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Climate Protection through Integrated Waste Management Projects in India - Project Findings and Results -

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Project commissioned by German Environment Agency (UBA)

Umwelt Bundesamt

Overview

1. Background selected cities & Status quo of solid waste management
2. Major observations & SWM challenges in India
3. SWM scenarios & potential GHG co-benefits
4. GHG results & extrapolation for urban India
5. Conclusions
6. Excursion „Waste data matters“

Background selected cities

City	Bangalore	Bhopal	Haridwar
State	Karnataka	Madhya Pradesh	Uttarakhand
urbanization rate[1)]	38.7%	27.6%	30.2%
Per capita income[2)]	low middle	low	low middle
Population 2011[1)]	8.5 million	1.8 million	230,000 (+165,000)
Climate Zone[3)]	Aw: tropical winter dry	Aw: tropical winter dry	Cwa: humid sub-tropical, winter dry
Waste generation used for calculations:	0.5 kg/cap/d 1,460,000 t/a	0.4 kg/cap/d 292,000 t/a	0.6 kg/cap/d 86,505 t/a

Data for India

Total population: 1.21 billion; average urbanization rate : 31.2%

Per capita gross national income ~1,600 USD → low middle income country according to Worldbank ranking

1) Census of India, 2) http://www.mapsofindia.com/maps/india/percapitaincome.htm,
3) Köppen-Geiger classification http://koeppen-geiger.vu-wien.ac.at/present.htm

Bangalore – data collection (pilot)

- A data template was established to enable systematic interviews, and to also receive information on the reliability of data and on data gaps
- During the initial data collection phase it was observed that most critical data is not available at a centralized level but at many various stations and levels, partly handwritten
- Therefore we
  - → extended secondary level data research
  - → enhanced efforts to derive first-hand information through site visits and expert interviews
  - → readdressed Workshops in the cities – originally meant to discuss optimization scenarios – to verify collected data and to potentially close data gaps

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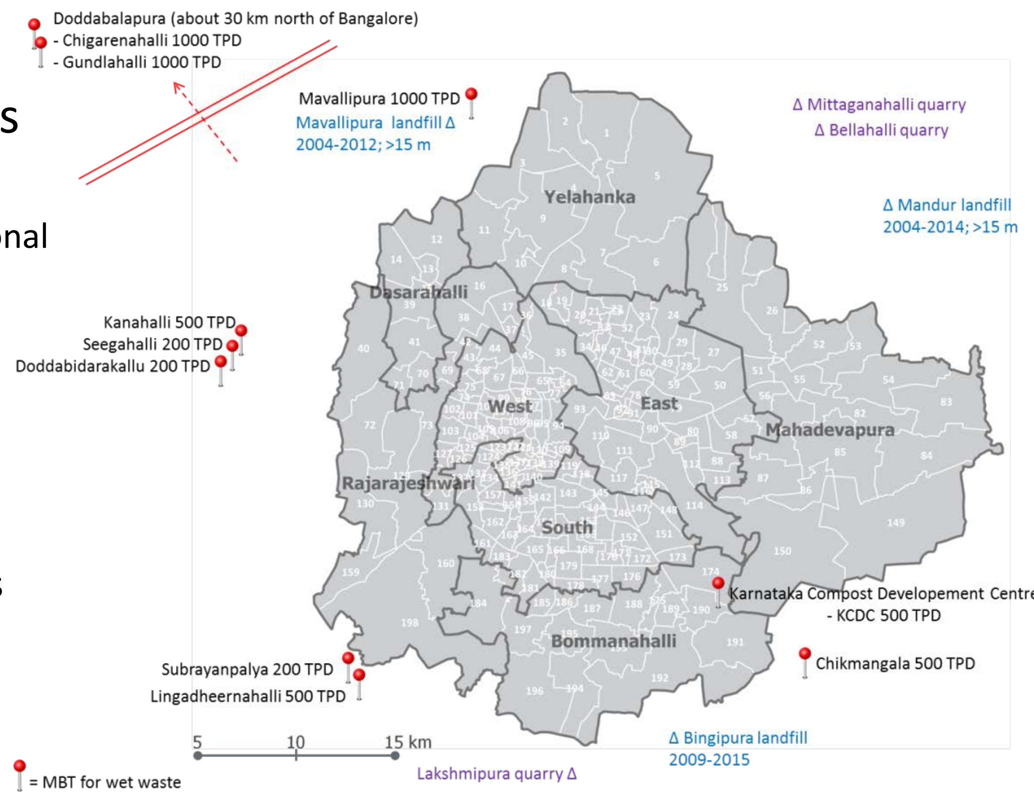
Bangalore

- IT hub of India with a rapidly growing economy
- City under administration of Bruhat Bangalore Mahangara Palike (BBMP)
- 198 wards in 8 zones
- Data on MSW generation varies from 3000 to 4000 TPD
  (bulk generators not incl., estimated additional 1700 TPD, and informal recycling not incl., presumably relevant amounts)
- Waste treatment
  - 10 treatment plants for wet waste
  - 185 Dry Waste Collection Centers
  - 16 small-scale biomethanation plants

Waste is still dumped at 3 closed dump yards or at non-designated dumps or quarries



Bangalore

- Bangalore is a bin less city, containers are placed only in commercial areas
- BBMP is responsible for MSW from households, where 100% waste collection coverage is implemented (bulk generators - commerce, markets, hotels, high-rise blocks, etc. - are notified to establish separate systems)
- Waste from households is collected on a daily basis, and waste is collected from litter spots and street sweeping
- SWM is financed through property tax and in some regions by an additional charge for households

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Bangalore

- Dry waste is taken to one of 185 DWCC, operated by BBMP or by NGOs (the latter mainly process waste from bulk generators)





- 16 small-scale biomethanation plants process 5 TPD of organic waste from e.g. canteens; 4 out of 16 were operational in 2016; simple technology with presumably low biogas yield, digestate is drained

Bangalore

- Wet waste – per definition 'organic waste' but still mixed with residual waste – is taken to one of 10 mechanical-biological treatment plants
- 6 newly built plants – set up after high court order of Karnataka not to dump waste the way it has been – are constructed in a modular concept:
  - electric weigh bridge
  - mechanical pre-treatment by trommel (200 and 100 mm)
  - RDF shredding & bailing
  - trapezoid windrow composting (6-7 weeks)
  - compost sieving & refining

- In Oct 2016, 7 plants were not operating due to blockades by protesting citizens, power cut-off due to not paid bills, fire at RDF storage, and pre-treatment trommels which are clogged regularly by 2-3 m long textiles and flower festoon strings
- RDF is mainly dumped due to low quality (rejected by cement kiln)

Bangalore – MBT Chikmangala

Windrows output trommel

RDF output of trommel

trommels for compost

Shredding of RDF

final compost

RDF bails

Bhopal

- One of the 20 most promising Smart Cities; under administration of Bhopal Municipal Corporation (BMC)
- 85 wards in 19 zones
- Data on MSW generation from households varies from 700 to 800 TPD; has increased by about 30% in the last decade
- 100% collection rate, though unsegregated
- Waste treatment
  - basically disposal at Bhanpura dumpsite
  - some treatment of waste from the landfill (separation of plastics, digging out material processing manure)
  - some small-scale NGO initiatives (composter, biomethanation)

Haridwar

- 1 of 7 sacred cities in India, primarily a pilgrimage destination at Ganga river
- City under administration of Haridwar Municipal Corporation (Nagar Nigam)
- 30 wards in 4 zones
- MSW generation 200 to 400 TPD, depending on floating population
- Door-to-door segregated collection in 22 wards, otherwise unsegregated or not collected (scattered)
- Collected waste is basically dumped
- New scientific landfill site and treatment facility under construction

(as of March 2017)

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Major observations

(as of data collection phase 2016/2017)

- Data is not easily available
  - not available on an aggregated level
  - data on MSW generation varies and fate of waste is partly not known
  - MSW from bulk generators and/or informal recycling are not recorded
  - data on waste composition or characteristics is available from studies which are partly old and not representative (only few random samples)
- MSW is partly not collected; collected waste is partly source segregated and treated, but still relevant amounts are dumped due to low quality or lack of treatment capacity, also in Bangalore:
  - Still high share of wet mixed waste causing treatment problems and low quality products (RDF unsuitable for co-incineration, compost from mixed waste)
  - Still high share of impurities in dry waste which is rejected and dumped (non-recyclables or low-quality)

Challenges in India

- The SWM situation and lack of data are consequences of rapid growth and change in life style in the last decade
- Challenges especially for urban India:
  - High population growth and migration into cities
  - Significant increase in waste generation, but the per capita waste generation is still low compared to industrialized countries
    (e.g. per capita waste generation in Berlin 2 kg/cap/d)
  - Change in life style led to a change in waste composition
    - Increase of packaging waste, especially plastics
    - Higher share of synthetic products, also with textiles
- Waste fractions like textiles, thermocole, plastics (especially thin plastic bags) cause problems in waste treatment

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SWM scenarios & potential GHG co-benefits

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- Due to the lack of representative data assumptions were necessary for the scenarios and the GHG calculation
- Scope of GHG balances is focused on MSW within responsibility of municipalities → waste from bulk generators and from informal recycling are not included, although important:
  - waste from bulk generators are relevant amounts partly ending up in the municipal waste stream at treatment plants (sufficient capacity)
  - informal recycling is an important contributor to climate protection due to substituting primary production (markets are well organized and value oriented, though working conditions are partly difficult)
- Data needed for the GHG scenarios – waste generated, fate of waste, waste composition & characteristics – are based on information from interviews, workshop outcomes and literature

SWM scenarios & potential GHG co-benefits

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- Optimization scenarios developed:
  - aim at integrated waste management systems with potential co-benefits for GHG mitigation
  - consider the different settlement structures of the 3 cities and existing approaches and plans, assuming as realistic as possible developments
  - 2 optimization scenarios are developed based on given (not representative) waste compositions as a step by step approach:
    - Scenario 1 as 1st step to a
    - further optimized Scenario 2

- Waste composition specifics:
  - high share of organics in Bhopal
  - high share of inert in Haridwar

	Haridwar[1)]	Bhopal[2)]	Bangalore[3)]
Food & green waste	44%	46%	53%
Hay, straw, leaves	6%	22%	
Paper & cardboard	5%	11%	13%
Plastic (incl. PE)	8%	6%	12%
Textiles	10%	1%	4%
Glass	0.1%	1%	3%
Inert (sand, debris, fines)	24%	10%	5%
Metal	0.1%	2%	1.5%
Wood	0.4%	0.5%	6%
Others	2%	0.4%	4%

1) (*IPE 2009) for Haridwar 2007/2008; 2) (Katiyar et al. 2013) for Bhopal 2009; 3) BBMP Website for Bangalore*

SWM scenarios & potential GHG co-benefits

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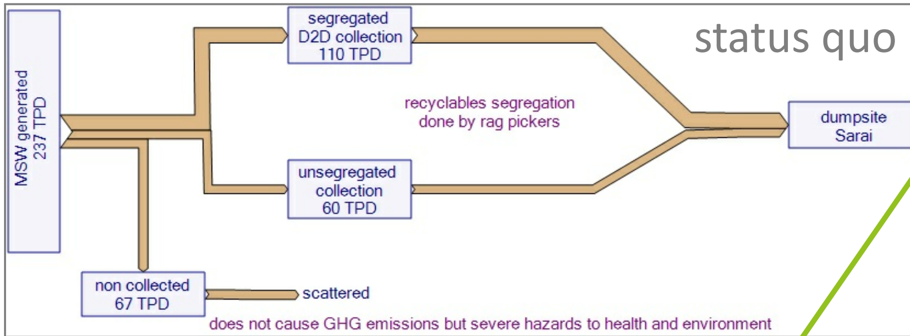
Scenario 1

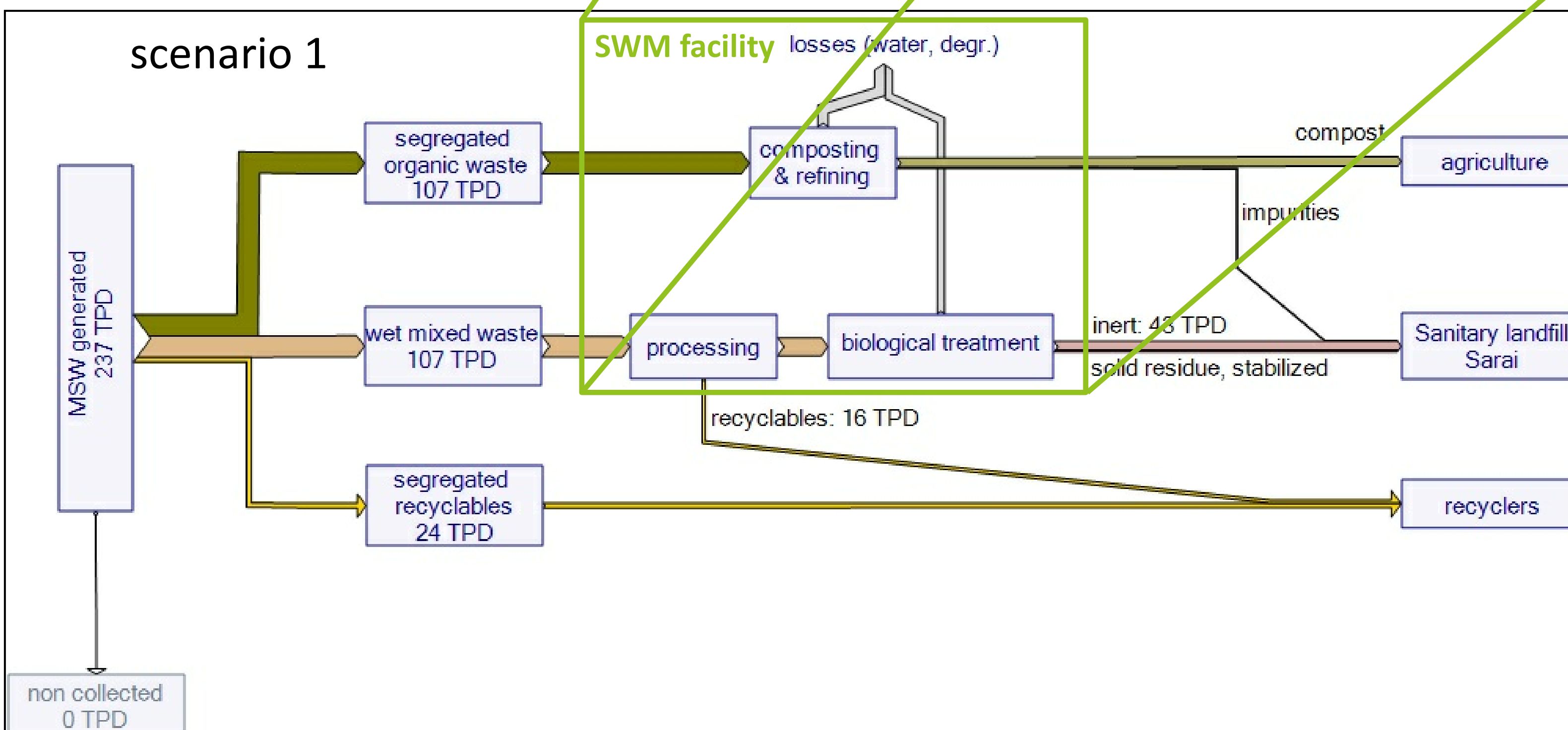
- 100% collection rate
- (improved) source segregation
  - of wet/organic waste producing high quality compost in Haridwar, partly in Bhopal, Bangalore
  - of recyclables in Haridwar, Bhopal; in Bangalore of dry waste with optimized sorting (e.g. MRF)
  - of combustables in Bhopal sent to cluster WtE (*Jabalpur concept*)
- optimized treatment of remaining wet/mixed waste, problematic fractions manually/technically separated producing high quality RDF for co-incineration and RDF for WtE

Scenario 2

- In Bhopal and Bangalore increase of source segregated wet/organic waste: 70% composted, 30% anaerobic digestion (AD); reduces remaining waste fraction -> less wet
- In Haridwar exclusion of inert (silt) from MSW stream through optimized D2D-collection leading to:
  - increase of recycling
  - reduction of litter spots
  - minimization of marine littering

Haridwar – status quo & scenario 1





Haridwar – status quo & scenario 2

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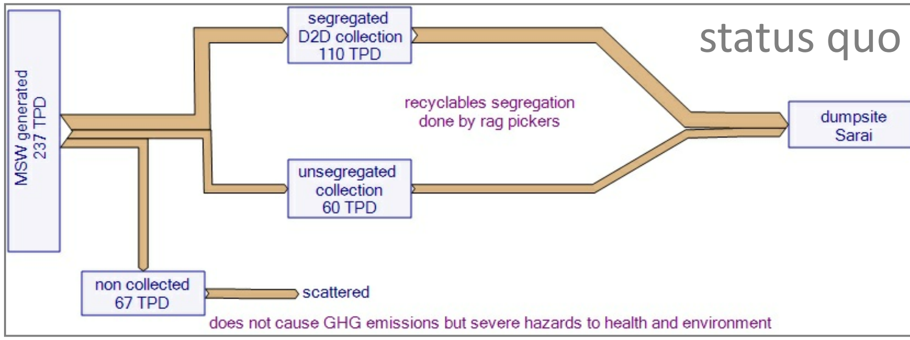
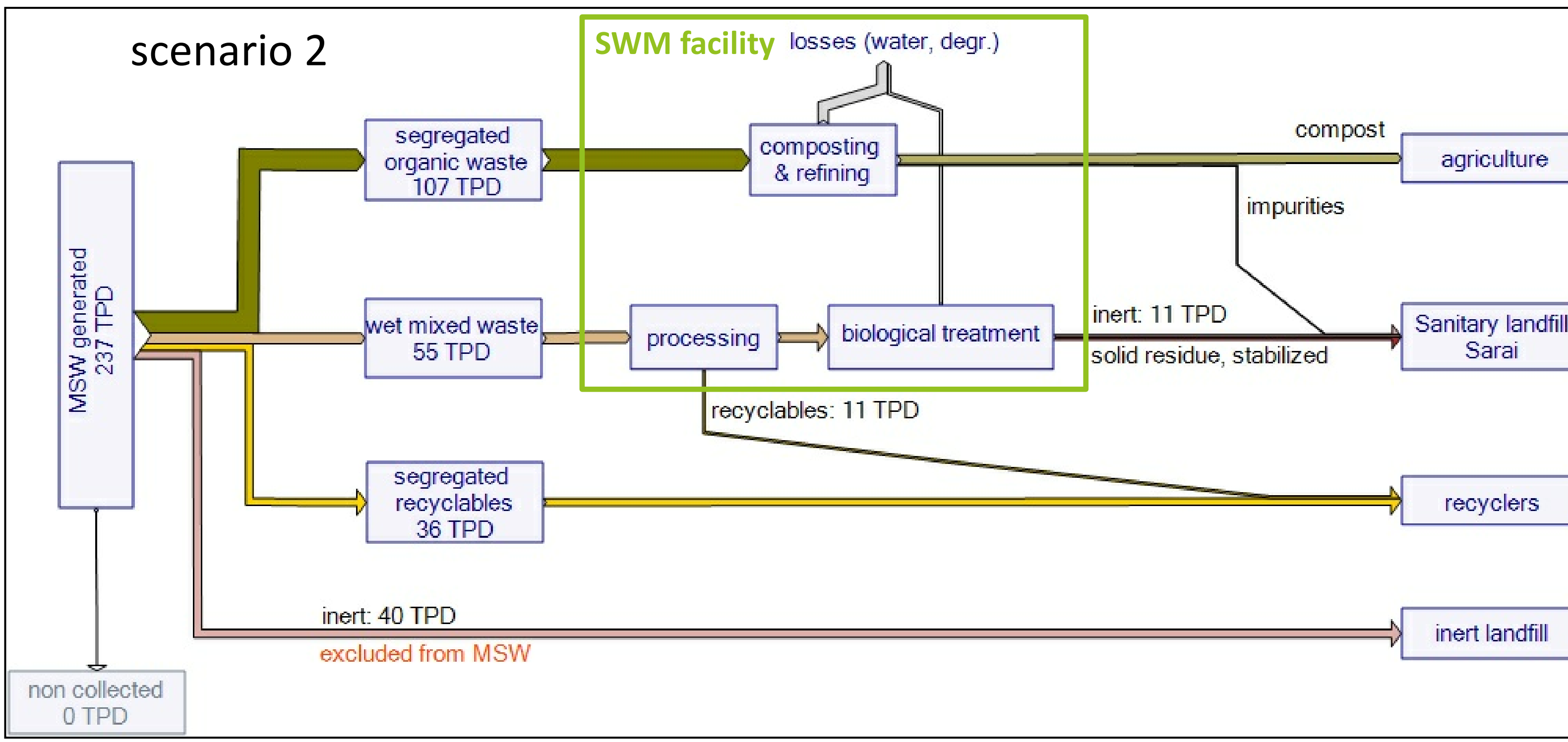
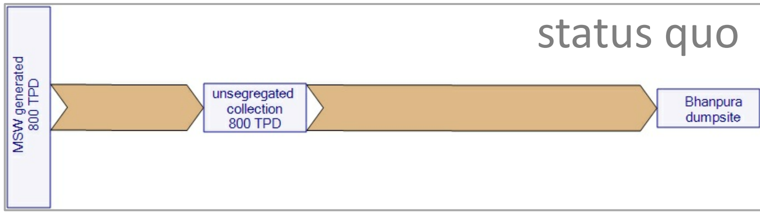
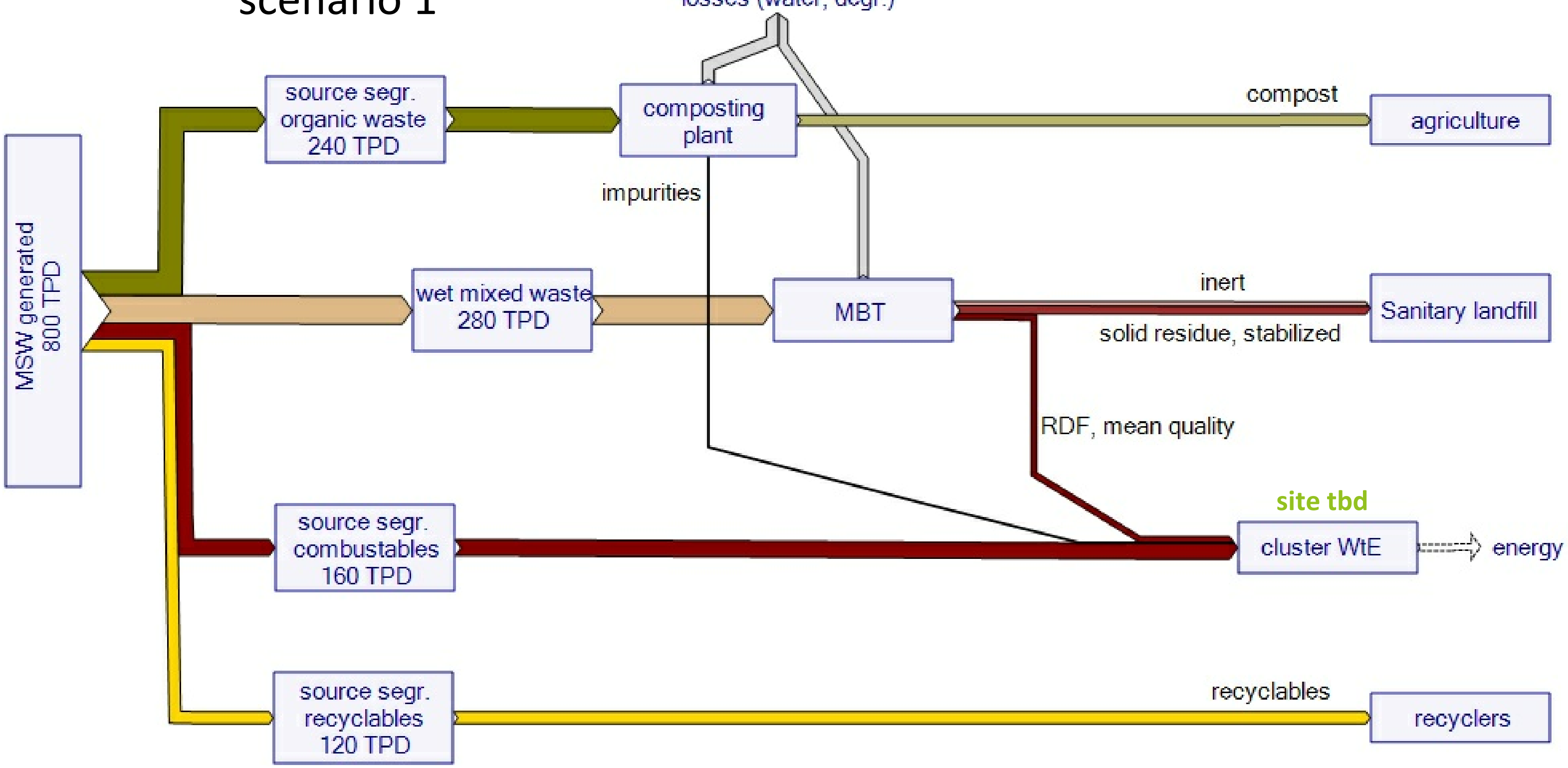




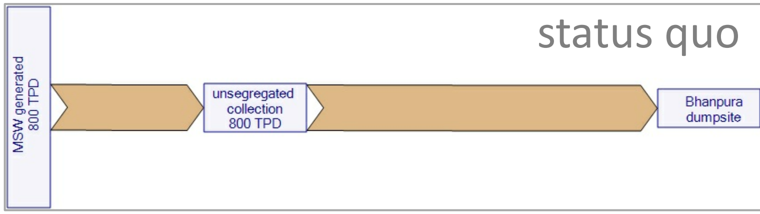
Bhopal – status quo & scenario 1

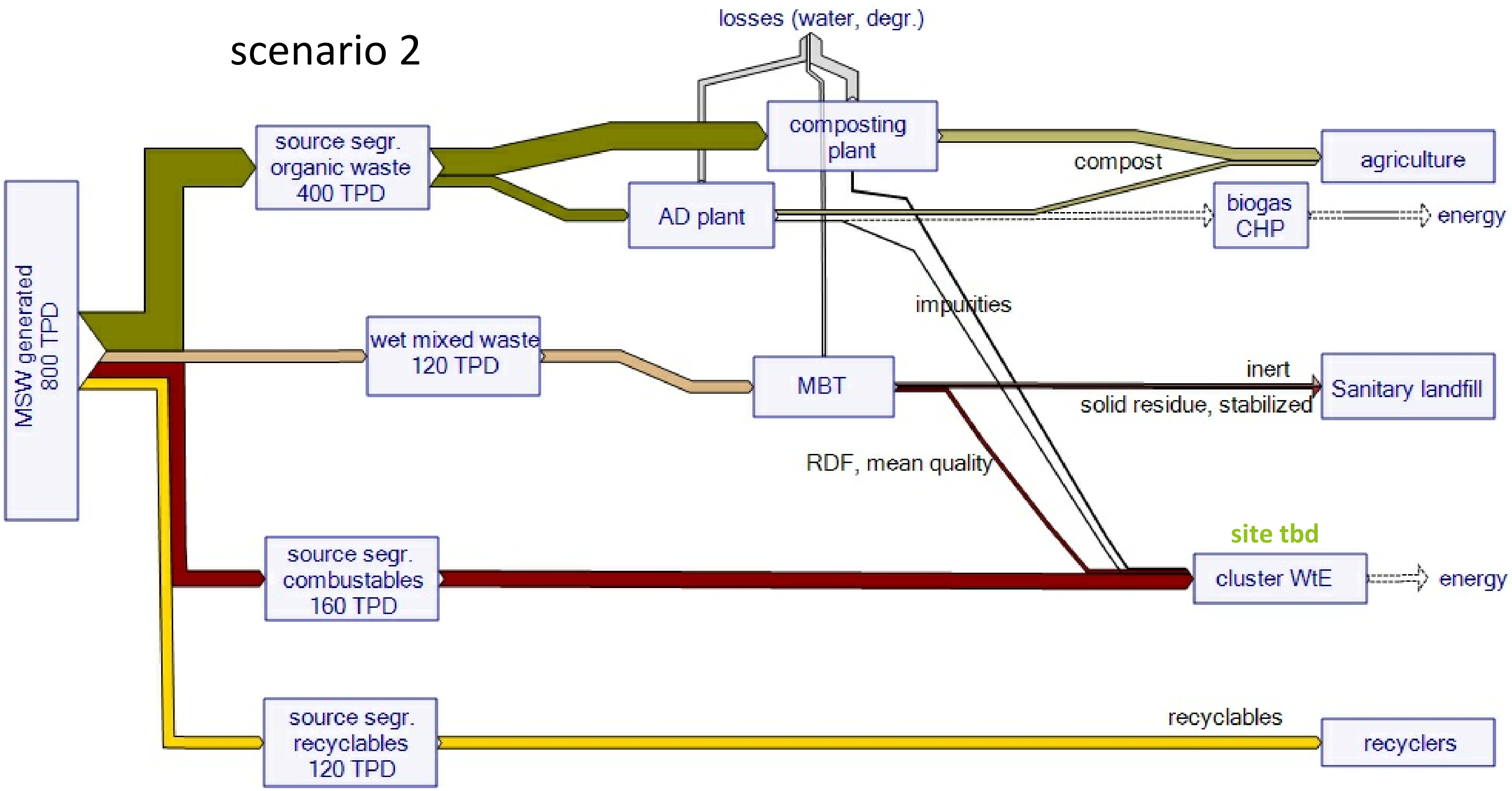


scenario 1



Bhopal – status quo & scenario 2





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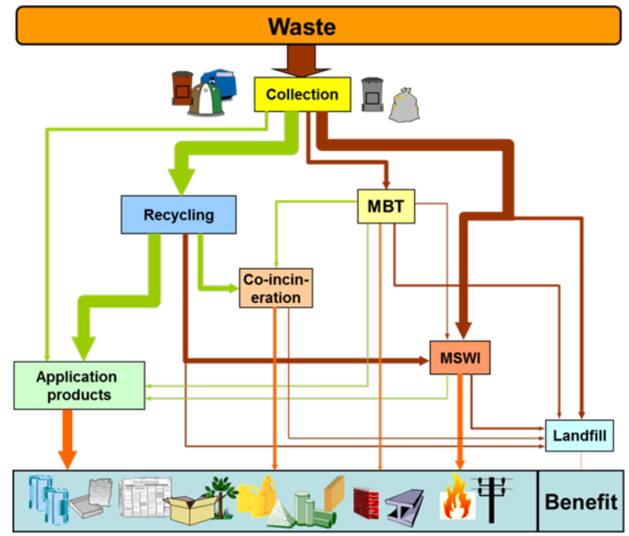
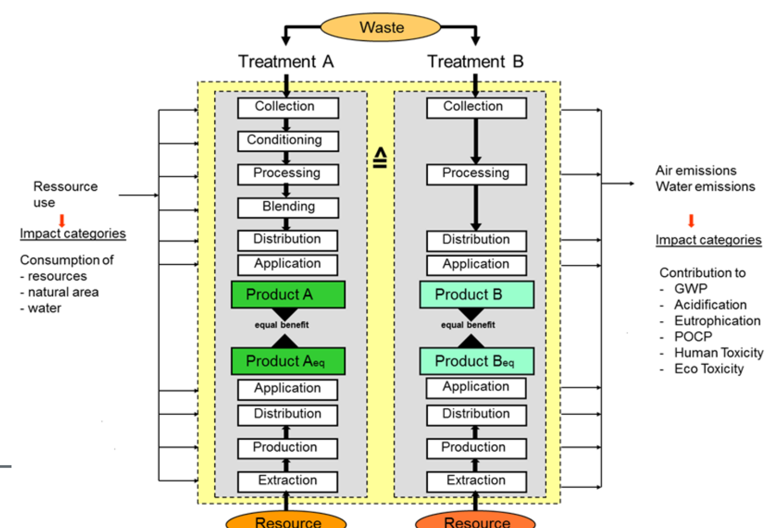
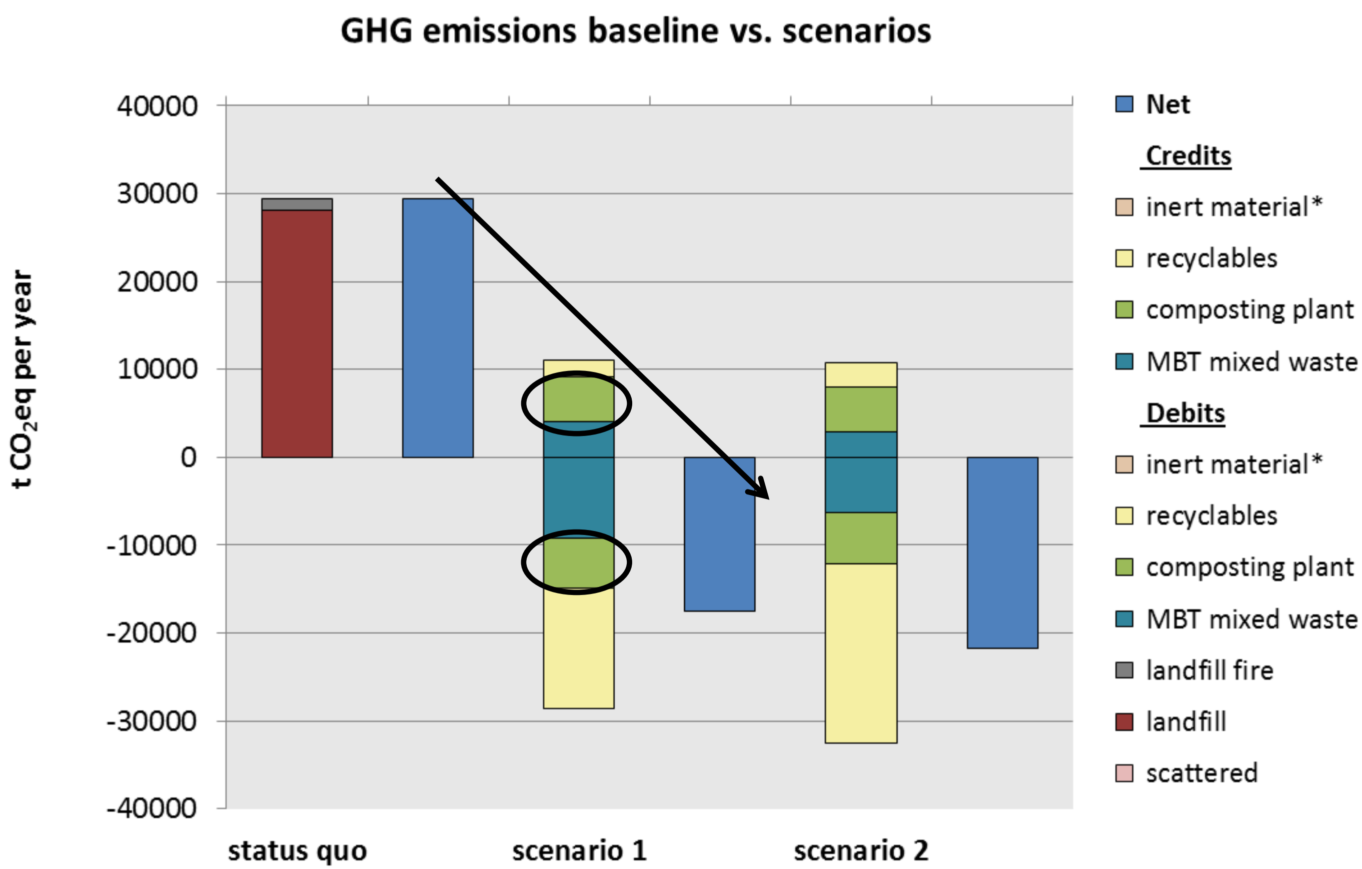
Life Cycle Assessment in waste management for GHG calculation

- Method intended to give decision-making aid
- It covers direct emissions from the waste sector <u>and</u> avoided emissions for substituting primary products and energy in other sectors
- Cradle to grave system starts with waste (no "previous life") and ends with final purpose of waste treatment (secondary product, energy)
- Benefits of compared systems must be equal = equal waste generated, credits for benefits
- Results represent mitigation <u>potentials</u>
- All emissions from waste treatment are related to the waste amount considered (landfilling 100 year time horizon)

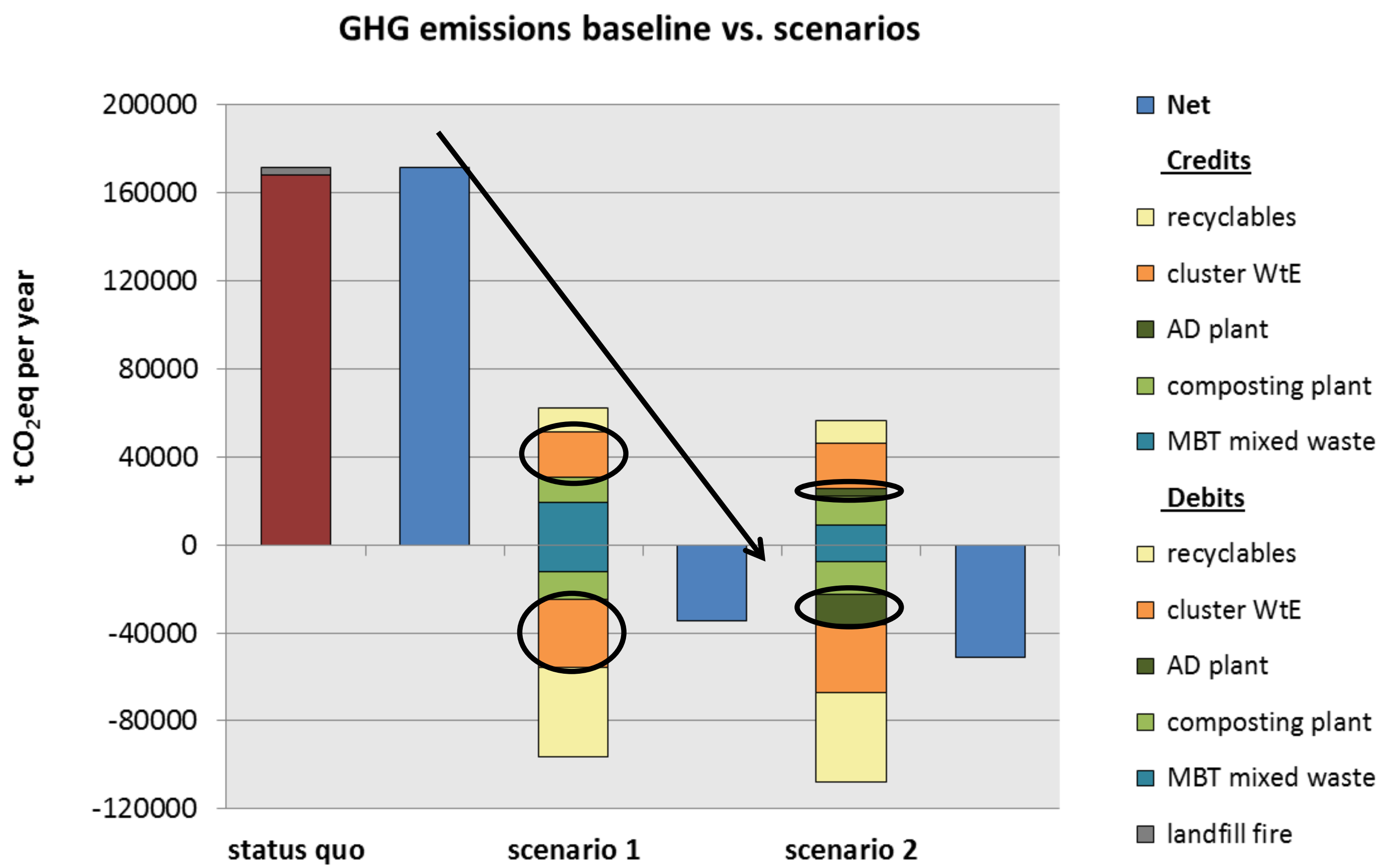




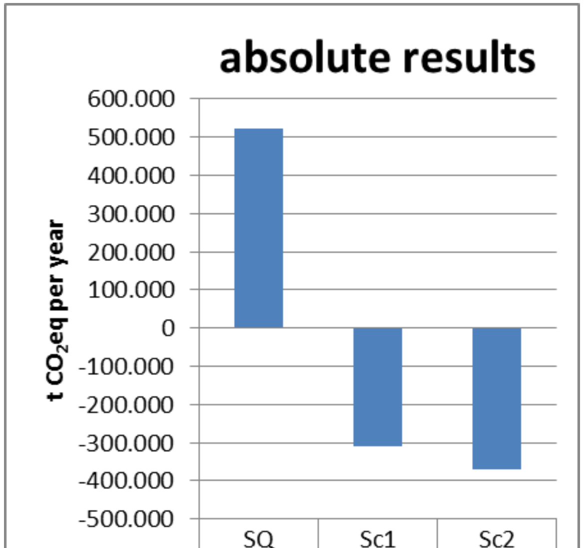
GHG results – Haridwar



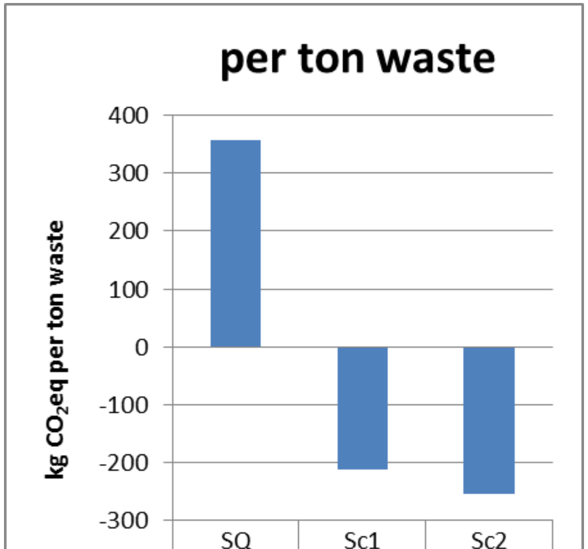
GHG results – Bhopal



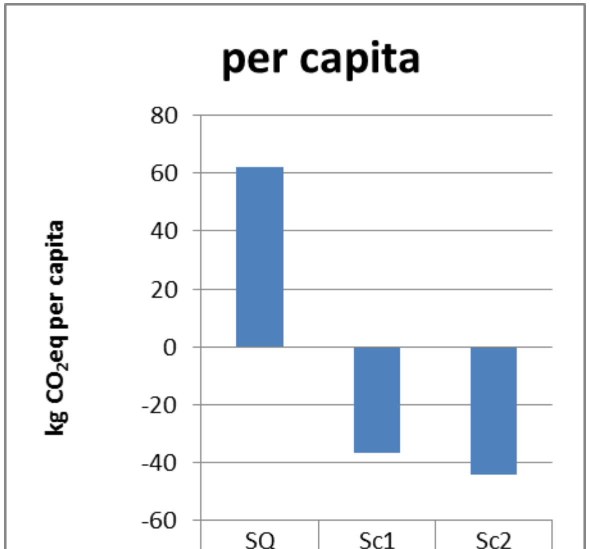
GHG net results – Bangalore



	SQ	Sc1	Sc2
t CO2eq/a	522.107	-309.049	-370.985



	SQ	Sc1	Sc2
kg CO2eq/t	358	-212	-254



	SQ	Sc1	Sc2
kg CO2eq/cap	62	-37	-44

Extrapolation for urban India

- Extrapolation - using the 3 cities as proxy for the clusters – was done to get an idea of the dimension of the potential GHG mitigation effect of mega cities, medium sized cities and small cities
- Typically larger cities are addressed by programs and financial support, e.g. because they generate relevant shares of waste, and it is easier to support measurements in a few cities than in hundreds
- Though large and medium sized cities may have the advantage of a centralized administration, the opportunities for sound source segregation, which is a prerequisite for efficient treatment of recyclables and organic waste, are higher in smaller cities
- The extrapolated results show a significant contribution of small cities to the GHG mitigation potential of the waste sector, and it is recommended to also consider supporting programs for small cities

Source population: Census of India 2011

Extrapolation for urban India

Cluster	> 3 million	1-3 million	0.1-1 million
Number of towns	10	34	424
Cumulated population towns	61,100,000	49,400,000	84,100,000
Specific GHG net results in kg CO_2eq per capita:			
Status quo	62	95	75
Scenario 2	-44	-28	-55
GHG mitigation potential	-106	-124	-130
GHG mitigation potential [t CO_2eq/a]	-6,500,000	-6,100,000	-10,900,000
Share in % of total	28%	26%	47%

- Such programs should support the development of methods/manuals for representative waste sampling and analysis and also e.g. the development of a construction set for biological treatment plants

 Source population: Census of India 2011

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Conclusions

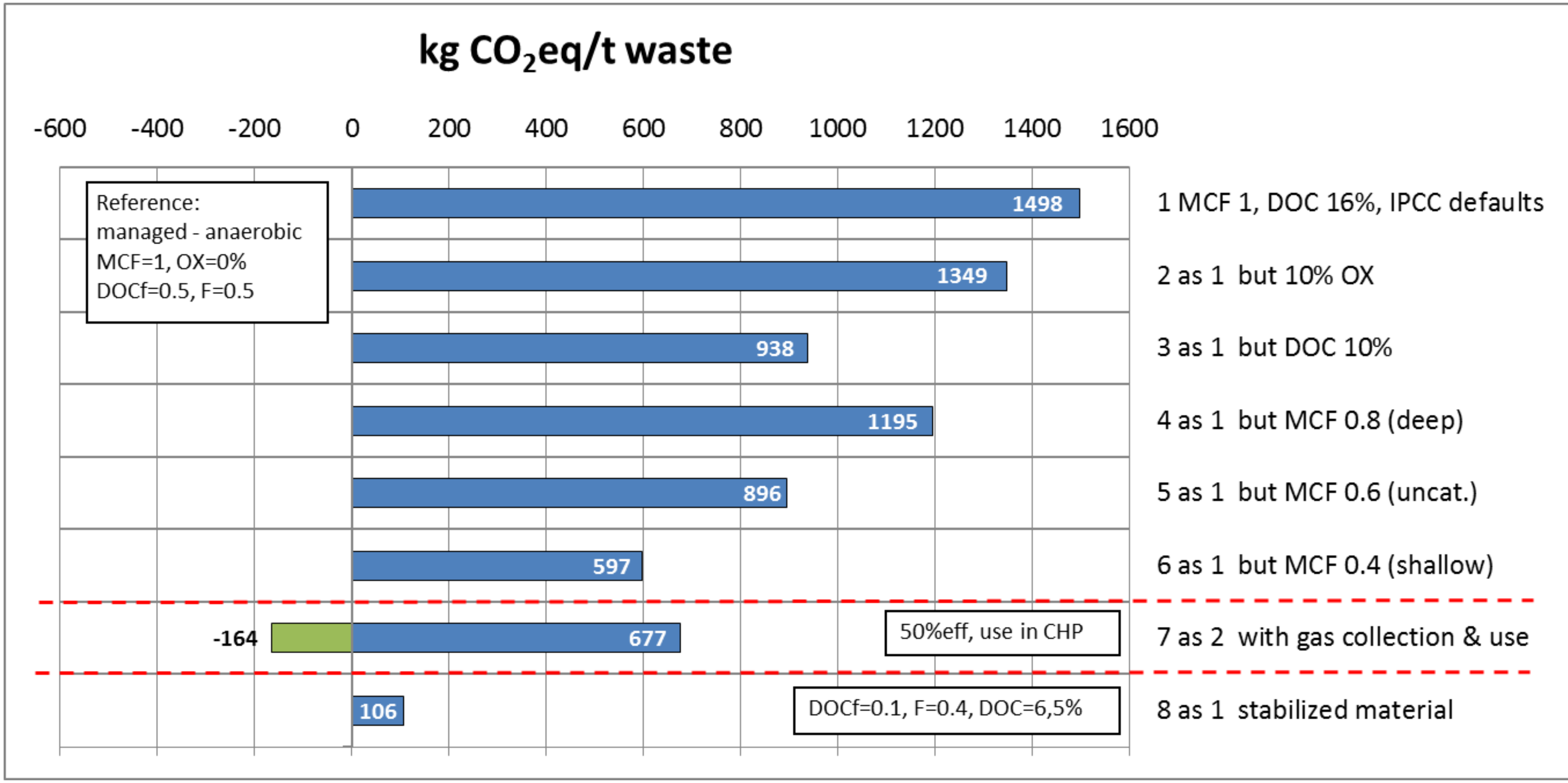
- India like other E+D-countries has to face major challenges due to rapid growth and change in life style
  - New waste materials cause problems and sheer waste volumes overflow landfills, sound waste collection as well as new treatment plants are not easily implemented
  - Although there are many very good private initiatives (e.g. from NGOs), different responsibilities, high staff turnover and administrative barriers make it difficult to monitor waste flows or to plan waste management
- Source segregation is key to clean waste fractions allowing high recycling rates and quality products
  - source segregation of organic wet waste is key for high quality compost (prevents contamination) --> feasible in small cities, partly in big/mega cities
  - proper segregation is a challenge, especially in dense and populous regions -> sorting solutions are needed respecting waste properties to avoid treatment problems and receive quality products (representative samples and tests)

Conclusions

- Big/mega cities may need incineration capacities (WtE plants)
  - for RDF which cannot be used for co-incineration, for impurities that shall not be landfilled (both from pretreatment; collected MSW is unsuitable, too wet)
  - proper flue gas cleaning is mandatory to consider human health concerns
- Extrapolation shows that small cities (0.1-1 million inhabitants) can significantly contribute to GHG mitigation in the waste sector
  - Though GHG results are not representative (lack of reliable data) and extrapolation is by no means meant to be exact, it shows a relevant contribution from small cities
  - By supporting some of these cities, ideally, standardized economical small-scale solutions can be developed and provide a merit of order effect for other cities
- Waste data matters! for proper planning and reliable GHG results
  → excursion

Excursion “Waste data matters”

Example landfill: specific GHG results depending on input data



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Excursion "Waste data matters"

- Although sanitary landfills with gas collection are better than unmanaged ones, and stabilized material has a much lower impact, the major contribution to GHG mitigation comes from diversion from landfill
- Waste data matters to assess current GHG emissions – especially if DOC and condition of the landfill are not known, specific results can vary by factor 3
- Reliable GHG results are needed to assess the extent of potential GHG mitigation, which may be required e.g. when applying for funds (e.g. NAMA facility)
- Generally, waste data matters, because data knowledge is essential for waste management plans, waste generated and waste properties decide on possible treatment routes and on the necessary design of treatment plants

Thank you for your attention!

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