Biogas Markets Asia
14-15 June 2007, Singapore
Addressing the ways of increasing Biogas usage.
a Green Power Conferences.com event

Biogas from Biodegradable Municipal Waste - Potential and Business Opportunities in China

**Biogas from municipal solid waste is still an underestimated resource.
What does the BMW utilisation from
source separation for biogas and clean compost production offer China ?**

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KNOTEN WEIMAR

Content of Presentation

- ✓*BMW Policy Drivers incl. Global Warming*
- ✓ *Landfillgas recovery in China*
- ✓*MSWM and Biogas production in China*
- ✓*RRU-BMW Project* **on BMW source separation Shenyang**
- ✓*China's Biogas & Renewable Energy Targets*
- ✓ *MSW & BMW Biogas Generation Potential in China*
- ✓*Technological solutions & Financial considerations*

China

on its way to the world economy No.1 (2005 22 – 30% of world population)

- 2005: China world largest coal consumer and 2nd largest Energy / Electricity / Mineral oil consumer, Asians largest mineral oil importer,
- 2020: 14 bill liters Bio-Ethanol, equal to current production in Brazil or US

- 2006: World biggest Solid Waste Producer.
- 2006: the Environmental Damages are compensating economic growth
- 2009: 2nd CO_2 producer (4497mt), after US (5778mt 2003) (WRI 2006)
- CHN will overtake US, but in 2030: CO_2/c still be only 60% of av. in industrialized countries)
- China uses 3 x more N-fertilizer than the world average
- 2002 China approved the Kyoto protocol as a developing country
- 2013: obligatory measures to fight Global Warming (Hu Jintau 04-2007) but UN (3rd Climate Report 5/2007) request to act within the next 8 years, G8 request for 50 % CO2 reduction.

China's direct and indirect Biogas-Generation Policy Drivers

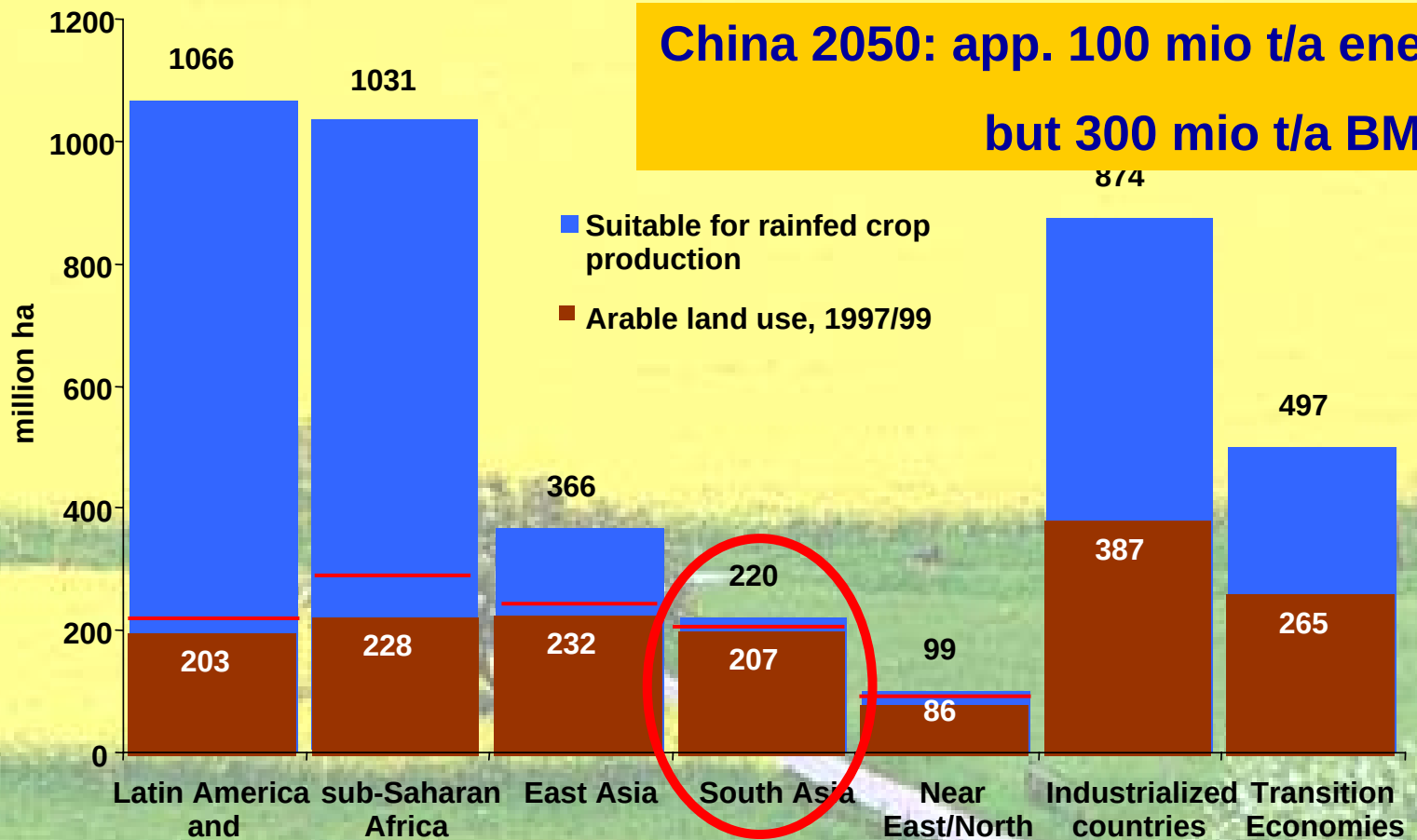
1) 'Circular Economy Policy', based on the 'Cleaner Production Law' (2002) by NDRC and SEPA, till 2020.
2) 'The Renewable Energy Law' by NDRC (2006), lays out the conditions for renewable energy to become a more important energy source till 2020
3) 'National 11th 5-Year Plan' (2006) till 2010, to - treatment ratio of MSW from 53.5% to 60% (80m t/a to 120m t/a)
4) 'National Rural Biogas Construction Plan', by MOA (2003), 23m units of BG plants, 20% of farmers biogas users in 2010.
5) 'Environmental Pollution from Livestock Breeding', SEPA (1999)
6) 'Construction of New Socialist Countryside' (2006), to boost modern agriculture infrastructure and farmers' income till 2010.
7) 'GHG Emission Reduction', relevant after 2013 (Post-Kyoto)

Biogas Source Waste ?
Energy Crops versus biomass from Waste

Worldwide area for crop production: 2400mio ha from 4100mio ha are not in use (Source:FAO Müller 2007), but in Asia.....

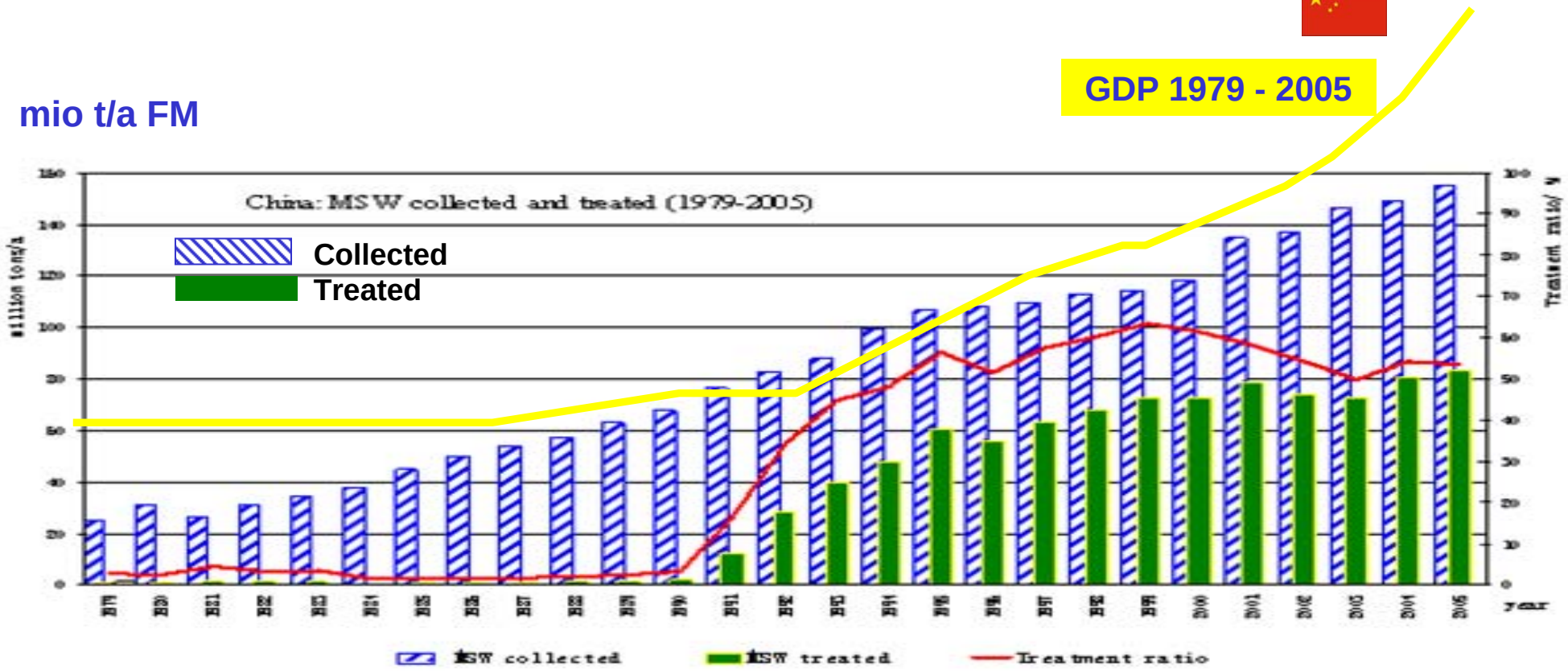
China 2050: app. 100 mio t/a energy crops, MOA

but 300 mio t/a BMW



CHINA MSW Collected & Treated 79 - 05

mio t/a FM



2005: 155 mio t MSW collected in 666 cities from 350 mio people (app. 0.8- 1 kg/d.c real)

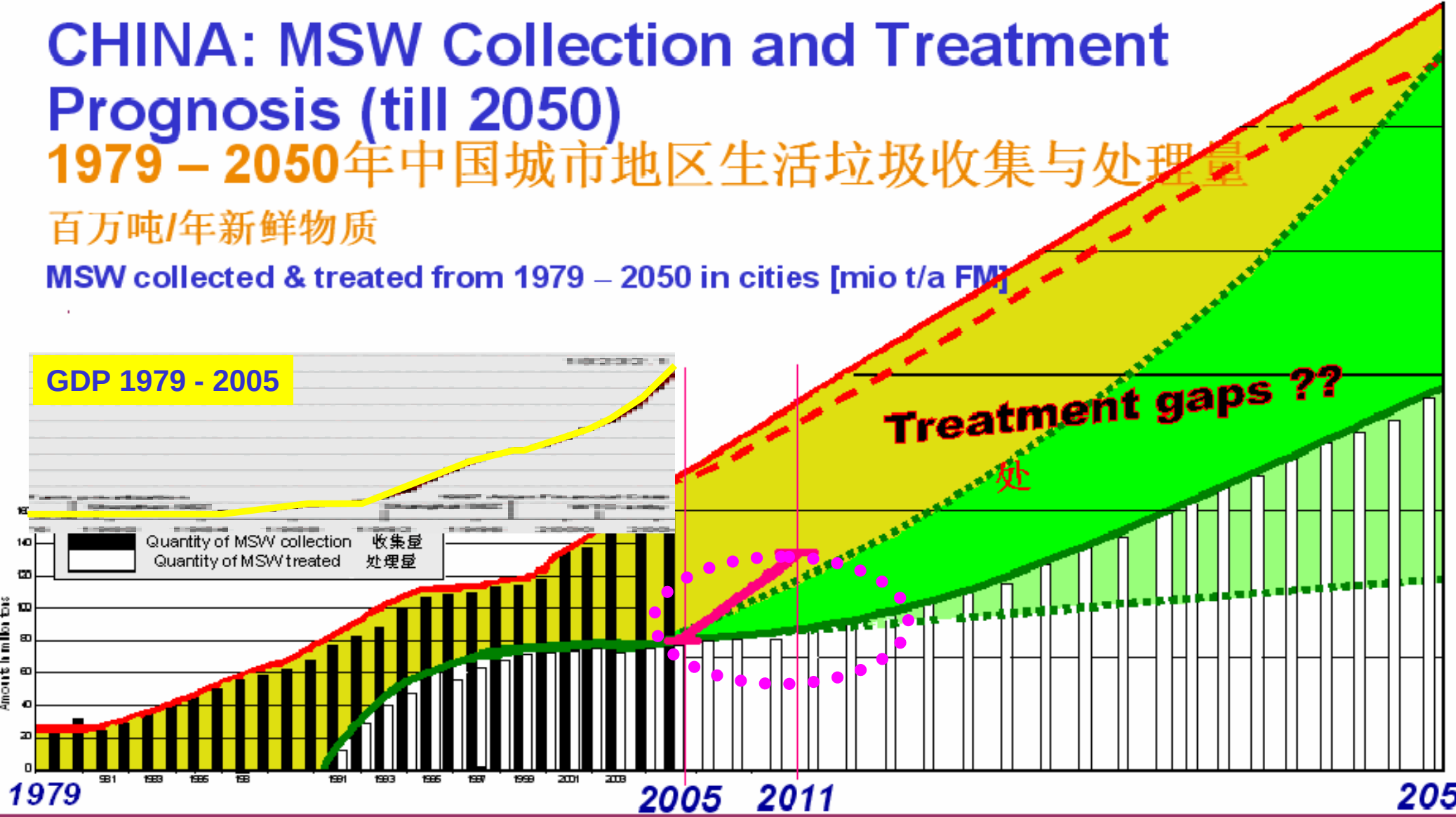
Treatment ratio of MSW in China = 53 % (incl. eng. landfill) – overall MSW potential = > 400 mio t/a

CHINA: MSW Collection and Treatment Prognosis (till 2050)

1979 – 2050年中国城市地区生活垃圾收集与处理量

百万吨/年新鲜物质

MSW collected & treated from 1979 – 2050 in cities [mio t/a FM]



Urbanisation:	28 % in 2005	40 % in 2010	70% in 2050
城市化:	2005年28%	2010年40%	2050年70%

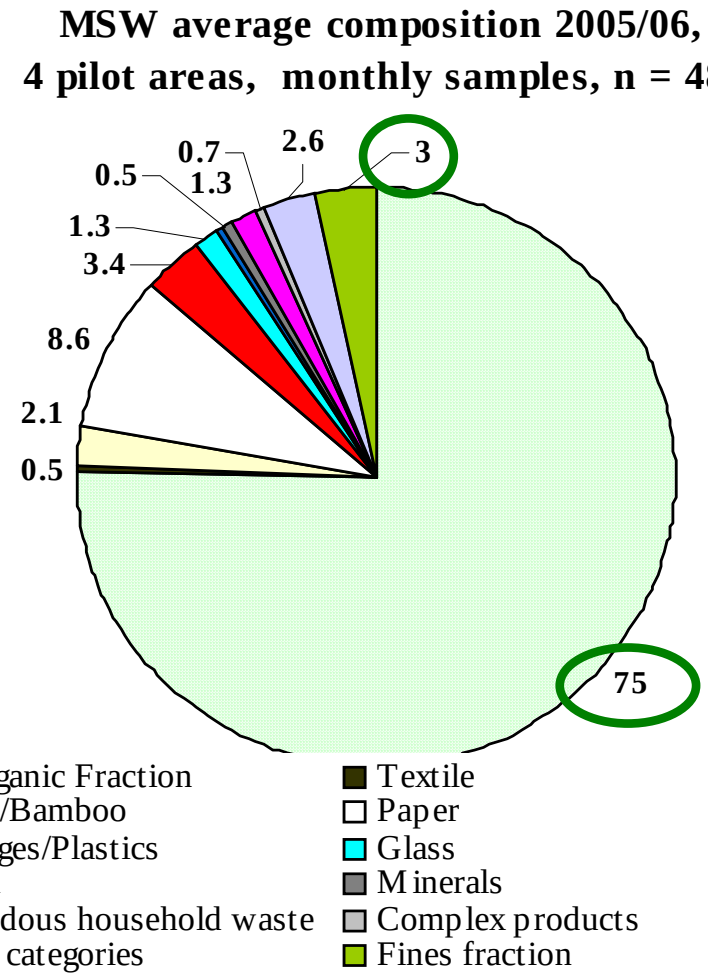
Population in > 700 cities / 1 bill people > 420 mio t MSW collected (app. 1 – 1.2 kg/d.c real)

CHINA: MSW Treatment (MOC 2006)

Type of treatment	n	Capacity (m t/a)	Capacity (%)
Landfill	580	72.7	86.1
Incineration	63	7.4	8.6
Composting	61	4.5	5.3
Total	704	84.6	100

CHINA MSW Composition

RRU-BMW pilot areas average of 12 monthly analysis Shenyang 2005/06



Average BMW content of MSW

China = ± 66 %

(average of 38 analysis from 27 cities in China, 1998 – 2005)

Europe = ± 33 %

Sanitary Landfills in China

(16% of anthropogenic GHG from LFG emissions)

2 new Landfill sites in Shenyang
Laochuchung & Daxing > 4,500 t p.d., anticipated: lifetime app. 30 years and LFG collection under CDM credits

CH_4 CO_2

Gaseous emissions

LFG 300 m3/t over 30 years – 65 % CH4)

Liquid emissions

China Problems with LFG collection

But on a long-term land filling has to be seen as an 'end of the pipe' solution. In China only 20 to 40% of the generated landfill gas (LFG) can be recovered at sites, which are equipped with a state of the art LFG-collection system. The reasons are:

- *The composition of waste:* high content on fast degradating bioorganic waste (with a very low content on cellulose, lignin and other slowly degradating biopolymers,)
- *The conditions in the landfill body:* water saturated, high density, high temperatures
- *The operating practise of landfills:* uncontrolled water levels, widespread open filling areas without temporary top-covers, if top-cover layers they are without HDPE linings, no functioning (horizontal) active gas well systems

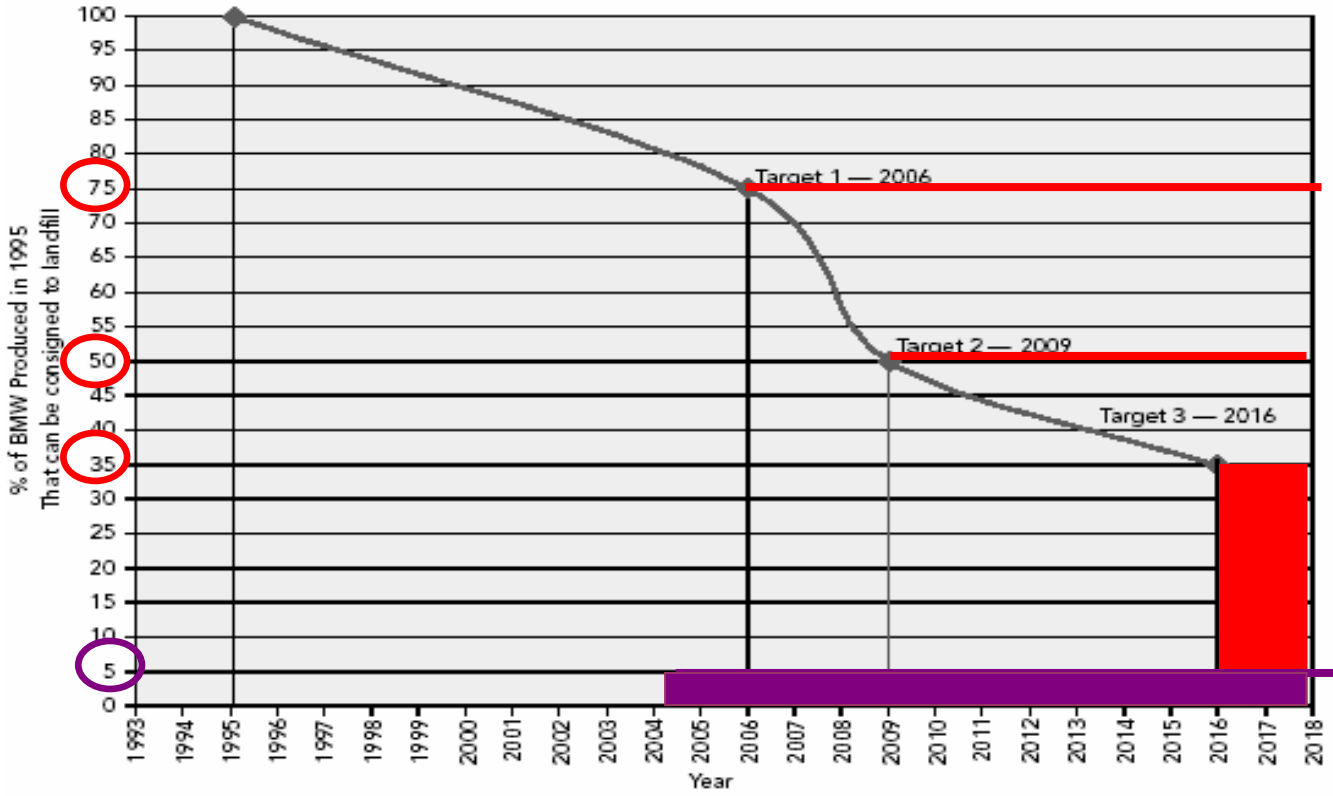
LFG recovery rate in western countries = < 60 %
China = < 20 %




EU Landfill Directive CD1999/31/EC1999

stepwise reductuion of BMW landfilldisposal till 2016

16% of anthropogenic GHG emissions from Landfills
EU landfill target: 65 % BMW reduction till 2016



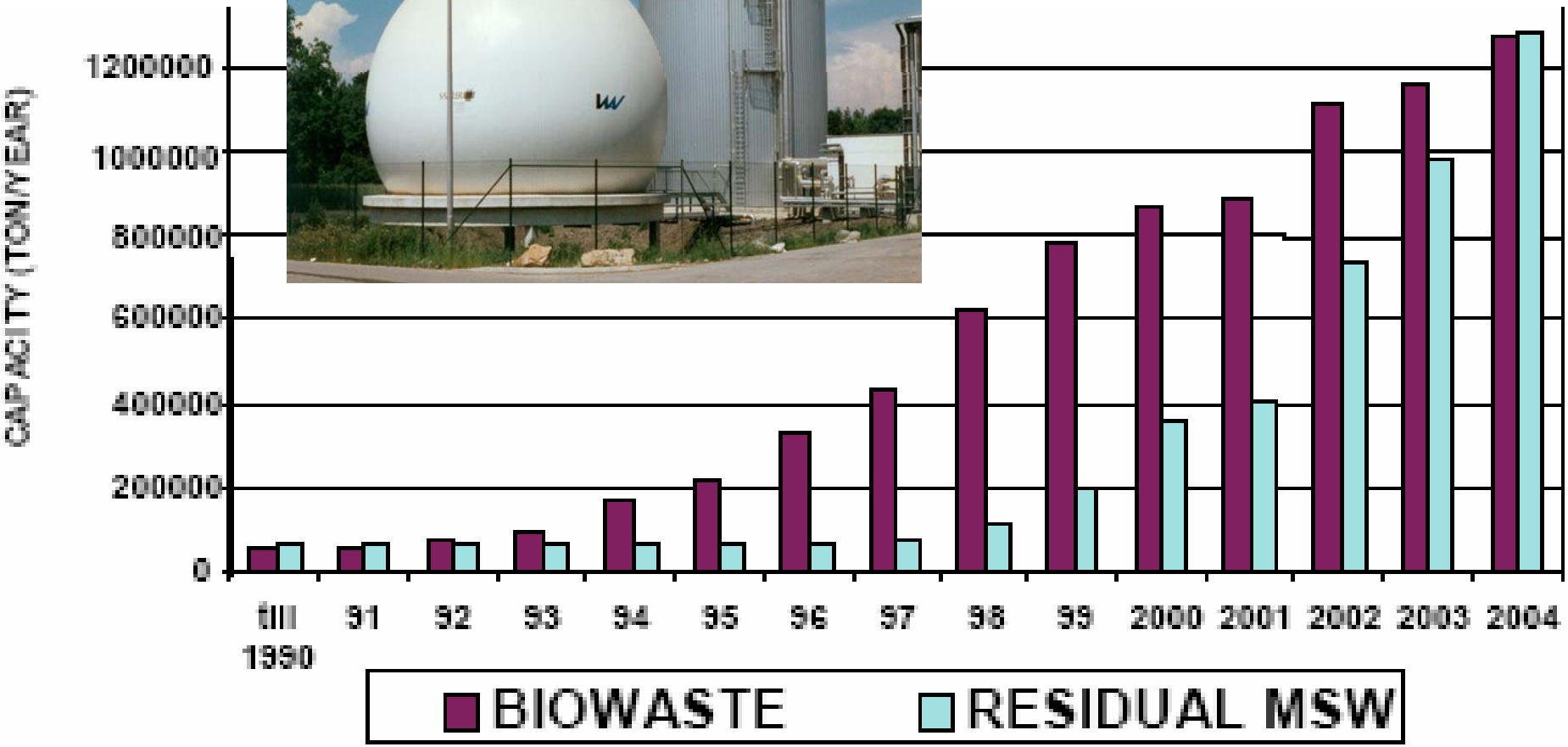
ote: Countries that landfilled more than 80 % of their municipal waste in 1995 can extend the deadlines showr in the above diagram by four years.

Specific targets in Germany 2005

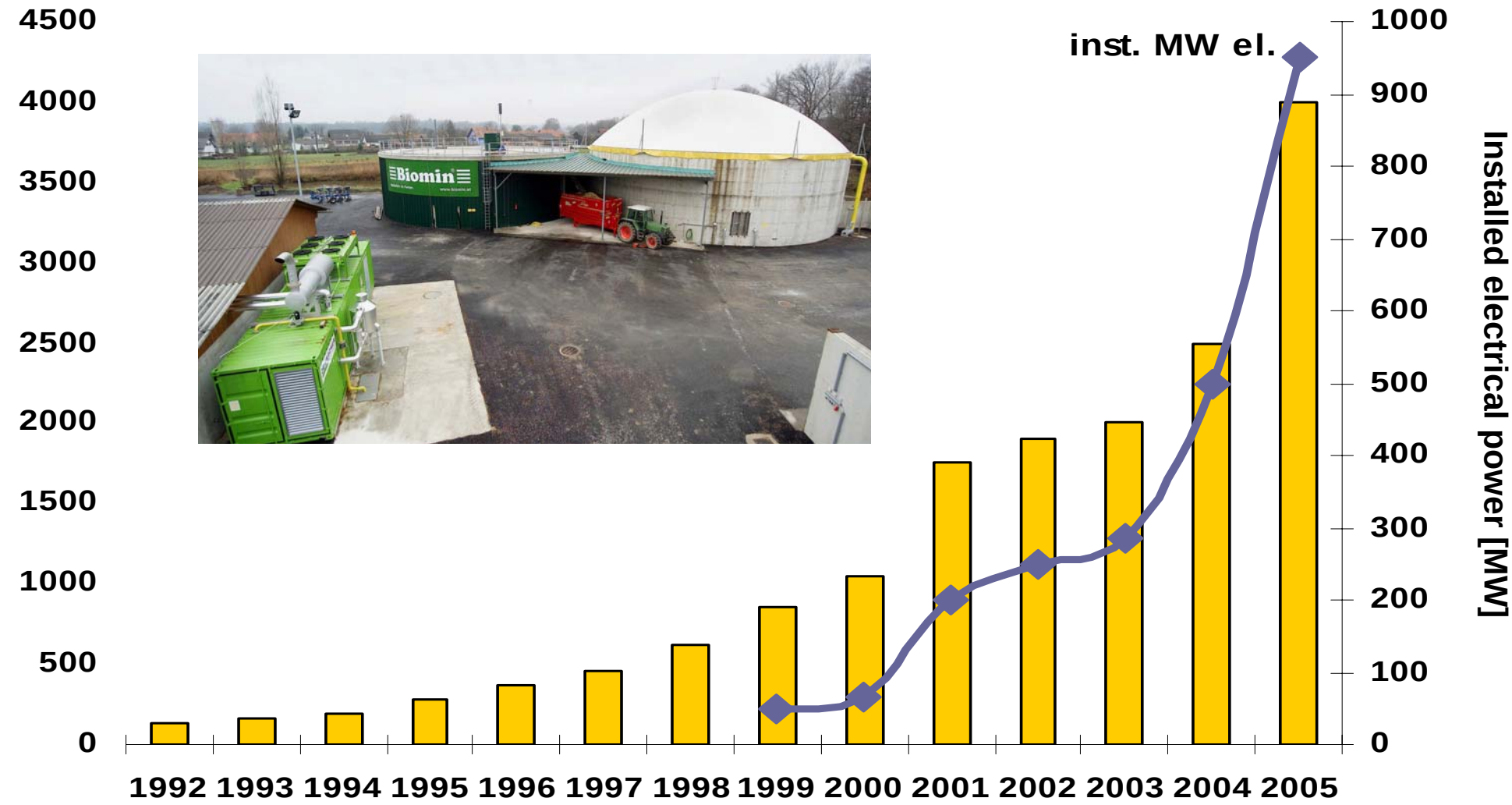
5 % TOC

BMW & MSW Digestion in Europe 2004

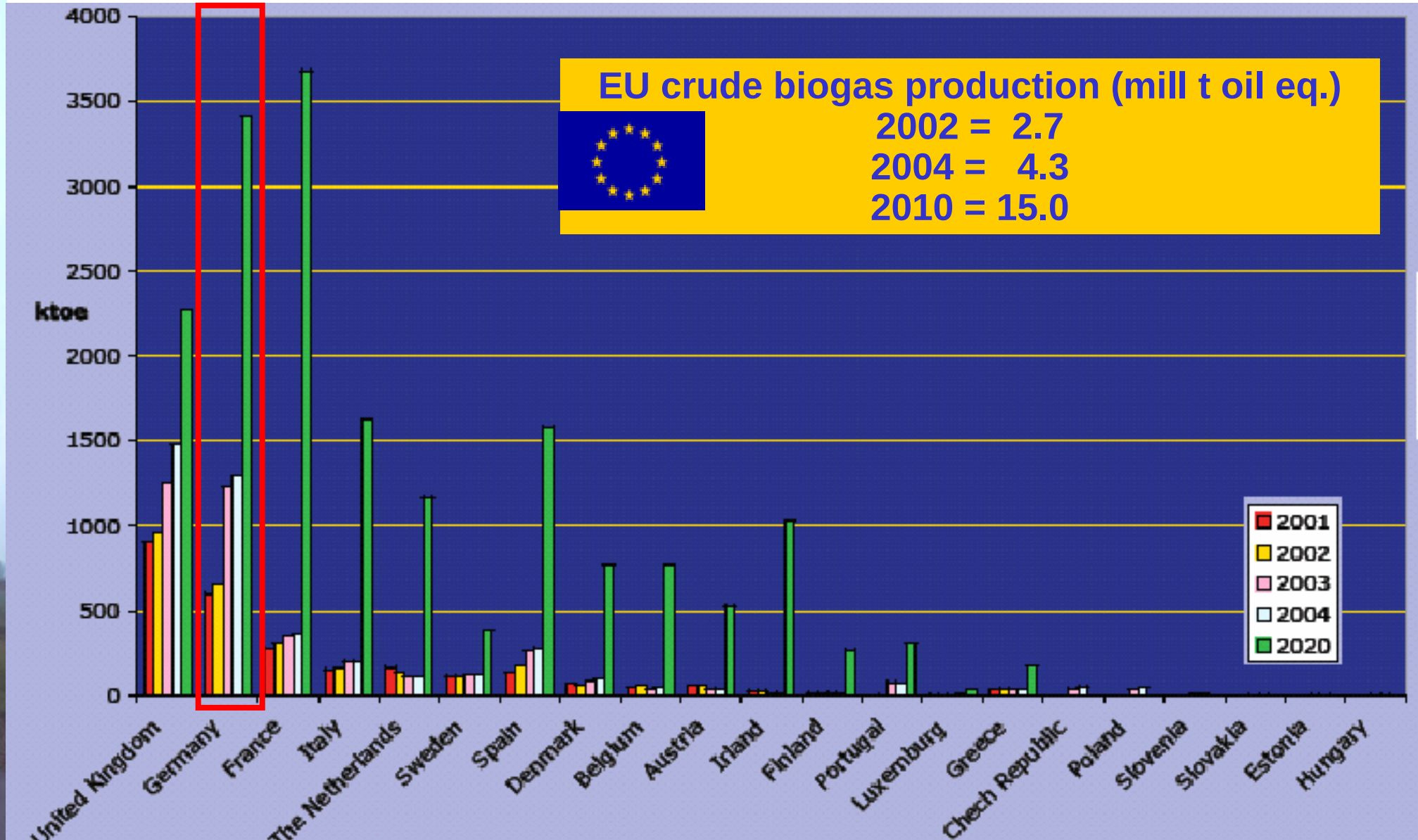
2.5 mio t/a



Agricultural Biogas Plants in Germany



EU Biogas Production 2001-2020

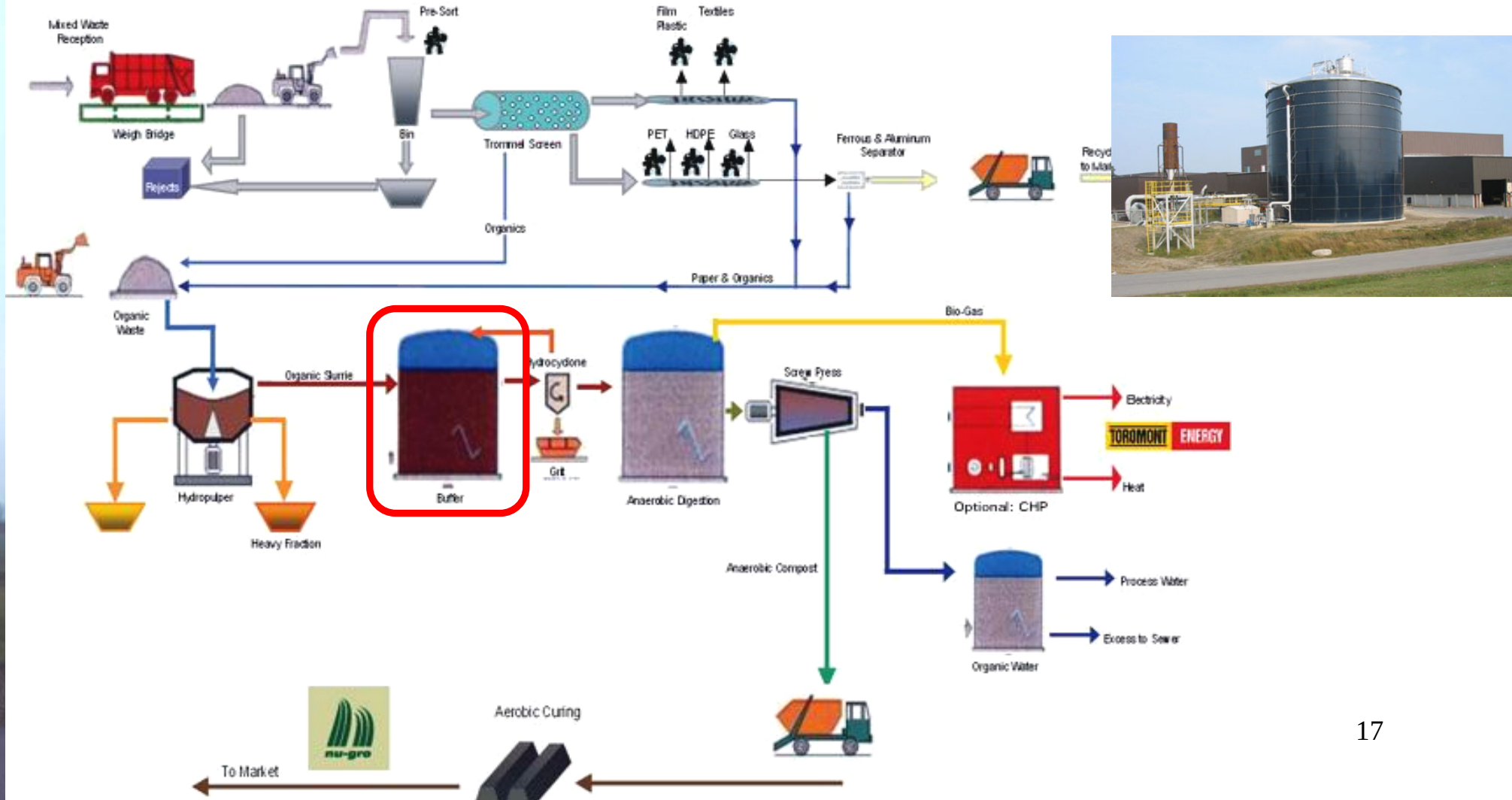


BT AD of BMW&MSW

Wels 25.000 t/a (A), LINDE Technology

Anaerobic digestion of Bio-Waste

2-step wet fermentation – BTA Toronto Plant

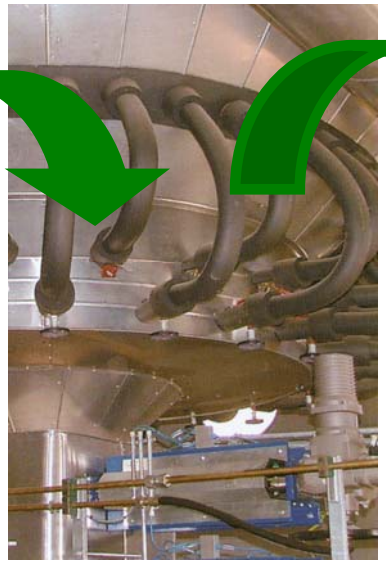


Anaerobic Digestion of BMW&MSW

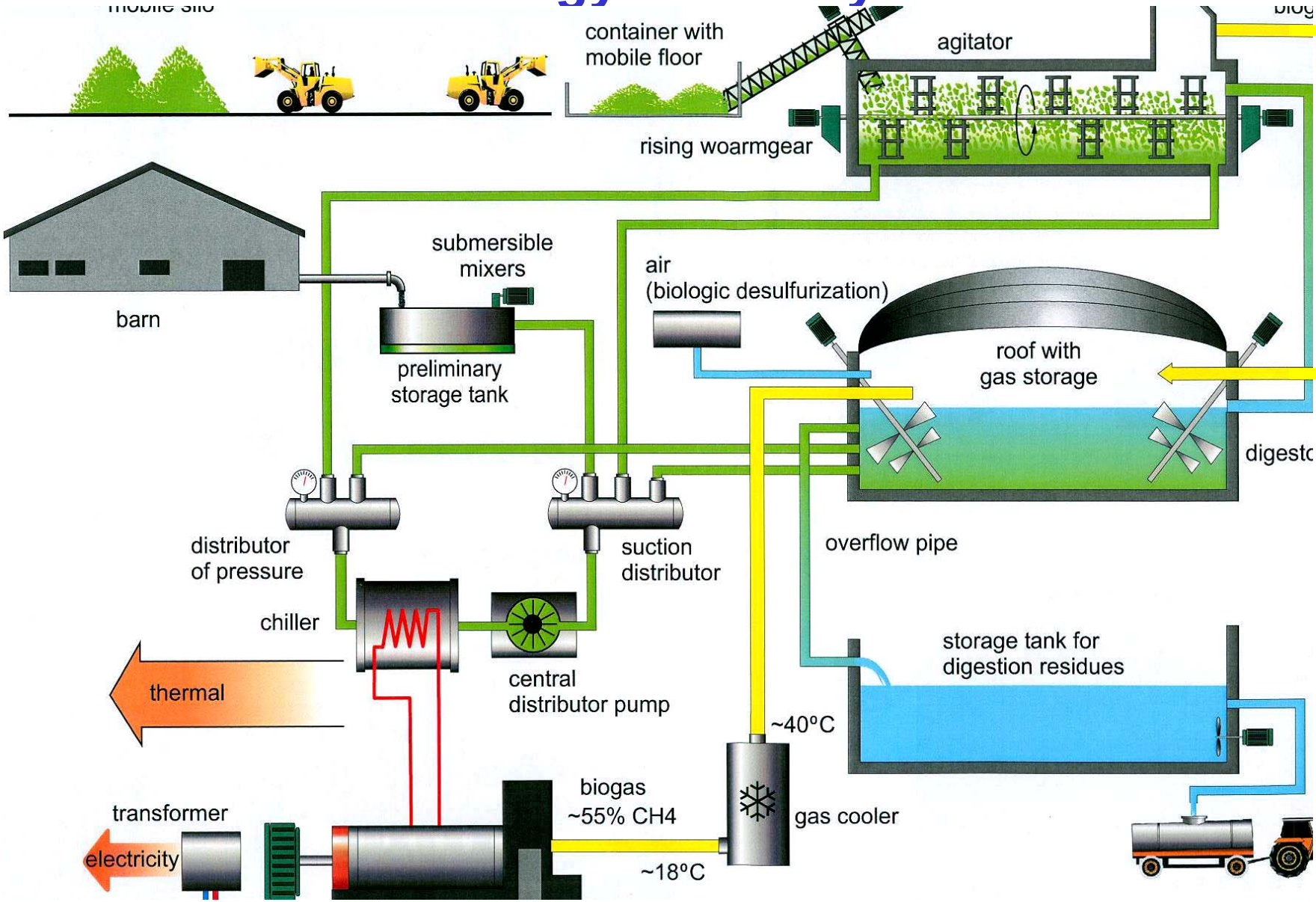
Boeblingen (D) 2005 – 30.000 t/a (DRANCO - Belgium)




Feeding – Crushing – Fe separation – Sieving - <40 mm into the AD reactor – AD – BG fuel cell/gas engine


Co-Digestion of BMW&Manure
COWATEC Technology Germany



RRU-BMW Pilot Project Objectives (6x)

- Behaviour and attitude of population towards BMW separation

- BMW collection – quantity (app. 60 - 100 kg/c/a) and quality

- Biogas production potential

- Compost quality

- Residual Waste utilisation

- Technological and Economic Feasibility

RRU-BMW project phases:

2004/05: 10 households
2005/06: 700 participants in 4 PSS/SSS pilot areas

2006/07: 2 PSS pilot areas
2008-10: Demonstration project anticipated

RRU-BMW ‘4 Waste Stream System’

1: BMW

2: RMW

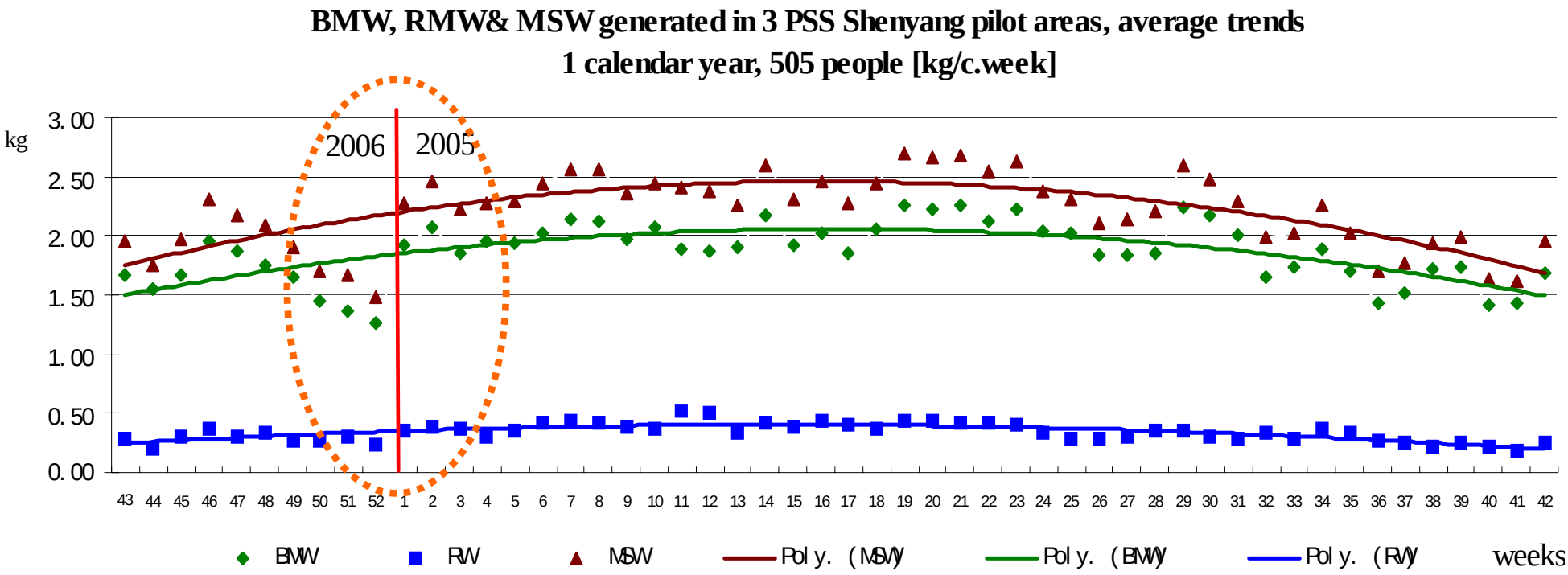
3: RW

4: HW

BMW Source Separation in Shenyang 2005-2007

BMW Source Separation Shenyang

BMW, RMW & MSW (net-Kg/c.week) from 3 PSS pilot areas, 505 participants, 1 year (calendar weeks), 2005/06, 84 % BMW, 16 % RMW



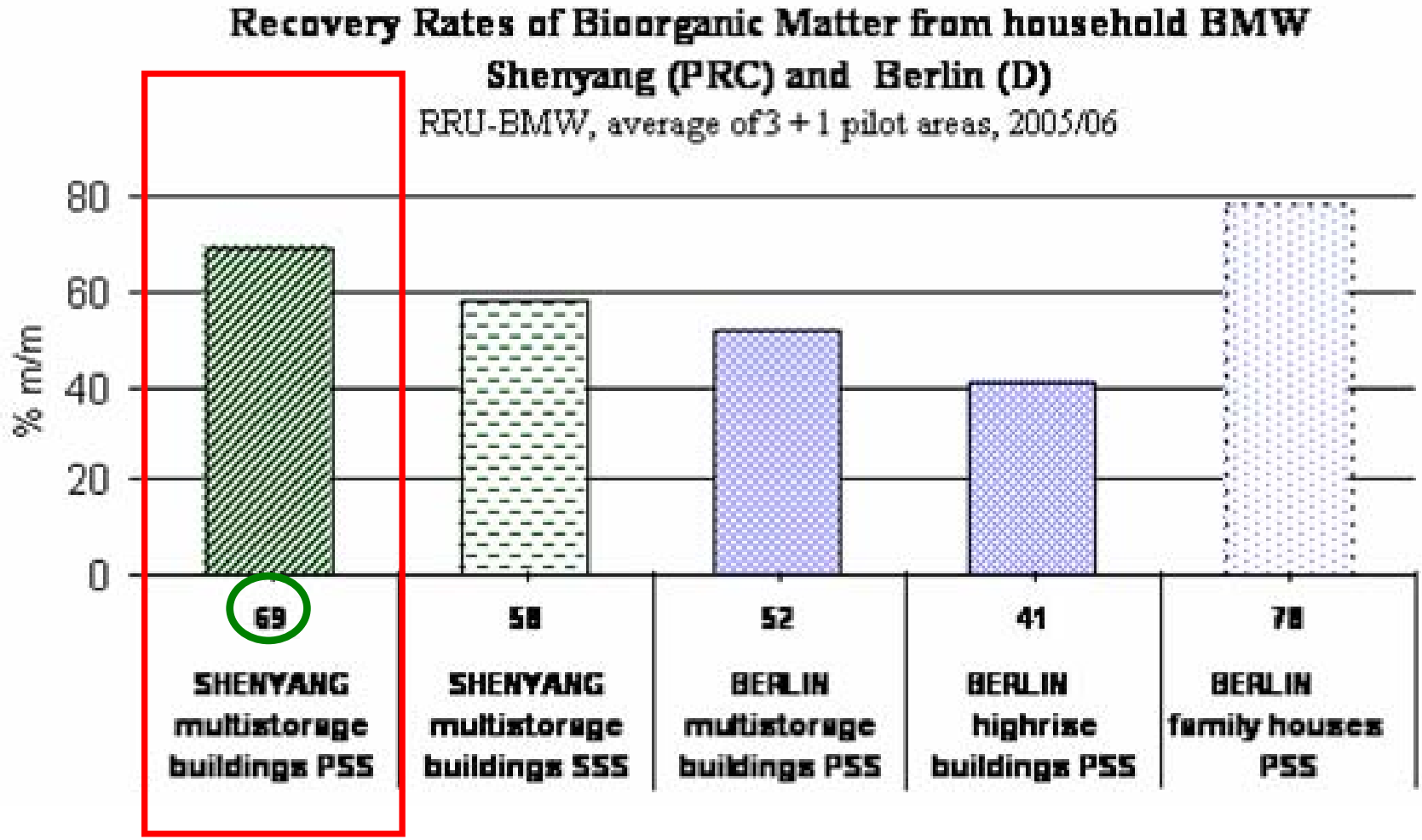
BMW Source Separation Shenyang

4 pilot areas collection results after 1 year, 2005/06

03/05 – 03/06	Pers. n	BMW			Non BMW	RMW		MSW	
365 days		kg	kg/ c.a	% m/m	%m/m n=6	kg	%m/m	kg	kg/c.a
Primary Source Separation – PSS									
Beifang Yiyuan	155	12538	81		3.4	2795		15333	99
Van Ke	143	9319	65		4.7	1213		10533	74
QuanYuan	207	13585	66		4.1	2755		16340	79
TOTAL PSS	505	35443	71	84	4.1	6763	16	42206	84
Secondary Source Separation – SSS									
Dong You SSS	180	11552	64	71	2.3	4767	29	16319	91

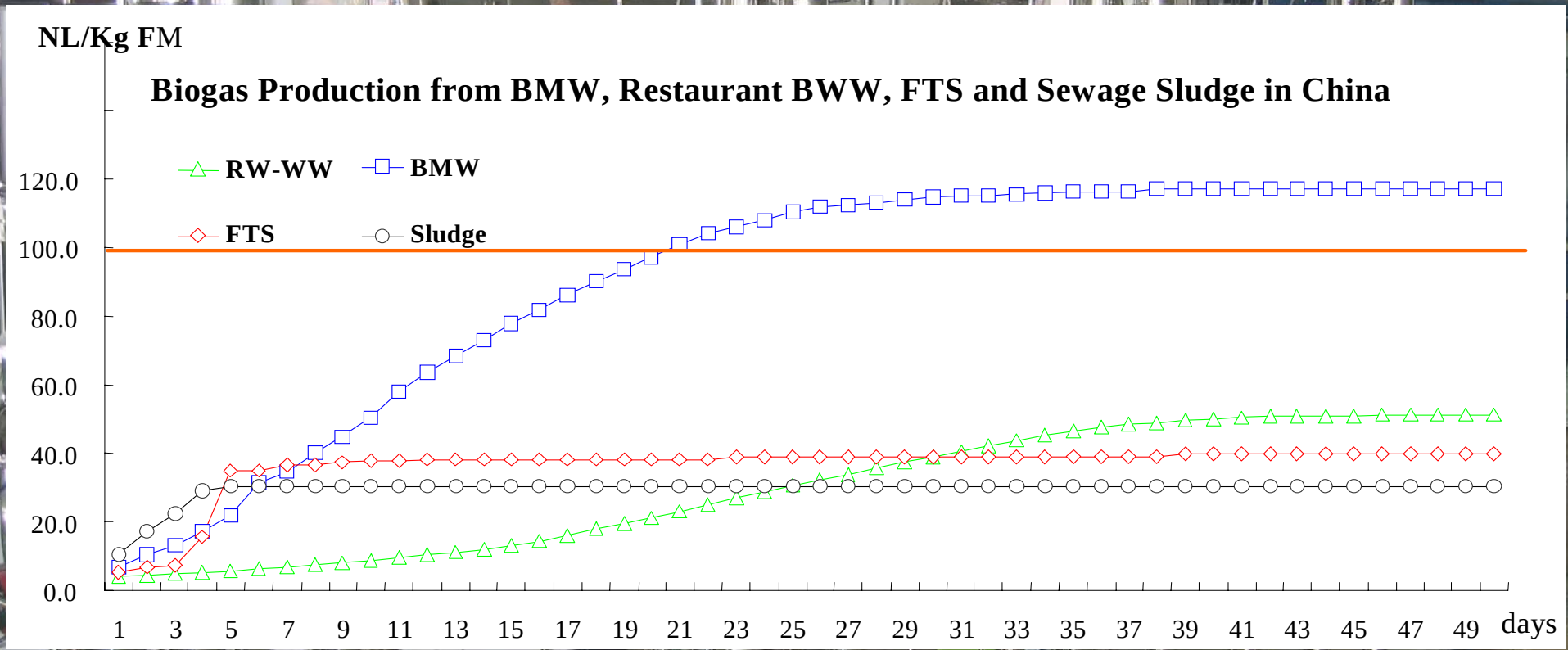
OM Recovery Rate

from PSS, SSS in China and in Germany (in % mm wm)



The AD Prozess Simulation Lab at ICEEE

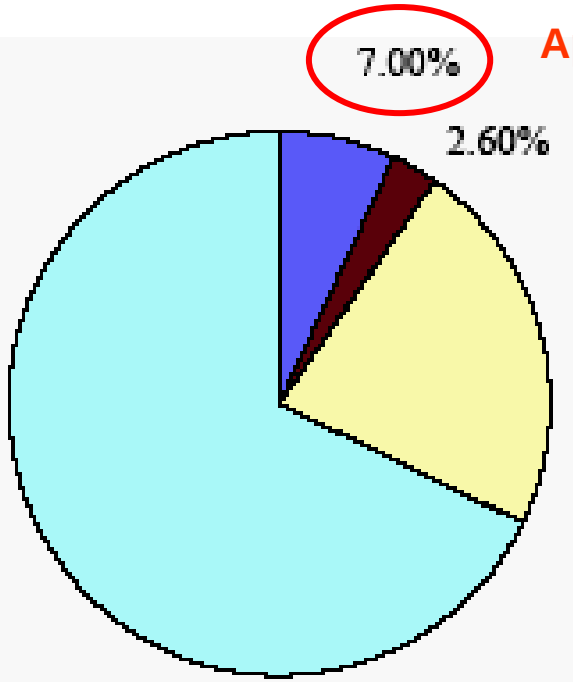
4x 30l automatic controlled fermenters, funded by CIM



China's Energy Generation 2004

7% Renewables

App. 60 GW



2007: 78% of 700 GWel installed capacity derive from coal !

China's Biogas Generation Targets
China Renewable Energy Law 2006

2020: 970 GW el. total

	2005	2010	2020	2030	Source
Share of RE among total energy mix (%)	7	10	16	(30)	NDRC, CS
Share of biomass within total RE mix (%)		18.4	18.5		NDRC, CS
Biogas: total production (bn nm³/a)	> 7.3		> 24		State Grid Comp.

18.5% of 'renewables' or 3% of the entire energy demand in 2020 should come from biomass (agriculture, industry, MSW, sewage sludge, small- and large-scale units, landfills)

Biogas from BMW not considered !!

China's Biomass Electrification Targets

2007: 78% of 700 GWel installed capacity derive from coal !

	2010	2020	Source
Landfillgas (in 2020: 100 out of 580 potential sites)	0.32 0.2 GW el	1.6 1.0 GW el	NDRC
Medium & large scale biogas production from agriculture and industry	1.3 0.8 GW el	4.8 3.0 GW el	NDRC
	4.700 units		MOA (BCP)
Biogas generated from municipal waste-water & septic sludge treatment	0.1		MOA
Rural small-scale household biogas (no electrification)	23m units (= 20% of pop.)	56m units (= 50% of pop.)	NDRC, MOA (BCP)
Overall biomass electrification target	-	30 GW el	NDRC
BMW Biogas electricity		**> 1.8 GW el**	**not considered !!**

Small Scale Anaerobic Digestion

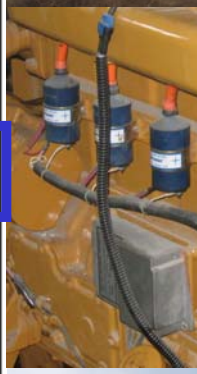
2006	17 m units	6.5 bnm3 biogas
2010	23 m	11
2020	56 m	21
2050		25 (max.)

Chinas MSW Biogas Potential till 2050

bn m3 BG/a

Description	2005	2010	2020	2050
Urbanisation rate (%)	28	36	51	70
Citizens (million)	360	470	650	940
MSW (t/c.a)	0.83	0.85	0.9	1.0
MSW collection rate (%)	52	60	65	75
MSW from cities (m t/a)	**155**	**240**	**380**	**700**
MSW organic matter (%)	66	62	55	45
Organic matter in MSW (t/a)	102	150	210	315
Citizens participation * (%)	70 *			80
BMW overall potential (m t/a)	**71**	**105**	**147**	**252**
BMW collection area (%)	40	45	55	75
BMW net-potential (m t/a) *	**> 28**	**> 47**	**> 80**	**> 189**
Biogas potential (bn m^3/a)	**> 2.8**	**> 4.7**	**> 8.0**	**> 19**
BG energy potential (GW_{tot})	> 1.8	> 2.9	> 5.0	> 11.8

* acc. to RRU-BMW field test results, participation rate 70% and net-BMW collection amount 70kg/c.a (2005/2006)



Chinas Biogas Production & Potential

bn m3 BG/a

	Source	2006	2010	2020	Potential
De-central	Household small-scale bio digesters	6.5	11.0	19 - 22	25 **
	Waste water DEWATS (<100 m^3/d)	0.05	0.12	*1.0*	15
				20	
Central	Urban MSW/BMW	0.0	0.16	**8**	**25** – 30 *
	Agriculture and agro industry, med/large (wet waste, manure,)	0.34	3.8	5.6	70 - 80
	Landfills (old and new MSW)	0.36	1.4	4.4	< 2 - 5 ***
	Sewage sludge (WWTP)	0.05	*0.5 ?*	**4**	25 *
Biomass based biogas production target (State Grid Company)				**24**	
Production / production target, potential		7.3	**19**	**44**	> 155
Non waste sources: Energy crops (but mainly to produce liquid bio fuels)					*10*

* potential for 2050, consideration of urbanisation and infrastructure development

** 50% realisation

MSW AD Projects in China, 2007

Name, location	Start up	Feedstock	Technology	Capacity t/a	Investment Gate fees €	Commends/
Beijing Dong Cun Taihu County, Biomax	2007	Restaurant MSW,manure	Wet AD Linde Dry AD Valorga	230.000 t/a	18 Mio € Fee € 13.5 /t	Feasibility study 2005, CDM
Beijing	2010	Restaurant, MSW, ..		2 mio t/a		9 plants anticipated
Shanghai Jinshan	2008	MSW, BMW		220.000 t/a	32 mio €	Public tender
Shanghai Putuo Shanghai Biomax	2007	Municipal wet waste	Valorga Dry AD	180.000 t/a 290.000 t/a	30 Mio € Fee 17 €/t	Feasibility study 05, CDM PDD1/06
Guangzhou Likeng (Guandong) Biomax	2007	Municipal wet waste	Valorga Dry AD	360.000 t/a	32 Mio €	preparation
Huiming Changsha (Hunan)	2005	MSW		730.000 t/a	11 Mio €	Biogas Power Plant operational
Minyang (Sichuan)	2002	MSW	Tunnel Dry AD	250.000 t/a AD: 3600t/a		AD as pilot project
Yingko (Liaoning)	2007	MSW,SS	French	270.000 t/a	20 Mio €	Tsinghua Tongfang
Shenyang (Liaoning)	2010	BMW source separation	Wet AD recommended	>120.000t/a	12 Mio € Fee 6 >€ /t	Pre-feasibility, RRU-BMW

App. > 8 mio t (< 3 %) of MSW/BMW are treated by AD in 2010

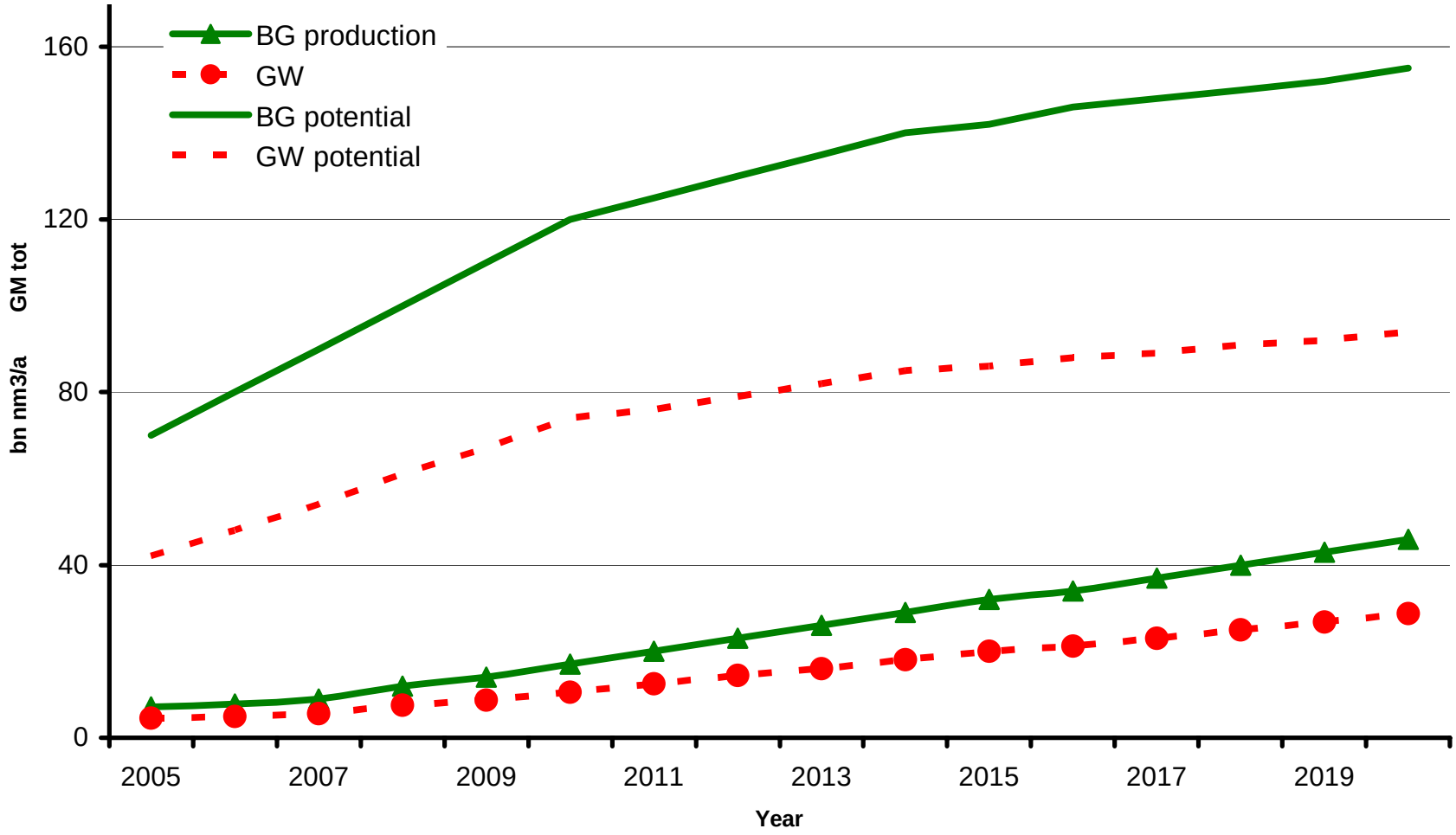
BMW Biogas joint Generation
Municipalities - private companies - farmers (20%)

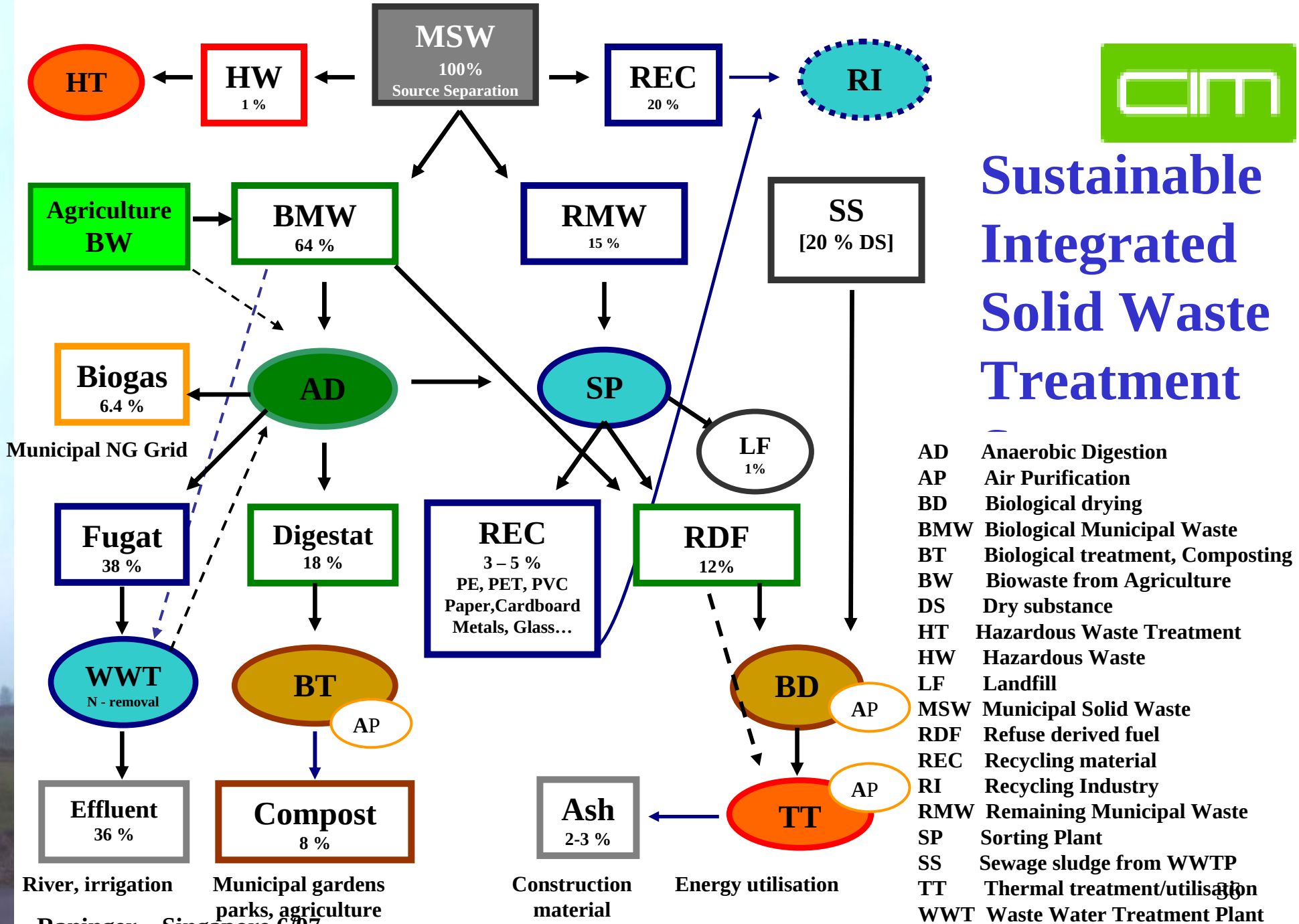
Biogas plants	Current	2020
Municipal – Private: Large scale MSW and BMW from cities (each 200 - 600 t/d)	Lab scale projects in Beijing, Shanghai, Guangdong under implementation	> 4.6 Bn m³/a about 200 units (av. 150.000 t/a for about 2 mio people each in the average)
Agriculture- Private: Small and middle size BMW from city suburbs (20 – 100 t/d)	No (only for animal feeding)	> 1.2 Bn m³/a about 800 units (av. 40.000 t/a for about 12.000 people each in the average)

< 20% Biogas from BMW by farmers ?!

CHN Biogas & Energy Production Potential till 2020

(acc. to RE law 2006, bnm3/a, GW tot/a)





Sustainable Integrated Solid Waste Treatment

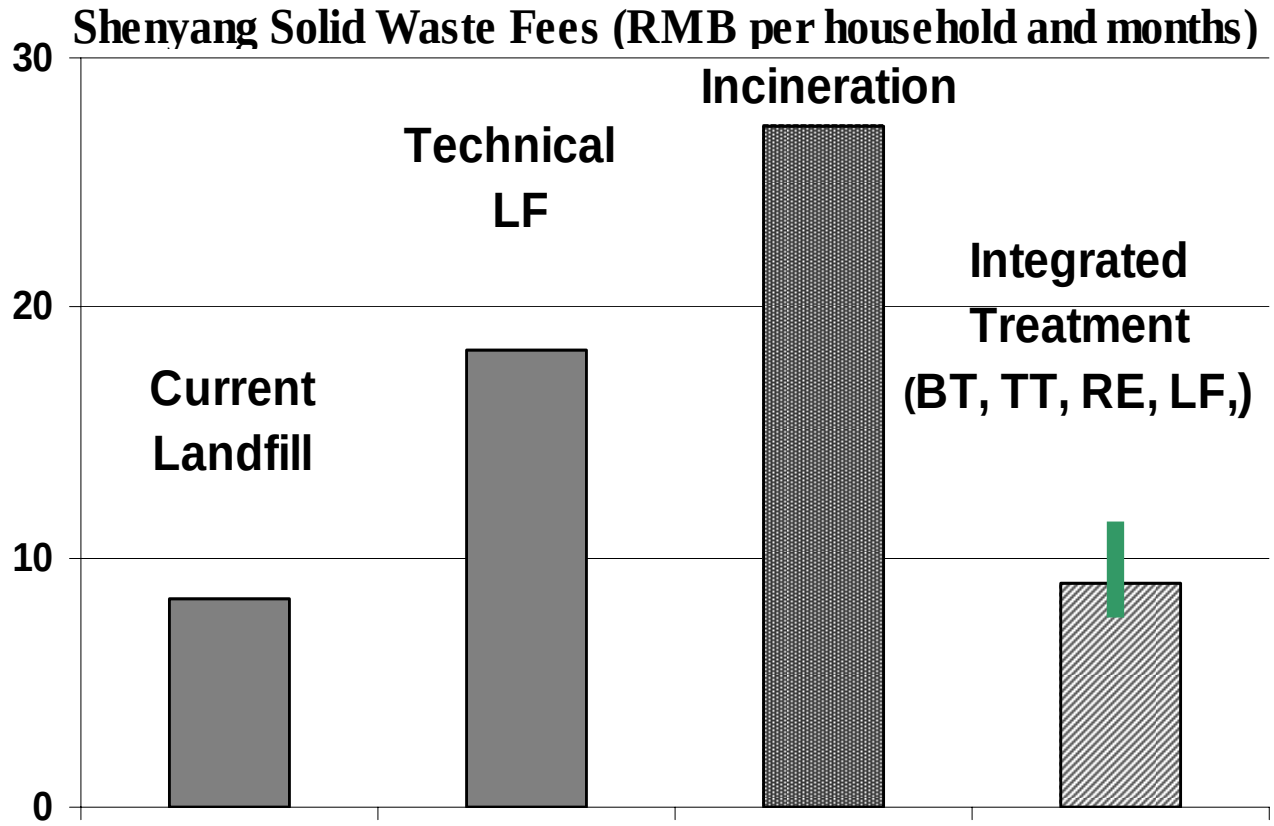
AD	Anaerobic Digestion
AP	Air Purification
BD	Biological drying
BMW	Biological Municipal Waste
BT	Biological treatment, Composting
BW	Biowaste from Agriculture
DS	Dry substance
HT	Hazardous Waste Treatment
HW	Hazardous Waste
LF	Landfill
MSW	Municipal Solid Waste
RDF	Refuse derived fuel
REC	Recycling material
RI	Recycling Industry
RMW	Remaining Municipal Waste
SP	Sorting Plant
SS	Sewage sludge from WWTP
TT	Thermal treatment/utilisation
WWT	Waste Water Treatment Plant

Investment & Operation Costs of SY BMW Waste Treatment Plant

	INVESTMENT (120.000 t/a – 1 m people)	mio RMB
Expenses	Civil Construction	19,40
	Equipment	152.70
	Planning, supervision, public relation	12.70
	Total Investment	184.80
	REVENUES	
Revenues	Biogas (8 mio m^3, 0.5 RMB/m^3)	4.0
	RDF (20,000 t/a, 150 RMB/t)	3.0
	Recyclables (3,600 t/a, 2.8 RMB/t)	1.0
	CDM Emission Trading (10 EUR/t CO2)	14.8
	Compost (12,000 t/a) – based on 1.5% dm N-equivalent	1.5
	Public waste fee (1.8 RMB/HH.months **= 58 RMB/t**)	**6.9**
	Sewage Sludge treatment (15.000 t/a, 35 RMB/t)	0.5
	Total annual revenues	31.7
	OPERATION COSTS	
	Total annual operation & financing cost (120.000 t/a)	31.7

Waste Fee Scenarios

Monthly Waste Fees (= collection, transport, disposal) per person and months



World Bank: the urban areas of Asia spend
1999: US$ 25 bn p.a. for 0.7 mill. t. p.d.
2025: US$ 50 bn p.a. for 1.8 mill. t. p.d

Conclusion

2020: CHN renewable energy target = 24 bn nm^3/a (5.5 bn nm^3/a from rural AD)
2050: BMW can deliver 19 bn nm^3/a = same energy as the 3-Georges Hydropower plant or 12 mid size Atomic power plants can produce !

2020: Wind power (30 GWel) and BG could be from similar importance for China !!

2010: only 3 % of BG from MSW/BMW resource will be used !!

App. 40 % of the annual operation costs (full cost calculation) of a large scale BMW AD plant can be financed bei CERs.

Thanks

END of Presentation

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