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# Experiences in co-digestion of vinasse

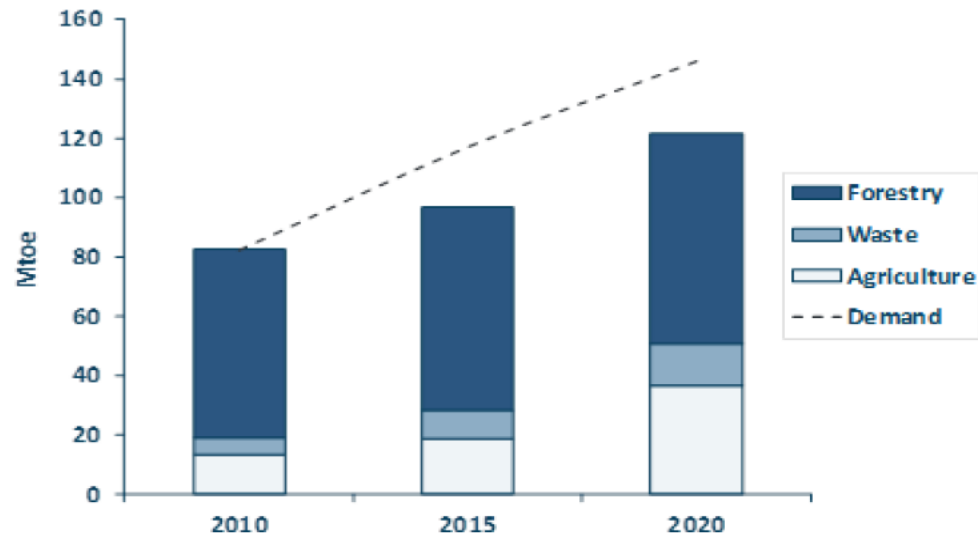
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# The importance of waste utilization for biogas production

- Economical and environmental reasons
- Substrate deficit
- High feedstock prices
- Rising biomass demand
- Low feed-in tariffs



## EU Biomass Supply-demand for power and heat

Source: Eurelectric, 'Biomass 2020: Opportunities, Challenges and Solutions', October 2011

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# Vinasse

- Vinasse is the by-product of ethanol production by fermenting sugar from sugarcane, sugar beet, hydrolyzed straw etc.
  - Vinasse contains easily digestible organic matter (xylose, glucose, nitrogen content heterocycle compound ect.) so it is a potential substrate for anaerobic digestion producing biogas
  - In Hungary sugar beet vinasse is produced in large amount (120 000 t year<sup>-1</sup>)
  - Methane yield of vinasse is 179 m<sup>3</sup> CH<sub>4</sub> t<sup>-1</sup> (913 m<sup>3</sup> CH<sub>4</sub> t VS<sup>-1</sup>)
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# Basic parameters of vinasse

- TS content 40%
- Density 1.2 g cm<sup>-3</sup>
- High H<sub>2</sub>S content in produced biogas (sulfur content of vinasse: 0.78 % in TS)

Composition:

Organic components	min. 50,0 w/w% d.s.
pH (water solution)	6 ± 0,5
N	min. 4,0 w/w% d.s.
P <sub>2</sub> O <sub>5</sub>	min. 0,1 w/w% d.s.
K <sub>2</sub> O	min. 8,0 w/w% d.s.
Ca	min. 0,9 w/w% d.s.
Na	max. 3,0 w/w% d.s.

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# Full scale anaerobic digestion of vinasse

## Parameters of the biogas plant:

- Technology: one-stage wet fermentation under mesophilic conditions (38 °C).
  - Type and size of the digester: CSTR, 2x1500 m<sup>3</sup>
  - Utilization of the biogas: power generation
  - Main substrate: maize silage
  - Monitoring system: pH, VFA, COD, NH<sub>4</sub>-N, P, K, TS (twice per month), micronutrient content (in every third month)
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# Full scale anaerobic digestion of vinasse

Month	Total Electricity (kWh month <sup>-1</sup> )	Total biogas (m <sup>3</sup> )	Maize silage (t)	Vinasse (t)	Other (t)	Sum (t)	Vinasse ratio (%)	Vinasse ratio in VS (%)
I.	211 464	106 789	340.8	86	152	578.8	14.9	10.5
II.	232 386	131 790	390	119	0	509	23.4	15.0
III.	263 103	157 026	552	98	0	650	15.1	9.3
IV.	166 974	93 346	353.6	65	0	418.6	15.5	9.6
V.	303 591	179 219	624.5	97	0	721.5	13.4	8.3
VI.	279 291	173 281	592	111	16.8	719.8	15.4	9.2
VII.	263 088	168 666	555	112	34.8	701.8	16.0	9.2
<b>Average</b>							<b>16.2</b>	<b>10.2</b>

# Full scale anaerobic digestion of vinasse

Month	Biogas (m <sup>3</sup> t <sup>-1</sup> substrate)	Electricity (kWh t <sup>-1</sup> substrate)	Biogas (m <sup>3</sup> t VS <sup>-1</sup> )	Average daily electricity production (kWh)	Biogas (m <sup>3</sup> m <sup>-3</sup> sludge d <sup>-1</sup> )	Potassium (mg L <sup>-1</sup> )	Total NH <sub>4</sub> -N (mg L <sup>-1</sup> )	Sum dilution (m <sup>3</sup> )	Sum dilution from post digester (m <sup>3</sup> )
I.	185	365	590	6822	1.15	3120	2250	40	403
II.	259	457	756	7497	1.42	4534	2331	67	70.6
III.	242	405	679	9072	1.80	5834	3430	91	123.5
IV.	223	399	628	5385	1.00	5700	3407	64	46
V.	248	421	693	10119	1.99	7207	3460	36	56
VI.	241	388	655	9009	1.86	9200	4470	68	64
VII.	240	375	632	8769	1.87	8440	5120	32	91

# Full scale anaerobic digestion of vinasse

Element	Concentration (mg kg <sup>-1</sup> )
Al	1508
B	12,5
Ba	21,8
Cd	0,155
Co	4,41
Cr	3,85
Cu	33,9
Fe	1144
Li	2,26
Mn	104
Mo	2,11
Na	16724
Ni	8,34
Pb	1,19
Zn	132

- Measurement by iCAP 6300 Duo ICP-OES
- Microelement supplementation was applied
- Sulfuric precipitation



# Full scale anaerobic digestion of vinasse

- Term of the experiment: 7 months
- Applied co-substrates: maize silage, soy
- HRT: 118 days
- OLR: 2.4 kg VS m<sup>-3</sup> d<sup>-1</sup>
- Average biogas yield: 662 m<sup>3</sup> kg VS<sup>-1</sup>
- Average specific biogas yield: 1.6 m<sup>3</sup> m<sup>-3</sup> sludge d<sup>-1</sup>
- Average methane content: 58%
- Average H<sub>2</sub>S content: 1300 ppm
- Initial average solved potassium content: 2.1 g L<sup>-1</sup>
- Average solved potassium content in the last 3 months: 8.3 g L<sup>-1</sup>
- Average pH: 8.9
- The average ratio of the vinasse in the substrate mix was 16.2% (10.2% in VS)
- The convenient dilution rate was 2 L m<sup>-3</sup> sludge d<sup>-1</sup>

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# Main experiences during long term co-digestion of vinasse

- Long term adaptation to the high solvated potassium content
  - Application of convenient dilution rate
  - During the adaptation phase the sludge of the post digester can be used for dilution, later on rain- and fresh water and apple marc were used
  - The applied solvated potassium content was 7-9 g L<sup>-1</sup> in the sludge
  - Application of individual micronutrient supplementation
  - Vinasse is a good substrate for fast biogas production regulation (2-3 hours)
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# Main experiences during long term co-digestion of vinasse

- Many biogas plants have had problems with vinasse co-digestion
  - Based on our monitoring for a non-adapted sludge the 8-9 g L<sup>-1</sup> solved potassium content caused serious inhibition (VFA level 33 000 mg L<sup>-1</sup>)
  - In case of an adapted sludge at 9 g L<sup>-1</sup> potassium content did not caused any inhibition (VFA level 4000 mg L<sup>-1</sup>)
  - After a serious potassium inhibition the recovery phase takes at least 2 months
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# Laboratory scale digestion of vinasse

- Based on the VDI 4630 German patent
  - 1 L working volume bottles (2500 ml capacity threaded brown bottle, Merck & Co., Germany)
  - Digesters were incubated in a water bath (Memmert WNB 14 Basic, Memmert GmbH. & Co.) at a constant temperature (38 °C)
  - Biogas was collected by a Tedlar® Gas Sampling Bag, and the volume was measured using a Hamilton Gas Tight Syringe (Sigma Aldrich Co)
  - The reactors were operated without mechanical mixing and were manually stirred three times per day.
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# Laboratory scale digestion of vinasse

- Term of the experiment: 90 days
  - Applied co-substrate: maize silage
  - HRT: 67 days
  - OLR:  $2.94 \text{ kg VS m}^{-3} \text{ d}^{-1}$
  - Average biogas yield:  $687 \text{ m}^3 \text{ kg VS}^{-1}$
  - Average specific biogas yield:  $1.9 \text{ m}^3 \text{ m}^{-3} \text{ sludge d}^{-1}$
  - Average methane content: 61%
  - Average solved potassium content in the last 30 days:  $8.4 \text{ g L}^{-1}$
  - The average ratio of the vinasse in the substrate mix was 33.3% (22.5% in VS)
  - The convenient dilution rate was  $6 \text{ L water m}^{-3} \text{ sludge d}^{-1}$
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Thank you for your  
attention!

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