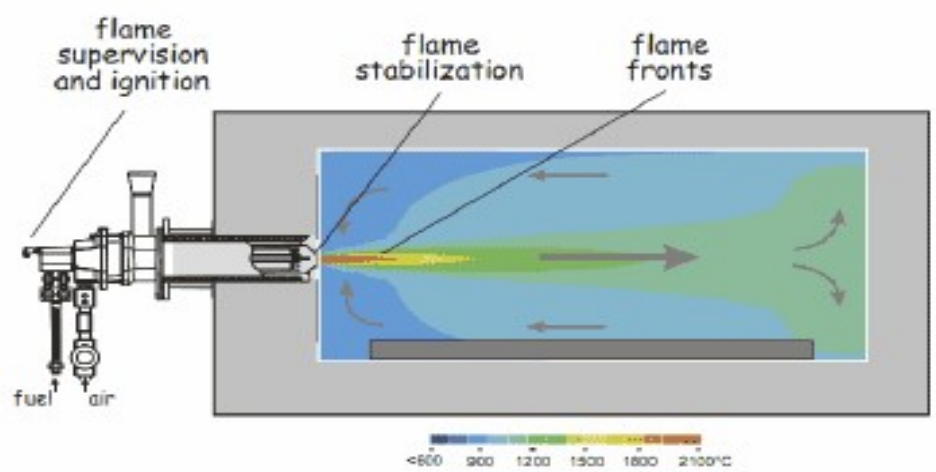
PYREG PROCESS



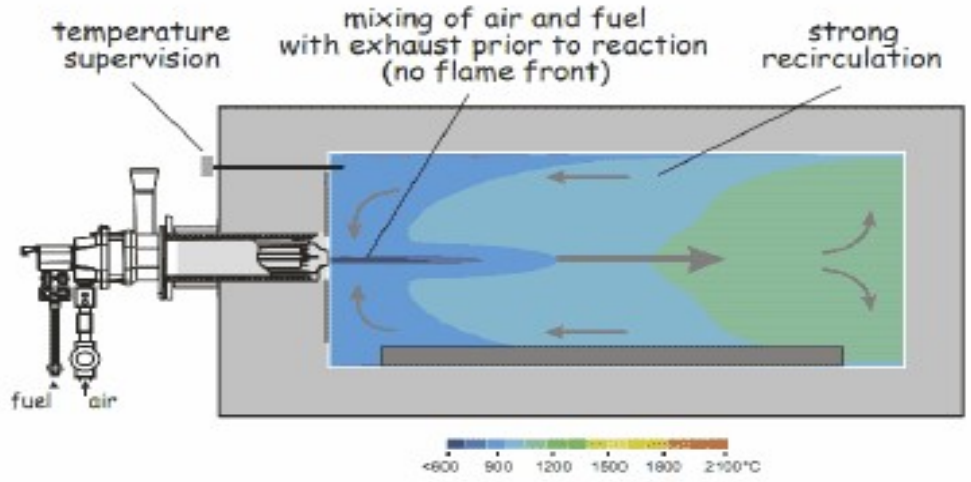
ECO FRIENDLY

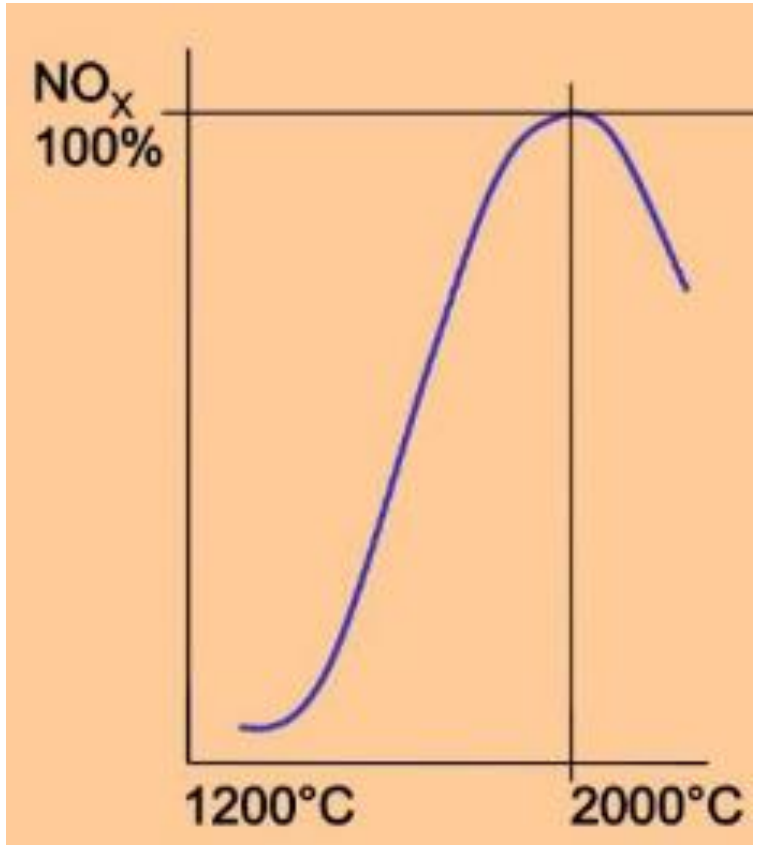
FLOX®-INCINERATION, reducing NOx emissions to avoid secondary gas cleaning

Conventional

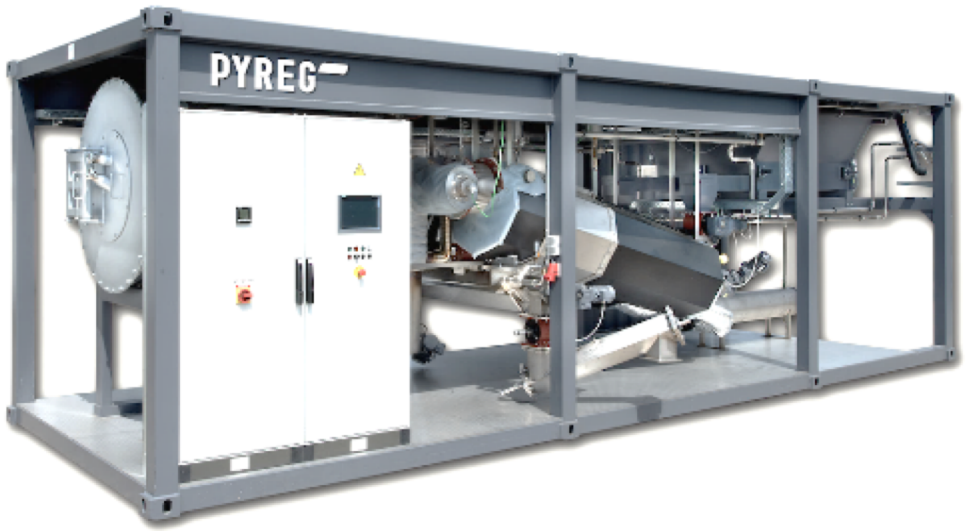


FLOX-Burner

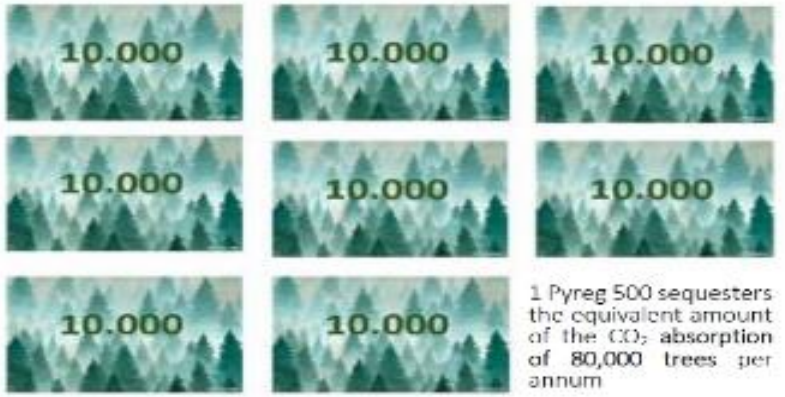




PYREG-TECHNOLOGY PLATFORM



- **PRODUCTION OF PREMIUM PRODUCTS**: EBC-Standard: Biochar, Feeding Char, Activated Carbon, Phosphorus-Fertilizer
- **COMPLETE REFINEMENT** of the input materials
- **INTEGRATION** in consisting local process cycles of materials and energy
- **SUSTAINABLE USE OF RESOURCES** (conservation of nutrients) and environmental protection (CO_2 capture & storage)
- **PROVEN TECHNOLOGY** (25 plants in operation)



BIOMASS – KEY FIGURES P500

	BIOMASS
MAXIMUM ENERGY INPUT	500 kW
ANNUAL THROUGHPUT*	up to 1,400 t (60 - 80 % DS)
ANNUAL DS-THROUGHPUT*	800 – 1,200 t DS/a
MINIMUM ENERGY INPUT	10,000 kJ/kg OS
EXHAUST GAS CLEANING	optionally, not required
CONVERSION RATE (refering to DS)	25 - 40 %
ANNUAL OUTPUT*	up to 200 - 350 t/a
C-EFFICIENCY	about 60 %
OPERATING HOURS	up to 7,500 h/a
EXCESS THERMAL ENERGY*	up to 150 kW_{th}
POWER CONSUMPTION	about 12 kW_{el}

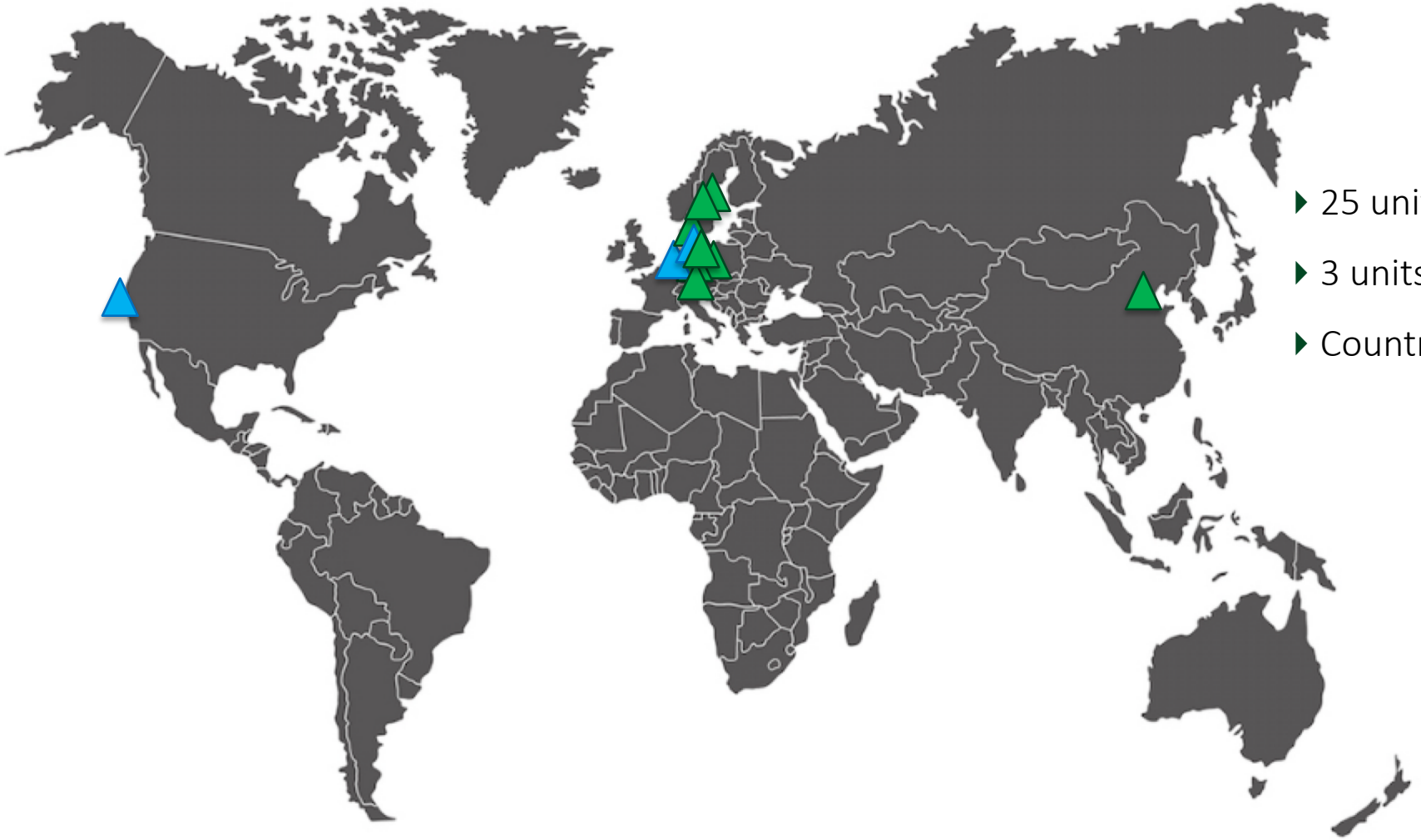
**Values depends on the quality of the input material (chemical and physical properties)*

PYREKA: Lab scale, electrically heated pyrolysis reactor
P1500: Available autumn 2018, Biochar output up to 1.000 tons/year.
A750: Available Winter 2018, Activated Carbon production

BIOMASS – USABLE INPUT MATERIAL

Fertilizer	Biochar					Special Applications
	Digestate	Agriculture	Forestry	Municipal Waste	Production Waste	
Sewage Sludge	Silage	Grain and Grain Waste	Wood Chips	Bush and Tree Cuttings	Nutshells	Fly Ash
Flotation Slimes	Renewable Biomass	Husks	Sawdust	Green Waste	Fruitstones	Plastics, Rubber
Liquid Manure	Foodwaste	Dung, Droppings, Manure	Wood Pellets	Landscaping Materials	Old Bread	Alu Flakes
	Organic Waste Collection Bin	Slaughterhouse Waste	Wood from Short Rotation Forestry	Screened Compost	Malt and Roasting Residues	Rinsing Slurry
		Silage waste		Organic Waste Collection Bin	Rape, Draff	Oil Contaminated Iron Slurry
		Hay, Straw	Sawn Timber		Residues from Extraction	
					Okara, Carrots	

PYREG TECHNOLOGY – REFERENCES



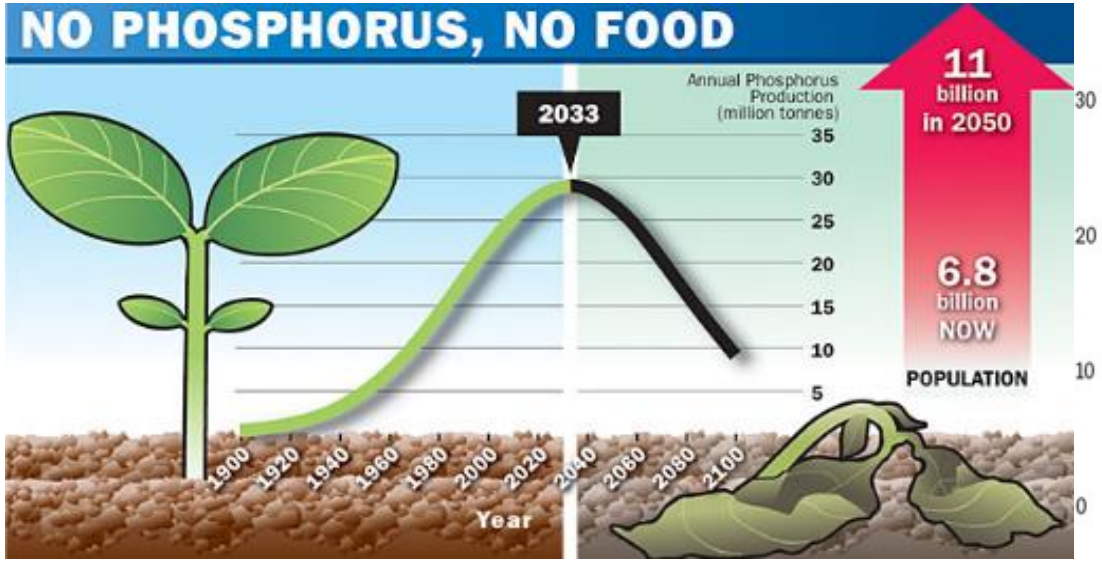
- 25 units for biomass recycling
- 3 units for sewage sludge treatment
- Countries: AT, BE, CH, CN, DE, SE, US,

PYREG - REFERENCES - BIOCHAR and SEWAGE SLUDGE BIOCHAR, examples

- STOCKHOLM VATTEN
  - Site: Stockholm, Sweden
  - In operation since 2017
- SONNENERDE GmbH
  - Site: Riedlingsdorf, Austria
  - In operation since 2011
- AH MEYER (ROESS NATURE GROUP)
  - Site: Tianjin, China
  - In operation since 2016

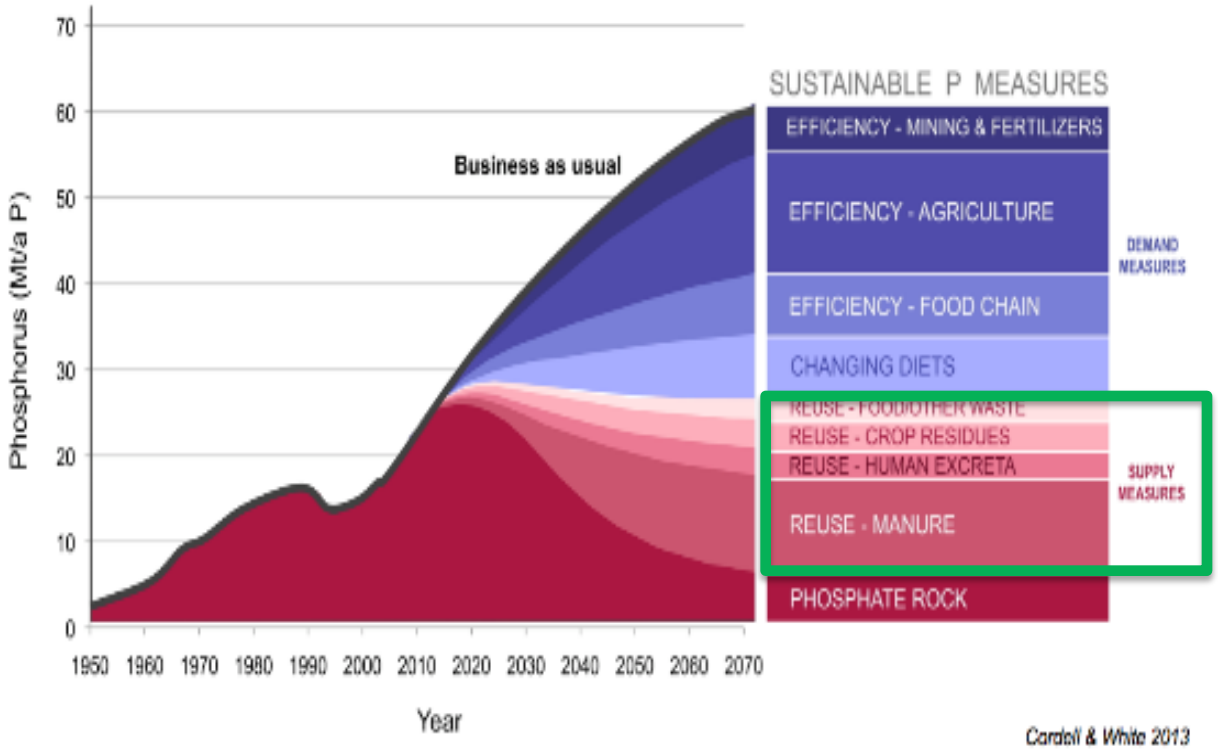
- WWTP ASSOCIATION LINZ-UNKEL
  - Site: Unkel, Germany
  - In operation since 2015
- WASTE DISPOSAL ASSOCIATION SAAR (EVS)
  - Site: Homburg, Deutschland
  - In operation since 2016
- BIOFORCETECH CORPORATION
  - Site: Silicon Valley WWTP, Redwood, Cal., USA
  - In operation since 2017

SEWAGE SLUDGE BIOCHAR - WORLD PHOSPHORUS reserves limited



http://www.spiegel.de/international/world/bild-690450-80337.html

Isaac Asimov: „Phosphorus is lifes bottleneck“

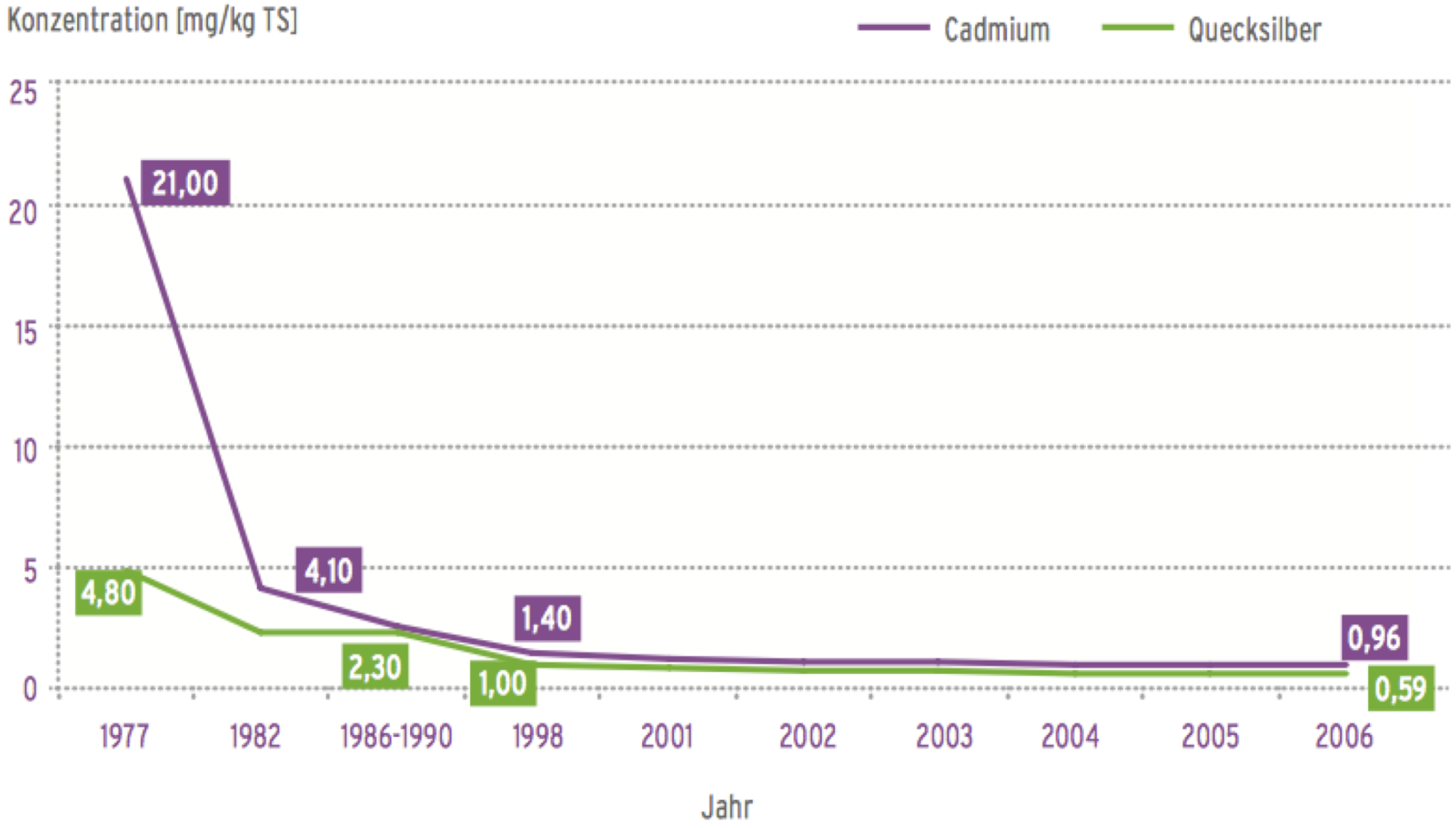


CADMIUM CONTAMINATION of phosphorus rock

Lagerstätten	Cd-Gehalt (mg/kg P_2O_5)	Lagerstätten-Typ
Südafrika	0,1 - 10	magmatisch
Russland	0,3 - 5	magmatisch
USA	7 - 375	sedimentär
Jordanien	12 - 28	sedimentär
Marokko	13 - 165	sedimentär
Israel	16 - 126	sedimentär
Tunesien	94	sedimentär
Senegal	161 - 336	sedimentär
Togo	164 - 179	sedimentär
andere Länder*	0,2 - 63	sedimentär/magmatisch

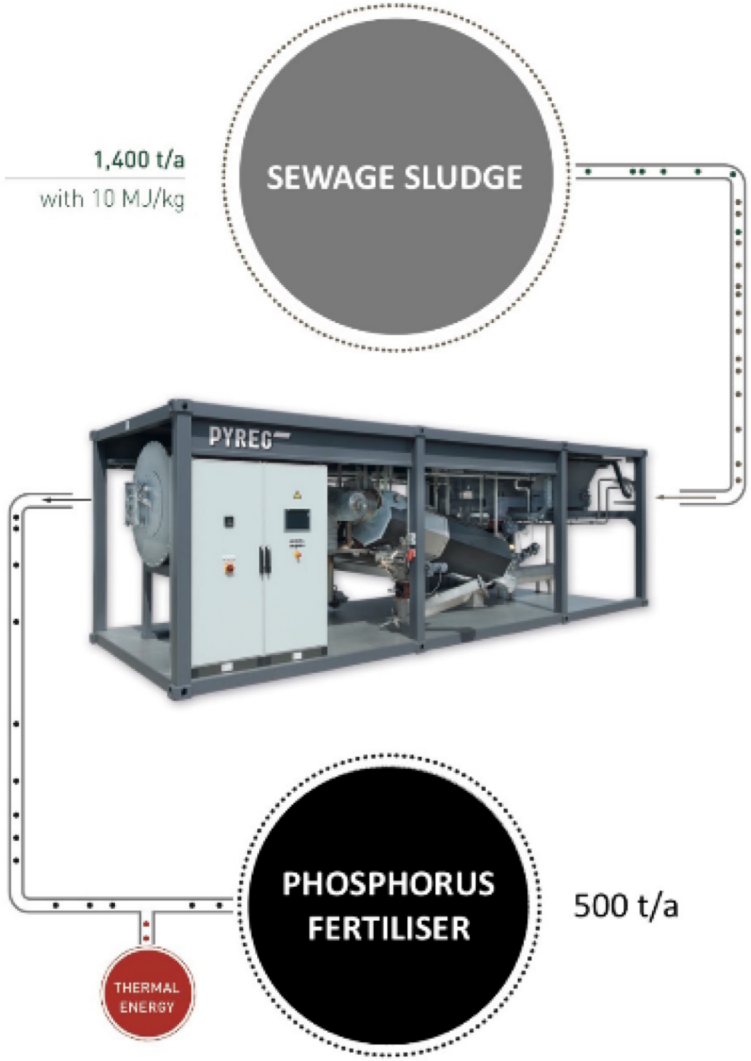
* Algerien, Syrien, Finnland, Schweden

HEAVY METAL CONCENTRATION in sewage sludge (Cd, Hg) Germany



Quelle: Klärschlammentsorgung in Deutschland, Umweltbundesamt 2013

SEWAGE SLUDGE



WHY USING PYREG-Technology?

1. A PYREG unit enables the WWTP operator to process the sludge directly on-site i.e. where it is produced.
2. The phosphorus fertiliser produced does not contain germs, hormones, residuals of pharmaceuticals, micro-plastics parts etc. A plant available phosphorus content of up to 20 % in the fertiliser can be achieved.
3. Transport cost can be reduced about 90 %, also Carbon Dioxide Emissions.
4. For larger sewage sludge quantities, the PYREG units can be up-scaled by a combination of additional units.
5. In the course of the running operation, supply of external energy is not necessary. Moreover up to 150 kW_{th} may become available, to be used for dryers installed upstream.

Phosphorus-rich Biochars: Waste water treatment plant Unkel, Germany

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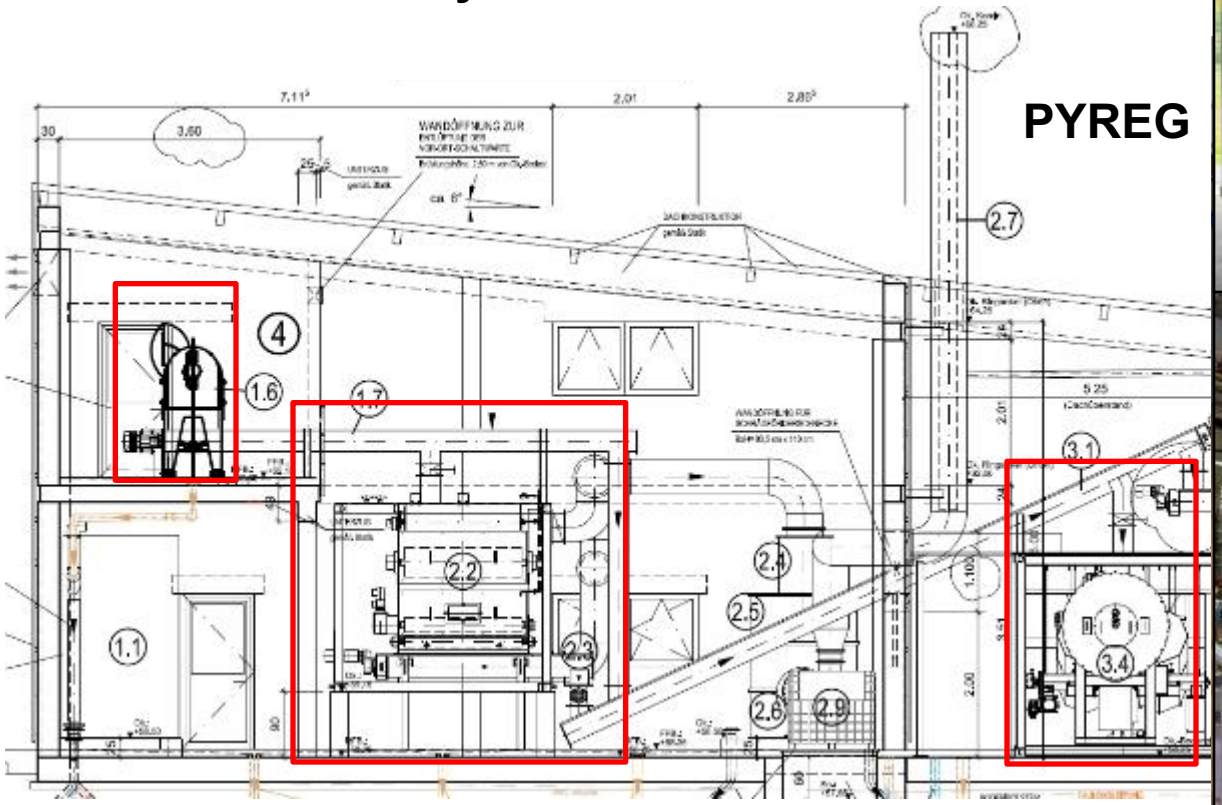
Components –project example.

Screw press

EloDry



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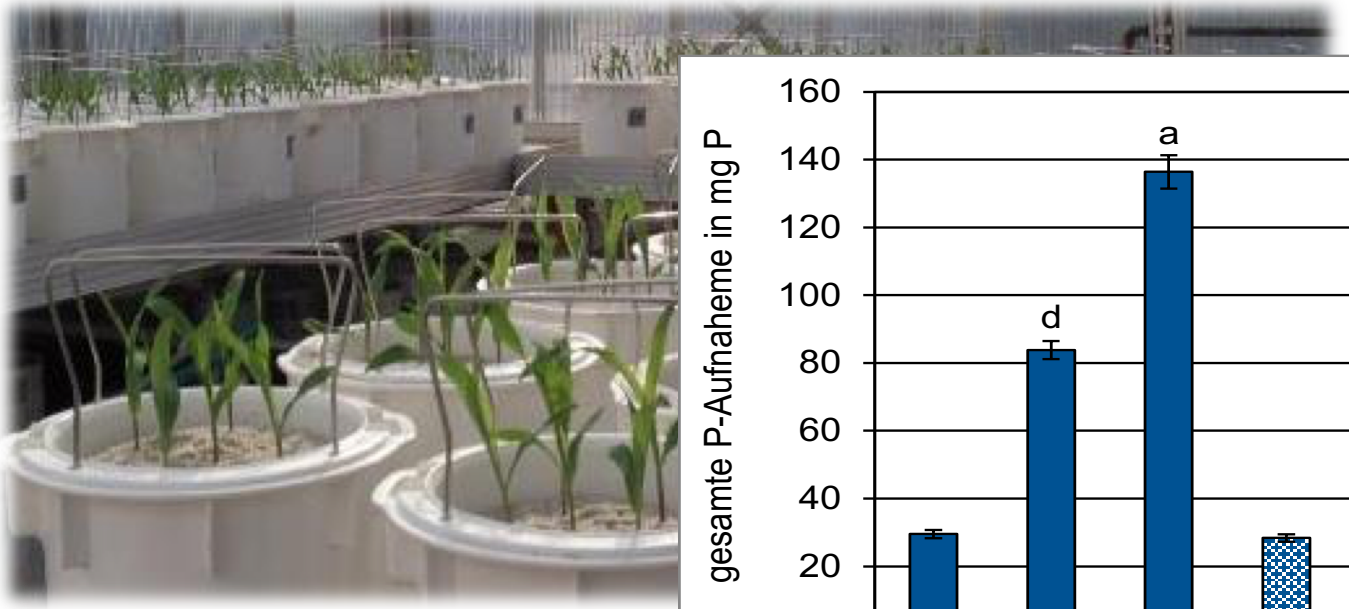
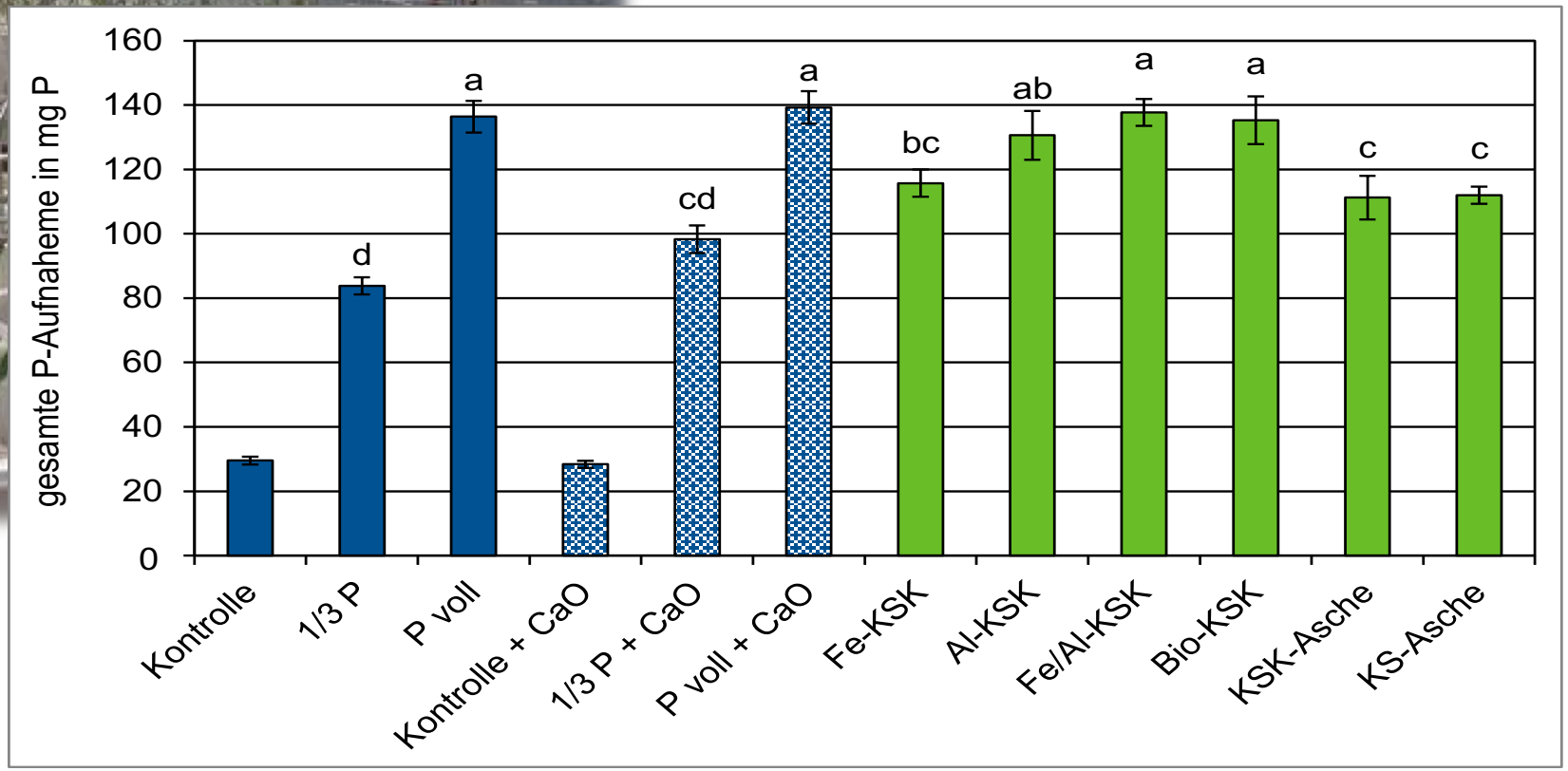
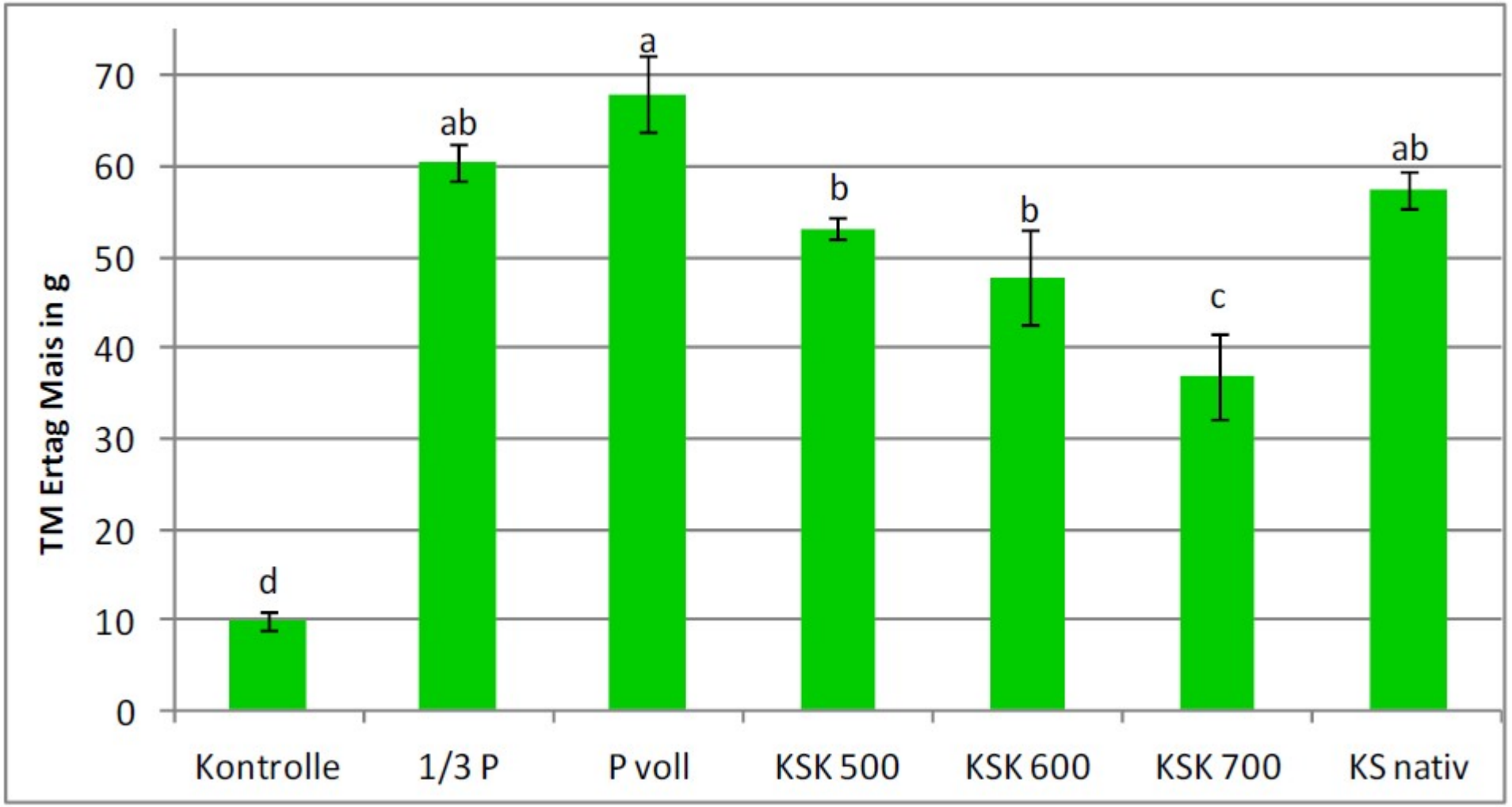
Approval of fertilizing effect: Bingen University, Giessen University 2014

Sewage Sludge Biochar: Kick-Brauckmann-Gefäßversuch TH-Bingen 2014; Mindermann, B., Friedrich, K., Appel, T.

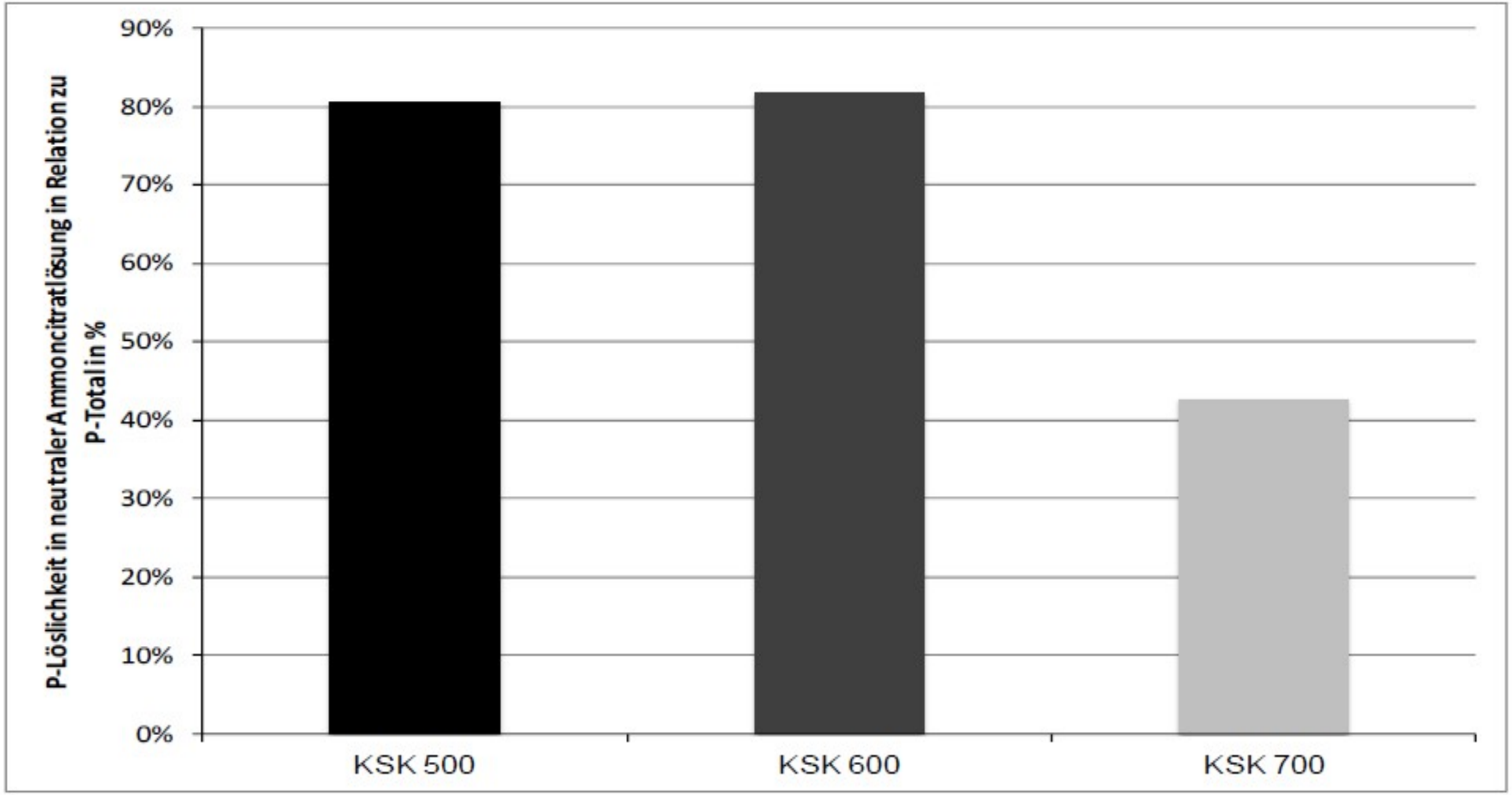




Crop mass, pot trial maize (Wald, L. 2017, University Bingen)



P-solubility, sewage sludge biochar with carbonisation temperatures (500°C,600°C, 700°C)



BIOCHAR FERTILISER legislation, a long way ……

- 2012 **German Fertiliser legislation** changed: Biochar Fertiliser allows Biochar **>80% Carbon** only as fertilizer.
- 2013 **Ministry of Environment state RLP** accepts sewage sludge based biochar as „Mineralic Phosphate fertiliser“ (refusing it one year later).
- 2014 **Ministry of Environment Saarland** accepts sewage sludge based biochar as fertiliser in the sewage sludge directive (refused later).
- 2015 **Ministry of Environment state NRW** accepts sewage sludge based fertiliser as „Organic Mineralic Fertiliser (refused later).
- 2015 PYREG launches a petition for a biochar fertiliser ammendment at the **German National Ministry of Agriculture**.
- 2017 PYREG and Partners changed the **german sewage sludge directive**, PYREG is accepted as phosphorus recovery method.
- Since then: Ongoing consideration with the Ministries in Germany and **European Union,**
- **Consolidated European fertilizer legislation awaited 2021**.

Biochar Stakeholders should work together to do more Lobbying

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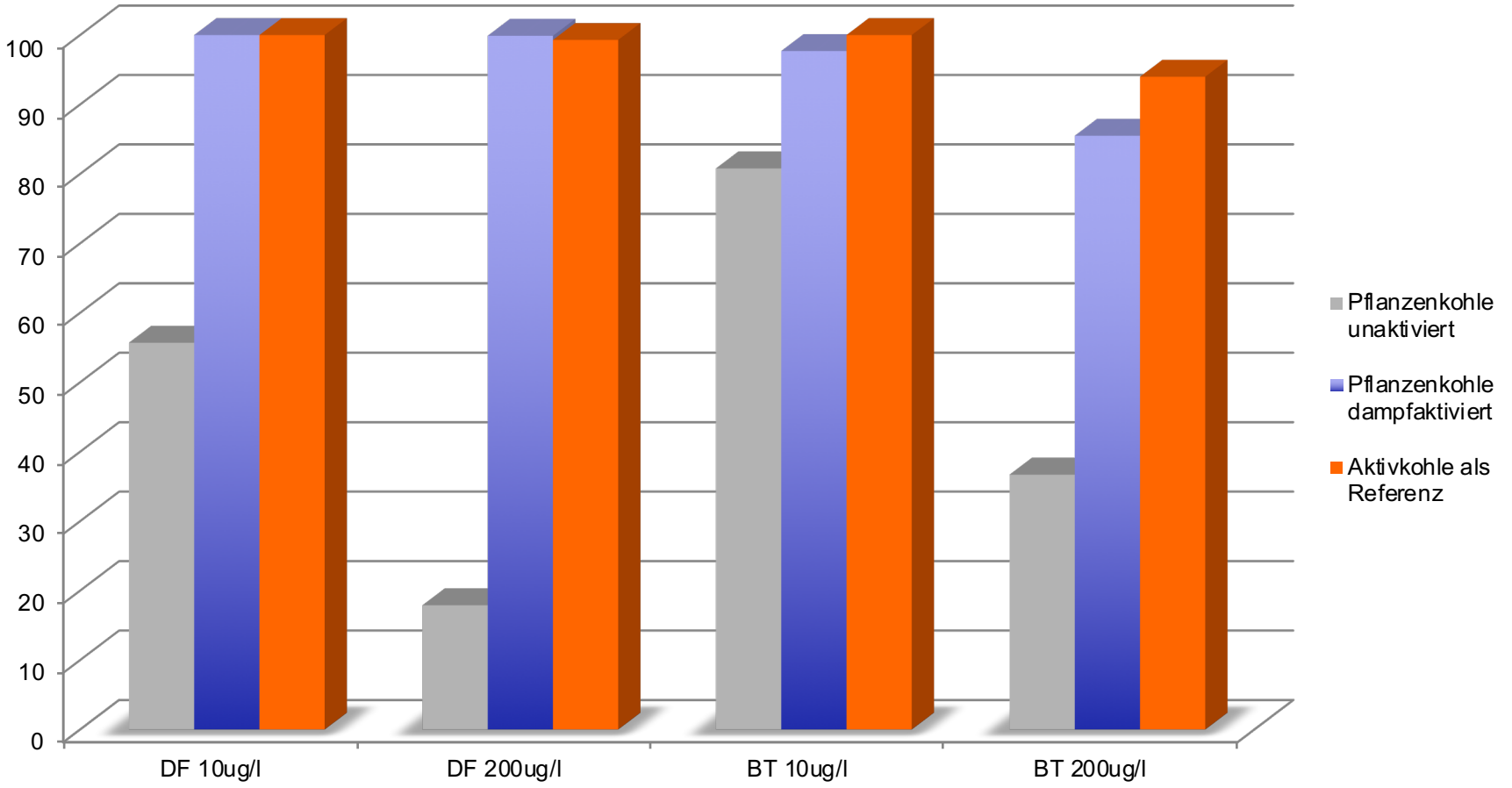
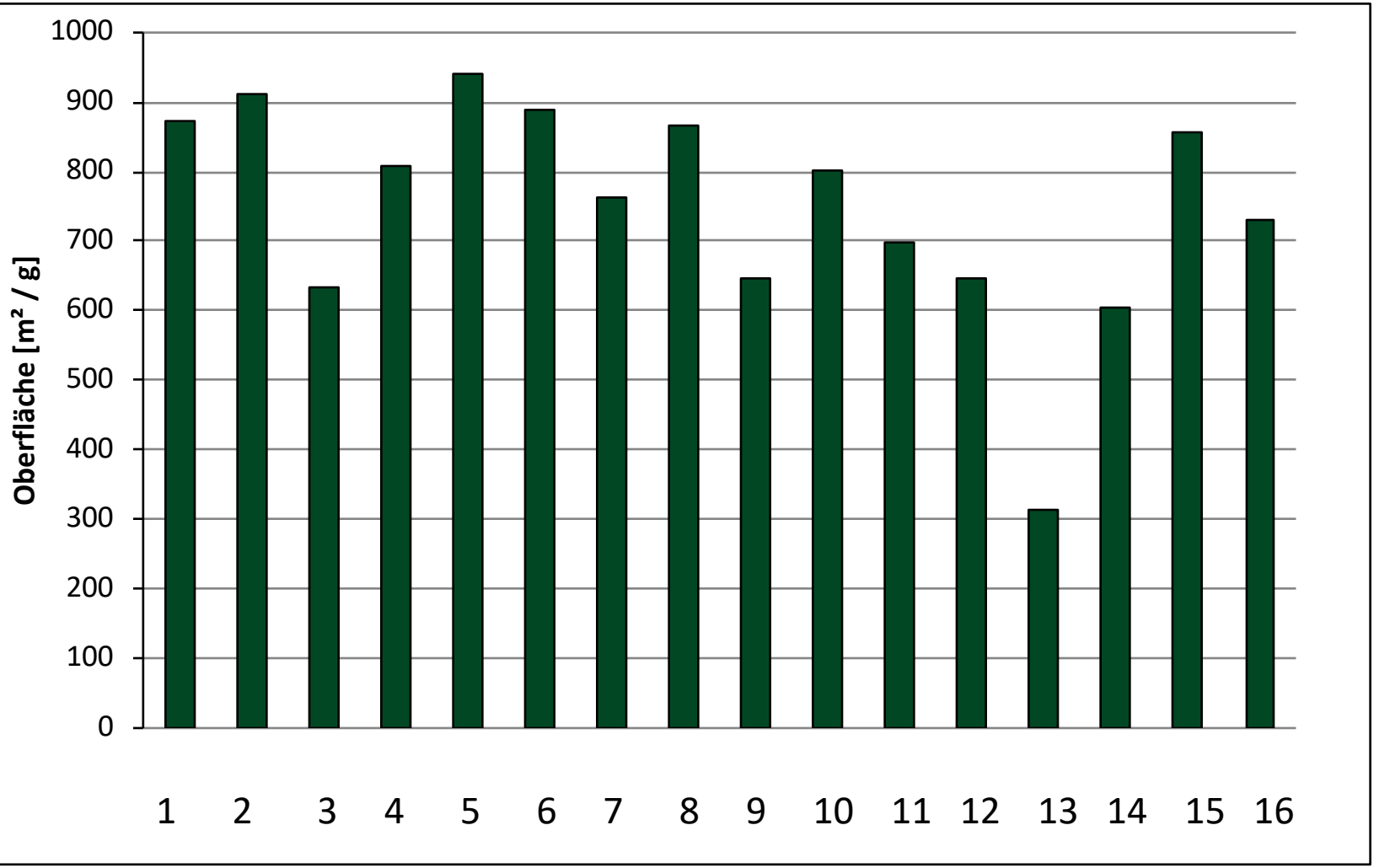
R+D: Activated Carbon Production, water pollutants removal



A. Slijepcevic, K. Friedrich, Favre, Schmidt (2013)

DF = Diclofenac (Entzündungshemmer)
BT = Benzotriazole (Rostschutzmittel)

Locally available alternative feedstock for activated Carbon (2016)



ACTIVATED CARBON production: City of Baden-Baden WWTP (2018)

- PYREG Activated Carbon: Global Markets and increasing demand
- UP to 1000 m²/g surface area with PYREG clean steam activation

R+D - ONGOING PROJECTS: Carbon fertilizer from manure (2017-2020)

Bundesanstalt für Landwirtschaft und Ernährung

In former times: Farm manure, stable and dry manure could simply be used as fertilizer in the fields.

Nowadays: Due to limits lowered and longer blocking periods for spreading manure, new methods of utilization are necessary.

OUR RESEARCH PROJECTS: CARBON FERTILIZER ON THE BASIS OF FARM MANURE

OBJECTIVE: CARBON FERTILIZER ORIGINATING FROM FARM MANURE, WITH RECUPERATION OF NITROGEN AND PHOSPHORUS.

PROJECT PARTNERS: TECHNICAL UNIVERSITY OF BINGEN, UNIVERSITY OF GEISENHEIM, JUSTUS-LIEBIG-UNIVERSITY OF GIESSEN, KLASS FILTER GMBH (GERMANY)

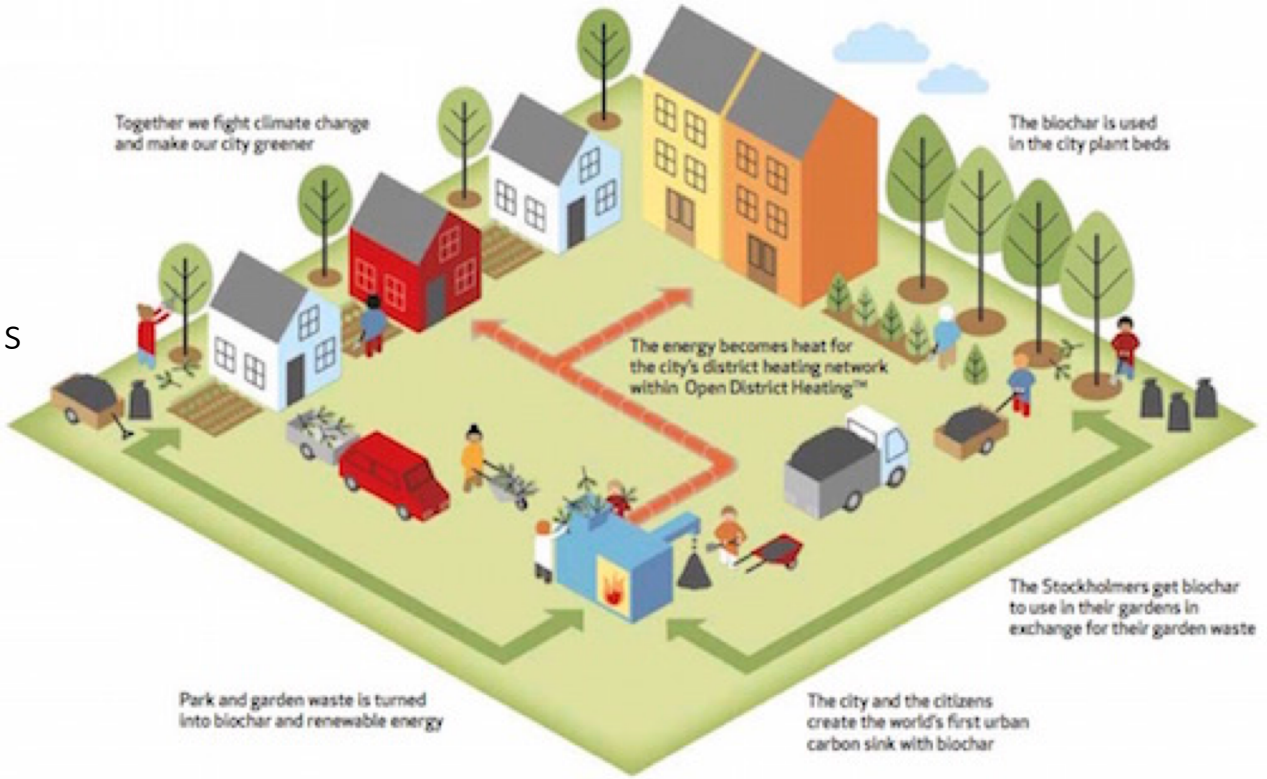
PROJECT DURATION: AUGUST OF 2017 TO OCTOBER OF 2020.

PROCESS INTENDED: SEPARATION OF MANURE INTO SOLID AND LIQUID PHASE, CARBONIZATION OF NUTRITIOUS SOLID PHASE BY MEANS OF A PYREG PLANT, PELLETIZING OF CARBONIZATES TO HYGIENICALLY IMPECCABLE COMMERCIAL FERTILIZER.

SUPPORTED: BY THE GERMAN MINISTRY OF AGRICULTURE (BUNDESMINISTERIUM FÜR ERNÄHRUNG UND LANDWIRTSCHAFT), FUNDING AMOUNT: 600,000 EURO.

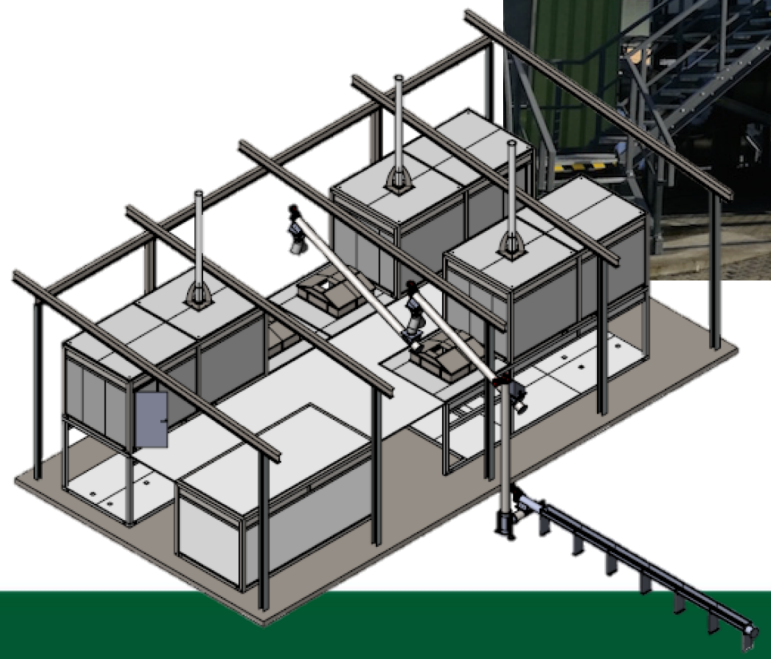
Stockholm Biochar project

- PROJET TITEL: STOCKHOLM biochar project
- PROJECT DESCRIPTION: The citizens of **Stockholm** produce their own **biochar** for urban gardening, **city trees** and landscaping. By carbonizing the biomass residues and storing the biomass into the soil Stockholm will compensate carbon dioxide emissions of around 3,500 cars per year. **Bloomberg Philanthropies** supported the project with 1 Million Dollar.
- PROJECT PARTNER: Stockholm Vatten
- PROJECT STATUS: 1 PYREG unit is in operation.



BIOMASS – PROJECTS (2018)

- PROJET TITEL: Carbo 3
- PROJECT DESCRIPTION: 3 PYREG units will produce about 1.000 tons of high-quality feeding char per year. So far unique in Europe.
- Electricity production (ORC-system) and district heating system included.
- PROJECT PARTNER: NOVOCARBO
- PROJECT STATUS: In operation



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