Co-production of fuel pellets, biogas and liquid fertilizer from food residues by means of hydrothermal processing (TORWASH®)

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Your energy. Our passion.

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How much biomass is there available?

Examples of Biomass availability in NL

Biomass feedstock	kton/a (wet)
Road-side grass and natural grass	1,500
Fruit-Vegetable-Garden waste	1,300
Cow, calve and pig manure	57,000
Aquatic biomass	1,000
Sewage Sludge	1,300

Examples of Biomass availability Worldwide

Biomass feedstock	kton/a (wet)
Chicken manure (India)	12,100
Empty Fruit Bunches (Indonesia)	22,000
Sugar cane tops (Colombia)	21,300
Peanut shells (Argentina)	40,000
Rice husk (Asia)	770,000

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Biomass – a difficult energy source

- In view of:
  - Logistics (handling, transport and feeding)
  - End-use (combustion, gasification, chemical processing)

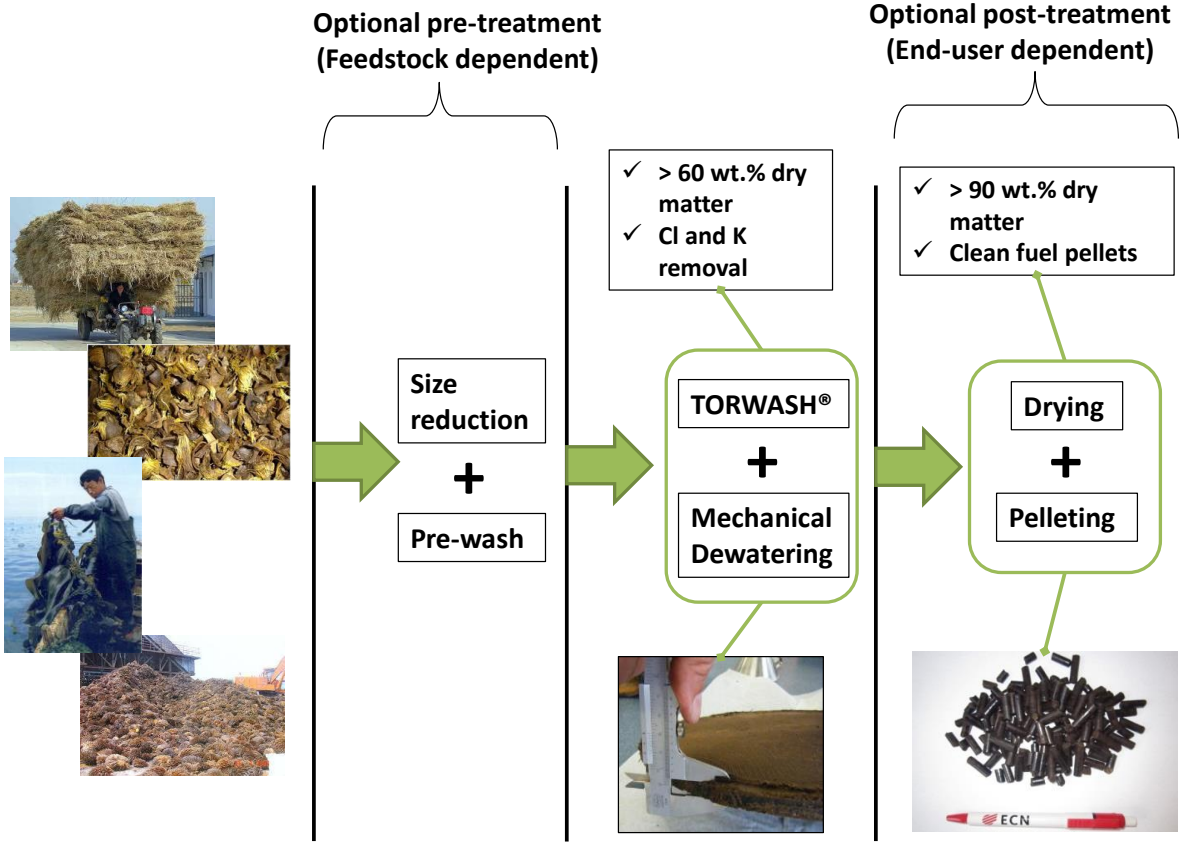
- Difficult properties are:
  - Low energy density (LHV_{ar} = 10-17 MJ/kg)
  - Hydrophilic
  - Vulnerable to biodegradation
  - Tenacious and fibrous (grinding is difficult)
  - Poor “flowability”
  - Heterogeneous

Limitations for wet and high-ash biomass

- Problems with high-moisture/high-ash biomass
  - Difficulties in combustion and gasification
    - Low combustion efficiency
    - chlorine = corrosion
    - potassium = slagging, fouling and agglomeration
  - Difficulties in ash utilization, e.g., in building materials
    - chlorine first element to cause problems
    - alternative: land filling at high costs

- Solution: Wash chlorine and potassium from the fuel
  - not all is removed – bound in cells, poor access
  - resulting 'fuel' is soaking wet – drying very energy-intensive

TorWash®: From biomass waste to a clean, green fuel



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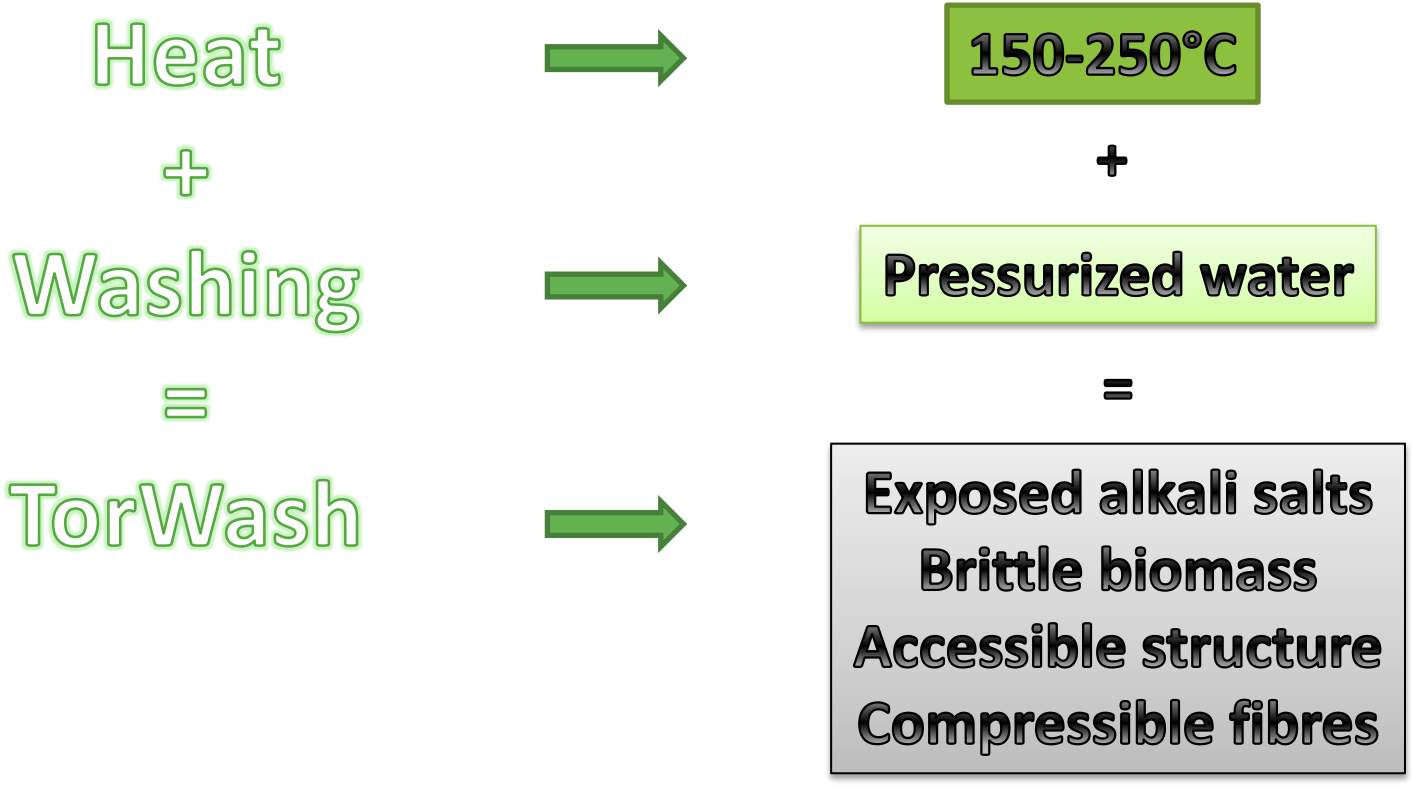
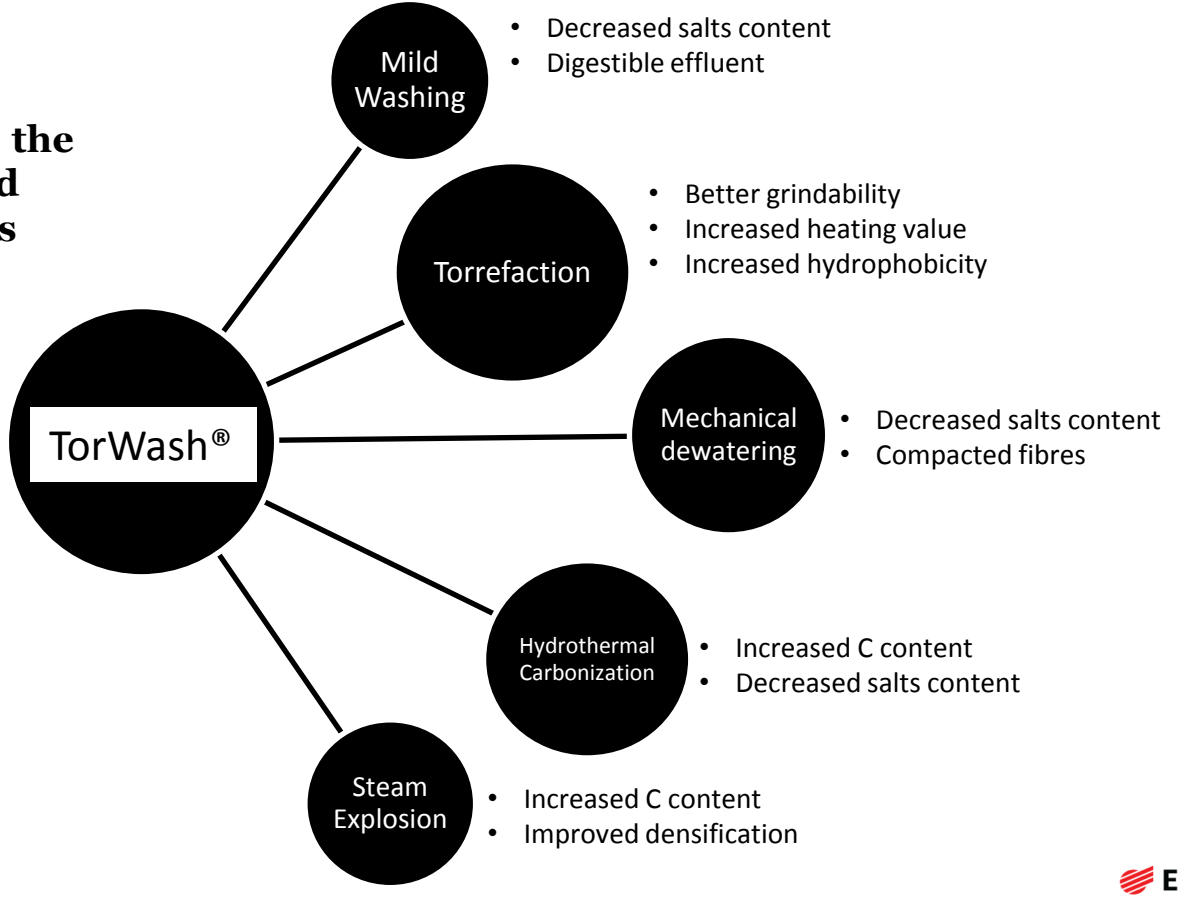
What is TorWash®?



Why is TorWash® unique?

It effectively combines the benefits of various solid pretreatment processes



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Type of feedstocks tested – Up to 20-L batches

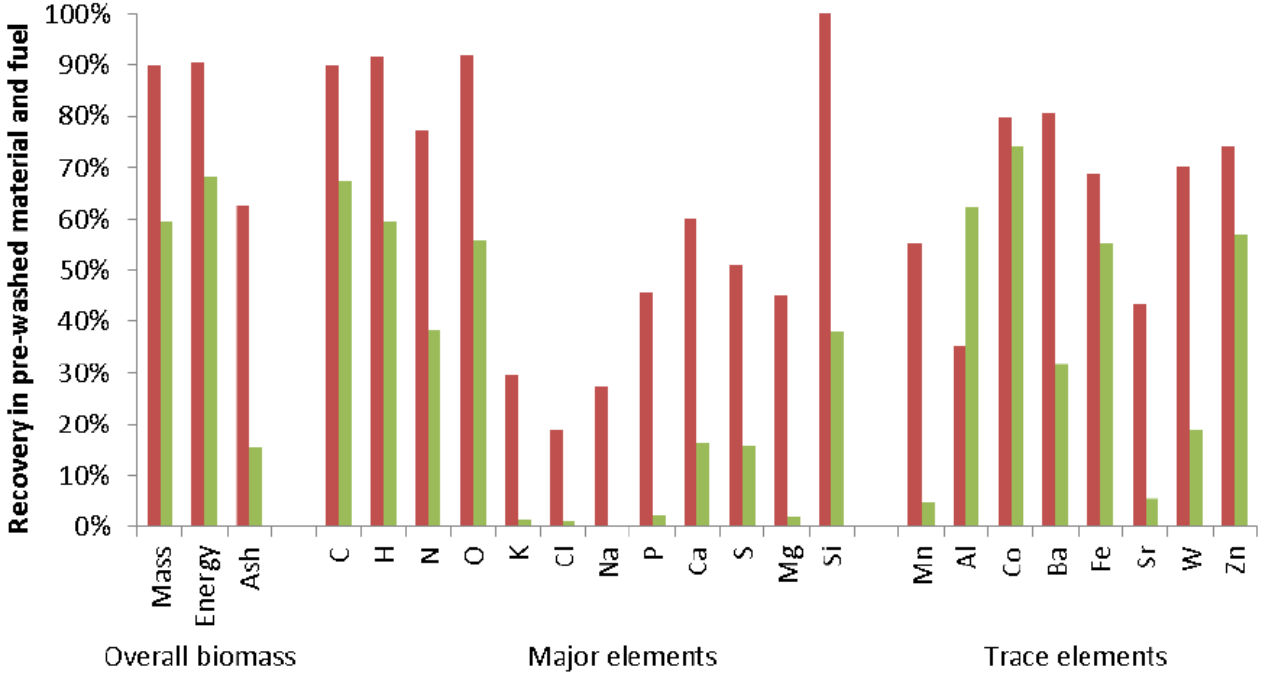
- Feedstock portfolio:
  - Grass, straw, hay
  - Arundo donax (Giant reed)
  - Water plants
  - Bamboo
  - Empty Fruit Bunches (EFB)
  - Cow/pig manure
  - Citrus fruit peels
  - OFMSW
  - Sewage sludge
  - Digestate

Arundo donax, before and after Torwash®, and after subsequent pelletization

Empty fruit bunches (EFB, shredded), before and after Torwash®, and after pelletization

The TorWash® process allows >99% removal of K and Cl

Typical recovery percentages for *Arundo Donax*



Red bars: washing only

Green bars: washing + TORWASH®

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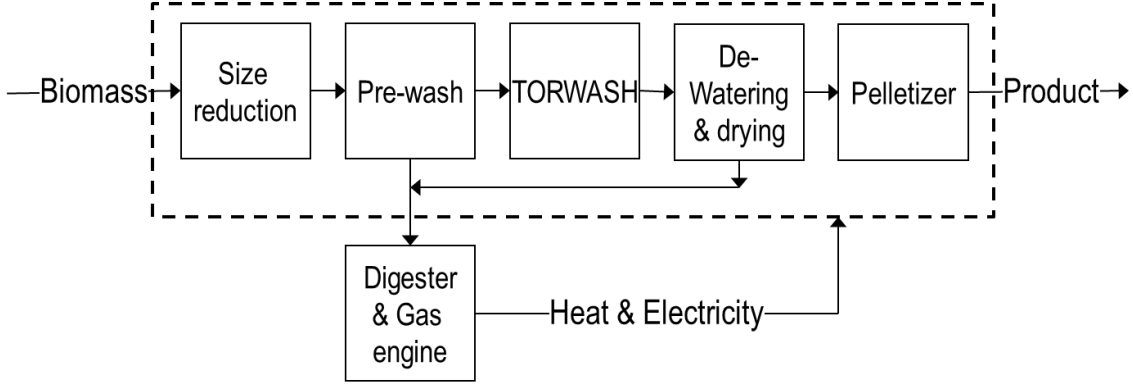
TorWash® is able to upgrade reed to top-class energy pellets

Compliance to pellet fuel standards

Parameter	Unit	EN Plus A1	IWPB-I2	Wood pellets	Orange Peels raw	Orange Peels Torwashed	Reed Raw	Reed Torwashed	EFB raw	EFB Torwashed
Additives	wt%	0	≤ 3	none	none	**none**	none	**none**	none	**none**
Water	wt%	≤ 10	≤ 10	8.3	70-90	**ND**	variable	**7**	variable	**3**
Bulk density	kg/m^3	≥ 600	≥ 600	636	-	**ND**	-	**ND**	-	**610**
NCV	GJ/ton DM	≥ 16.5	≥ 16.5	18.6	15.6	**23.4**	17.9	**20.6**	17.5	**19.8**
Ash	wt% DM	≤ 0.7	≤ 1.5	0.3	3.4	**1.6**	2.3	**0.6**	4.4	**2.9**
Cl	wt% DM	≤ 0.02	≤ 0.05	0.012	0.02	**0.003**	0.227	**0.005**	0.34	**0.005**
K	mg/kg DM	-	-	380	8 200	**600**	4 924	**116**	16 200	**660**

TorWash® features and process scheme

- Mechanical dewatering (down to 25-35% moisture content)
- Mild TorWash® conditions allow excellent pelletization
- The effluent is suitable for biogas production (covers process power & heat requirements)
- The (digested) liquid effluent contains most of the nutrients
  - 99% of K, 50 % of N and 10-90% of P
- Efficient solid-liquid contacting to maximize washing efficiency and minimize fresh water requirement



TorWash® current projects and opportunities

- Empty Fruit Bunches (EFB)
  - Partners with Felda Global Ventures (FGV)
  - TorWash® pilot plant (1 ton/h)

- Sewage sludge & digestate
  - Consortium formed together with Dutch Water Authorities
  - TorWash® + biogas production pilot (40 kg/h)

- Road-side grass
  - Dutch consortium
  - Grass washing pilot plant (500-1000 kg/h)

- Chicken manure…
- Rice husk…

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