# Cost-comparison tool for different integrated waste management systems


Ingenieurgesellschaft Prof. Czurda und Partner mbH

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## Decision support tool in waste management

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# Approach of Integrated Waste Management

**To avoid mis-management**

**To avoid mis-investment**

# Costs for Waste Management ?

# Background and problem - specific

## KFW (German Development Bank)

- Developing and financing programs in waste management
- **Target:**

  ***„Implementation of environmental sound waste management system“***
- In early stage first decisions are required
  - Economically most advantegous option
  - Fulfilling targets
- Cost preview is key element

# Background and problem - general

**Decision-maker in waste management**

Local, regional, national and international authorities

- No sufficient knowledge about
  - Costs in existing waste management system (mostly underestimated)
  - New system options (technical and financial)
  - Cost components

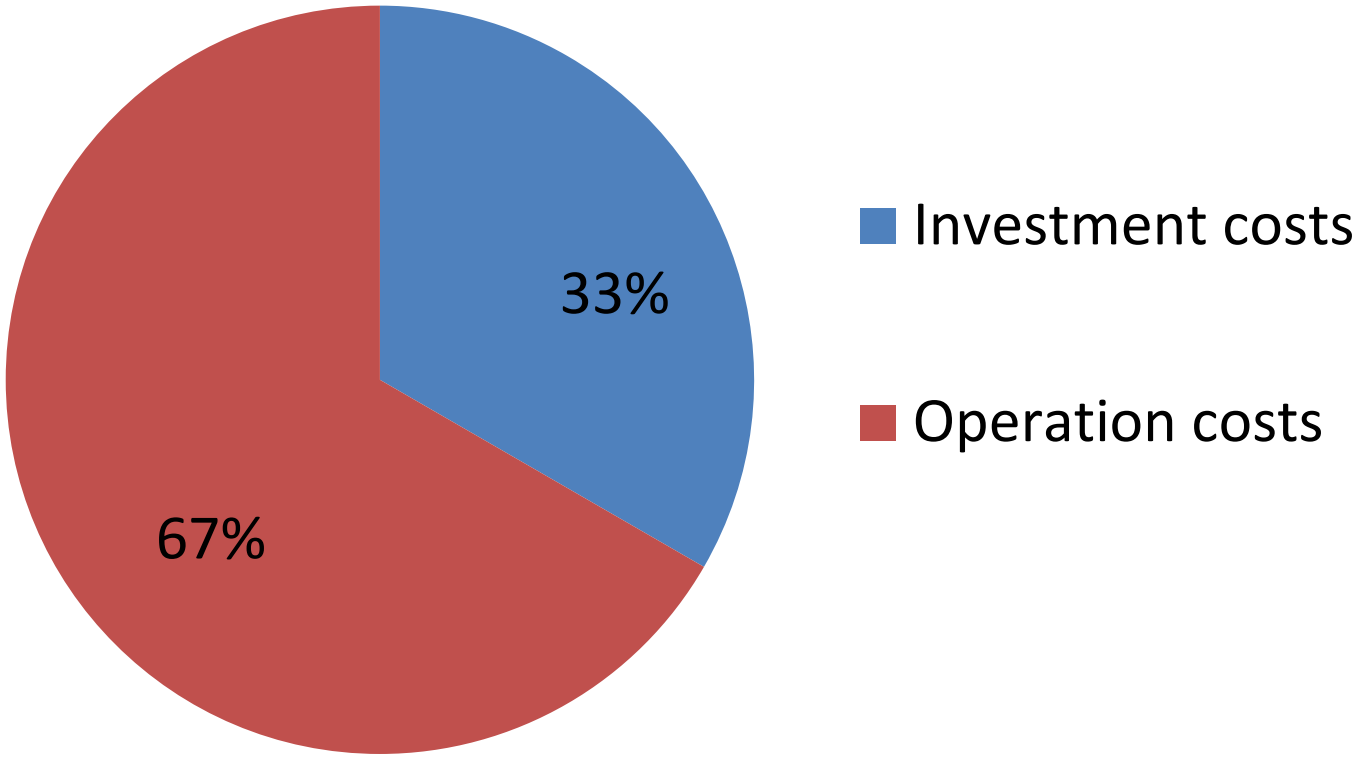
- No sufficient decision tool available to calculate and compare different options

# Background and problem - general

**Cost efficiency of waste management systems**

- Major focus on investment costs
- Investment follow lowest price principle
- Other costs/total costs not sufficiently considered

# Total cost distribution in waste management



# Total cost calculation in waste management

## Total cost calculation in waste management

- Done
- Looking individually on each system component
- Relevant cost component parts are missing
- Dependencies amongst components not sufficiently taken into account
  - E.g. MBT before landfill requires adjusted dimension and design of landfill

# Total cost calculation in waste management

**Total cost calculation for a complete system‘s lifetime**

1. Planning
2. Construction
3. Operation
4. Closure
5. Post-treatment

# Cost simulation tool for waste management

## Aim

- to calculate and compare the total costs of each system chosen
  - based on similar frame conditions
  - including all phases from planning, construction, operation up to closure
- to provide additional support for decision makers in waste management from beginning on

# Options of cost simulation tool

## Waste management scenarios S1 – S3

| | |
|---|---|
| S1 | MBT aerobic + landfilling of treated waste |
| S2 | MBT anaerobic + landfilling of treated waste |
| S3 | Only landfilling of untreated mixed waste |

# Principle

**General data relevant/same for all 3 scenarios S1-S3**

- Waste quantities and composition of waste,
- Existing waste collection system
- Population figures and demographic trends
- Economic basis data

  (interest rates, inflation , sales tax, cost of general consumables (electricity , water, fuel, etc ...)

**Scenario- specific data**

- information on investment and operating costs

➔ can be individually added to datasheets

➔ Procedure of data filling is equal for all scenarios

➔ cost of these scenarios to be compared

# Structure

**Datasheets as results of input**

5. Total costs
6. Mass balance (startup)
7. Mass balance (average)
8. Graphs
9. Cost comparison Scenarios S1-S3

# Basic Data

**Required data relevant for all scenarios**

1. Project relevant data
2. Schedule for all project phases
3. Climate data
4. Waste specific data for all different waste types
5. Socio-Economic data

# Basic Data

## Required data for each specific scenario S1 – S3

1. Mechanical treatment (S1 and S2)
2. Biological treatment
   a. Aerobic (S1)
   b. Anaerobic (S2)
3. Landfill (S1 – S3)

# Basic Data - Example

*Mechanical Treatment*

| | Year |
|---|---|
| **Input to Mechanical Treatment** | 2015 |
| Household Waste | 71.489 Mg/a |
| Commercial Waste | 0 Mg/a |
| Other Waste 1 to MBT | 0 Mg/a |
| **Total Input** | **71.489 Mg/a** |

| | | | Year |
|---|---|---|---|
| **Total Output Recycling Materials from Mechanical Treatment** | Sorting Quota in % from Input | | 2015 |
| Ferrous Metal | 35,00% | = | 375 Mg/a |
| Non-Ferrous Metal | 30,00% | = | 107 Mg/a |
| Paper | 30,00% | = | 858 Mg/a |
| Plastic - PET | 35,00% | = | 250 Mg/a |
| Plastic - Other Plastics | 35,00% | = | 751 Mg/a |
| Glass | 35,00% | = | 250 Mg/a |
| Textiles | 35,00% | = | 626 Mg/a |
| Secudary Fuel (RDF) | 1,00% | = | 57 Mg/a |
| Wood | 35,00% | = | 375 Mg/a |
| Others | 35,00% | = | 0 Mg/a |
| **Sum of Recycling Materials as Share from Input** | **5,11%** | **=** | **3.650 Mg/a** |

# Investment costs

## Required data

1. Components of investment
2. Refinancing period
3. Costs for maintenance & repair

# Investment costs

## Main cost components

1. Site selection
2. Purchase of site
3. Incidental building costs
4. Construction costs for infrastructure
5. MBT (S1 and S2)

   Construction, technical equipment, others
6. Landfill (S1 – S3)

   construction of cells, closure, post-treatment, leachate, gas (only S3)

# Investment costs - example

| 5 | Costs of MBT | | | | | | |
|---|---|---|---|---|---|---|---|
| | ○ specific costs | Start | 2014 | | | | |
| | | End | 2014 | | | | |
| | ○ total costs only | | | | | | |
| | | Phase 1 | Phase 2 | | | | |
| | | DNT | DNT | | | | |
| 5.1 | **Additonal construction costs specific for MBT** | 3.284.902,00 | 0,00 | 0 | 2,12% | 1,00% | |
| | | | | | 69.639,92 | 0,00 | |
| 5.1.1 | Land | 3.284.902,00 | 0,00 | | | | |
| 5.1.2 | Cleaning and leveling | 0,00 | 0,00 | | | | |
| 5.1.3 | Concrete culverts for surface water | 0,00 | 0,00 | | | | |
| 5.1.4 | Pipes for surface water | 0,00 | 0,00 | | | | |
| 5.1.5 | Asphalt surfaces | 0,00 | 0,00 | | | | |
| 5.1.6 | Leachate pool | 0,00 | 0,00 | | | | |
| 5.1.7 | Building for sorting ,unloading,storing, administration | 0,00 | 0,00 | | | | |
| | | Start | 2015 | | | | |
| | | End | 2034 | | | | |
| | ○ specific costs | | | | | | |
| | ○ total costs only | Phase 1 | Phase 2 | | | | |
| | | DNT | DNT | | | | |
| 5.2 | **Technical equipment for mechanical part of MBT** | 1.380.836,43 | 7.726.039,00 | 0 | 1,35% | 0,40% | |
| | | | | | 18.641,29 | 30.904,16 | |
| *5.2.1* | *Fix Equipment* | 796.675,43 | 5.913.124,00 | | | | |
| 5.2.1.1 | Conveyor Belt | 796.675,43 | 5.913.124,00 | | | | |
| 5.2.1.2 | Magnetic Separator | 0,00 | 0,00 | | | | |
| 5.2.1.3 | Sieves | 0,00 | 0,00 | | | | |
| 5.2.1.4 | Belt for manual separation | 0,00 | 0,00 | | | | |
| 5.2.1.5 | Air classifier | 0,00 | 0,00 | | | | |
| 5.2.1.6 | Other classifier | 0,00 | 0,00 | | | | |
| 5.2.1.7 | Pumps | 0,00 | 0,00 | | | | |
| 5.2.1.8 | Laboratory | 0,00 | 0,00 | | | | |
| 5.2.1.9 | Other | 0,00 | 0,00 | | | | |
| *5.2.2* | *Mobile Equipment* | 584.161,00 | 1.812.915,00 | | | | |
| 5.2.2.1 | Screener | 584.161,00 | 1.812.915,00 | | | | |
| 5.2.2.2 | Loader | 0,00 | 0,00 | | | | |
| 5.2.2.3 | Container | 0,00 | 0,00 | | | | |
| 5.2.2.4 | Tractor with trailer | 0,00 | 0,00 | | | | |
| 5.2.2.5 | Tank trailer | 0,00 | 0,00 | | | | |
| 5.2.2.6 | Other | 0,00 | 0,00 | | | | |
| 5.3 | **Technical equipment for biological part of MBT** | 6.437.059,00 | 25.667.733,00 | 0 | 2,15% | 0,21% | |
| | | | | | 138.396,77 | 53.902,24 | |
| | | | | | | Maintenance and reparation | |
| | | Phase 1 | Phase 2 | | Phase 1 | Phase 2 | |
| | | DNT | DNT | | DNT | DNT | |
| 5.4 | **Total costs for MBT (5.1-5.3)** | **11.102.797,43** | **33.393.772,00** | | **226.677,98** | **84.806,40** | |

# Operational costs

## Main cost components

1. Staff
2. Consumption of consumables
3. Leachate treatment
4. Landfill gas treatment (only for S3)
5. Administration
6. Others

# Operational costs - example

**Block 3: Electricity consumption**

○ detailed costs

○ total costs only

| | | | Electricity per kWh | | | | |
|---|---|---|---|---|---|---|---|
| | **Basic costs consumables** | | 0,21 | | | | |
| | **Fix equipment MBT** | | | | | | |
| | | **No** | **Consumtion kWh** | **Hours/d** | **d/year** | **Cost/KWh** | **Total costs/a** |
| | | | | | | | DNT |
| 3.1 | Conveyor Belt | 11 | 5 | 7 | 300 | 0,21 | 24.255,00 |
| 3.2 | Magnetic Separator | 2 | 5 | 7 | 300 | 0,21 | 4.410,00 |
| 3.3 | Sieves | 4 | 30 | 7 | 300 | 0,21 | 52.920,00 |
| 3.4 | Belt for manual separation | 0 | 500 | 8 | 300 | 0,21 | 0,00 |
| 3.5 | Air classifier | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| 3.6 | Other classifier | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| 3.7 | Pumps | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| 3.8 | Laboratory | 1 | 50 | 4 | 125 | 0,21 | 5.250,00 |
| 3.9 | Others | 2 | 406 | 7 | 300 | 0,21 | 358.092,00 |
| | **Mobile equipment MBT** | | | | | | |
| | | | | average tons waste treated/y | | | DNT |
| 3.10 | Screener | 1 | 2 | 84.400 | | 0,21 | 35.448,00 |
| 3.11 | Others | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| | | | | | | **Total costs/a** | |
| | | | | | | DNT | |
| | | | | | | 480.375,00 | |
| | **Infrastructure and Landfill** | | | | | | |
| | | | | | | | DNT |
| 2.7 | General consumption (IT etc.) | 1 | 1 | 10 | 300 | 0,21 | 630,00 |
| 2.8 | Lighting | 1 | 5 | 4 | 250 | 0,21 | 1.050,00 |
| 2.9 | Landfill gas treatment | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| 2.10 | Leachate pumping | 1 | 10 | 24 | 333 | 0,21 | 16.800,00 |
| 2.11 | Leachate treatment | 0 | 100 | 8 | 300 | 0,21 | 0,00 |
| 2.27 | Others 1 | 1 | 5 | 8 | 125 | 0,21 | 1.050,00 |
| 2.28 | Others 2 | 1 | 2 | 24 | 333 | 0,21 | 3.360,00 |
| | | | | | | **Total costs/a** | |
| | | | | | | DNT | |
| | | | | | | 22.890,00 | |
| | | | | | | **Total costs/a** | |
| | | | | | | DNT | |
| | | | | | | 503.265,00 | |

# Evaluation of results

**All following datasheets are computed with input given**

1. Total costs
2. Mass balance (startup and average)
3. Graphs
4. Cost comparison (S1, S2 and S3)

# Total costs

**Calculation of average total costs including all**

- investment cost components
- operational cost components

- **over the whole project's lifetime**
  - planning,
  - construction,
  - operation,
  - Closure
  - Post-treatment
- **separately for MBT and landfill in relation to**
  - Input quantity for MBT
  - Input quantity for landfill
  - Total waste amount

# Total costs - example

| Operation time in years | | MBT: 20 | Landfill: 20 | EUR | Units |
|---|---|---|---|---|---|
| Depreciation/ write-down | | | | 5% | |
| Present investment costs MBT- Basis: MBT Input | | | | 19,03 | Euro/ton |
| Present investment costs MBT- Basis: Waste total | | | | 19,03 | Euro/ton |
| Present investment costs Landfill - Basis: Waste direct to landfill | | | | 8,82 | Euro/ton |
| Present investment costs Landfill - Basis: Waste total | | | | 7,35 | Euro/ton |
| **Present investment costs MBT+Landfill - Basis: Waste total** | | | | 13,64 | Euro/ton |
| Present operation costs MBT (without revenues) - Basis: MBT Input | | | | 6,52 | Euro/ton |
| Present operation costs MBT (without revenues) - Basis: Waste total | | | | 6,52 | Euro/ton |
| Present operation costs landfill (without revenues) - Basis: Waste direct to landfill | | | | 11,74 | Euro/ton |
| Present operation costs landfill (without revenues) - Basis: Waste total | | | | 9,79 | Euro/ton |
| **Present operation costs MBT+landfill (without revenues) - Basis: Waste total** | | | | 16,31 | Euro/ton |
| Present total costs MBT without revenues | | | | 21,67 | Euro/ton |
| | | | | 22.818.935 | Euro |
| Present total costs landfill without revenues | | | | 16,22 | Euro/ton |
| | | | | 17.077.004 | Euro |
| **Present total costs MBT+Landfill without revenues** | | | | 37,89 | Euro/ton |
| | | | | 39.895.938 | Euro |
| **Present total costs MBT+Landfill with revenues** | | | | **35.46** | **Euro/ton** |
| | | | | **37.332.480** | Euro |

# Mass balance

## Data sheet shows

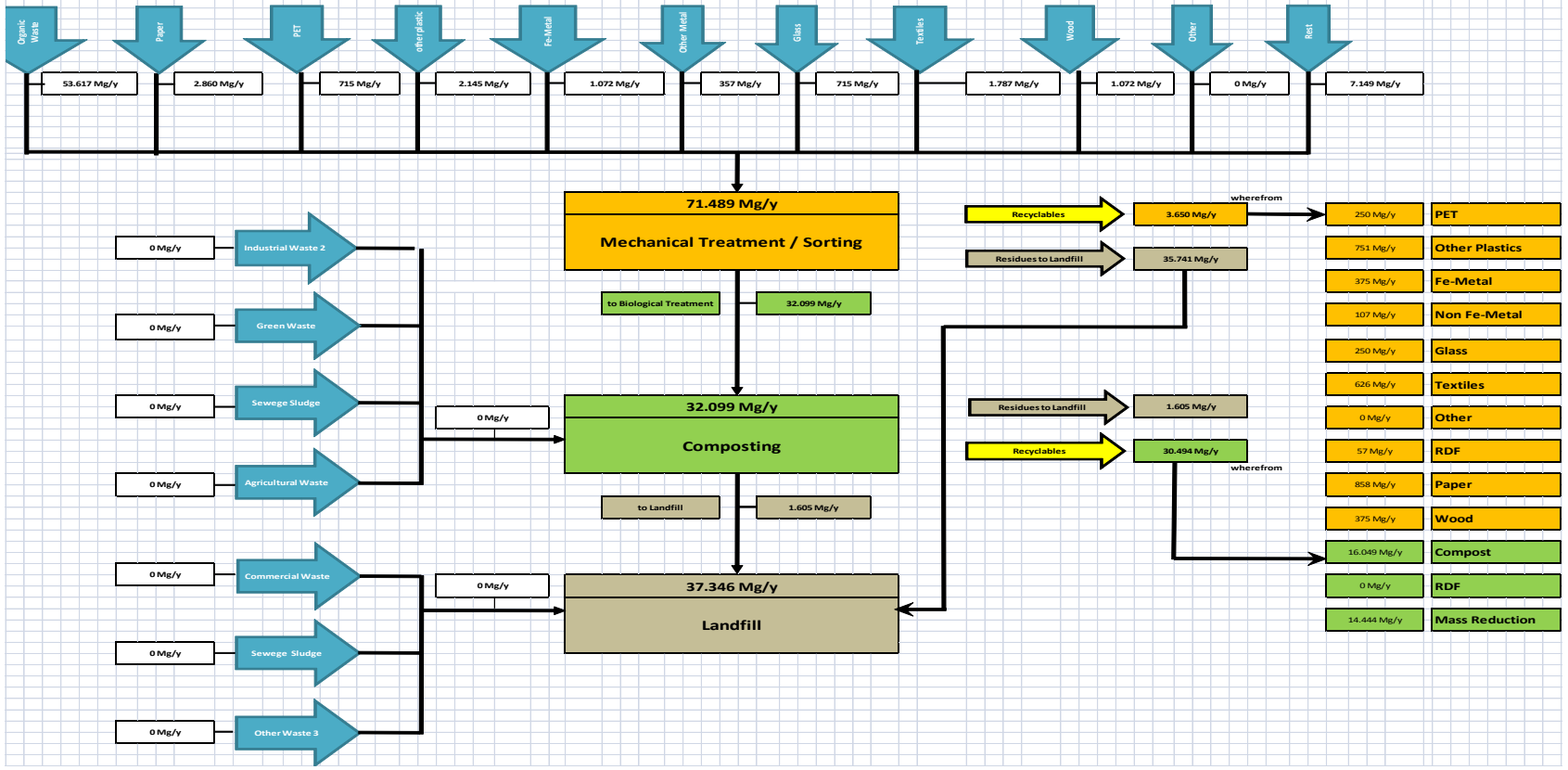
- Flow chart (mass balance) of each scenario for
  - Startup
  - Average

# Mass balance – example S1

tart of operation for S1

| | |
|---|---|
| **Waste Input Total to Mechanical-Biological Treatment (MBT)** | **71.489 Mg/y** |
| in the Year of Start of Operation | 2015 |
| **Total to Mechanical Treatment:** | **71.489 Mg/y** |
| Household Waste | 71.489 Mg/y |
| Commercial Waste | 0 Mg/y |
| Industrial Waste Type 1 for MBT | 0 Mg/y |
| **Total to Biological Treatment** | **32.099 Mg/y** |
| Sewege Sludge for Biological Treatment | 0 Mg/y |
| Green Waste for Biological Treatment (S1&S2) / Landfill (S3) | 0 Mg/y |
| Agricultural Waste for Biological Treatment (S1&S2) / Landfill (S3) | 0 Mg/y |
| Industrial Waste Type 2 for Biological Treatment | 0 Mg/y |

**Input Mechanical Treatment** 71.489 Mg/y

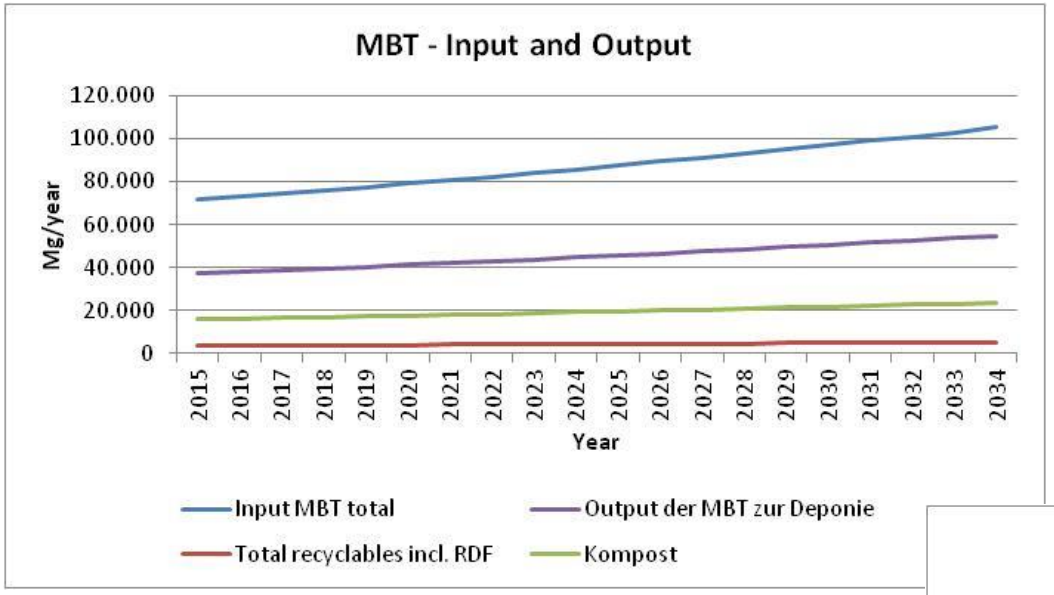


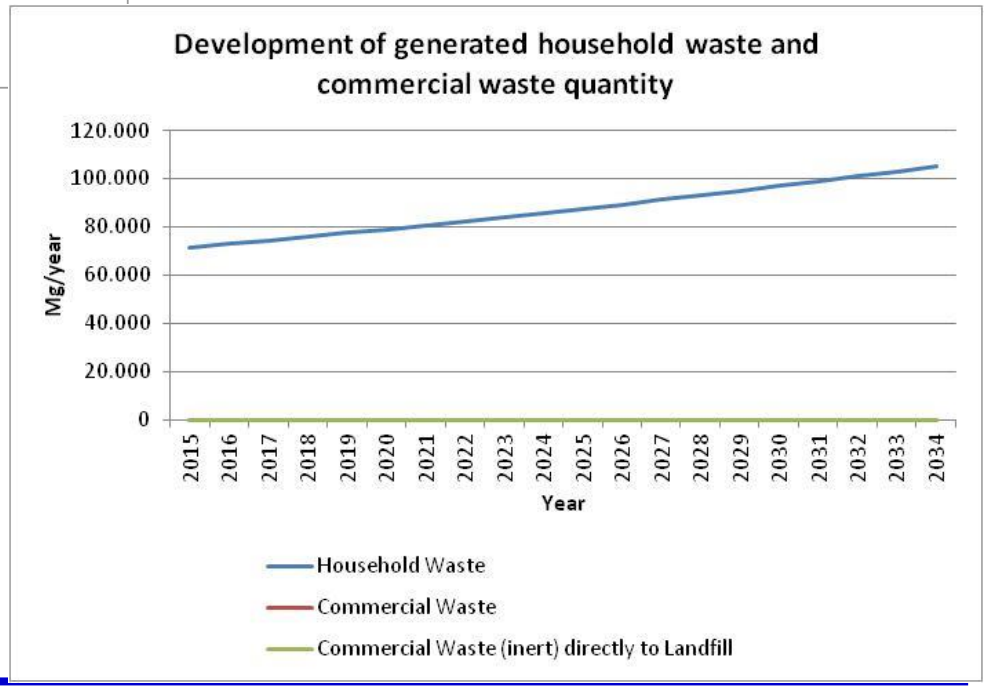
# Graphs

**All relevant results and calculation are visualized such as**

- Population development
- Projection of waste amounts
- Collected and generated waste streams
- Waste composition
- MBT input and output
- Landfill input

# Graphs - example



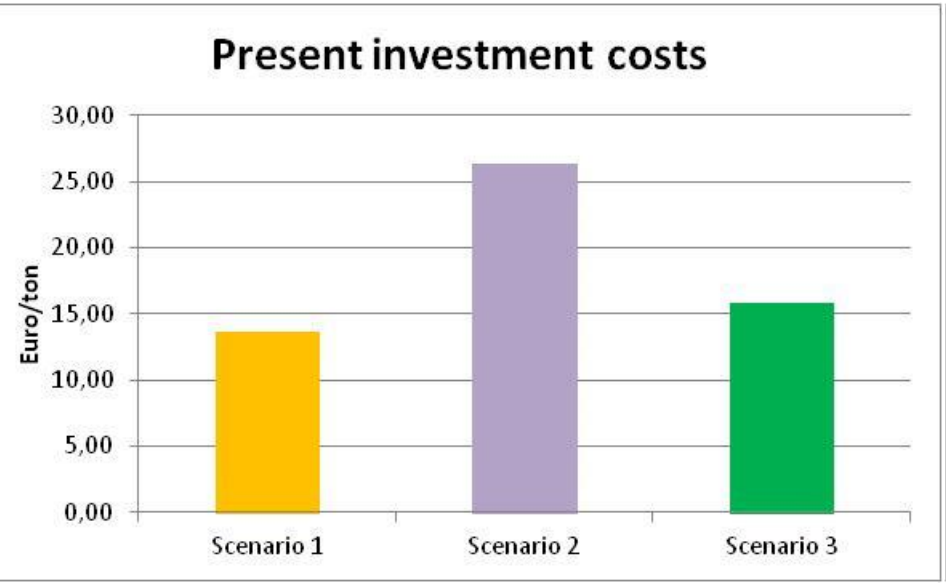



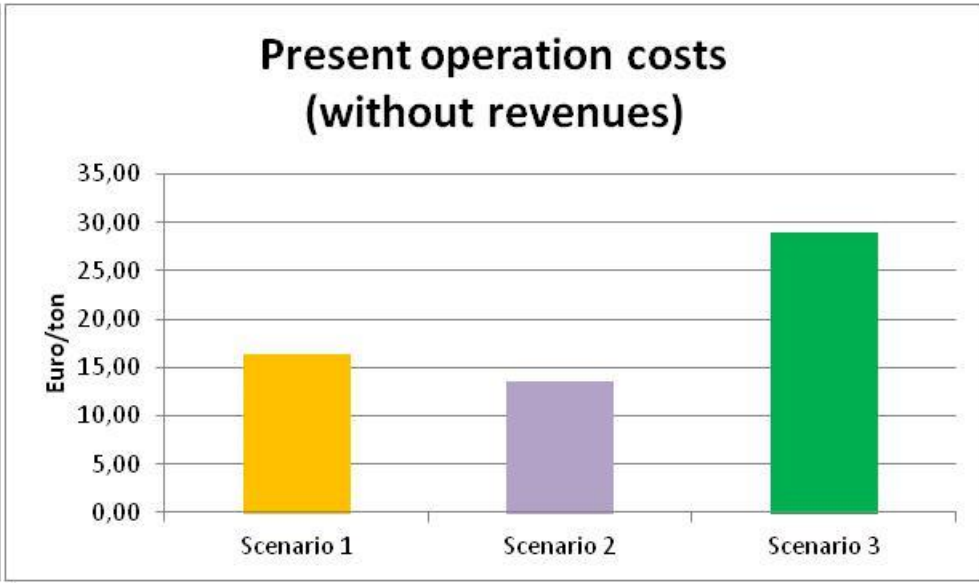
# Total costs comparison

**All relevant results of all 3 scenarios are presented here**

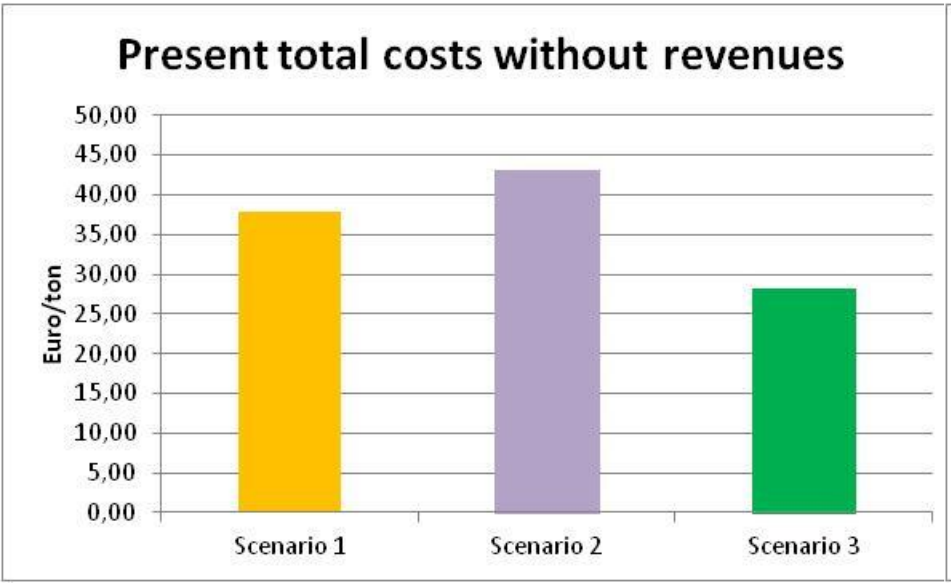
- In comparative table form
- As graphs
  - investment costs
  - Operational costs
  - Total costs

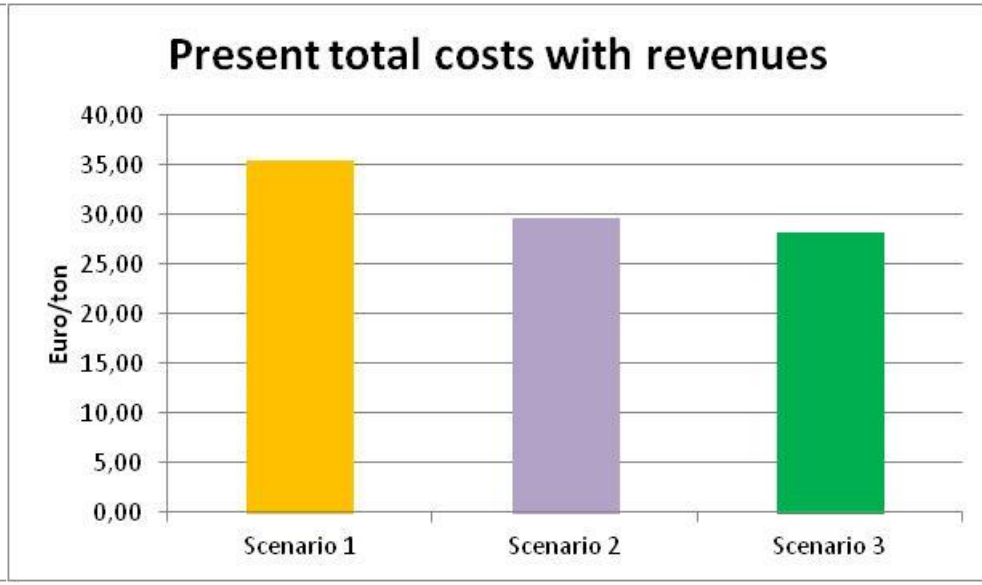
# Total costs comparison - example

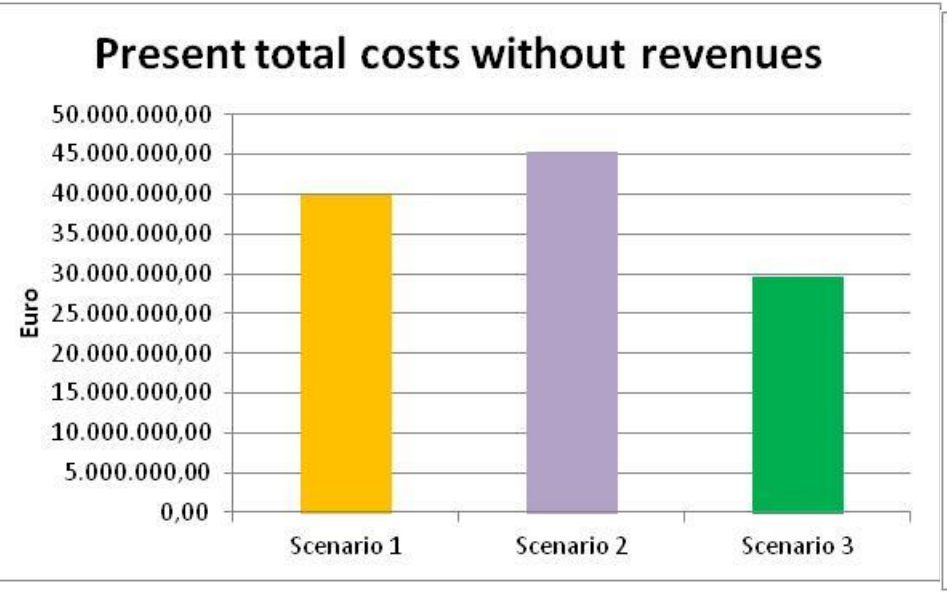


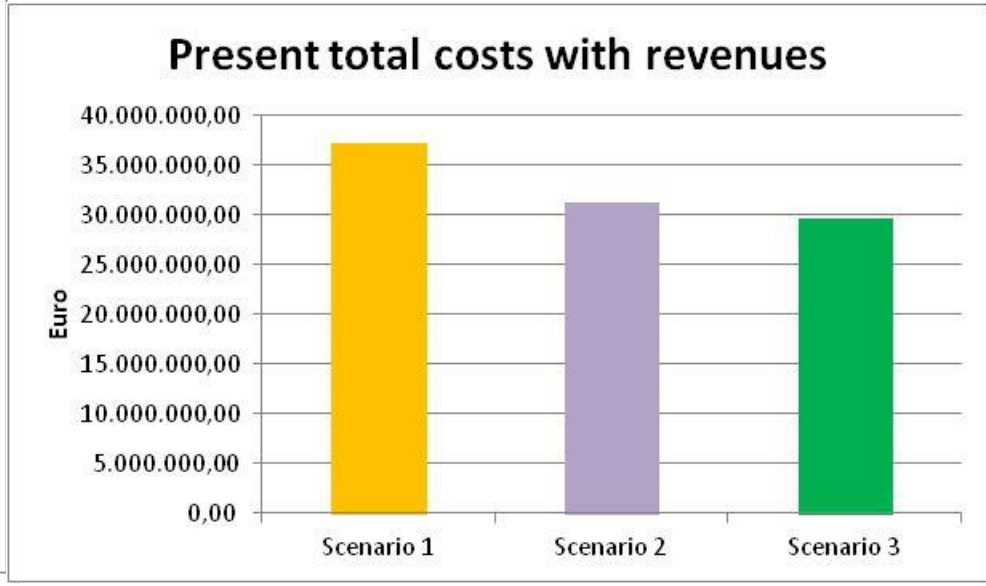



# Total costs comparison - example



# Conclusion and outlook

## Cost simulation tool

- Provides sufficiently accurate data taking into account total costs occurred during whole project's lifetime
- Individual data still has to be investigated
- Enables decision makers to decide in early stage
- For case study in Tunisia
  - *System costs including treatment can be comparable or must not be significantly higher than systems without Treatment (only landfilling)*
  - *Facilitated decision for a system more environmental sound*

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# Thank you for your attention

**Athens June 2014**