Landwirtschaftskammer Niedersachsen

Comparative economic analysis of various types of biogas plant

Profitability of small and medium biogas plants on the basis of slurry and maize silage in Germany

1. **Description**
   a) Results of medium-sized plants 2006 - 2014 (LWK Niedersachsen)
   b) Results of small biogas plants study(slurry only) 2014 (LAZ Baden Württemberg)
2. **Analysis**
   a) Specific substrate costs of (cow) slurry and maize silage
   b) Specific construction costs of (ideal) biogas plants
   c) Dimensions and masses
   d) Costs / Benefits (necessary feed-in tariffs)
3. **Conclusion**
   a) Efficient management with maize silage (electricity and heat)
   b) Efficient management with own slurry (refine before storage)

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1a. Medium Biogas Plant 1

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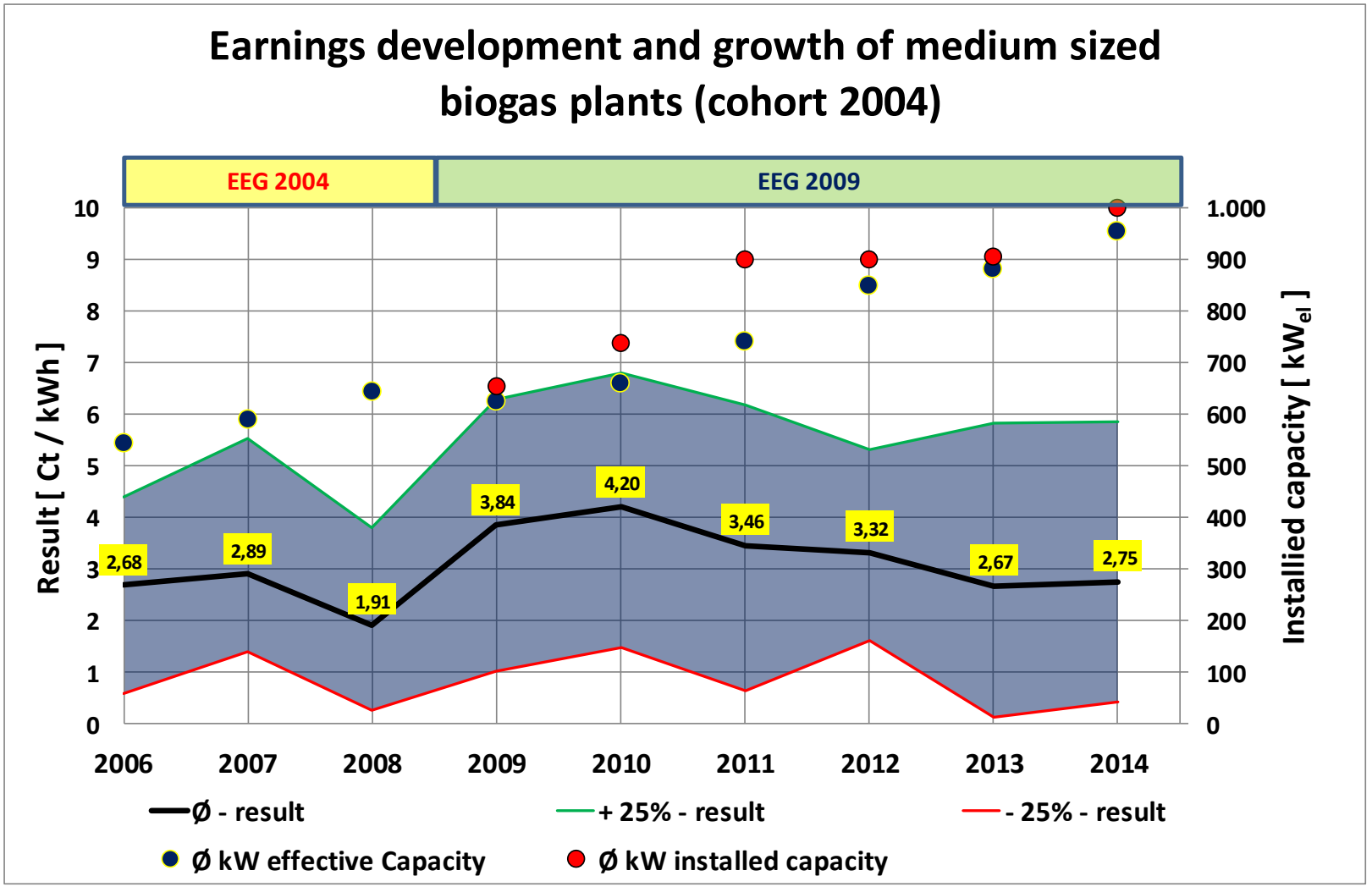

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1a. Medium Biogas Plant 2

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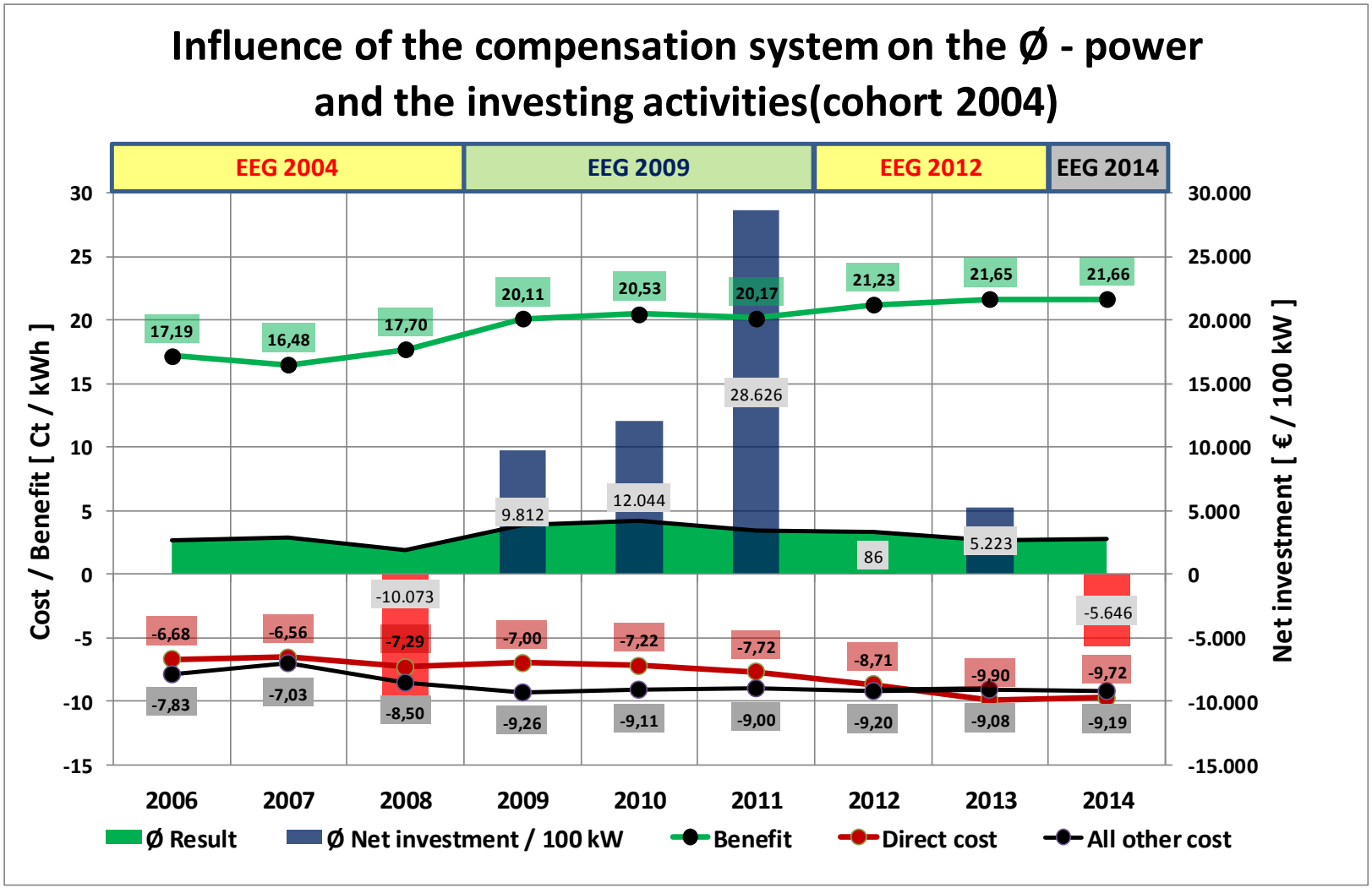

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1b. Small Biogas Plant (slurry) 1

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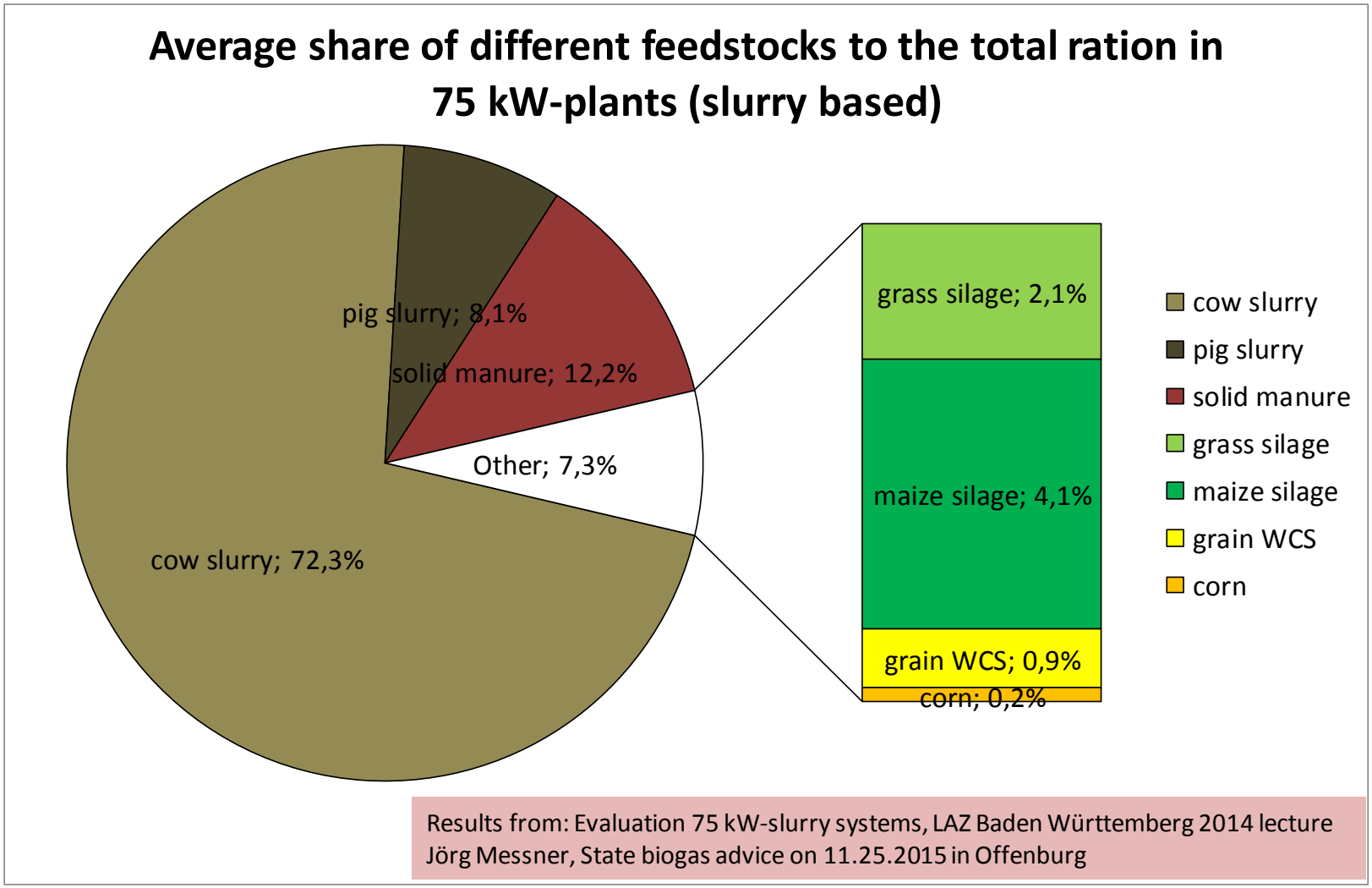

Results from: Evaluation 75 kW-slurry systems, LAZ Baden Württemberg 2014 lecture Jörg Messner, State biogas advice on 11.25.2015 in Offenburg

1b. Small Biogas Plant (slurry) 2

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Evaluation 75 kW-manure plants: results after slurry share grouped						
Slurry share	number	Invest/kW	substrate/a	% Gas-KTBL	% utilization	Ø result
> 80% - <= 85%	2	8.750	34.000	102,0%	96,0%	2,80
> 85% - <= 90%	9	6.550	29.000	102,0%	97,0%	4,55
> 90% - <= 95%	5	6.700	14.000	109,0%	95,0%	7,40
> 95% - <= 100%	8	7.350	1.500	108,0%	94,0%	8,88
Summe / Ø	**24**	**7.031**	**17.125**	**105,5%**	**95,5%**	**6,44**

Results from: Evaluation 75 kW-slurry systems, LAZ Baden Württemberg 2014 lecture Jörg Messner, State biogas advice on 11.25.2015 in Offenburg

Bemerkungen:

1. Feed-in tariff 25 Ct / kWh
2. Minimum slurry mass fraction 80%
3. Evaluation type: Actual values calculated with uniform calculation sets (depreciation, interest, wages, etc.)
4. Investment difficult to define (Agriculture / Biogas - general contractor / builders model)
5. Gas yield uncertain as input materials and qualities are difficult to determine
6. Results agree well with model calculations of the LWK Niedersachsen!

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2a. Specific substrate costs

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feed	€ / t FS free plant	% DS	%oDS / % DS	m^3 CH_4 / t oDS	m^3 CH_4 per t FS	Ct / kWh at ηel 40%	Ct / kWh at ηel 36%	m^3 ferm. res. per t FS	m^3 CH_4 per ferm. res.
grain	170,00	87,0%	97,0%	380	321	13,29	14,77	0,25	1.283
maize silage	**40,00**	**35,0%**	**95,0%**	**340**	113	**8,87**	**9,86**	**0,76**	**149**
grass silage	35,00	35,0%	90,0%	320	101	8,71	9,67	0,75	134
whole crop silage	35,00	35,0%	95,0%	330	110	8,00	8,89	0,75	146
sugar beet	32,00	23,0%	90,0%	360	75	10,77	11,96	0,80	93
Cattle slurry own	**0,00**	**10,0%**	**80,0%**	**210**	17	**0,00**	**0,00**	**0,98**	**17**
Cattle slurry foreign	**5,00**	**10,0%**	**80,0%**	**210**	17	**7,46**	**8,29**	**0,98**	**17**
Pig slurry own	**0,00**	**5,5%**	**80,0%**	**250**	11	**0,00**	**0,00**	**0,99**	**11**
Pig slurry foreign	**5,00**	**5,5%**	**80,0%**	**250**	11	**11,40**	**12,66**	**0,99**	**11**
solid manure	5,00	25,0%	85,0%	250	53	2,36	2,62	0,93	57
poultry manure	15,00	40,0%	75,0%	280	84	4,48	4,98	0,76	111

1. Maize is cheaper than grain and sugar beets
2. Maize provides higher yield per unit area compared to grass and WPS
3. Own slurry is free, because agriculture needs to liquidate it!
4. Strangers slurry costs as much as maize, with storage space twice as much!
5. Maize yields per ton Input 8-10, per m^3 fermentation residues 9 -14 times as much gas as slurry!
6. Pig slurry can not be used in a rule alone.

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2b. Ideal Maize Plant
(100% Maize silage)

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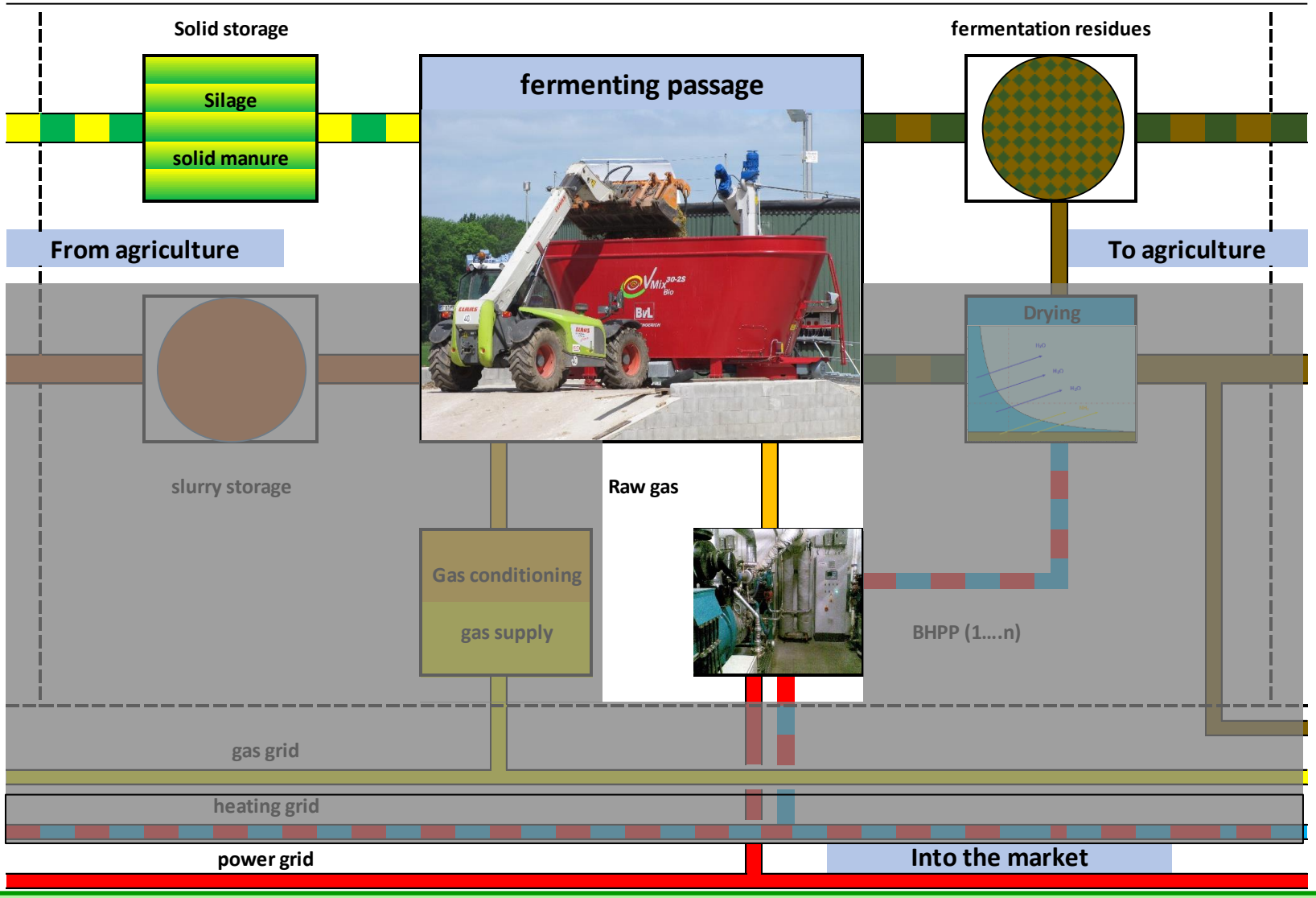

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2b. Ideal slurry plant
(100% slurry)

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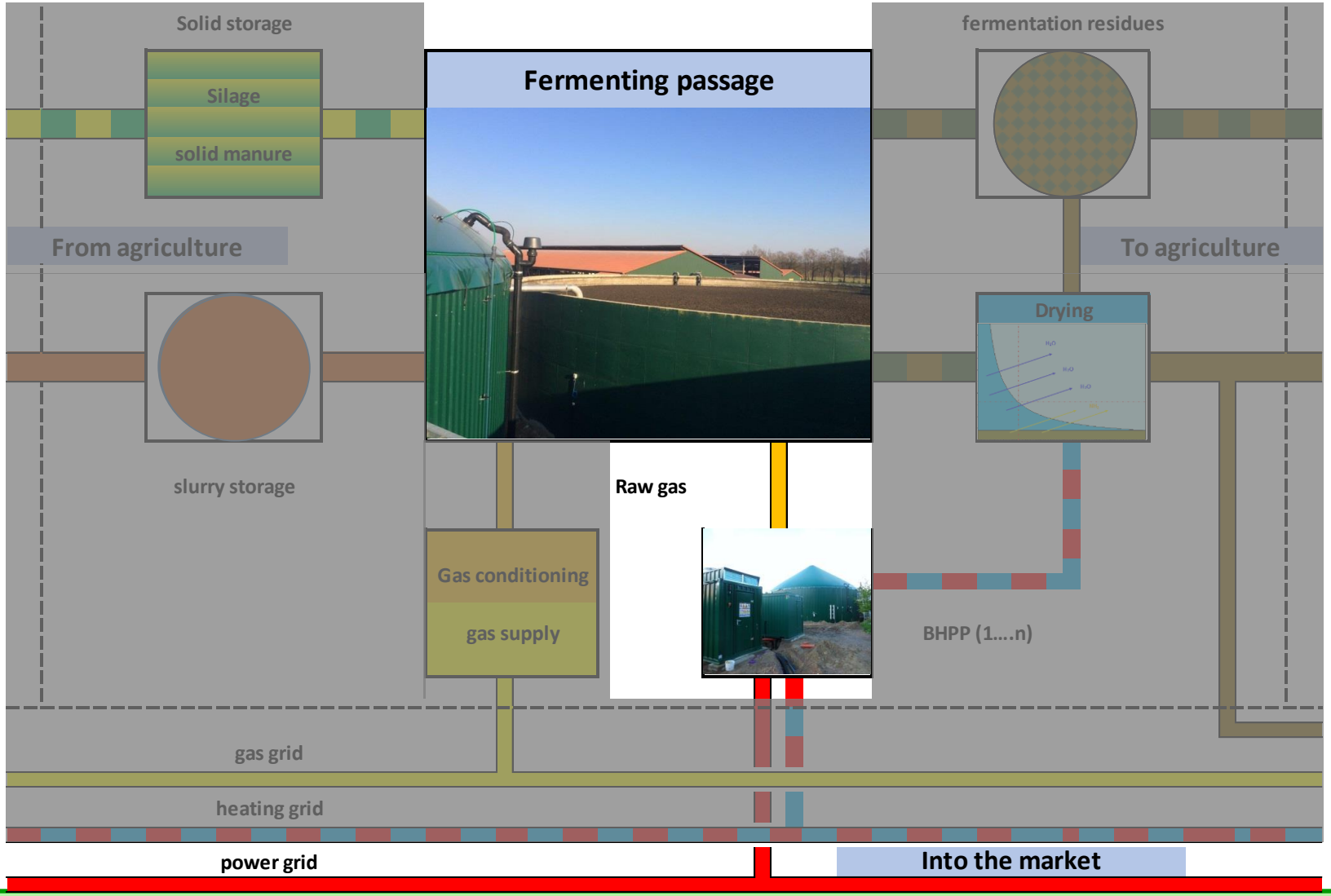

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2c. Dimensions and Masses

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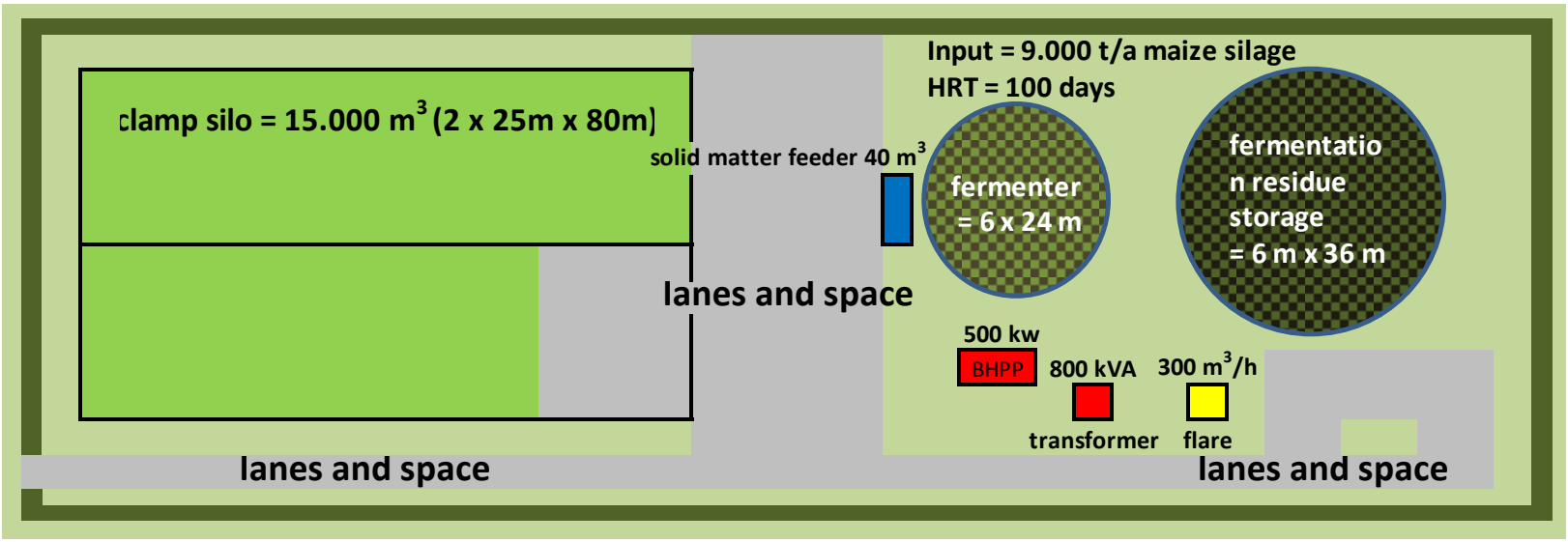

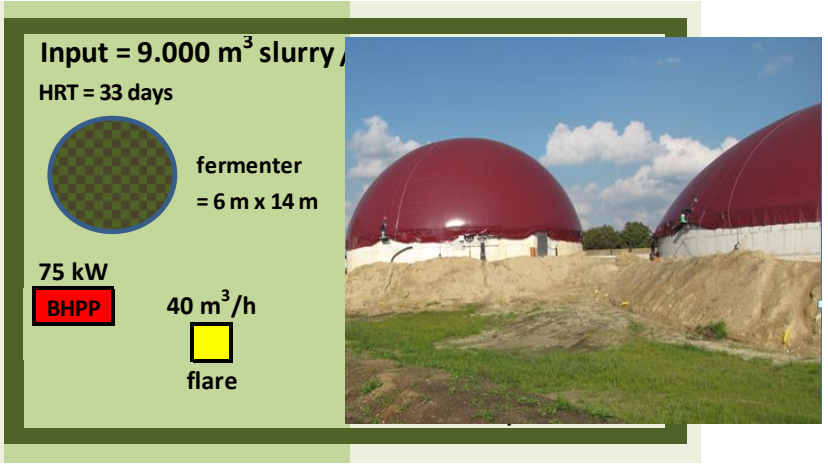

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2d. Costs

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	Biogas Plant 100% maize			Biogas Plant 100% slurry	
Capacity	500	kW		75	kW
Gas Yield rate	110%	KTBL		100%	KTBL
Efficiency BHPP	40%			36%	
Electricity Production (95%)	4.161.000	kWh		624.150	kWh
Investment	1.800.000	3.600 €/kW		500.000	6.667 €/kW
- thereof BHPP/Flare	400.000	800 €/kW		125.000	1.667 €/kW
- thereof other technique	300.000	600 €/kW		200.000	2.667 €/kW
- thereof Construction/Planning	1.100.000	2.200 €/kW		175.000	2.333 €/kW
Ø Usual Life (UL)	15,0	Years		13,2	Years
Costs	Total	Ct / kWh		Total	Ct / kWh
Annuity(Ø UL; 3%)	150.780	3,62		**46.469**	**7,45**
Maintenance	62.415	1,50		**21.845**	**3,50**
Input free fermenter	**356.861**	**8,58**		4.000	0,64
Other Material	15.396	0,37		4.000	0,64
Electricity	46.603	1,12		9.986	1,60
Personal	20.000	0,48		7.300	1,17
Other Costs	24.966	0,60		8.000	1,28
Total	**677.021**	**16,27**		**101.600**	**16,28**

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2d. Necessary Feed-In Tariff
(necessary benefit at r_{tc} = 10%)

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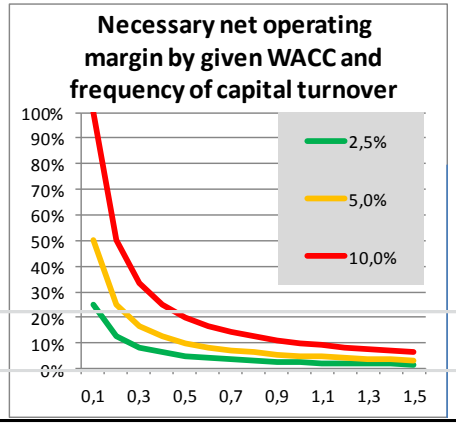

$$\text{net operating margin} = \frac{\textit{return on capital}}{\textit{frequency of capital turnover}}$$

	Biogas Plant 100% maize		Biogas Plant 100% slurry	
	Total	Ct / kWh	Total	Ct / kWh
Annuity (Ø UL; 3%)	150.780	3,62	46.469	7,45
- Ø annual depreciation	120.000	2,88	37.917	6,07
= Ø annual Interest costs	30.780	0,74	8.552	1,37
WACC (10%)	180.000	4,33	50.000	**8,01**
- Ø annual interest costs	30.780	0,74	8.552	1,37
= Ø annual equity interest	149.220	3,59	41.448	**6,64**
Total Costs	677.021	16,27	101.600	16,28
+ annual equity interest	149.220	3,59	41.448	6,64
= necessary benefit	826.241	19,86	143.048	**22,92**
= net operating margin	21,8%		**35,0%**	
= frequency of capital turnover	0,46		0,29	
Real Benefit	**EEG 2004/06**	**20,26**	**EEG 2014/I 16**	**23,41**

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3a. Efficient management with maize silage

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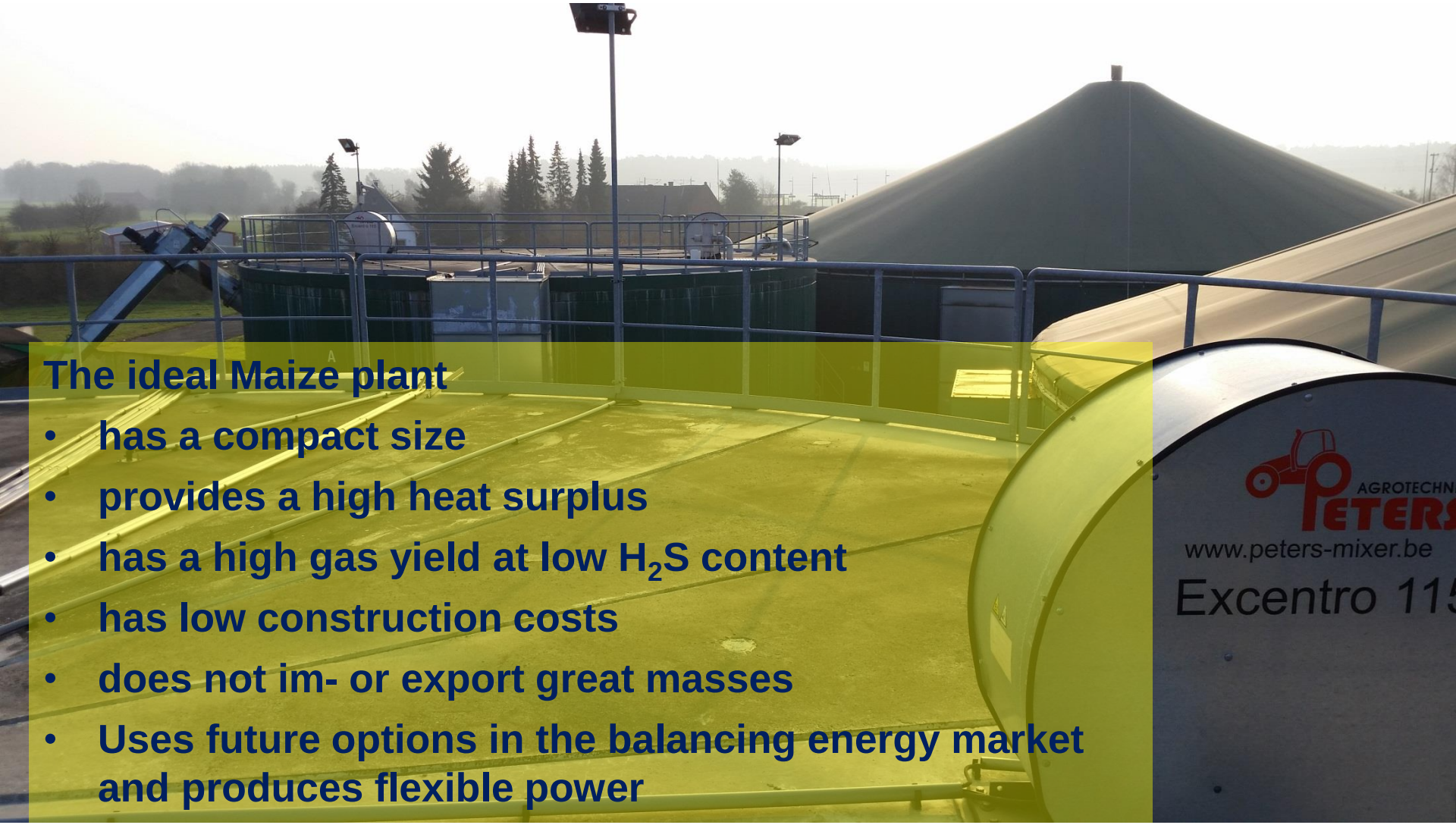

The ideal Maize plant

- **has a compact size**
- **provides a high heat surplus**
- **has a high gas yield at low H_2S content**
- **has low construction costs**
- **does not im- or export great masses**
- **Uses future options in the balancing energy market and produces flexible power**

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3b. Efficient management with own slurry

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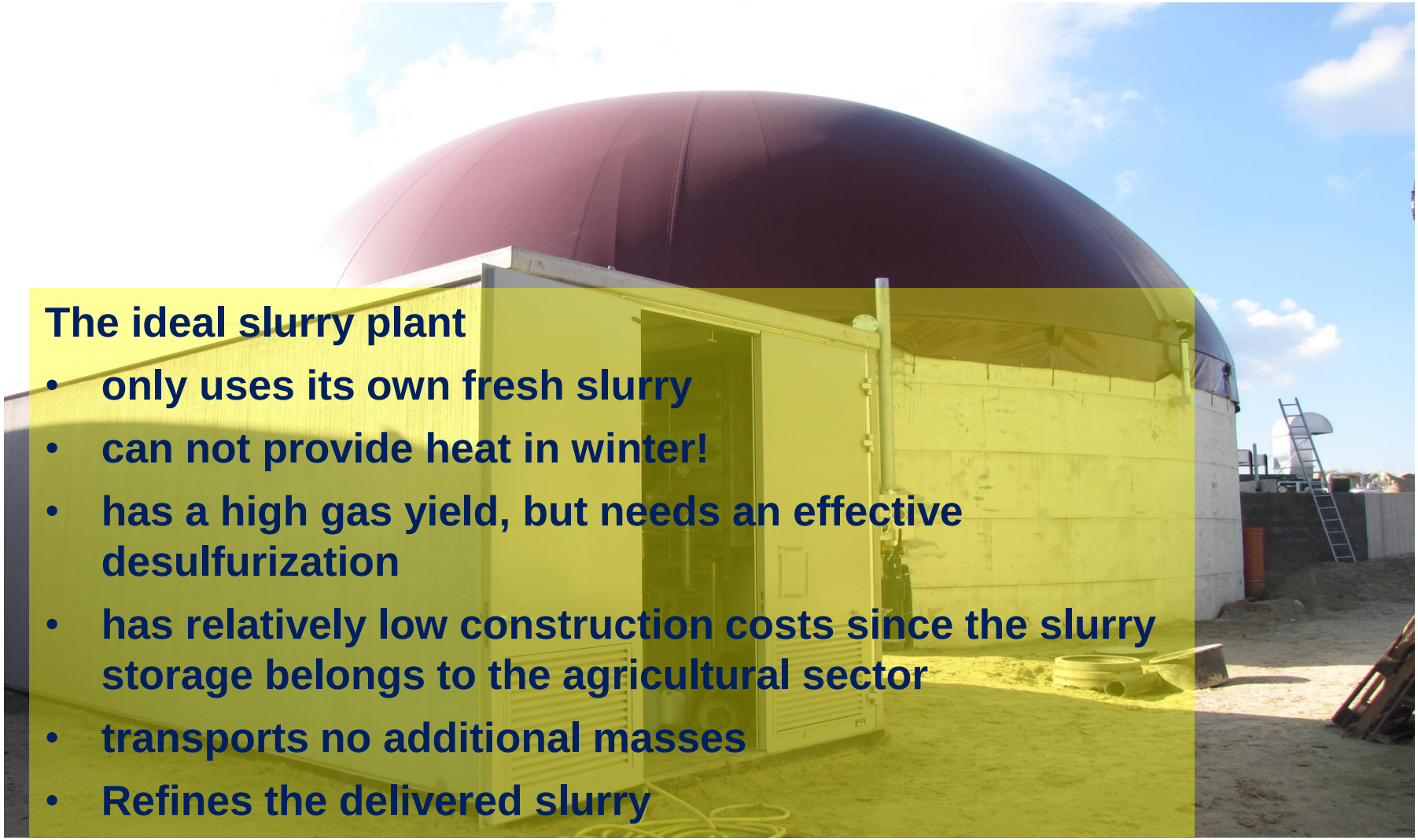

The ideal slurry plant

- **only uses its own fresh slurry**
- **can not provide heat in winter!**
- **has a high gas yield, but needs an effective desulfurization**
- **has relatively low construction costs since the slurry storage belongs to the agricultural sector**
- **transports no additional masses**
- **Refines the delivered slurry**

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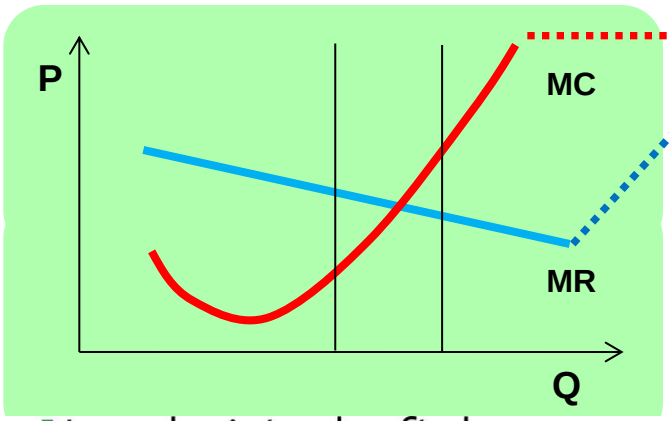

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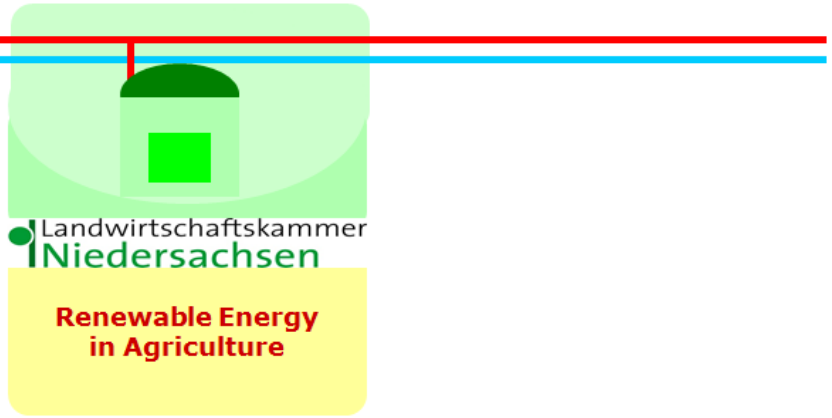
Renewable Ideas in Agriculture



Thank you for your attention!

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