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Quality of ashes from thermal gasification of sewage sludge and biomass - for use as CPK fertilizers

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Structure of **presentation**

1. **Gasification at BGG**
2. **Ash quality at BGG - why and how?**
3. **Result examples**
4. **General conclusions**

Gasification at BGG

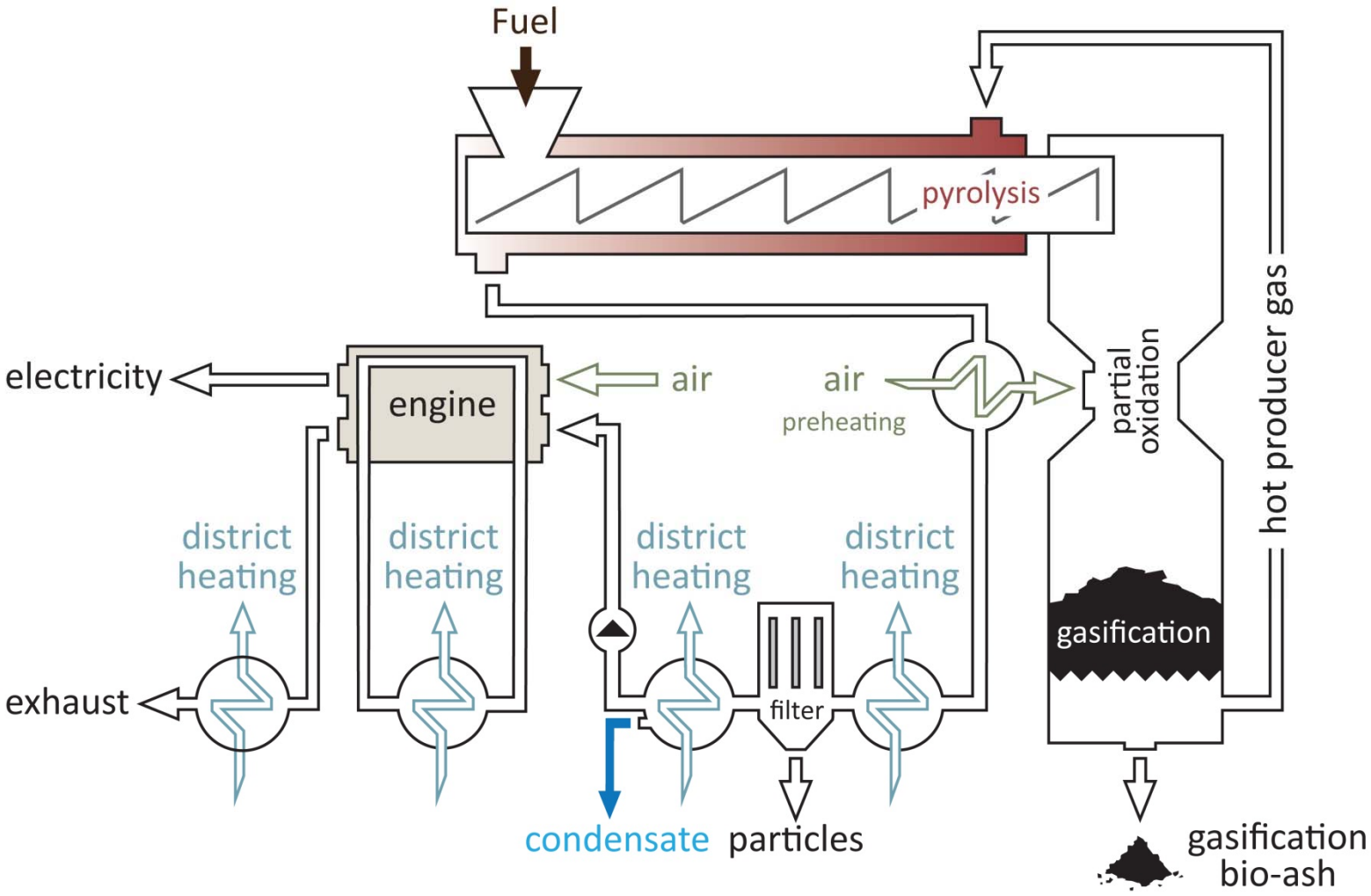
TwoStage Down Draft gasification

- Small scale application (<2 MW_{TH}). Stand alone unit.
- **Eff.:** Cold gas efficiency 93%
- **Current R&D focus:** Gas synthesis, fuel/electrolysis cell integration and ash
- **Fuel:** Wood chips, sewage sludge pellets and straw with additives

Low Temperature Circulating Fluidized Bed gasification (LT-CFB/Pyroneer)

- Fully scalable. Stand alone (R&D) or w. boiler (current)
- **Eff.:** Hot gas efficiency up to 95%
- **Current R&D focus:** Gas cleaning, fuel & product flexibility and ash quality
- **Fuel:** Straw, sewage sludge, manure fibers, biogas fibers, various organic residues from food industry and fuel mixes

Introduction of **the TwoStage gasifier**

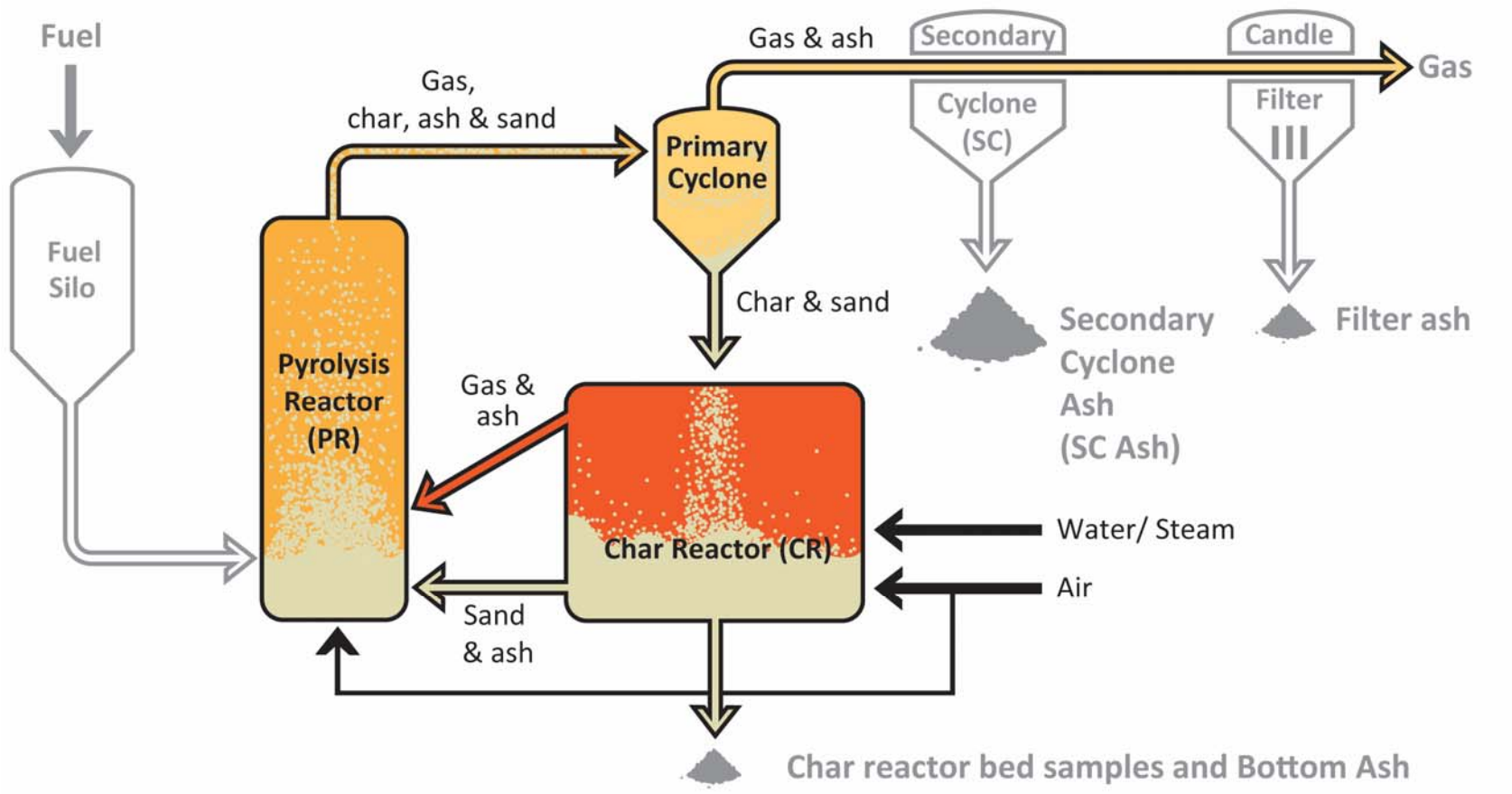


Introduction of **the TwoStage gasifier**

Camilla
Thermal capacity: 25-50 kW
Location: DTU Risø Campus
Owner: DTU

Viking
Thermal capacity: 75-100 kW
Location: DTU Risø Campus
Owner: DTU

Introduction of **the LT-CFB gasifier**



100 kW LT-CFB
Location: DTU Risø Campus
Owner: DTU

6 MW Pyroneer
Location: Asnæs power plant
Owner: DONG Energy

ASH FERTILIZER QUALITY AT BGG

WHY AND HOW?

General **motivation – why ash?**

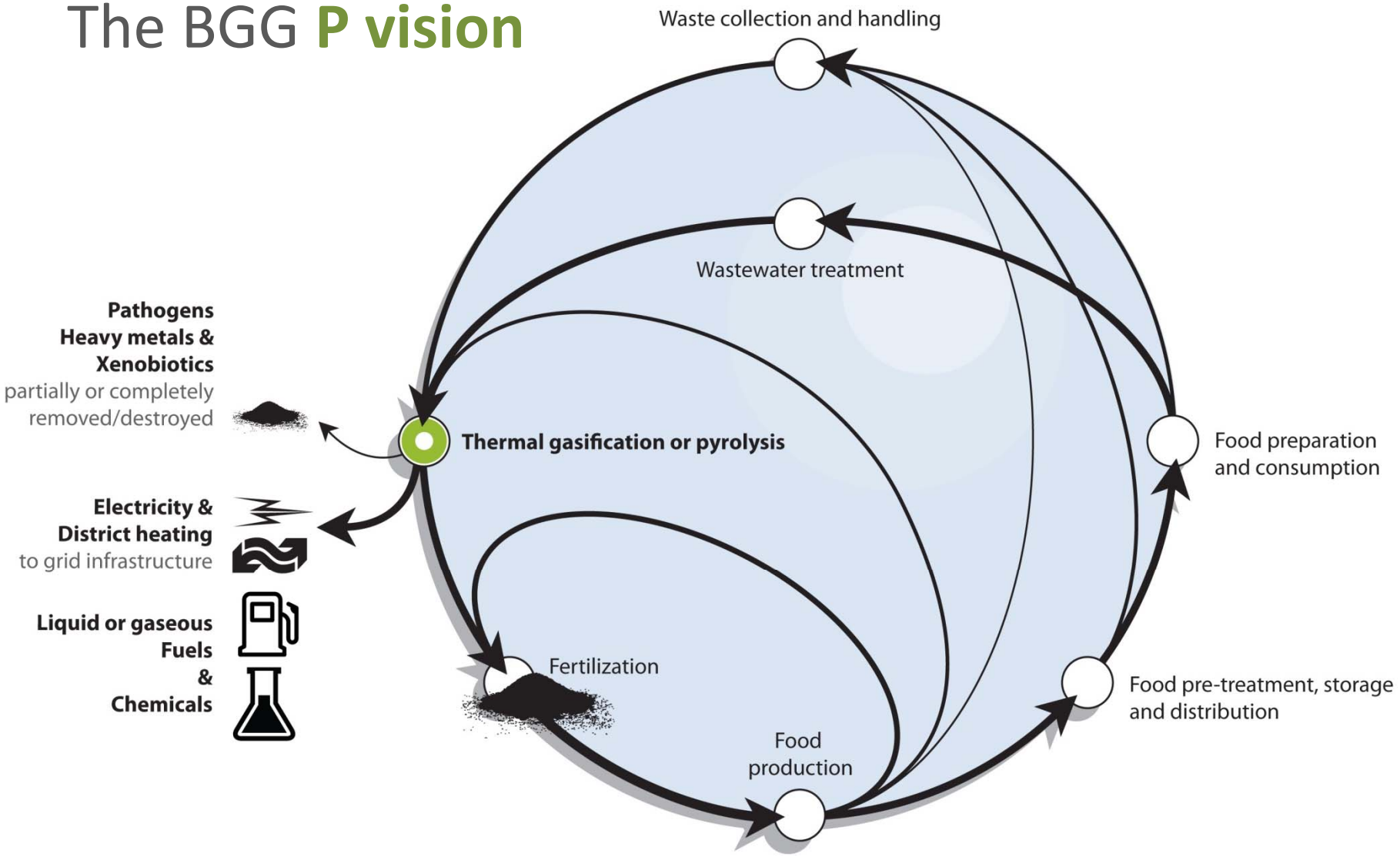
1) Improve the life cycle impact of thermal gasification:

- **Reduce pollution e.g. toxicity and eutrophication**
- **Recover and reuse critical elements**
- **Enhance soil quality and sequester carbon**

2) Improve feasibility of thermal gasification in a circular economy:

- **Develop new markets**
- **Valorise ash products**

The BGG **P vision**



Ash investigations: Effect on plant yield

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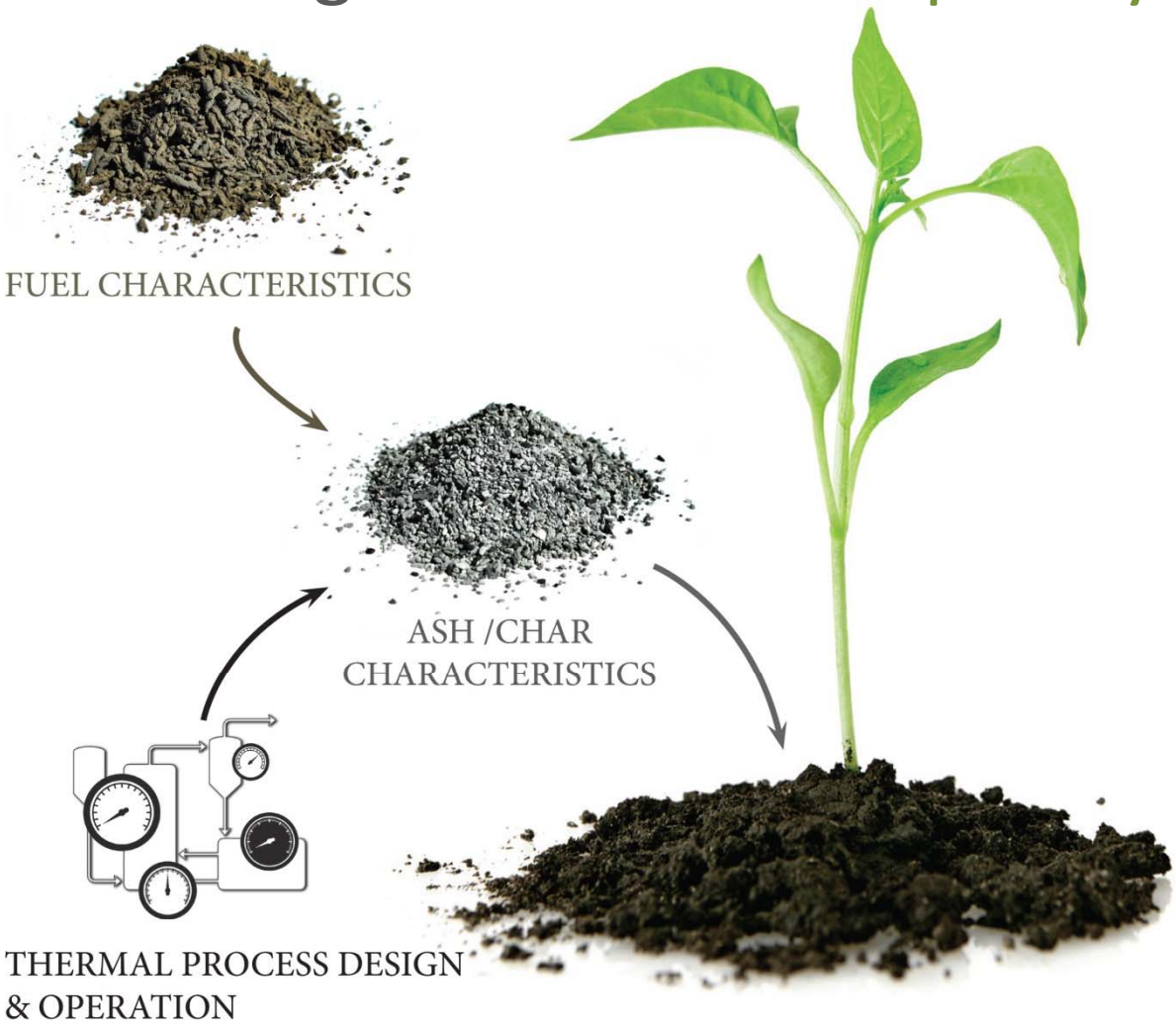
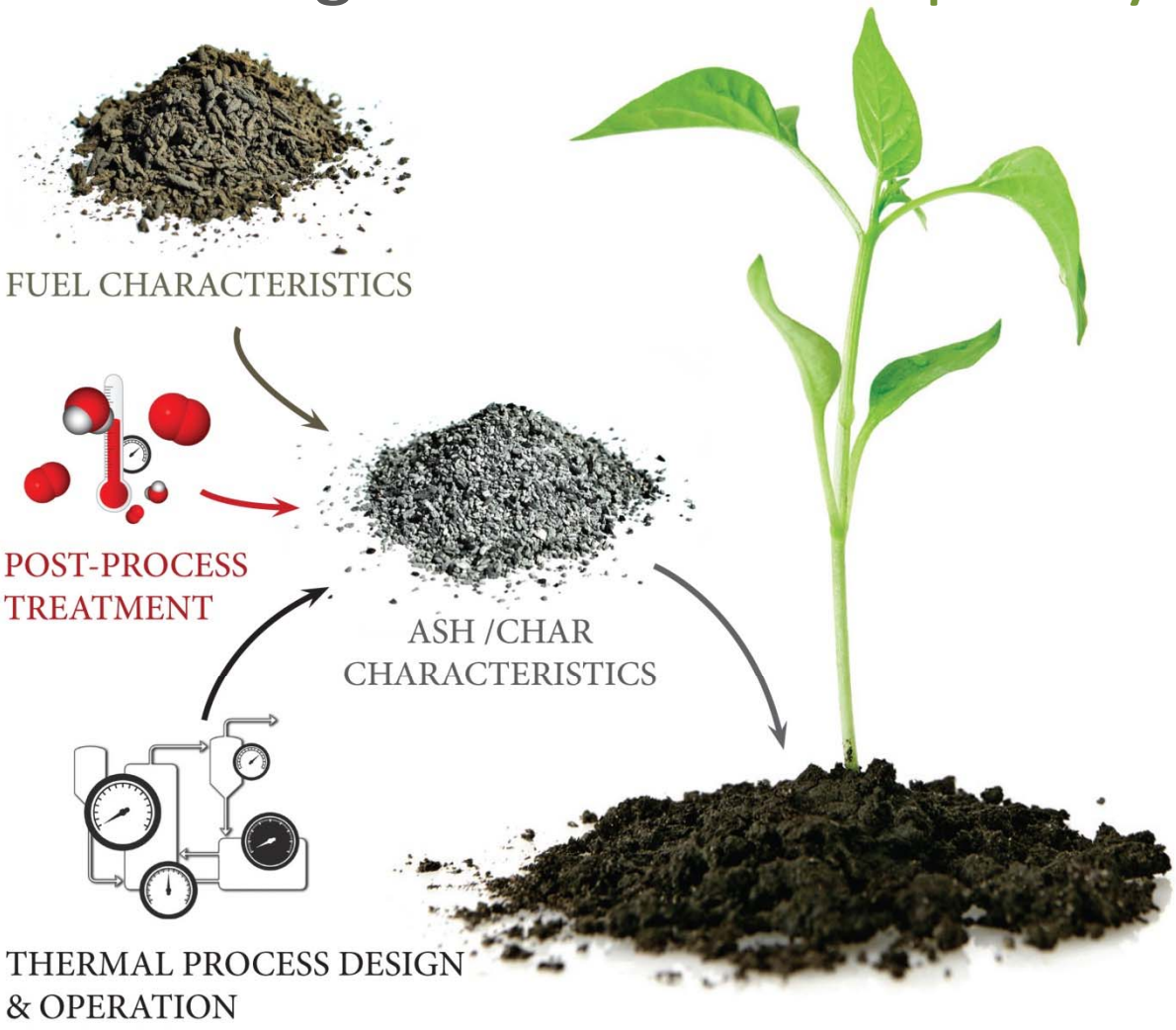


Ash investigations: Effect on plant yield



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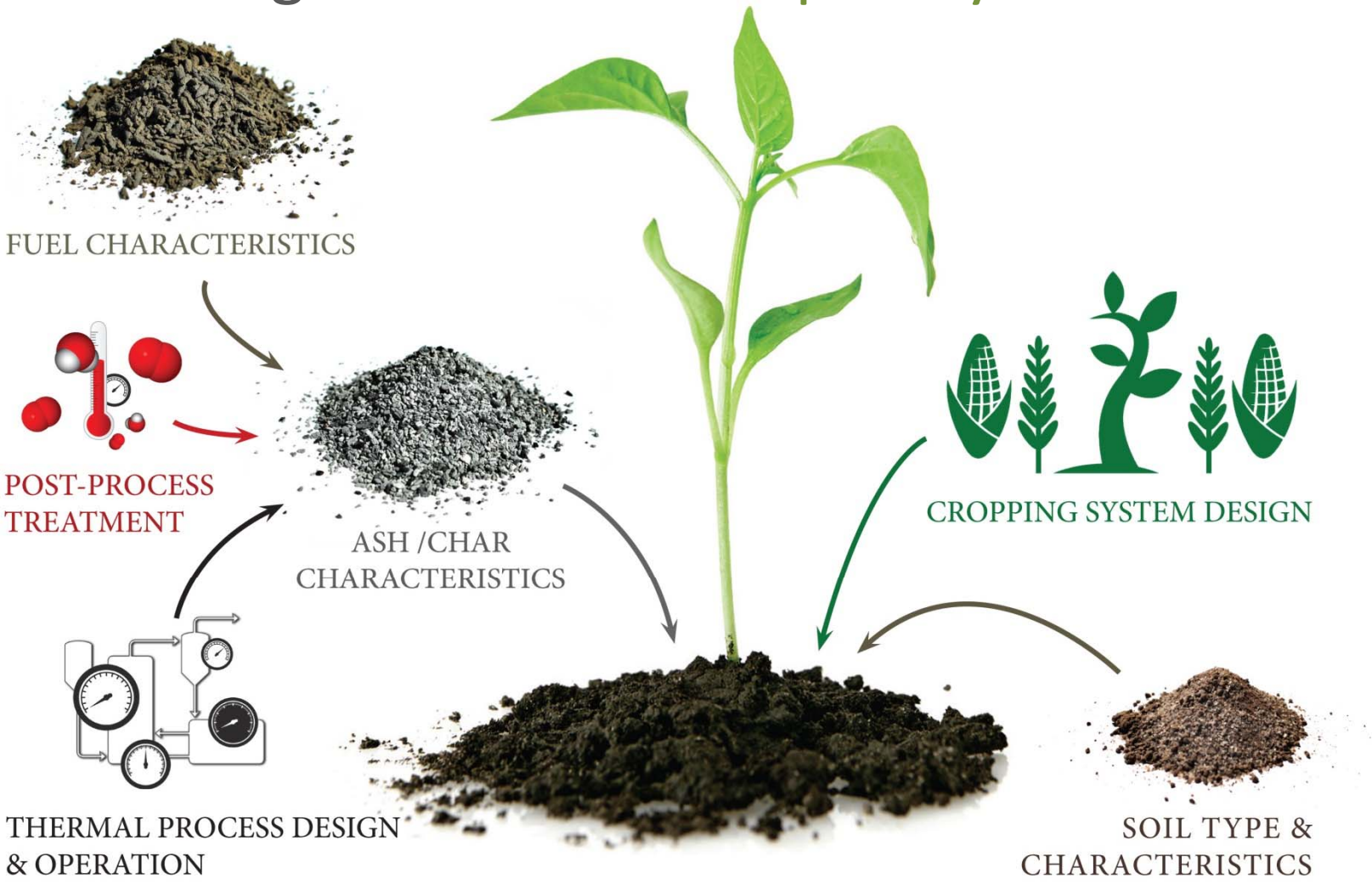
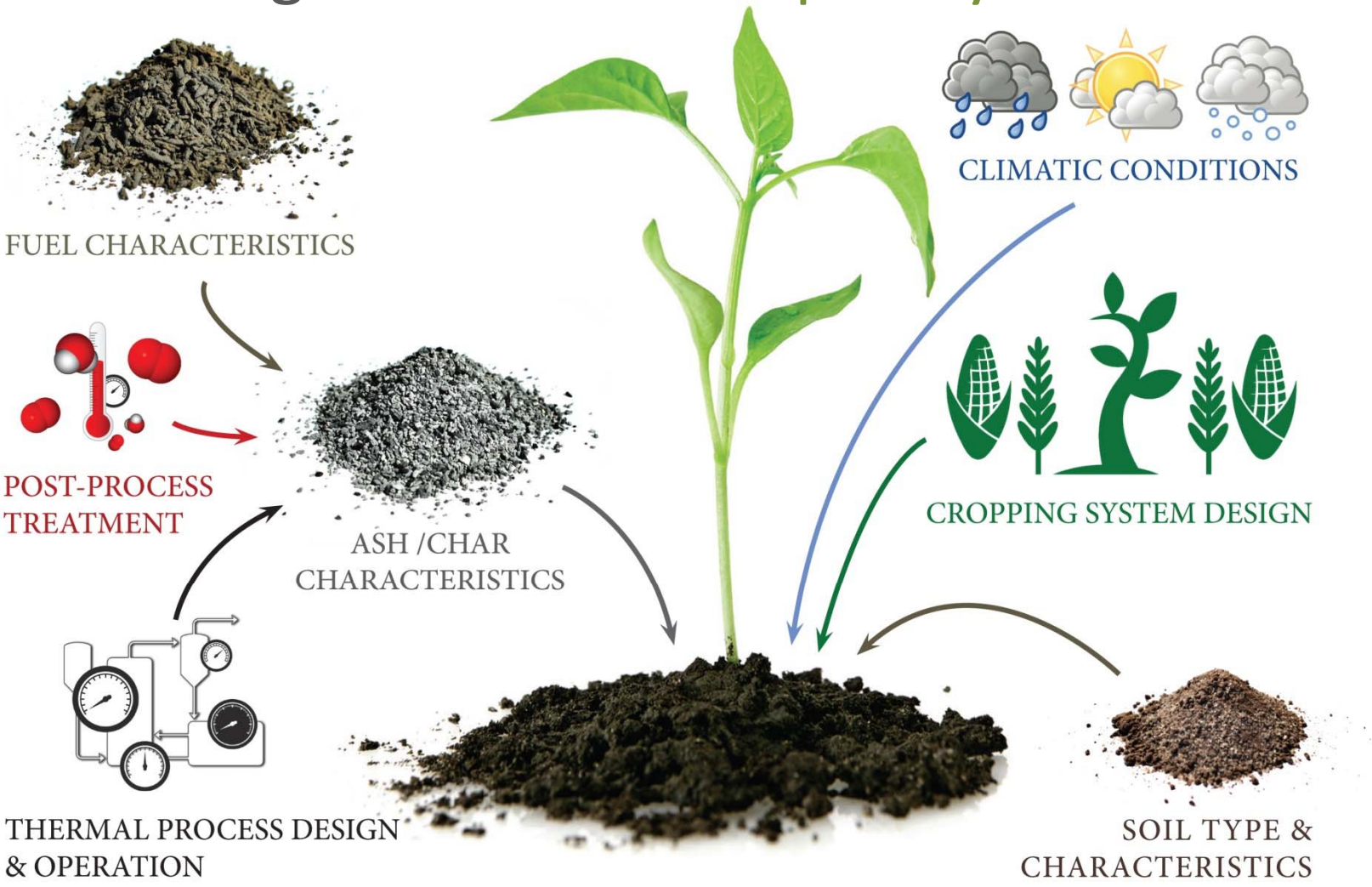
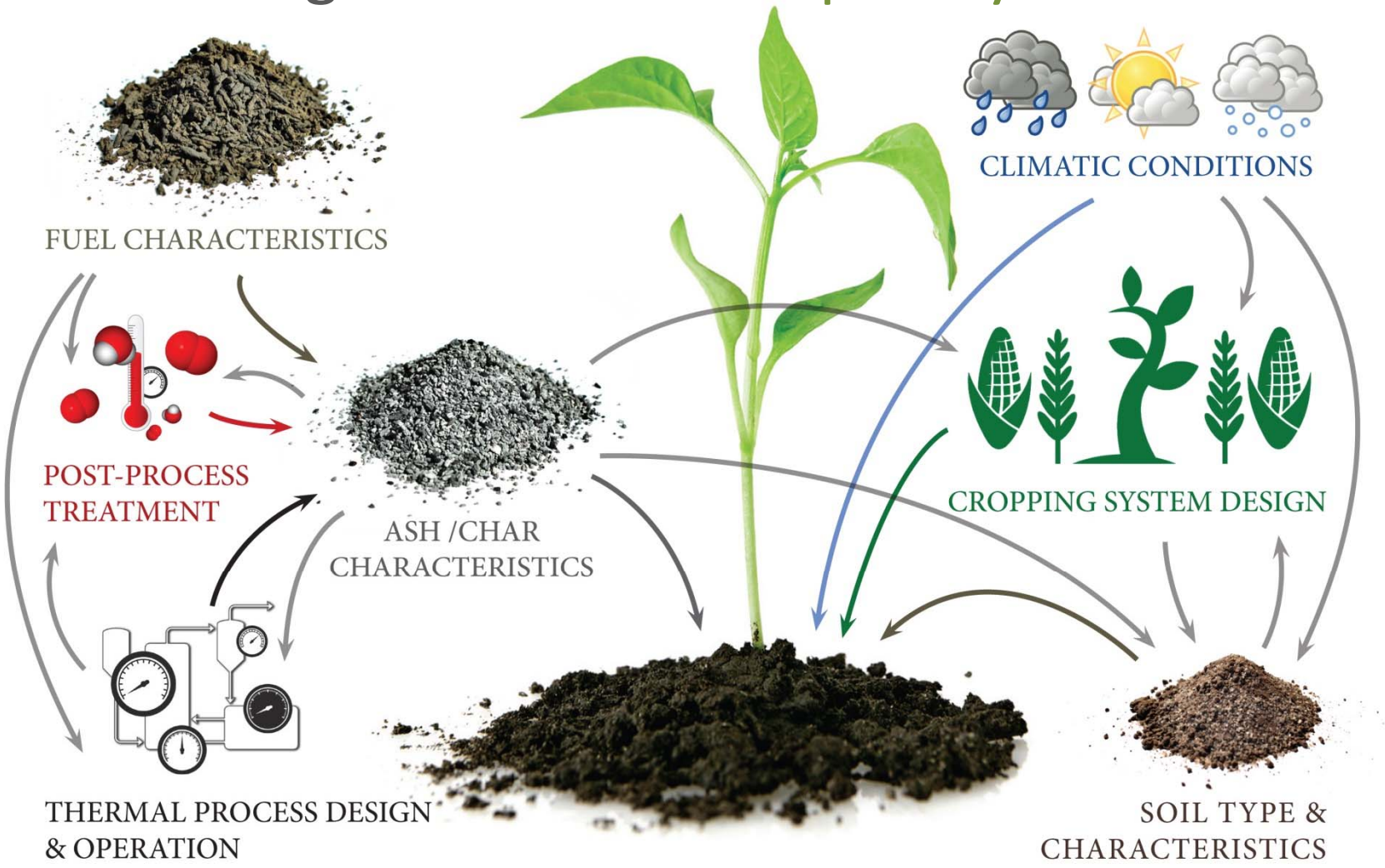


Ash investigations: Effect on plant yield



Ash investigations: Effect on plant yield



Ash investigations: BGG involvement

- **Practical** and legal aspects w. farmers & consultants
- Toxicological aspects w. KU, DTU ENV and RUC
- **Fertilizer potential** and –value w. KU, AU, farmers and consultants
- Soil enhancement properties and –value w. KU, RUC, farmers and consultants

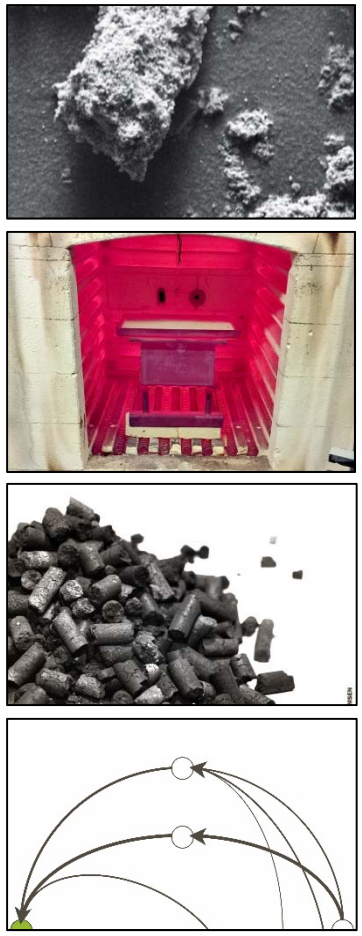
- **Influence of fuel characteristics** w. DFBT, DONG, KU, AU
- **Influence of thermal process design and operation** w. DFBT, DONG, Dall Energy, KU
- **Influence of post-process treatment** w. DTU BYG, KU

Ash investigations: How?

- **Fuel and ash characterization e.g.**
  - Elemental content, solubility and speciation
  - Content of PAH and other organic toxins
  - pH
  - Morphology and structure

- **Application and handling test e.g.**
  - Pelletization and granulation properties
  - Storage and transportation losses
  - Distribution and field application

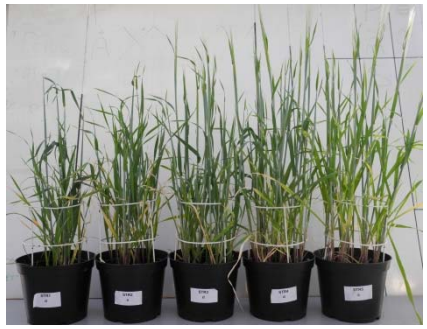
- **System analysis e.g.**
  - Energy- and mass-balances
  - Carbon footprint assessment
  - Full life cycle analysis



Ash investigations: How?

- **Soil incubation studies**
  - P & K fertilizer value
  - pH of soil/substrate mixtures
  - Carbon stability
  - Water holding capacity

- **Plant experiments (pot and field trials)**
  - P and K uptake
  - Plant growth response (P and K)
  - Leaching
  - Soil structural changes, SOC, respiration and eco-toxicology
  - Liming effect



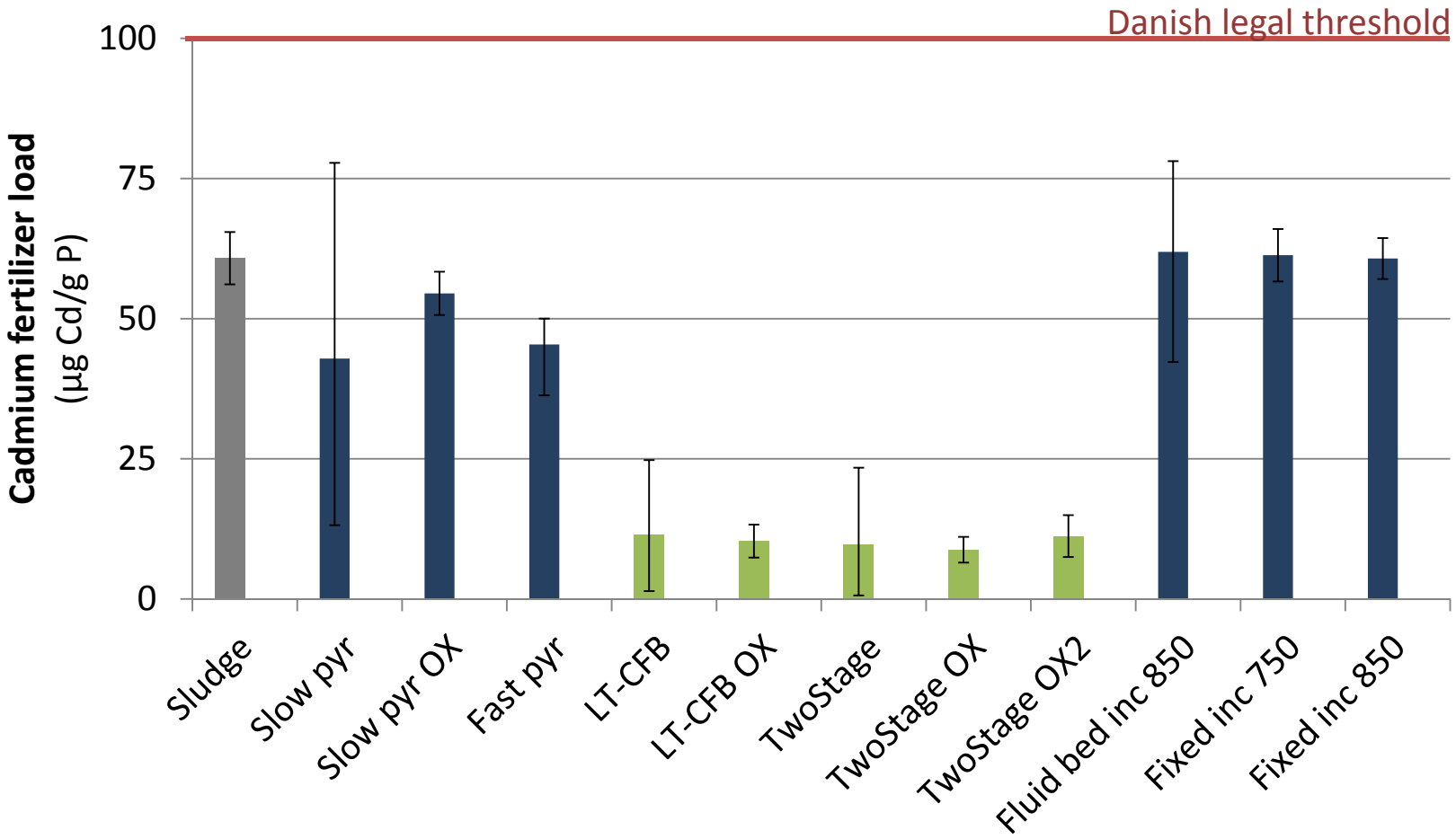
Ash investigations: How?

ASH FERTILIZER QUALITY AT BGG

RESULT EXAMPLES

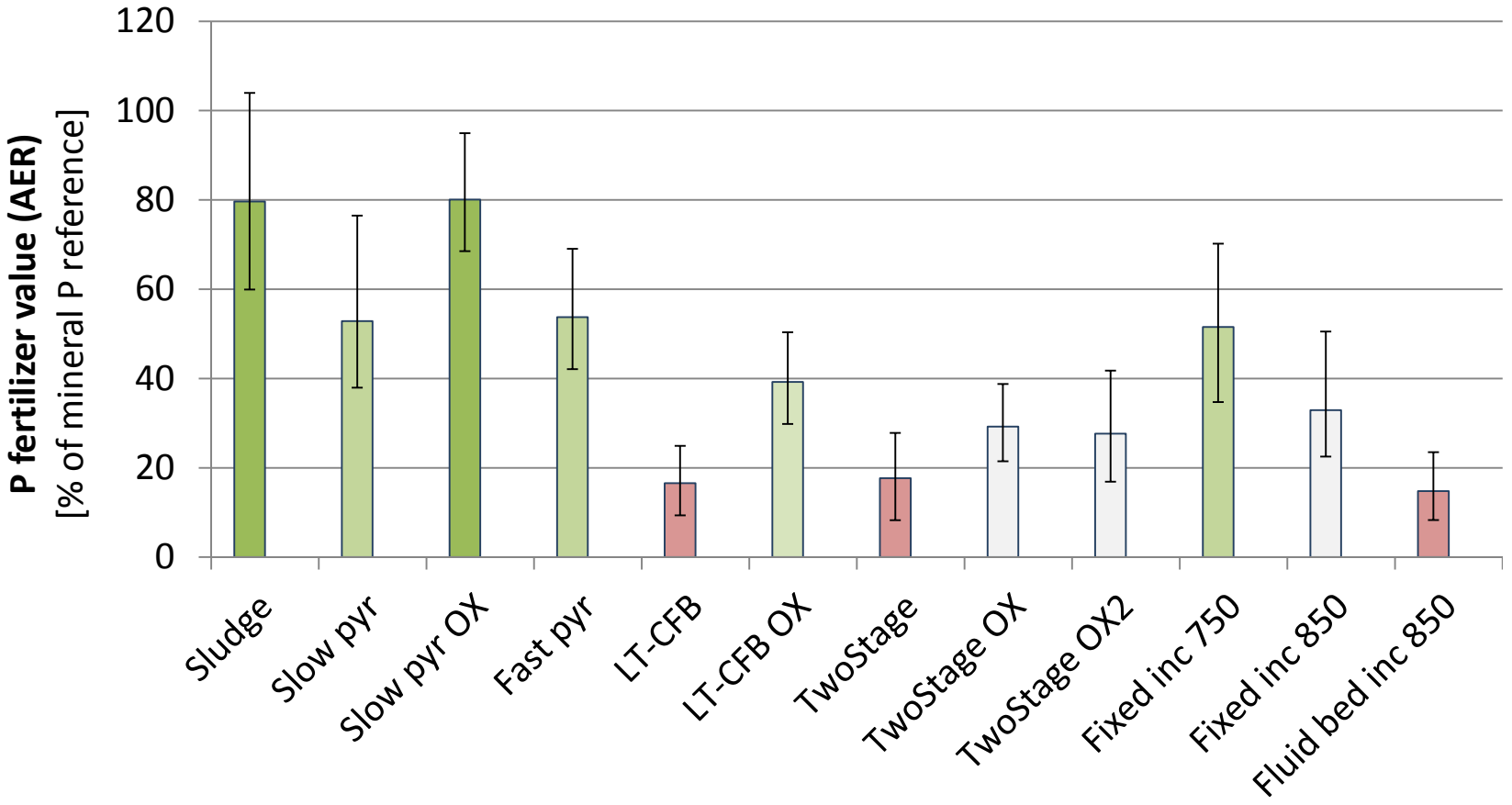
Result example: Tech. influence on ash quality

Result example: Tech. influence on ash Cd load



Tobias Pape Thomsen, Zsuzsa Sárossy, Jesper Ahrenfeldt, Ulrik Henriksen, Flemming Frandsen and Dorette Sophie Müller-Stöver: *Changes imposed by pyrolysis, thermal gasification or incineration on elemental composition and phosphorus fertilizer quality of municipal sewage sludge*. Accepted for publication in: Journal of Environmental Management

Result example: Tech. influence P fertilizer value



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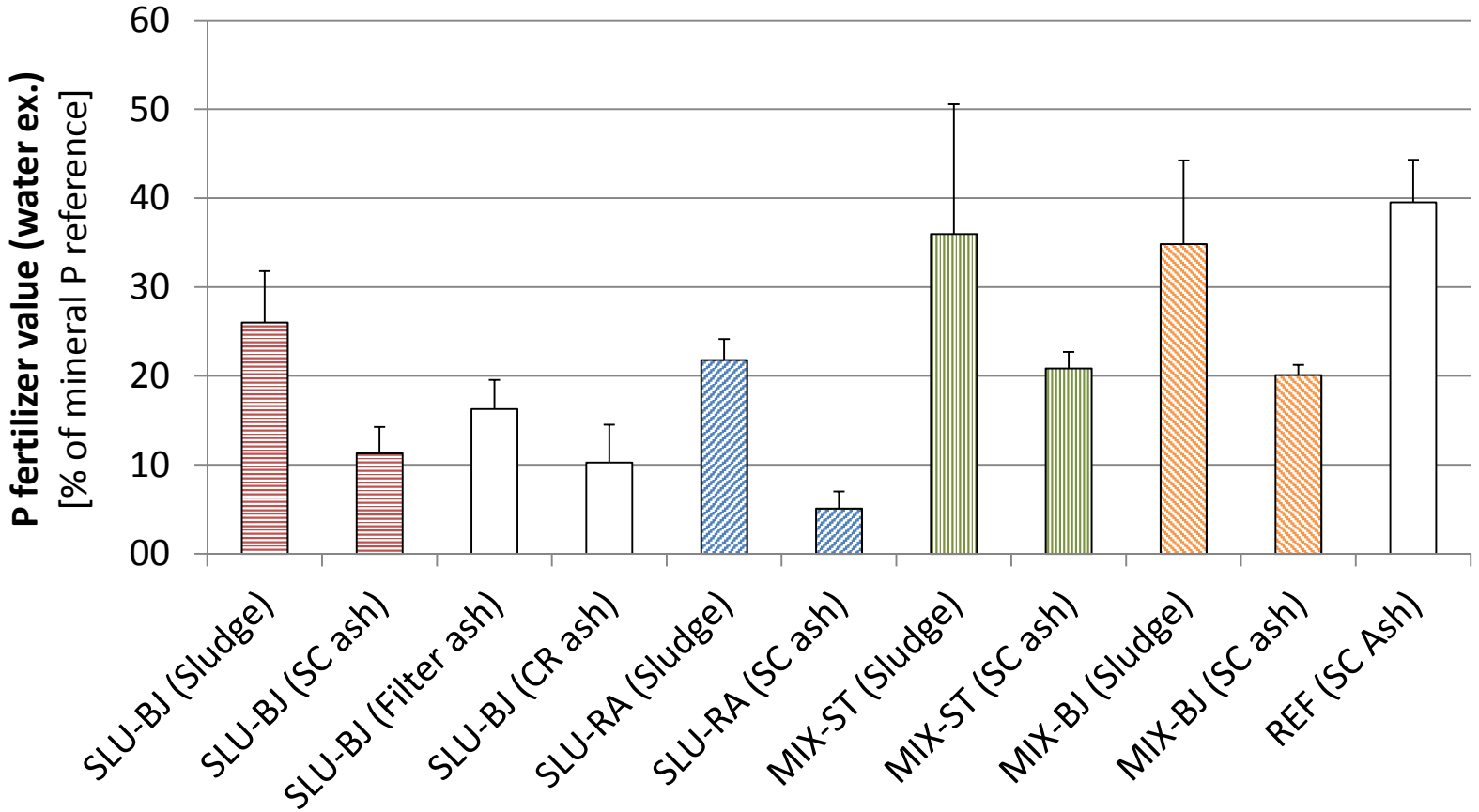
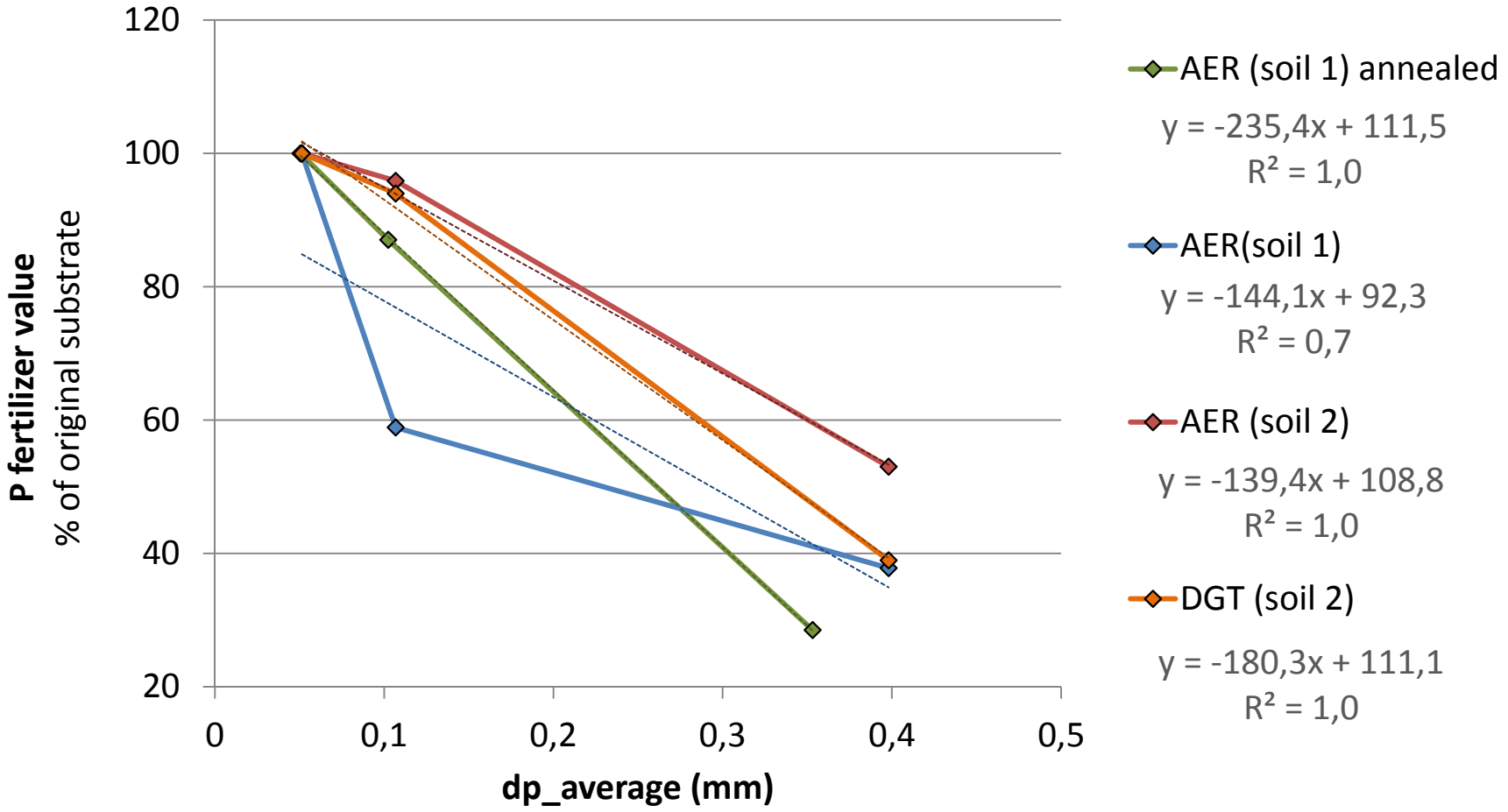
Accepted for publication in: Journal of Environmental Management

Result example: Fuel influence P fertilizer value



Tobias Pape Thomsen, Henrik Hauggaard-Nielsen, Benny Gøbel, Peder Stoholm, Jesper Ahrenfeldt, Ulrik B. Henriksen and Dorette Sophie Müller-Stöver: *Low Temperature Circulating Fluidized Bed gasification and co-gasification of Municipal Sewage Sludge. Part 2: Evaluation of ash materials as phosphorus fertilizer*. In review in: Waste Management

Result example: particle size influence P fert. val.



Ash quality: A few general conclusions

- Not simple!
- Substantial variation from
  - Fuel
  - Technology
  - Post-process treatment
  - End-use scenario
- General trends
  - Generally low ECO-tox of biomass ashes
  - Highly stabile C content (carbon sequestration)
  - Profound liming effect
  - High loss of N, minor loss of P and K
  - Increase water and nutrient retention
- **Immense potential benefits**
- **Success only through cooperation**

Acknowledgements

DTU KT, DTU ENV, DTU MEK, DTU MAN, DTU CEN & DTU BYG
KU PLEN & KU IGN
RUC ENSPAC
DFBT
DONG
AU
FRICHS
FORS
BIOFOS
ADELAIDE
WERKSTATTEN
EUDP (Danish Energy Agency)
And many, many more …

Thank you for your time and attention