SECTOR

Production of Solid Sustainable Energy Carriers from Biomass by Means of TORrefaction

# Characteristics of torrefied products and their dependence on process conditions

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The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement n° 282826

# Topics

Fuel analysis

Analysis methods

Dependencies on process conditions

Method development

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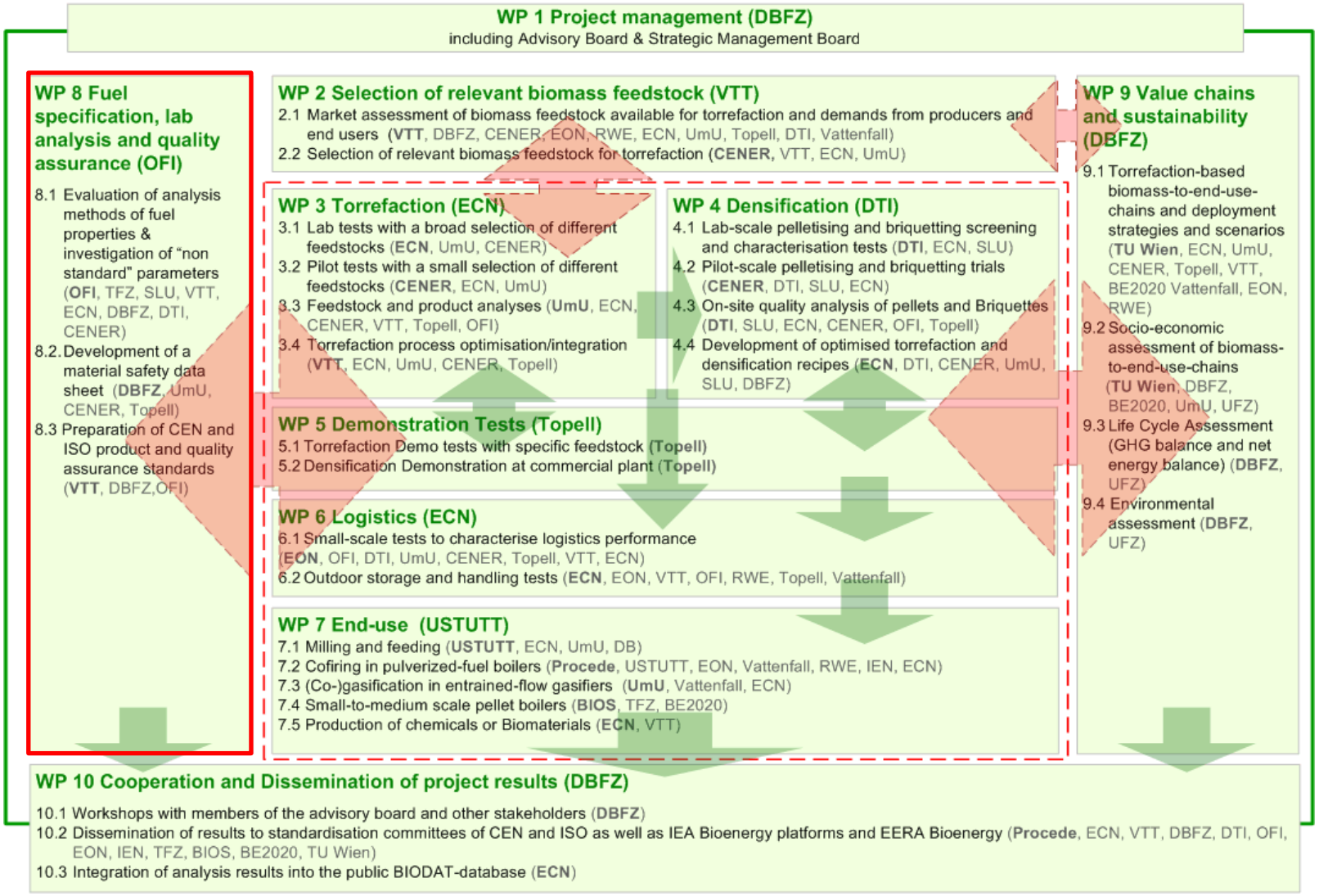
# SECTOR - project

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# Characterization of torrefied material I

- Fuel characterization of torrefied materials and corresponding raw materials (62 samples - chips and pellets)
- Parameter
  - Moisture content (ar)
  - Ash
  - Volatile content
  - Net calorific value
  - Carbon content
  - Hydrogen content
  - Nitrogen content
  - Sulfur content
  - Chlorine content

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# Characterization of torrefied material II

- Round Robin test
  - Applicability of biomass standards
  - 43 Participants
  - 18 Countries
  - 11 Parameter
  - 19-41 participants per Parameter

| Parameter | Method/ Standard |
|---|---|
| Bulk density | acc. EN 15103 |
| Mechanical durability | acc. EN 15210-1 |
| Moisture content | acc. EN 14774-1 or 2 |
| Ash content | acc. EN 14775 |
| Calorific value | acc. EN 14918 |
| Content of chlorine and sulphur | acc. EN 15289 |
| Content of volatile matter | acc. EN 15148 |
| Content of carbon, hydrogen, nitrogen | acc. EN 15104 |
| Content of major elements | acc. EN 15290 |
| Content of minor elements | acc. EN 15297 |
| Ash melting behaviour | acc. CEN/TS 15370 |

(http://www.sector-project.eu - Results)

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# Material - data

- Raw material

| | Moisture, $M_{ar}$ w-%$_{ar}$ | Ash, A w-%$_d$ | Net calorific value, $Q_{net}$ MJ/kg$_d$ | Volatile Matter, VM w-%$_d$ | Carbon, C w-%$_d$ | Hydrogen, H w-%$_d$ | Nitrogen, N w-%$_d$ | Sulfur, S w-%$_d$ | Chlorine, Cl w-%$_d$ |
|---|---|---|---|---|---|---|---|---|---|
| Spruce | 14,8 | 0,3 | 18,7 | 85,0 | 49,5 | 6,8 | 0,2 | 0,005 | 0,005 |
| Willow | 14,9 | 1,5 | 18,0 | 83,3 | 47,9 | 6,3 | 0,3 | 0,022 | 0,002 |
| Pine (a) | 10,4 | 0,6 | 18,4 | 86,8 | 49,2 | 6,9 | 0,2 | 0,008 | 0,008 |
| Pine (b) | 10,7 | 0,3 | 19,1 | 84,6 | 49,8 | 6,3 | 0,1 | 0,011 | 0,009 |
| Poplar (a) | 12,0 | 0,8 | 18,0 | 84,4 | 47,4 | 6,5 | 0,1 | 0,016 | 0,008 |
| Poplar (b) | 10,7 | 0,9 | 18,2 | 84,0 | 48,1 | 6,7 | 0,1 | 0,013 | 0,024 |
| Beech | 12,3 | 0,8 | 18,1 | 83,4 | 48,1 | 6,1 | 0,2 | 0,011 | 0,004 |

- Material raw and at different torrefication temperatures

Spruce-raw

Spruce 240° C

Spruce 260° C

Spruce 280° C

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# Material - experimental matrix

- Torrefication temperature
- Different wood types - different origins

| Torrefication Temperature (° C) | Spruce | Willow | Pine (a) | Pine (b) | Poplar (a) | Poplar (b) | Beech |
|---|---|---|---|---|---|---|---|
| **240** | **x** | | | | | | |
| **260** | **x** | | | | | | |
| **270** | | | **x** | | **x** | | **x** |
| **280** | **x** | | | **x** | | **x** | |
| **290** | | | | **x** | | **x** | |
| **300** | | **x** | | **x** | | **x** | |
| Pellet diameter (mm) | 8 | 8 | 6 | 6 | 6 | 6 | 6 |

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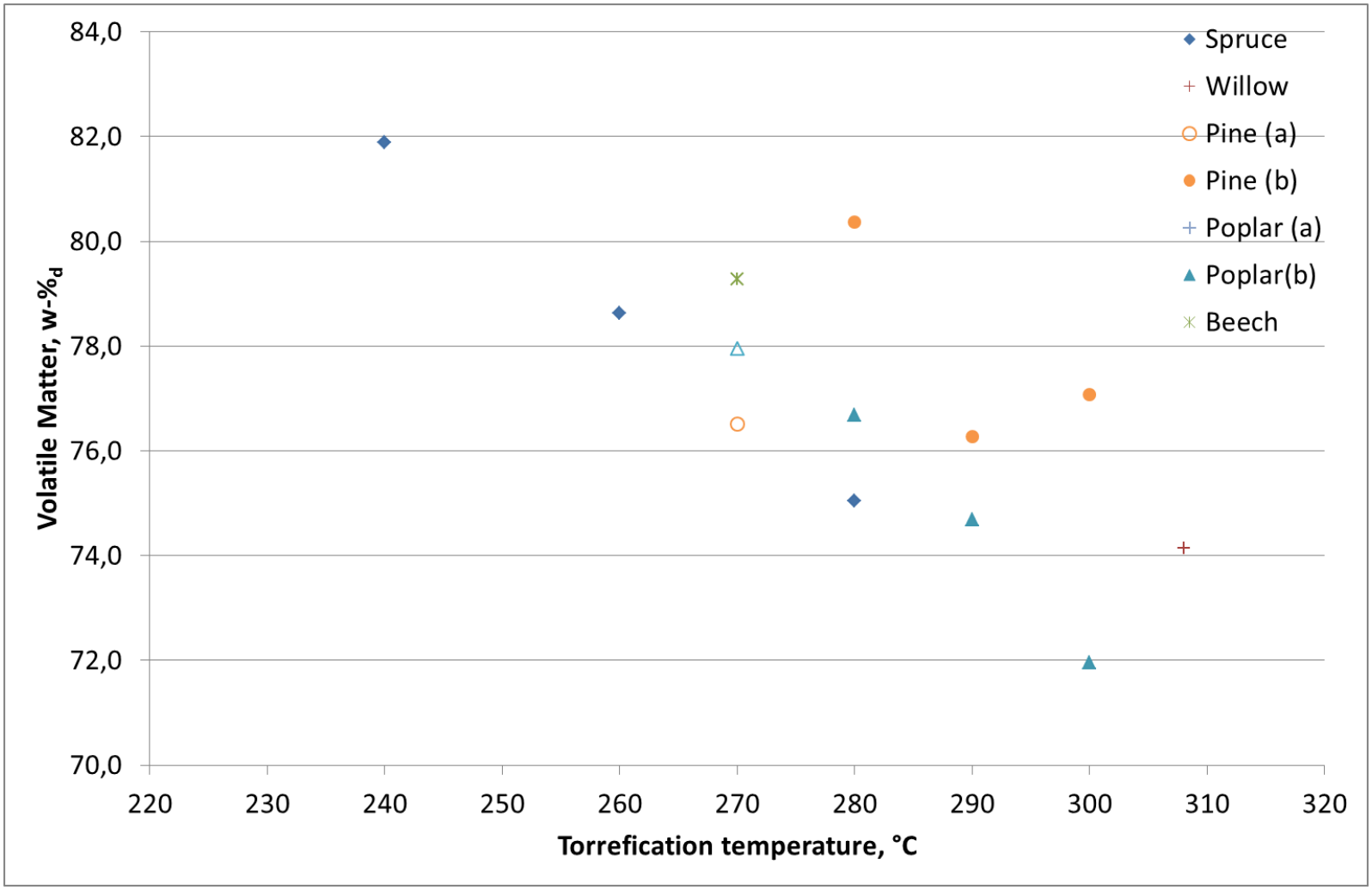
# Torrefication temperature - Volatile matter

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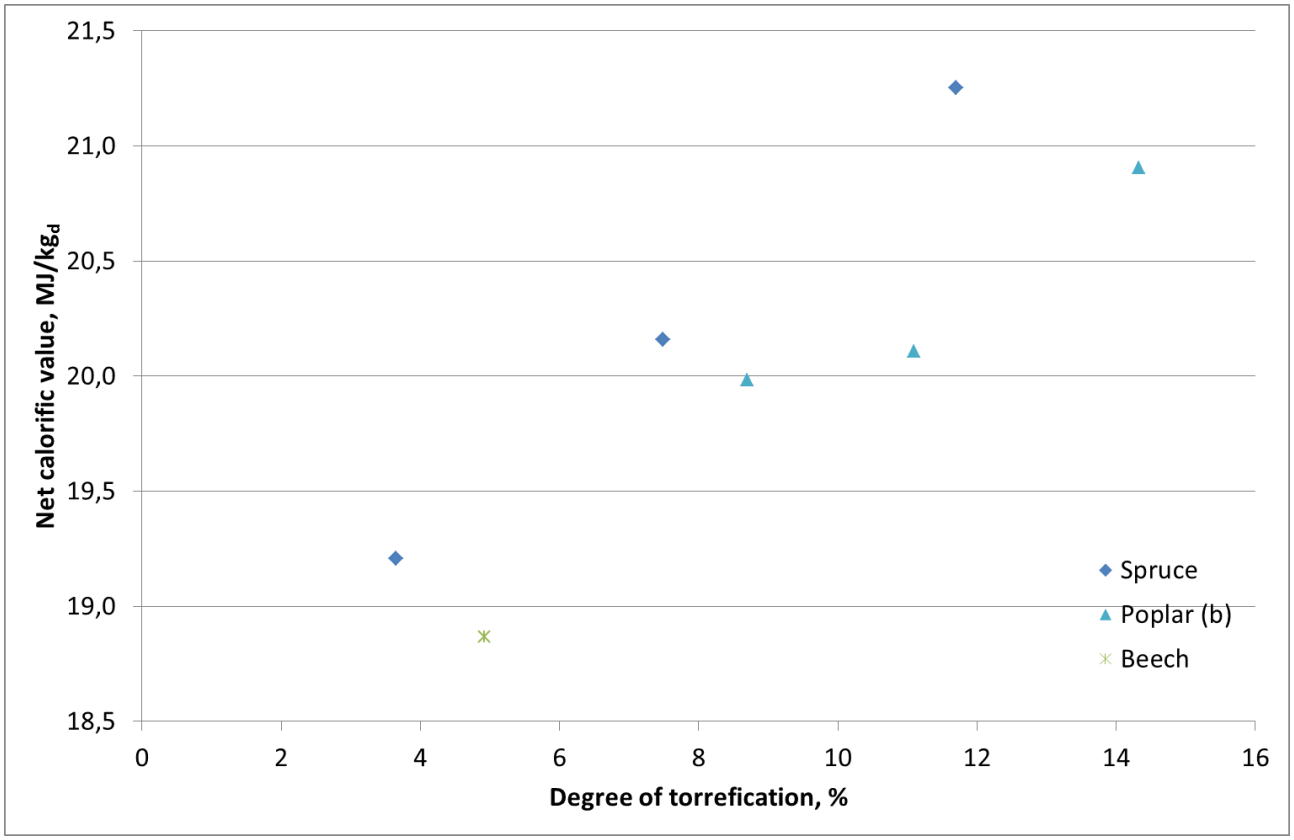
# Degree of torrefication

- $$Degree\ of\ torrefication = 100 - \frac{VM_{torr}}{VM_{raw}} \times 100$$

$VM_{torr}$ … Volatile matter torrefied material [%]; $VM_{raw}$ … Volatile matter raw material [%]

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# Further methods

- Different behavior of torrefied pellets
  - Grindability,
  - Leaching behavior,
  - Hardness
  - …
  - Water absorption (Method (a); Method (b))
  - Storage (Exposure tests)

- Within SECTOR project – second Round Robin with new developed methods

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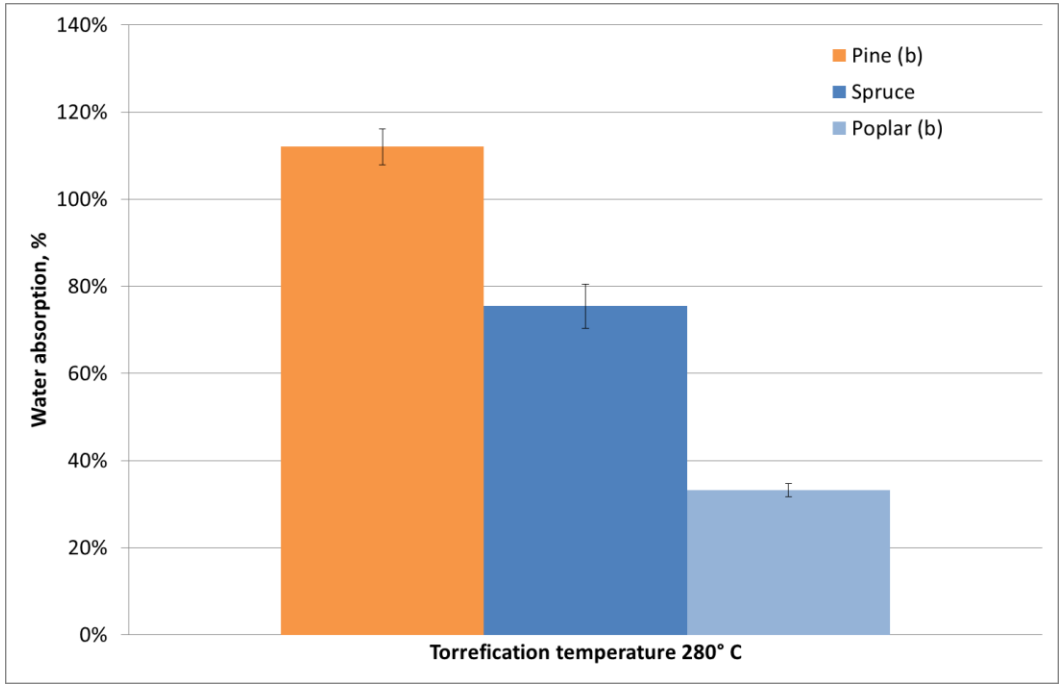
# Water absorption (a)

- Water immersion test with torrefied pellets (280° C torrefication temperature)

15 g sample Container with mesh inset

Triplicates in water (15 min) Draining 10 min

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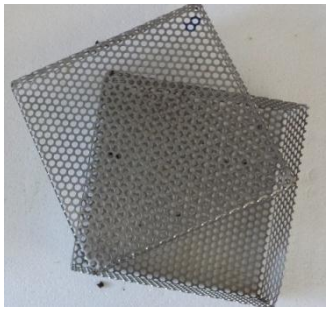
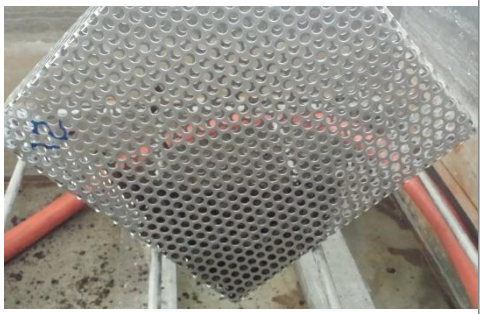
# Water absorption (b)

- Water immersion test with mechanical durability tests

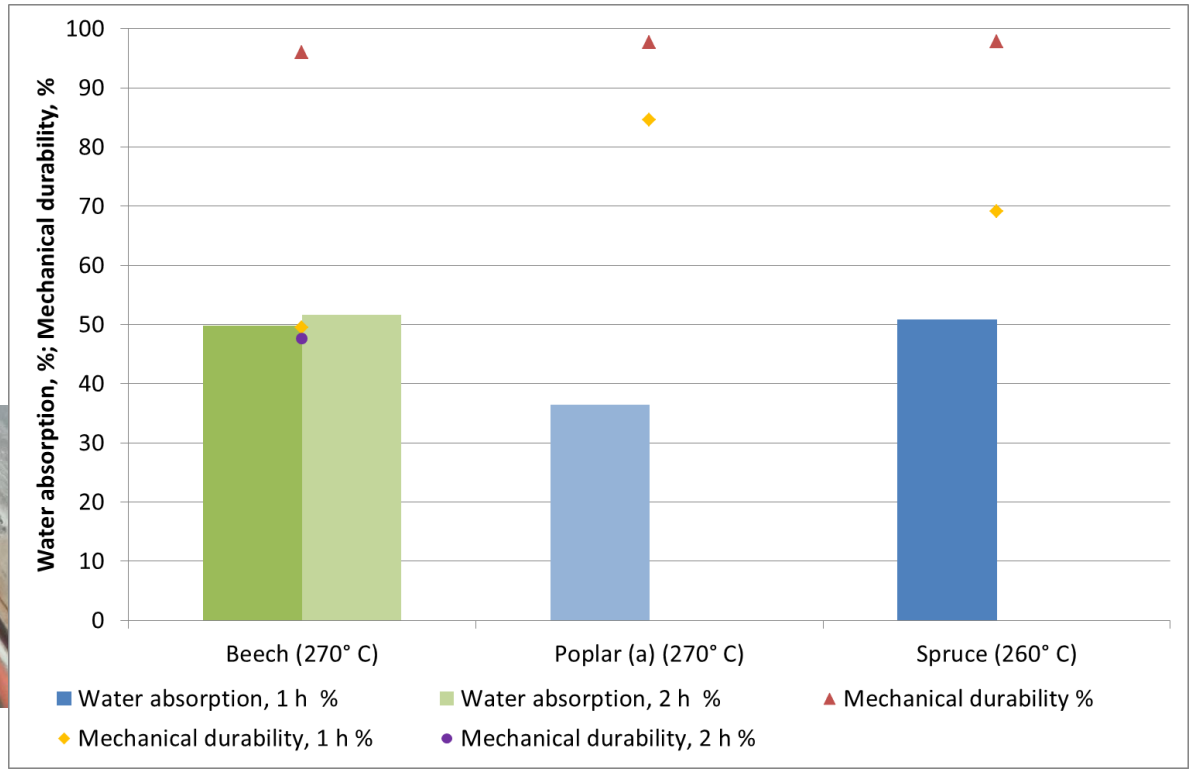


Metall sample box

Immersion in water for 1 h/2 h



Sample draining 1 h
Drying 105° C
Mechanical durability

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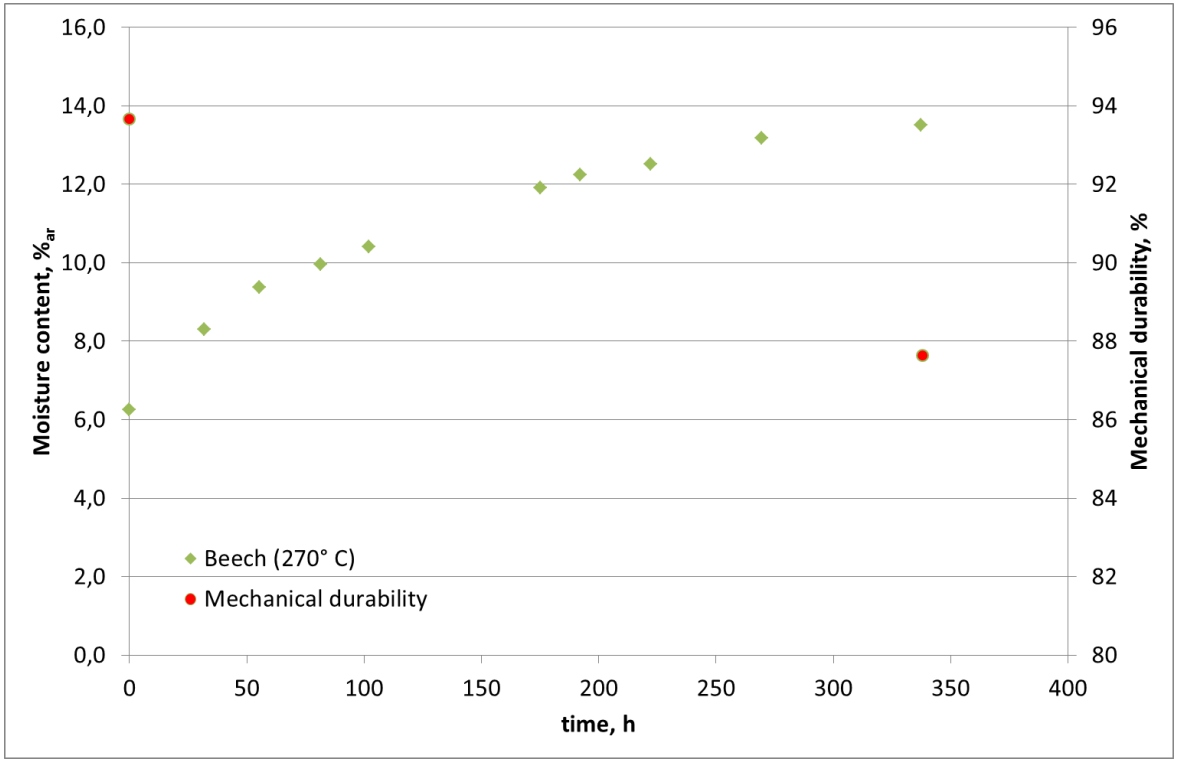
# Exposure test

- Defined climatic properties – saturated $K_2SO_4$ solution; app. 95,5 % rel. Hu (at 23° C) – exposure for 14 days

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# Conclusion & outlook

## Analysis methods

- Applicable for torrefied material (RR I)
- Planned RR II for new developed methods

## Dependencies on process conditions

- Increasing degree of torrefication – increase net calorific value
- Higher torrefication temperature – lower volatile matter
- Difference between wood origin and types

## Further methods

- Three different methods for the water behavior of torrefied pellets considered
- Water absorption reduces the mechanical durability

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# thank you very much for your attention

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