

Changes of the Calorific Value through Separate Collection

$$H_{u,mgS} = \frac{H_{u,ogS} - \sum_{i=1}^{i=n} \left(\frac{p_{ASi}}{100} \cdot H_{u,ASi} \right)}{1 - \sum_{i=1}^{i=n} \frac{p_{ASi}}{100}}$$

*) assuming that the energy for the heating of the (tinplate) metal is outbalanced by the calorific value of the label and the varnish on the tin

| Fraction | Gross caloric value H_0 | Total Water content TWC | Hydrogen content H | Caloric Value $H_{u,raw}$ | Comments |
|---------------------|---------------------------|-------------------------|--------------------|---------------------------|----------|
| | kJ/kg DM | % of raw Mat. | % of DM | kJ/kg raw Mat. | |
| Recovered paper | 16.300 | 6 | 5 | 14.100 | humid |
| Scrap plastic | 40.000 | 3 | 10 | 36.500 | humid |
| Recovered glass | - | - | - | -570 | Warming |
| Scrap metal | - | - | - | - | *) |
| DSG light materials | | | | ca. 20000 | |
| Vegetables | 13.650 | 60 | 4 | 3.700 | |

Container-less Collection

- Usable for
 - bulky waste
 - large appliances
 - shrubs
 - RP (cleanliness?; higher efforts regarding the collection time)

Problematic Waste Collection

- apart from resource collection, there is also pollutant collection
- predominantly product return
 - batteries/accumulators
 - waste oil
 - drugs
- ca. 0,8 - 2 kg /L·a; collection rates often < 50%, collected products/substances;
 - residues of paints/varnishes; plant protection agents
 - chemicals
 - fluorescent lamps
- Is this still necessary today in view of the thorough waste treatment, particularly with garbage incineration plants??

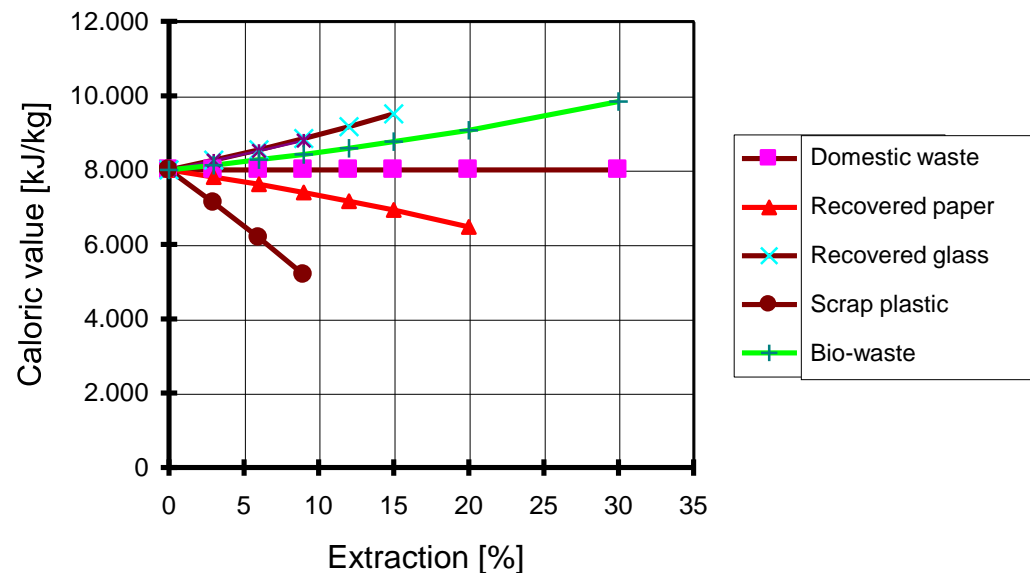
Changes of the Caloric Value in Residual Waste through Separate Collection (1)

*) assuming that the energy for the heating of the (tinplate) metal is outbalanced by the caloric value of the labels and the varnish on the tin

| Fraction | Gross caloric value H_{O} kJ/kg DM | Water contents W % (raw) | Hydrogen contents H % of the DM | Caloric value $H_{u,raw}$ kJ/kg roh | Comments |
|---------------------|---|-------------------------------|--------------------------------------|--|----------|
| Recovered paper | 16.300 | 6 | 5 | 14.100 | humid |
| Scrap plastics | 40.000 | 3 | 10 | 36.500 | humid |
| Recovered glass | - | - | - | -570 | warming |
| Scrap metal | - | - | - | - | *) |
| DSG light materials | | | | ca. 20000 | |
| Vegetables | 13.650 | 60 | 4 | 3.700 | |

$$H_{u,mgS} = \frac{H_{u,ogS} - \sum_{i=1}^{i=n} \left(\frac{p_{ASi}}{100} \cdot H_{u,ASi} \right)}{1 - \sum_{i=1}^{i=n} \frac{p_{ASi}}{100}}$$

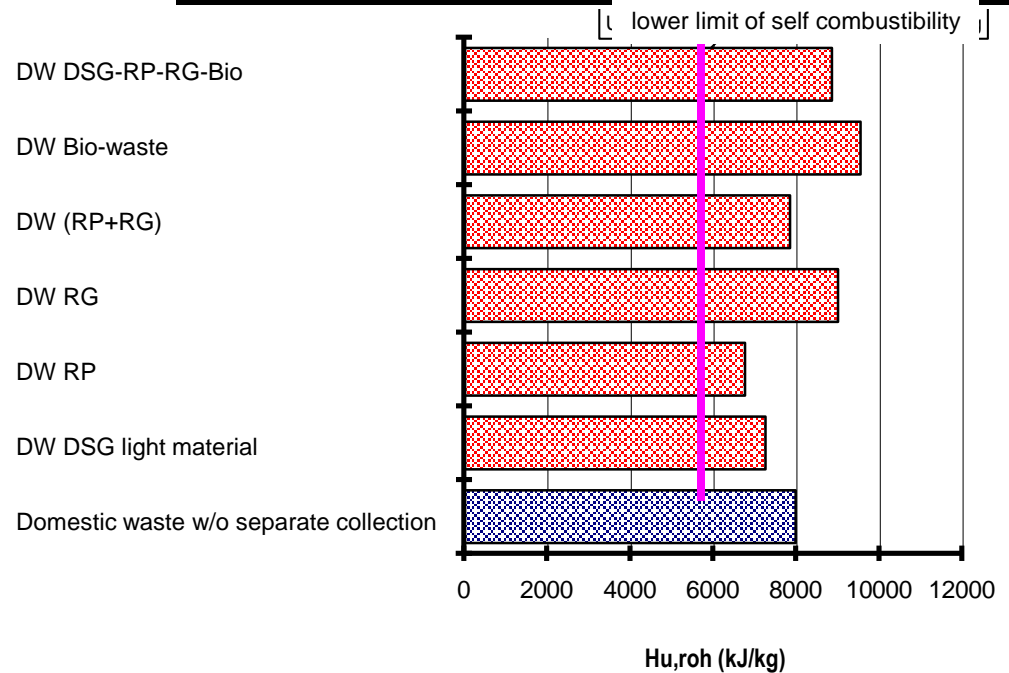
- Residual waste stays ...selbstgänglich combustible and also bio-degradable

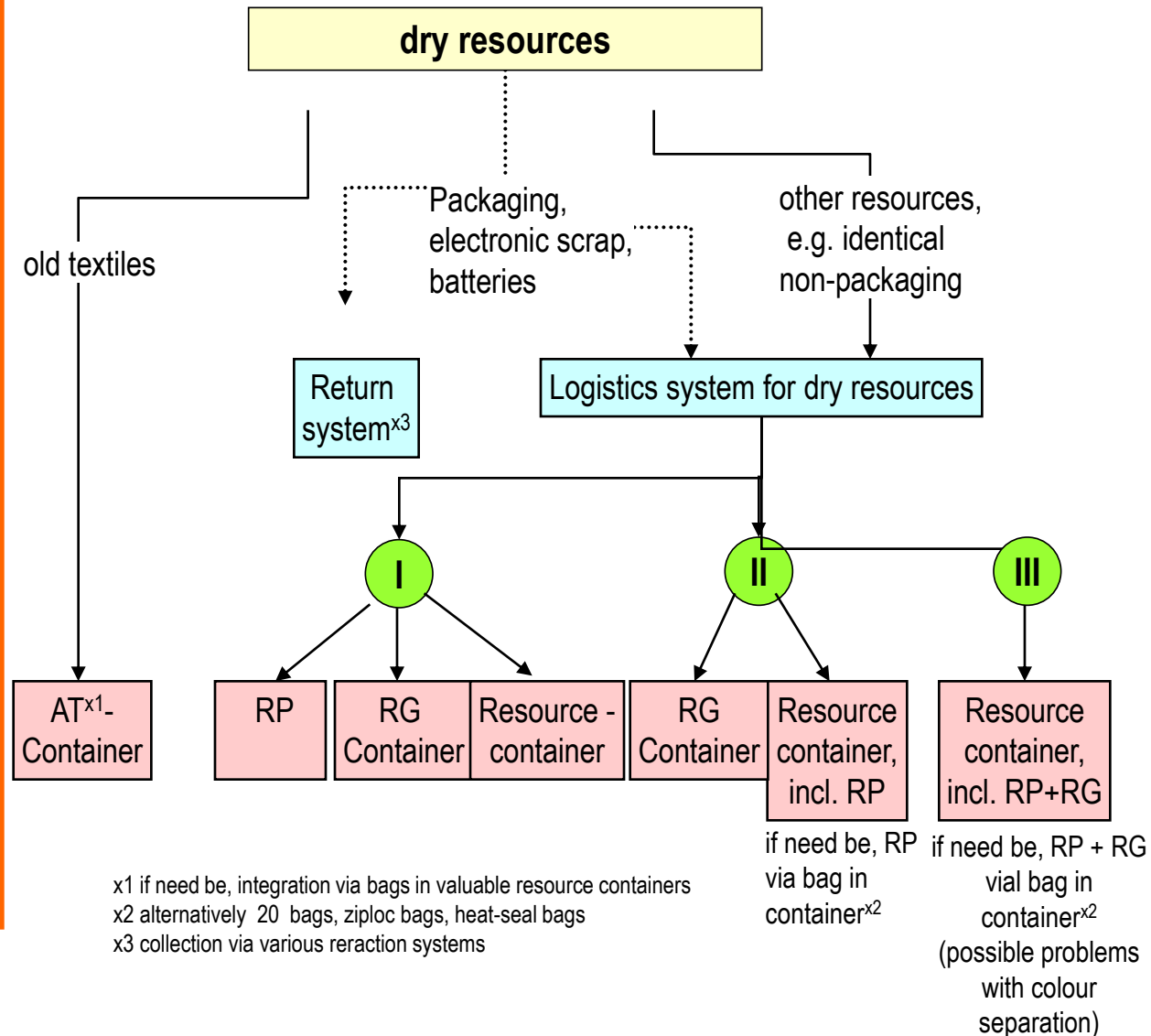
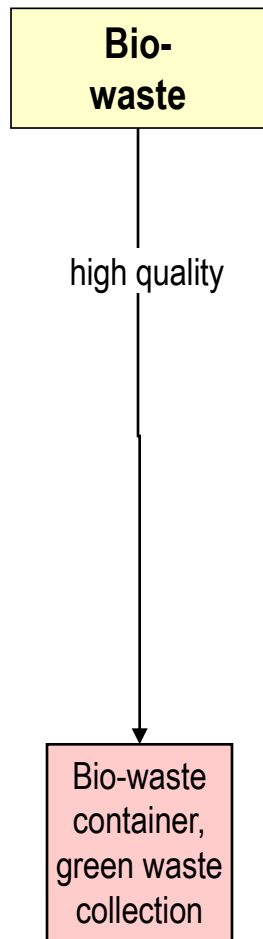
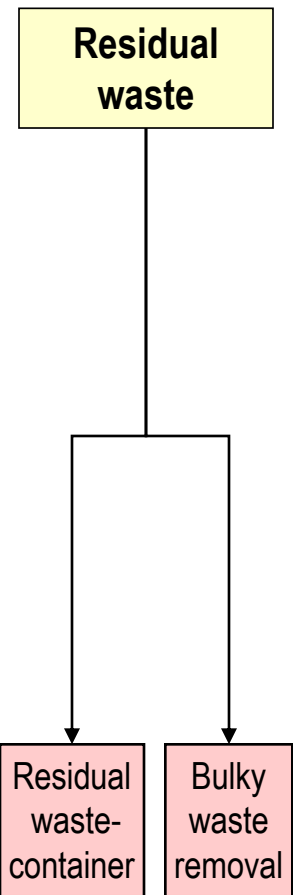


Changes of the Caloric Value in Residual Waste through Separate Collection (2)

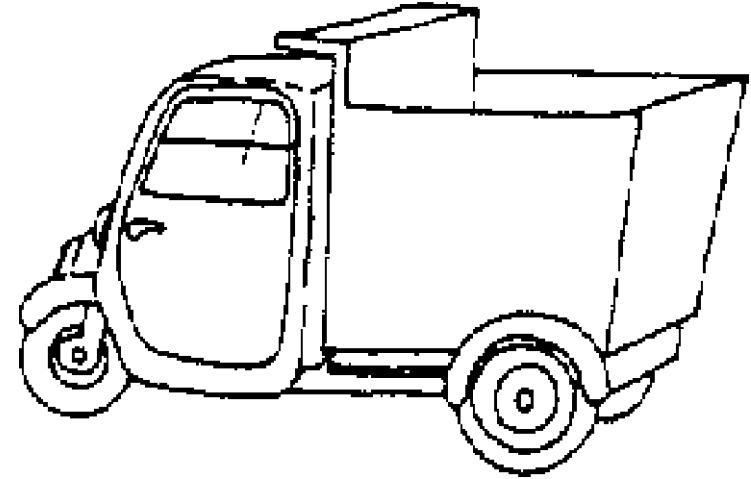
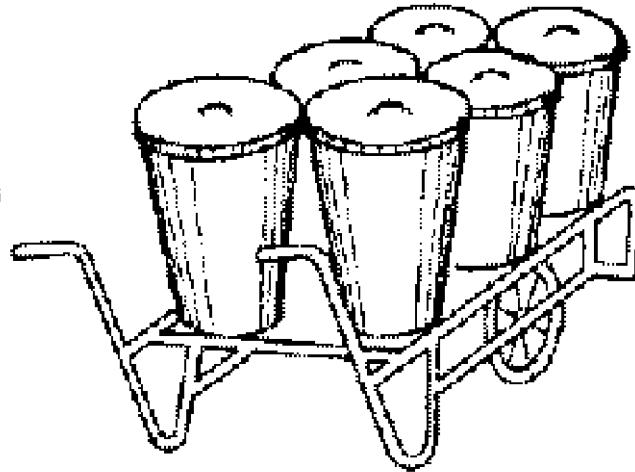
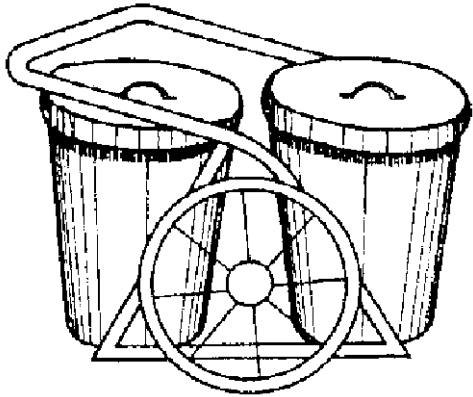
- Examples
- Residual waste stays self combustible in the Waste Incineration Plant (without support combustion)
- Residual waste also stays bio-degradable in MBTs
- Yet, mass reduction in Germany by at least 50%

| | extracted resource kg/L-a | Residual waste amount kg/L-a | Caloric value Hu,raw kJ/kg |
|-------------------------------|------------------------------|---------------------------------|----------------------------------|
| Domestic waste w/o sep. coll. | | 300 | 8000 |
| DW DSG light material | 17,3 | 282,7 | 7266 |
| DW RP | 50 | 250 | 6780 |
| DW RG | 32 | 268 | 9023 |
| DW (RP+RG) | 82 | 218 | 7859 |
| DW Bio-waste | 80 | 220 | 9564 |
| DW DSG-RP-RG-Bio | 179,3 | 120,7 | 8875 |





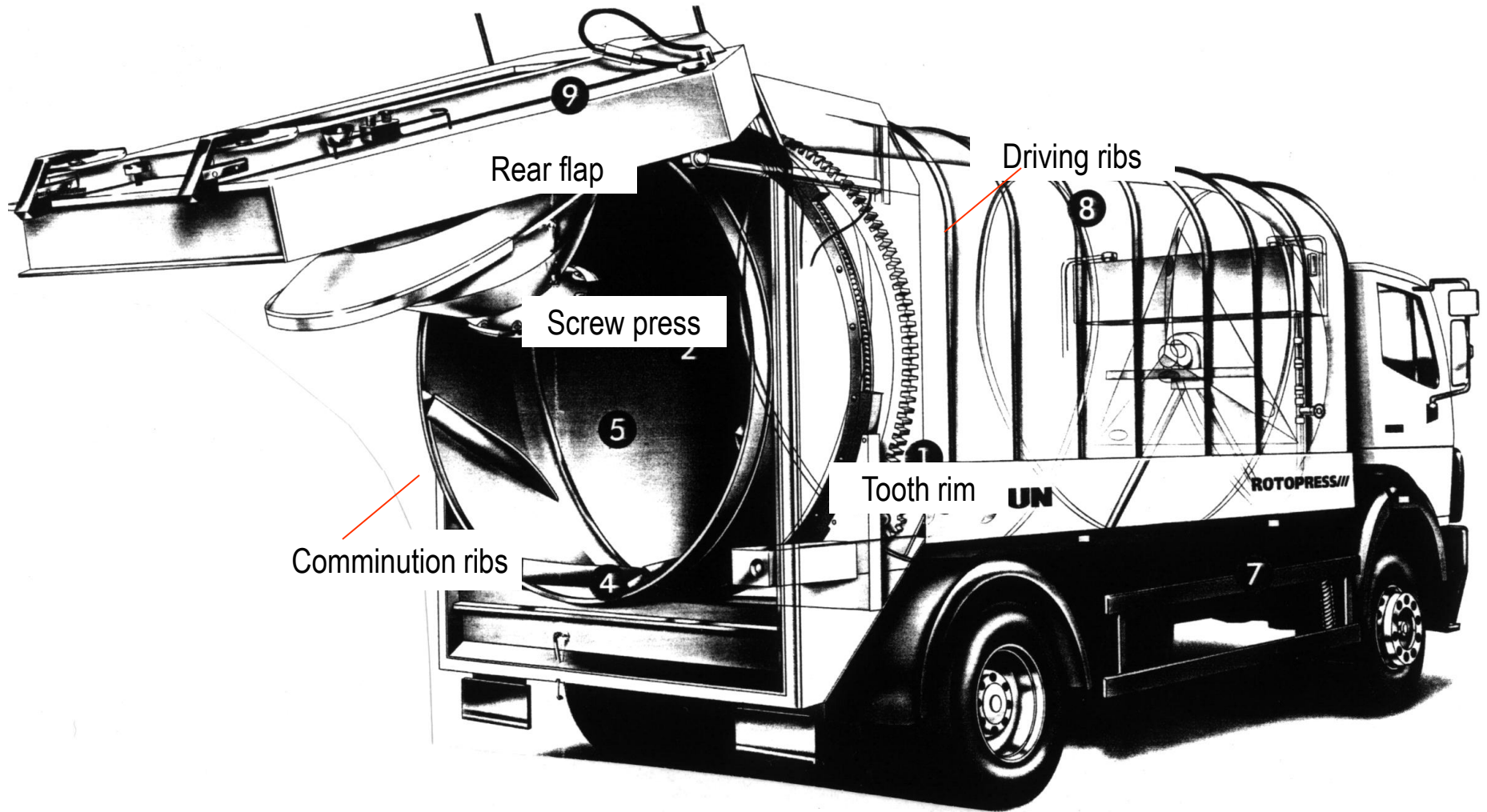
Simple Collection Systems



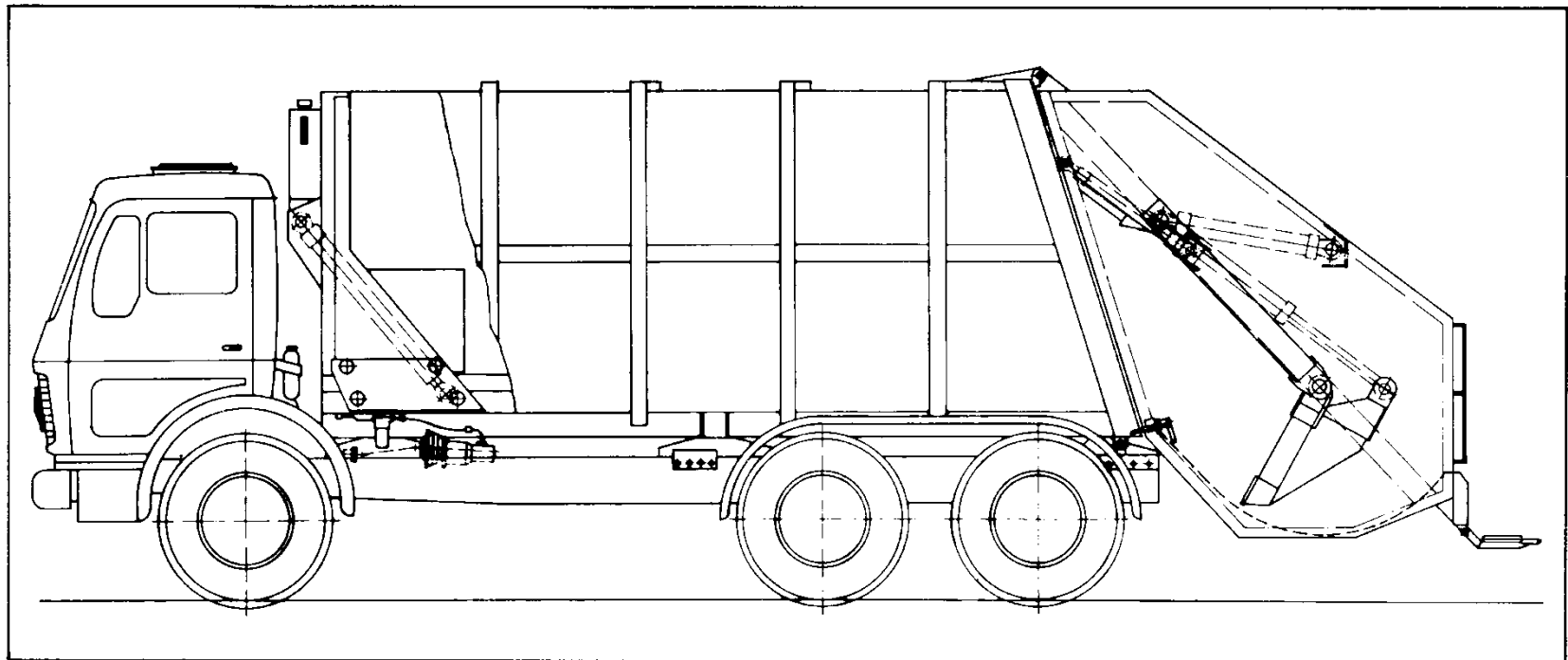
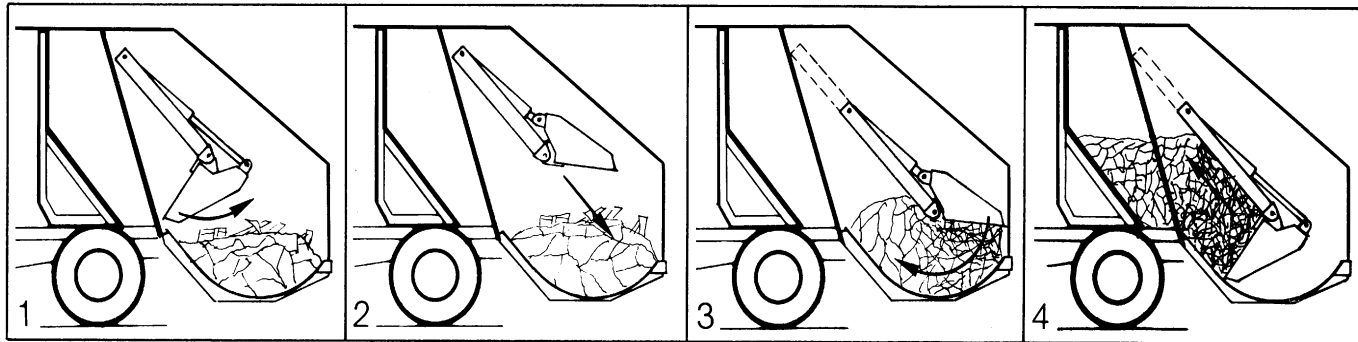
Waste Collection Vehicles

- Different demands on vehicles for collection and transport:
 - for collection: agile, that is small vehicles;
 - for transport: as high a load capacity, that is large vehicles.
- Different vehicles for discharge system or swap containers
- permissible total weight according to the Road Traffic Licensing Regulations = 18 / 24-27 / 32-35 / 40-44 t for 2 / 3 / 4 / 5 axle vehicles, respectively:
 - chassis weight
 - - weight of the superstructure
 - - bulk weight of the waste
 - = permissible load capacity ca. 5,5-7 / 10-12 / 15-18 / 20-22 t for 2 / 3 / 4 / 5 axle vehicles, respectively.
At load volumes of (8)-16 / 18-23 / 25-32 / 35-42 m³ in 2/ 3/ 4 or 5 axle vehicles (compacted), or a maximum of ca. 70 m³ uncompacted in 5 axle vehicles.

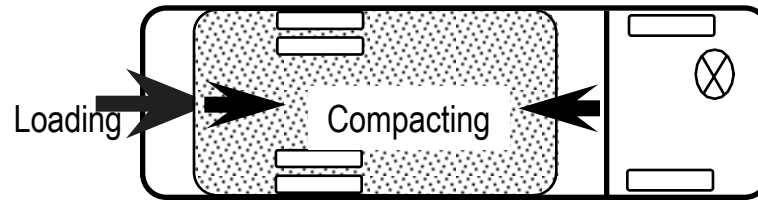
Rotary Drum Collection Vehicle



Compactor Truck (Rear Loader)

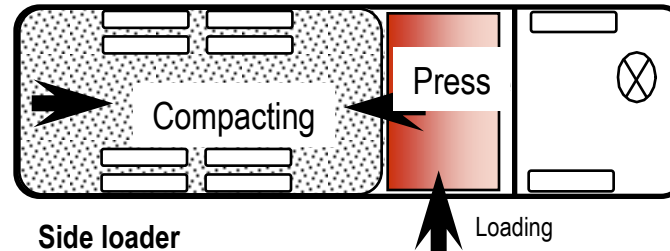


Design of Waste Collection Trucks



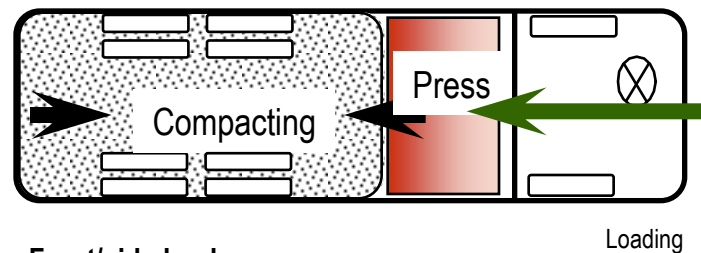
Rear loader

fixed rotary drum or waste compactor superstructure;
driver's cabin common above the front axle



Side loader

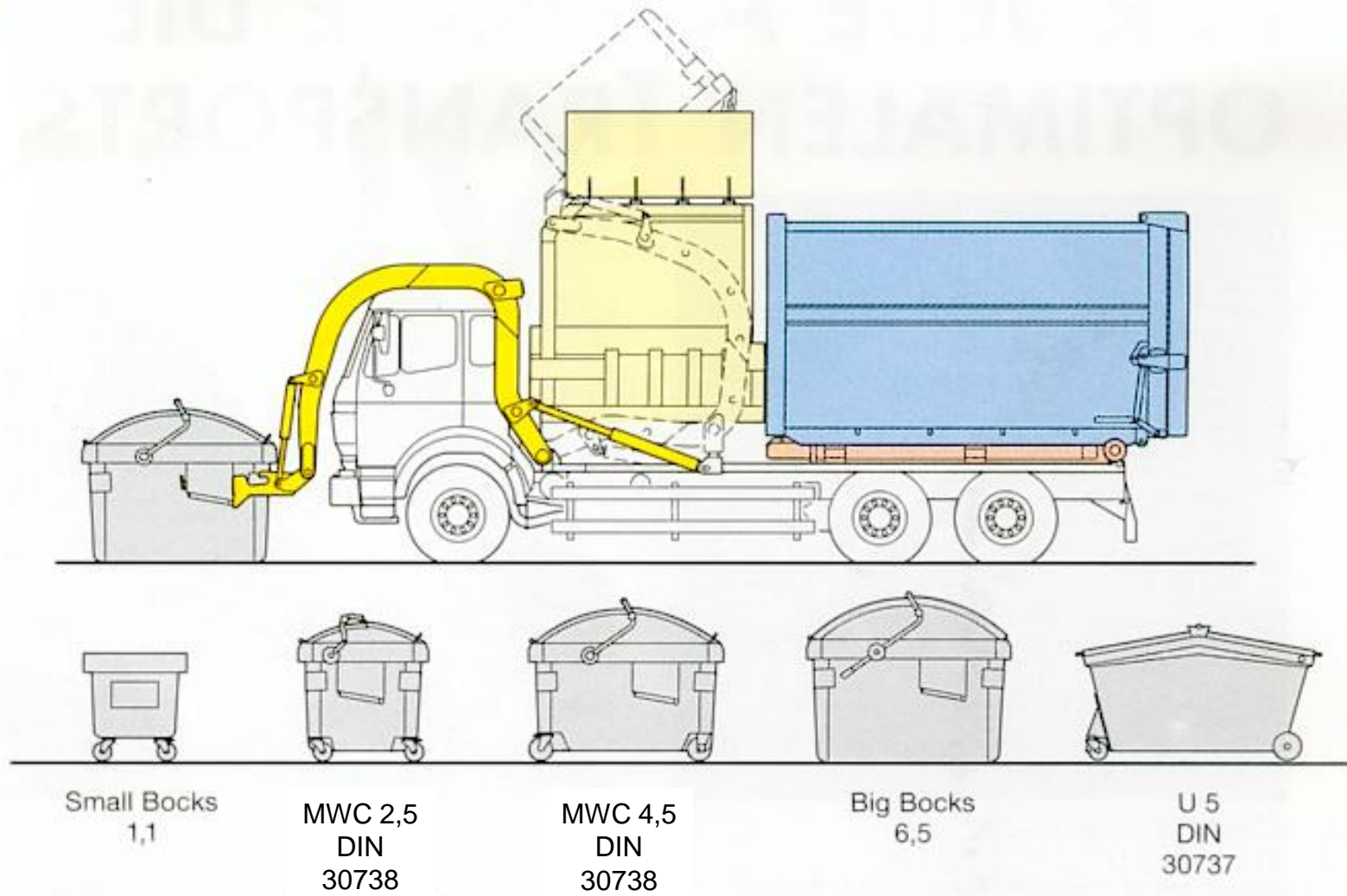
fixed waste compactor superstructure; driver's cabin
commonly above or in front of front axle



Front/side loader

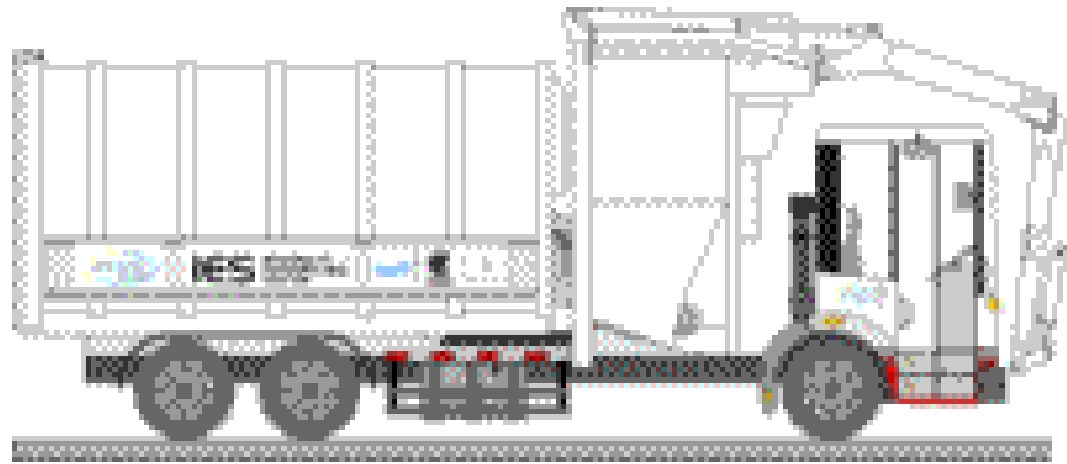
Waste compactor superstructure as swap container for long-
distance transport; low-entry driver's cabin in front of front axle

Front Loader for Mobile Waste Containers

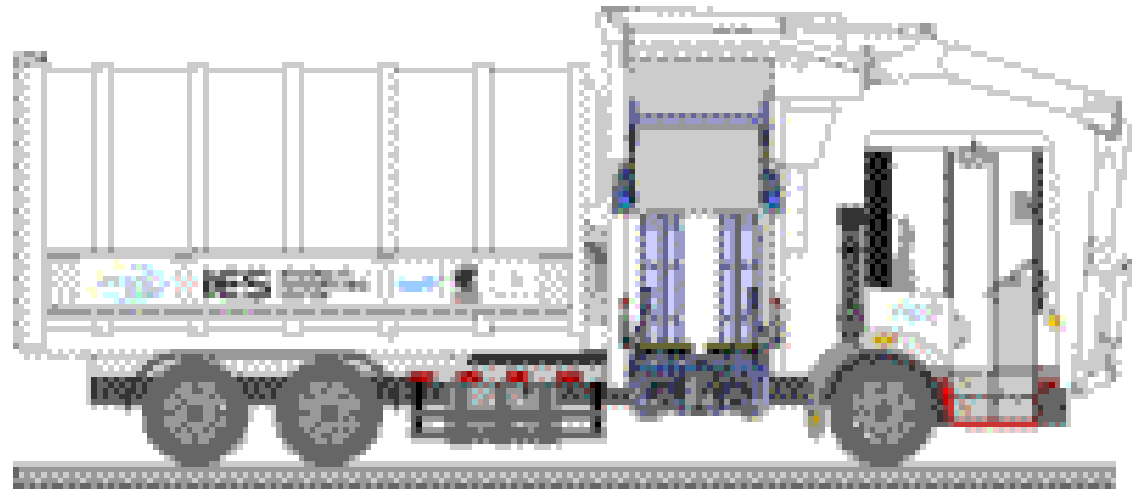


Low Entry Trucks

Front loader



Front and side loader



Comb Pouring Truck of the Zoeller Company

Offener Kamm-Lifter

System 249



Einsatzbereich

Wohn- und Gewerbegebiete
Systembehälter- und Sperrgutabfuhr

Antrieb/Arbeitsweise

Einteilige Kammaufnahme zur Aufnahme von MGB nach EN 840-1/-2/-3

Anbau

Fahrgestellabhängige Anbindung als feste Schweiß- oder lösbare Schraubverbindung offene Abfuhr gem. EN 1501-1

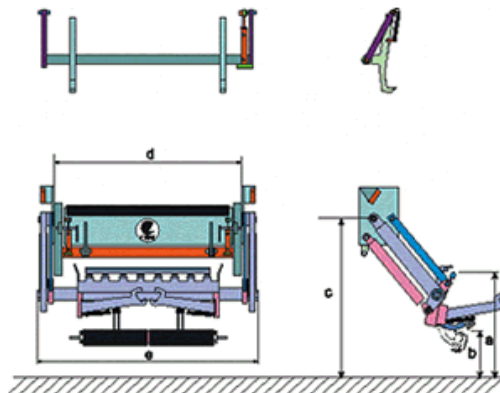
Vorteile

- Staubarme, geräuschreduzierte und behälterschonende Entleerung
- hohe Abfuhrleistungen
- geprüfte Bauteile
- ergonomische Leichtbauweise
- geringe Unfallgefahr, EU-konforme Sicherheitstechnik

Optionen

- Sonderbehälter-Aufnahme

Technische Daten



- for the loading of MWC EN 840-01 to 03

Multi-Purpose Pouring Truck of the Zoeller compan



Antrieb/Arbeitsweise

hydraulisch angetriebene Liftereinheit(en) mit Kammaufnahme

Anbau

Montage auf Universablende gem. Spezifikation nach DIN EN 1501-1 für geschlossene Abfuhr

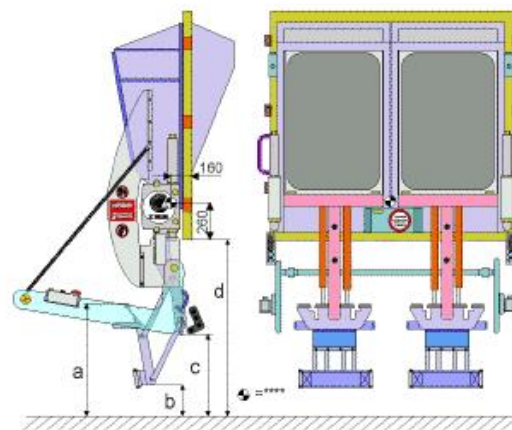
Vorteile

- Staubarme, geräuschreduzierte und behälterschonende Entleerung
- hohe Abfuhrleistungen
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Optionen

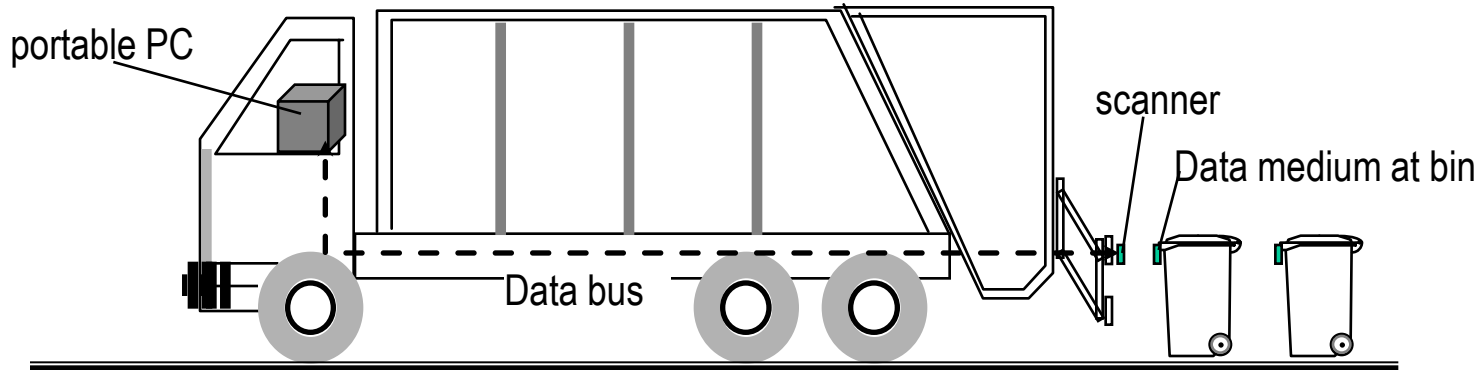
- Doppel- oder Einzelanordnung
- Kombinationsmöglichkeit mit anderen Lifter-Systemen
- Software-Paket [Touren-Analyse](#)
- Sonderbehälter-Aufnahme

Technische Daten



Online Identification or Weighing

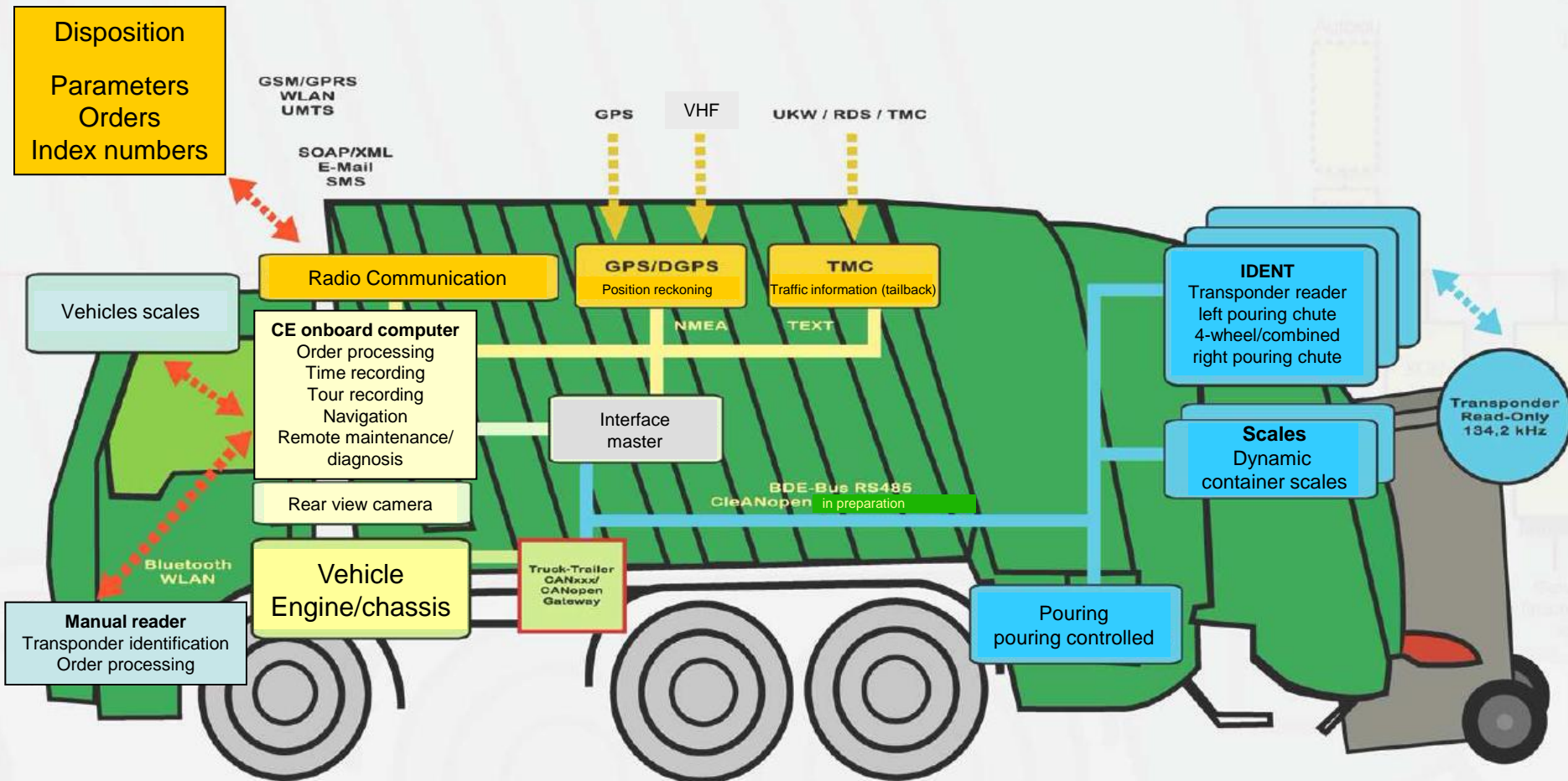
- Combination of pouring and identification or weighing of the loaded container for fee calculation



- Also combined with the pouring: pollutant identification at bio-waste containers

Information Management in Disposal Logistics

Vehicle Components

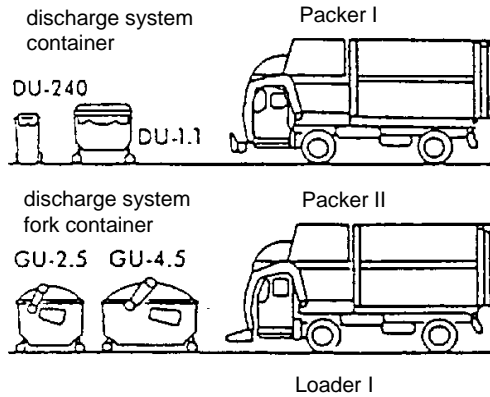


Waste Collection Vehicle

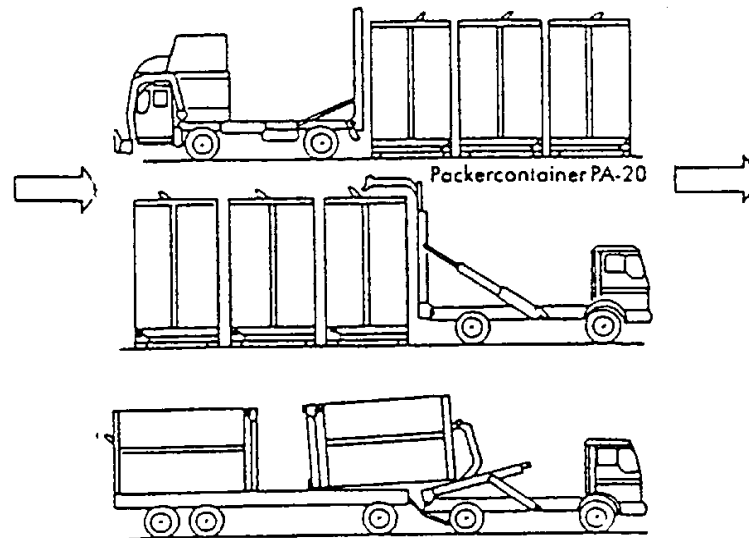


Multi-Service-Transport-System-Container - Collection Trucks

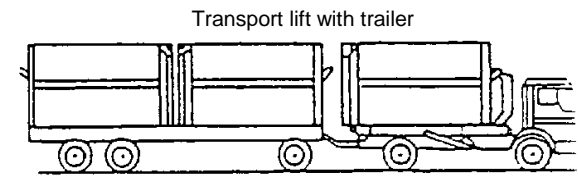
Collection



Reloading



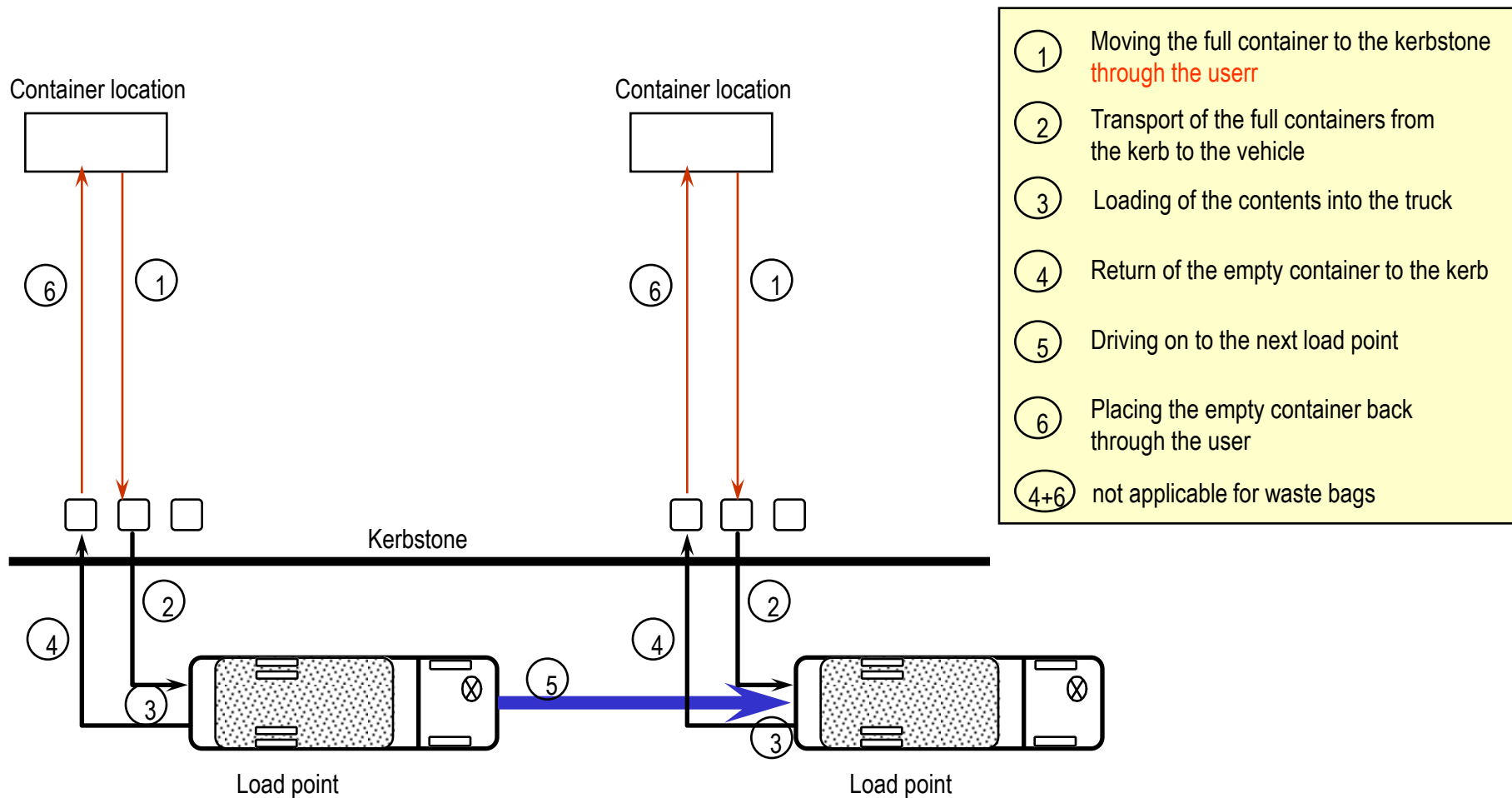
Transport



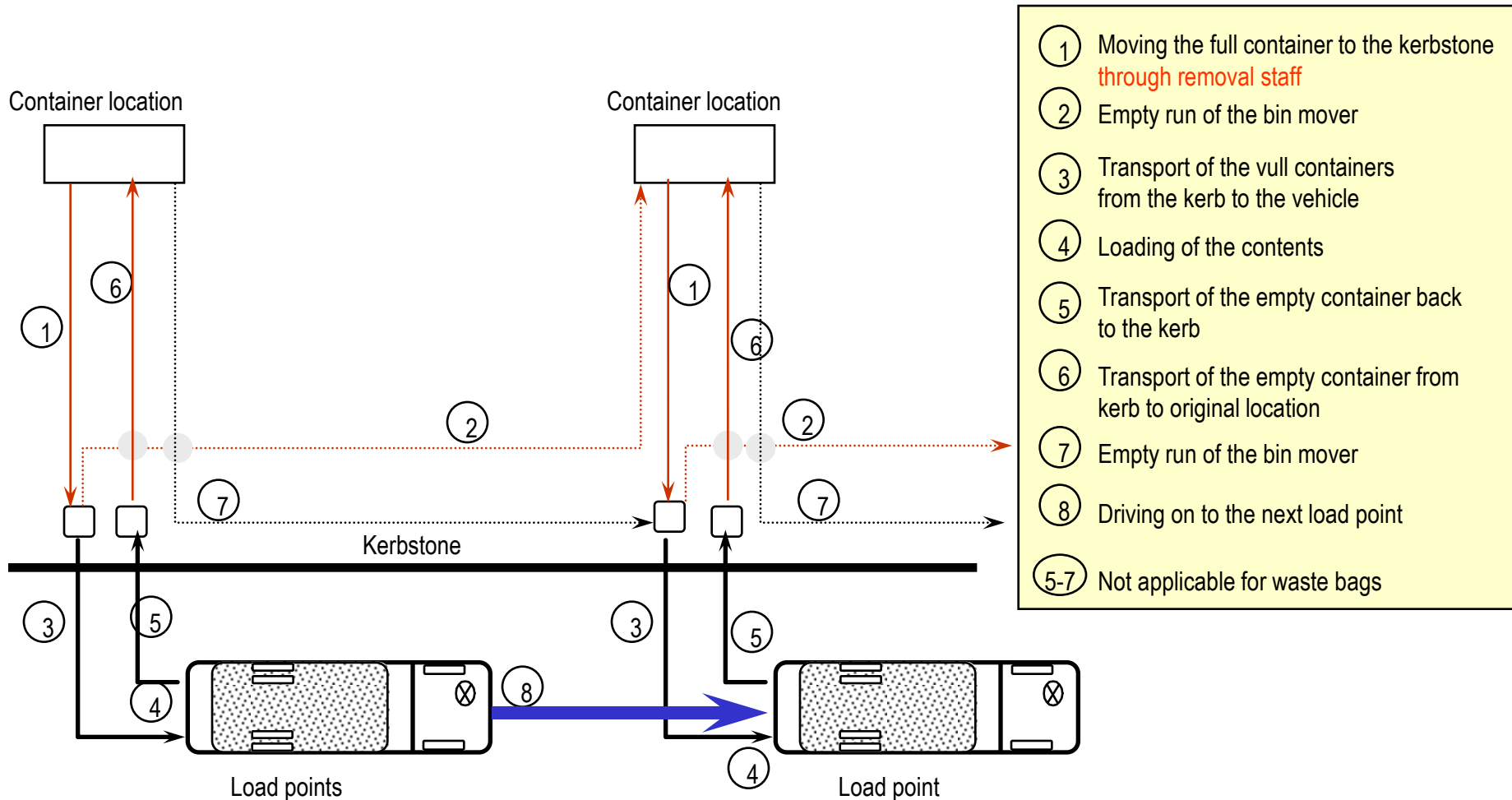
Activities during the Waste Collection with Discharge System Containers

- Preparing the vehicle
- Drive to the collection district (part of the transport)
- Container transport to the location at the kerb (only with full service))
- Loading of the containers (if the vehicle is standing: moving the containers to the pouring chute); pouring out the waste (if necessary with identification or weighing); putting the containers back to the kerb
- Returning the containers to their original location (only with full service)
- Driving between the single load points
- Driving between loading areas without collection to the next load point
- After loading the last container: transport to discharge point
- All activities from start to the collection district up to the discharge = collection tour and the sum of all collection tours as day tour.

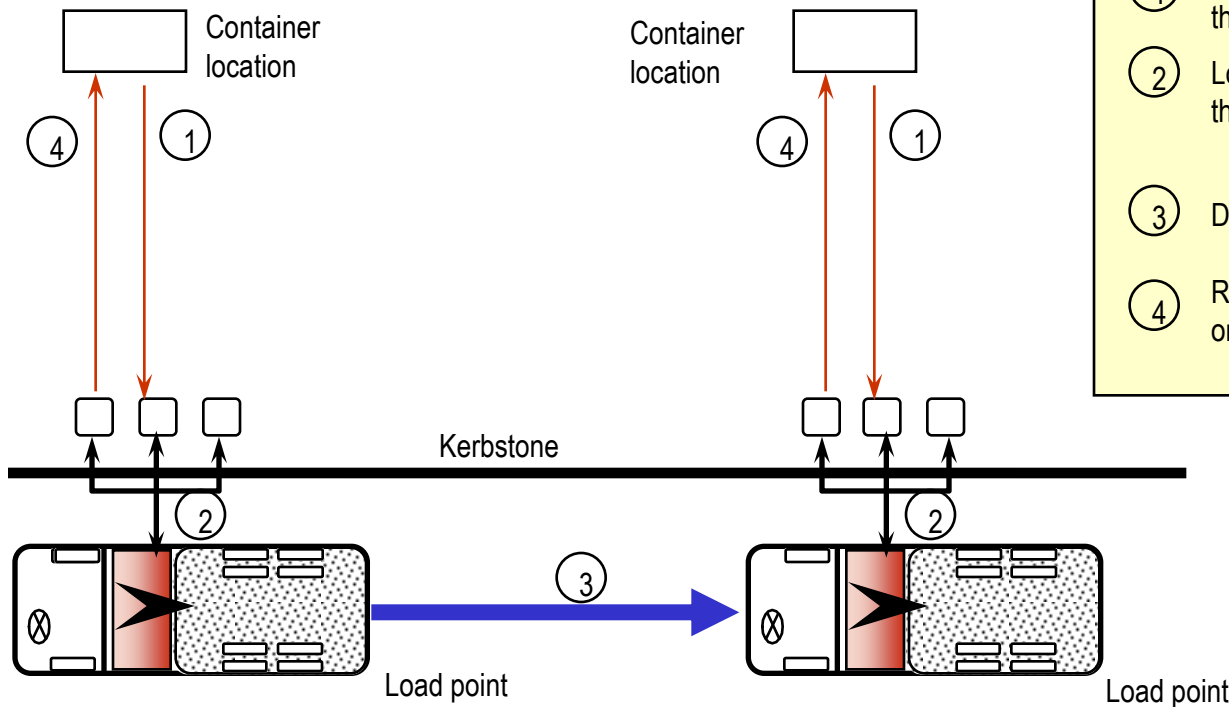
Activities during the Collection with Part Service



Activities during the Collection with Full Service



Activities during collection without loaders



- 1 Moving the full container to the kerbstone through the user
- 2 Loading of the full container from the kerb into the vehicle and returning it to the kerb
- 3 Driving on to the next load point
- 4 Returning the empty container to its original position through the user

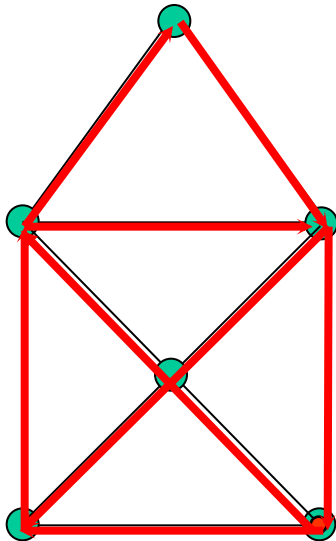
Performance Data for Collection and Transport without long-distance transport

Sources: VKS-Infoschrift "Leistungsdaten bei Sammlung und Transport" 25, 1995; Gallenkemper (1985), Müllhandbch, Ziff. 2565; VKS Info 40: Betriebsdaten-auswertung 1998

| | Loaded containers /(Vehicle*Work day) | | | | | Collected amount | |
|--|---------------------------------------|-------------------|--------------------------------------|--------------------|---|------------------|--------------------------|
| | Full service | | User transport | | | Mg/d | Mg / (Vehicle discharge) |
| | 1993/94 | 1998 | 1993/94 | 1998 | | | |
| Residual waste Annular container LRB ≤240 LRB ≥550 MS 50 1 Loader | 852 695 171 | 733 824 210 | 1548 936 156 1200 - 2300 | 1386 897 153 | Residual waste 2 axle truck 3 axle truck | 15-18 | 5-7 7-10 |
| Bio-waste LRB ≤240 | 473 | 856 | 768 | 793 | Bio-waste | average 10 | average 6 |
| Recycling paper (RP) | | 988 | | 964 | Recycling paper bunch RP LRB 120/ 240 | 13 12-15 | average 6 |
| LWP (DSG) bags LWP LRB ? 240 | 1457 780 | ? ? | 2687 459 | ? 1356 | LWP (DSG) | 4 -5 | 1,5-3 |

Tour Planning

- Minimisation of collection ways, times, and costs, under consideration of the time restrictions of a workday.
- Entering the road network of a collection area as nodes and edges of a network (also via GIS) with input of the
 - load points,
 - container numbers and sizes,
 - permitted driving directions,
 - permitted collection type (on one side of the street or on both)
 - collection times (can be ascertained today also with GPS)




- Example:
connect the green nodes in such a way that all streets are passed only once!!

- **1. Container costs** from
 - capital costs (interest, depreciation),
 - distribution, maintenance, losses,
 - administration costs
 - total 4 - 6 €/a for LRB 80-240 and approx. 46 €/a for LRB 1100 (without VAT).
- **2. Collection costs** from required collection time t_{SG} [h/t] (cf. for instance minus transport times) multiplied with costs for collection vehicles and for personnel (driver and loader) in [€/h), e. g.:
 - Rear loader + driver + 1 loader: 72 - 82 €/h
 - Side loader + driver: 60 - 70 €/h (without VAT)

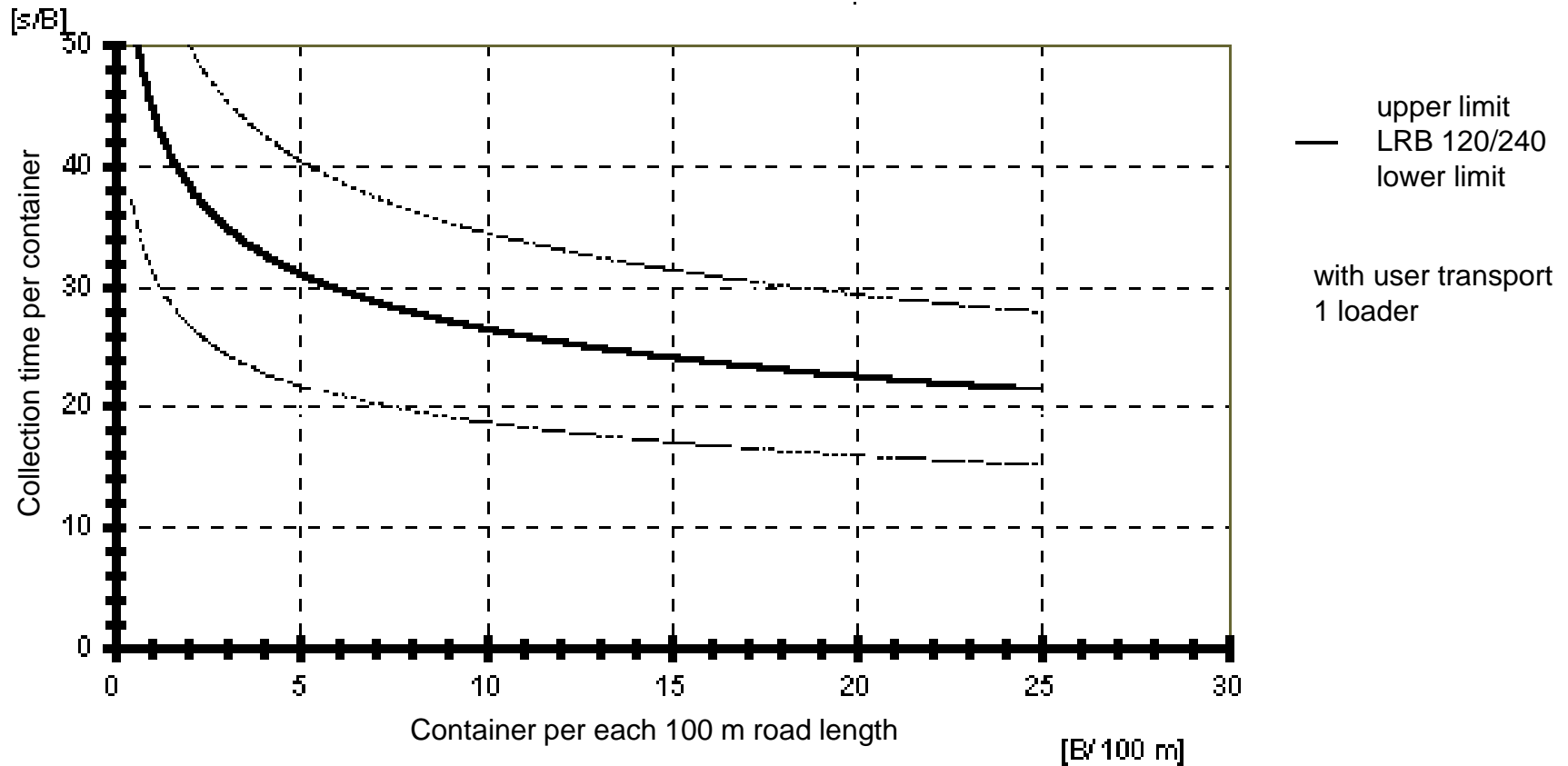


Collection Costs (with direct transport, without long-distance transport) (2)

- Net container costs for LRB 120 - 240 L 4 €/a 
- **Collection costs (1+1)** 80 €/h
= 640 €/d
Collection performance incl. direct transport 15 - 18 Mg/d
specific collection costs incl. direct transport
640 € /d / 15 Mg/d 43 €/Mg
- **Container costs**
 $120 \text{ L} * 0,100 \text{ kg/L} * 26 / 1000 = 0,312 \text{ Mg/ Cont.} * a$
4 € /a / 0,312 13 €/Mg
- **total** 56 €/Mg

Collection Performance

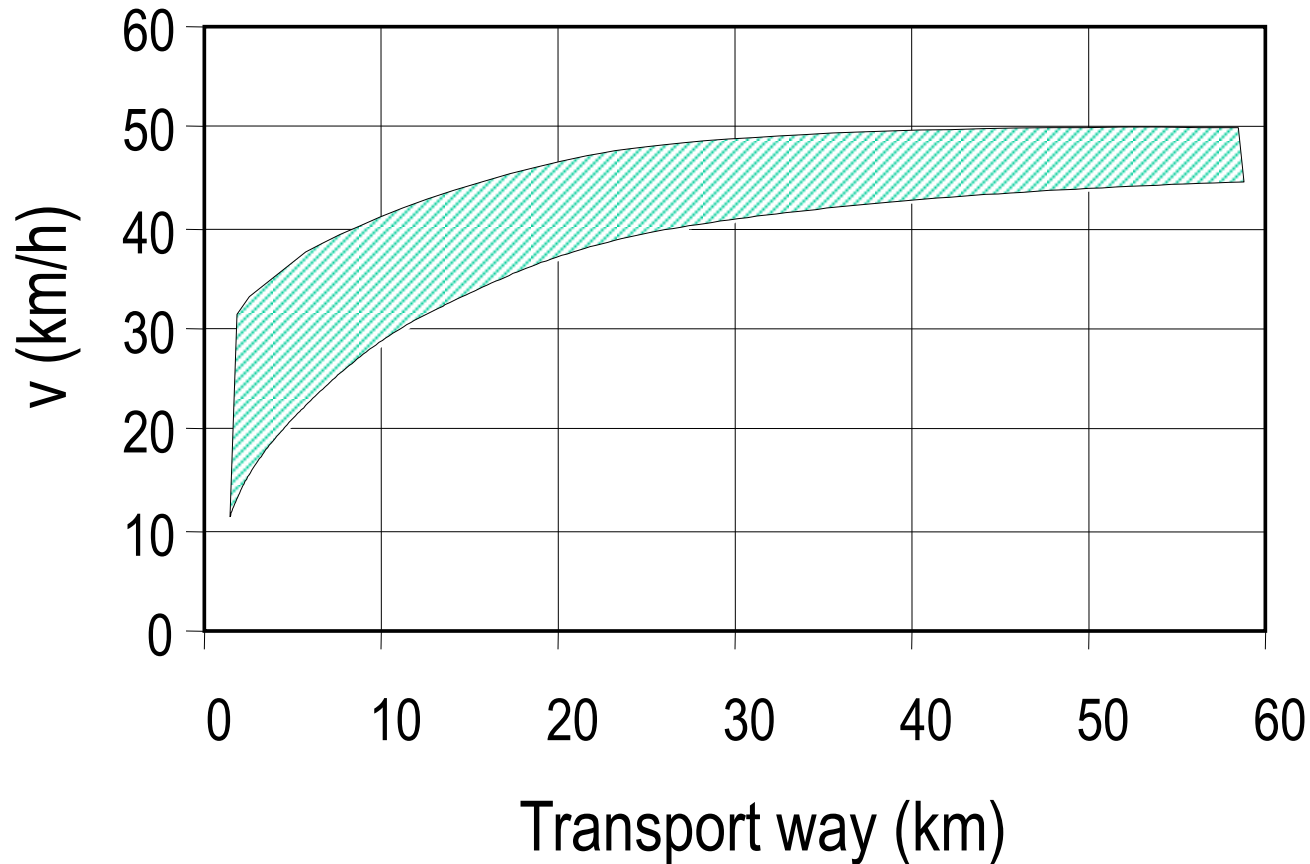
Source: Gallenkemper / Doedens



Waste Removal Fees

- Principles according to municipal fee regulations:
 - Equality principle: the same fee for the same service
 - Equivalence principle: fee and service have to correspond; raising of fees as much as possible according to the reality measure, alternatively according to a probability measure close to the reality measure
 - Cost recovery principle: no debit or credit balance of the chargeable costs; sharing of costs
 - Finality of the fee: equivocally determined in the statutes.
- Administration law demands a cost-covering fee for relevant performances (for instance also for bio-waste containers)
- For residual waste, there is a combined fee:
 - Basic fee per container location
 - Basic fee per container
 - volume or weight proportionate additional fee

Transport Speeds according to Gallenkemper in Tabasaran, 1994



Waste Transport

- Transport = link between collection and disposal plant
 - short ways without maximum load capacity of a truck: directly in the collection vehicle
 - longer ways: transition and long-distance transport
- The **transport times** t_T for a single transport way WT (km) at an average transport speed v (km/h; e.g. constantly 20 to 60 km/h, depending of traffic situation and road type, or depending on the way) a loading and discharge time t_E (h):

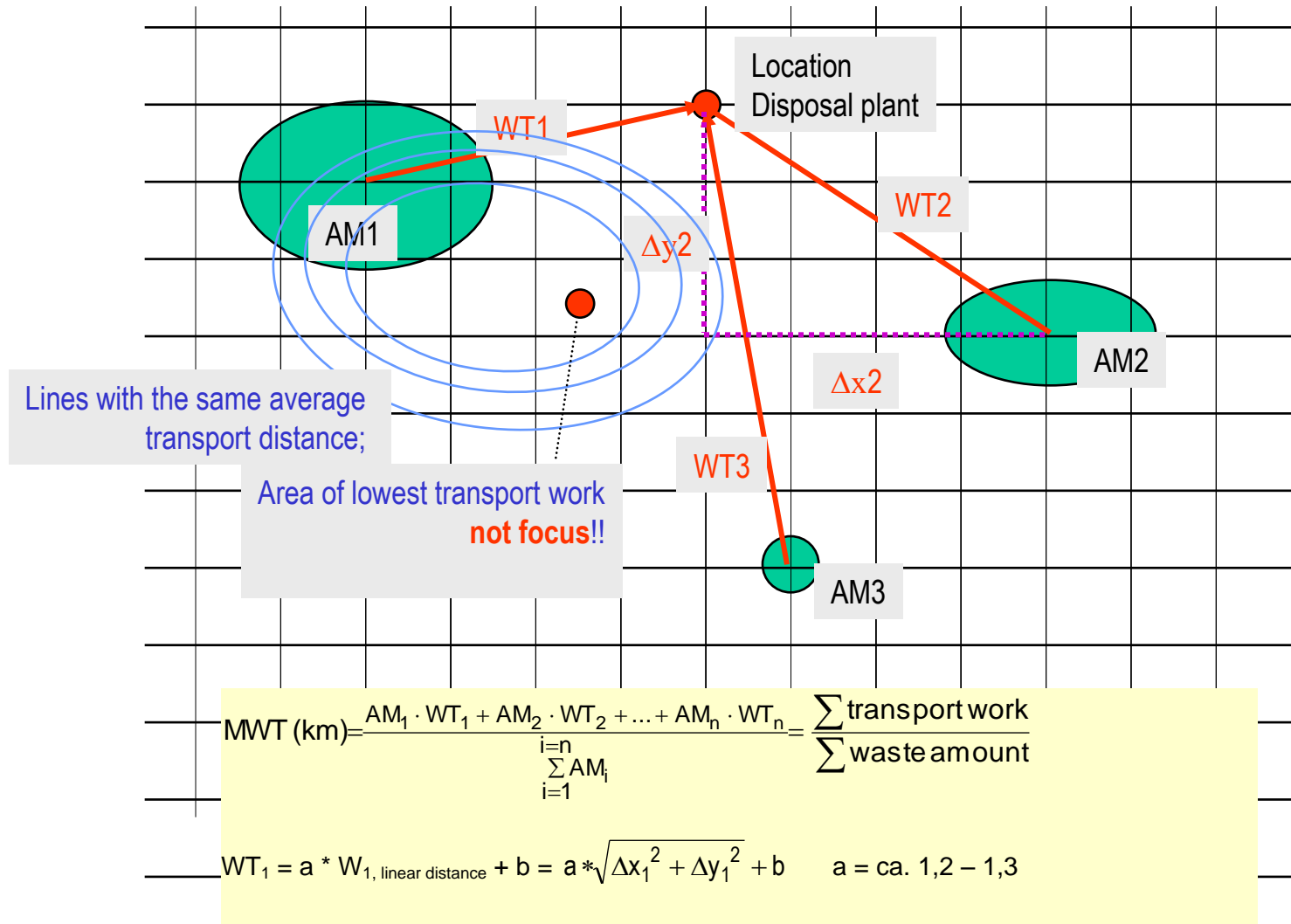
$$t_{T,E} \text{ (h)} = 2 \cdot WT / v + t_E$$

with $t_E = 5$ to 20 min discharge time, depending on dispatch and internal ways at the disposal plant
 $t_{T,E}$ = time for transport and discharge

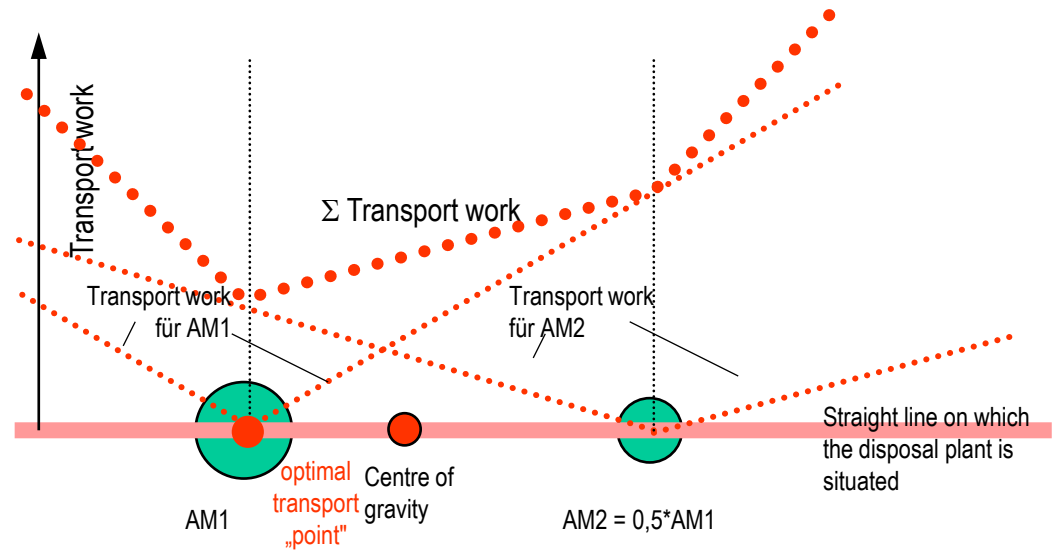
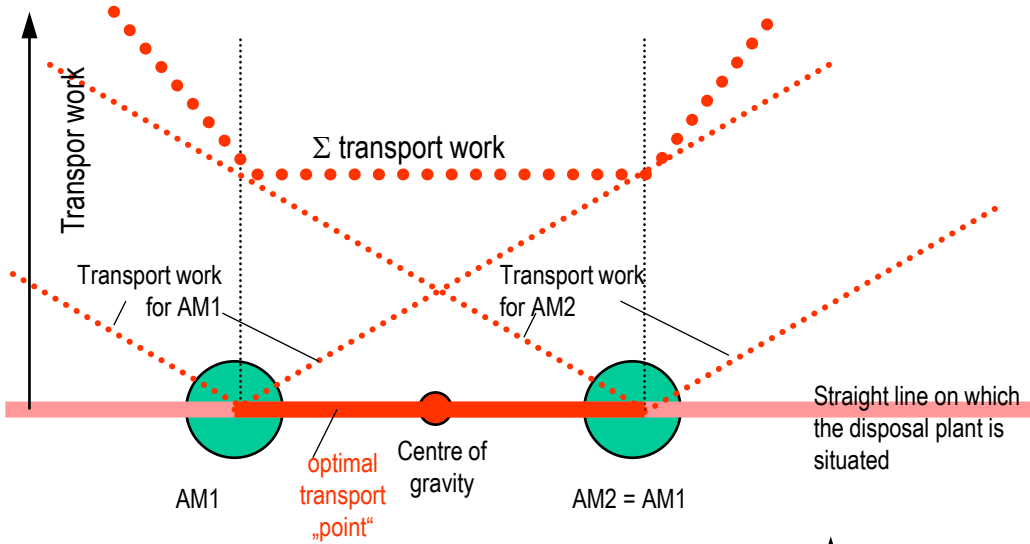
The transport costs CT are comprised of the vehicle costs KFz (€/h) and a waste load capacity LC (t) and thus amount to:

$$CT \text{ (€/t)} = t_{T,E} \text{ (h)} \cdot KFz \text{ (€/h)} / LC \text{ (t)}$$

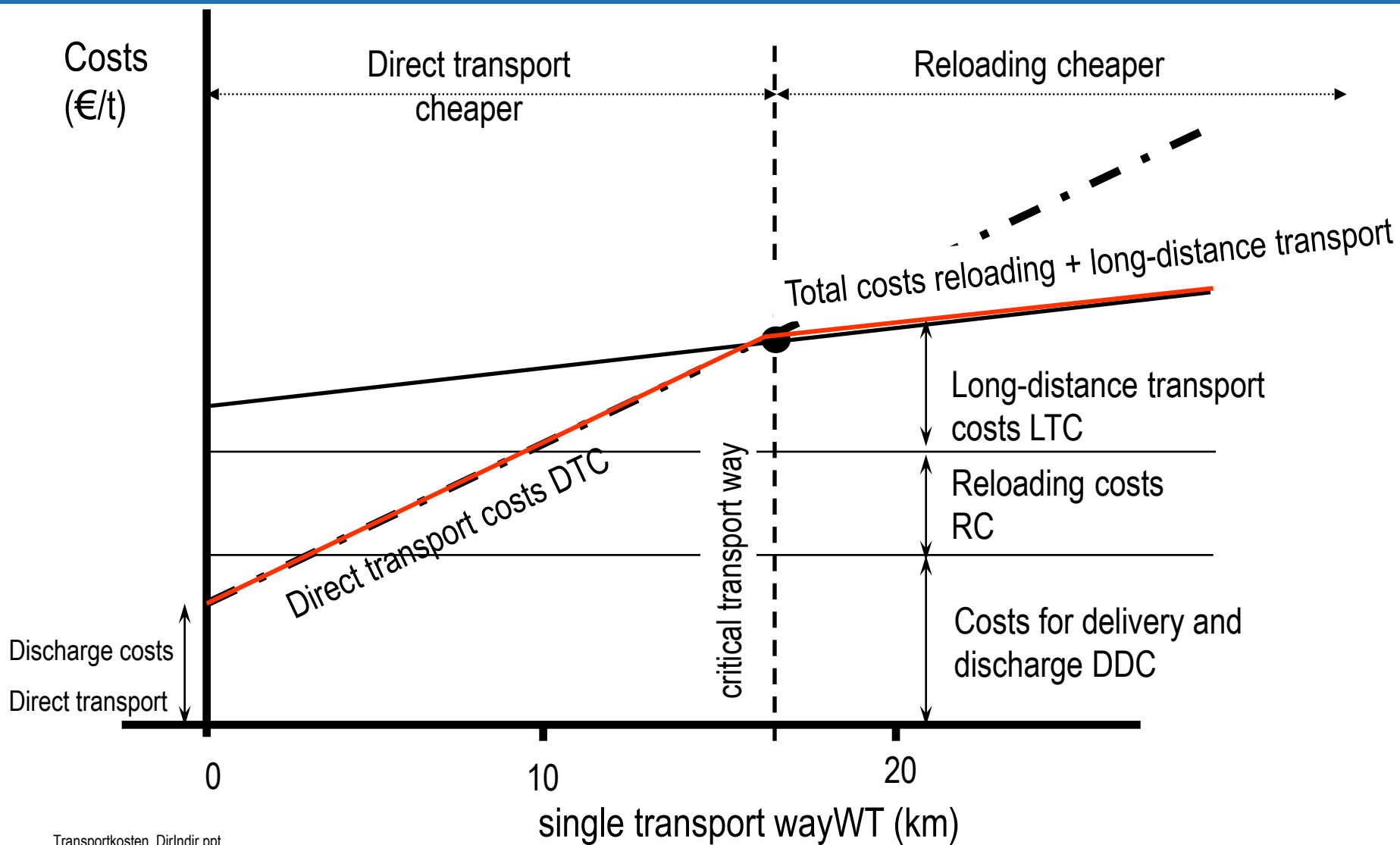
Transport Work and Average Transport Distance



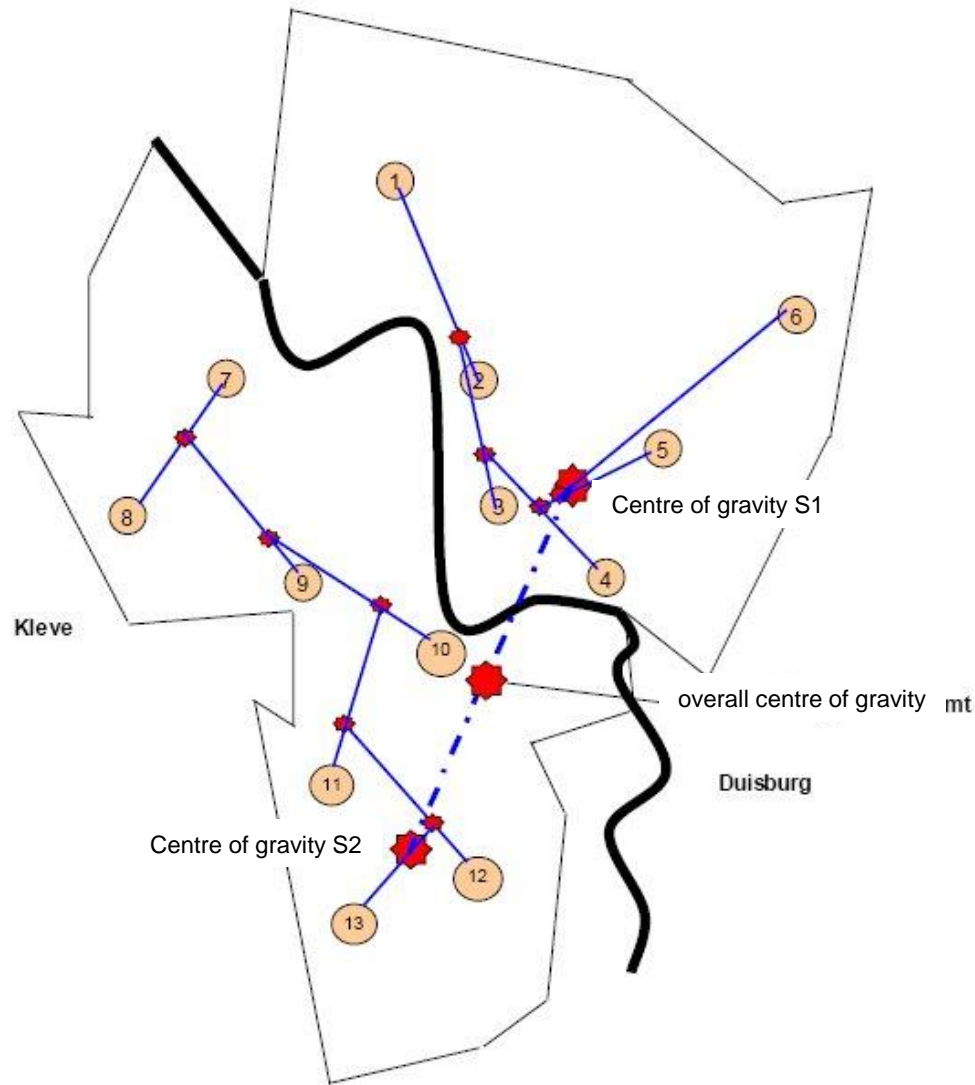
no centre, but point of lowest transport work



Direct Transport or Reloading with Long-Distance Transport – Critical Transport Way



Direct transport or Reloading with Long-Distance Transport – Critical Transport Way



Operation Costs for Collection Vehicles/Direct Collection

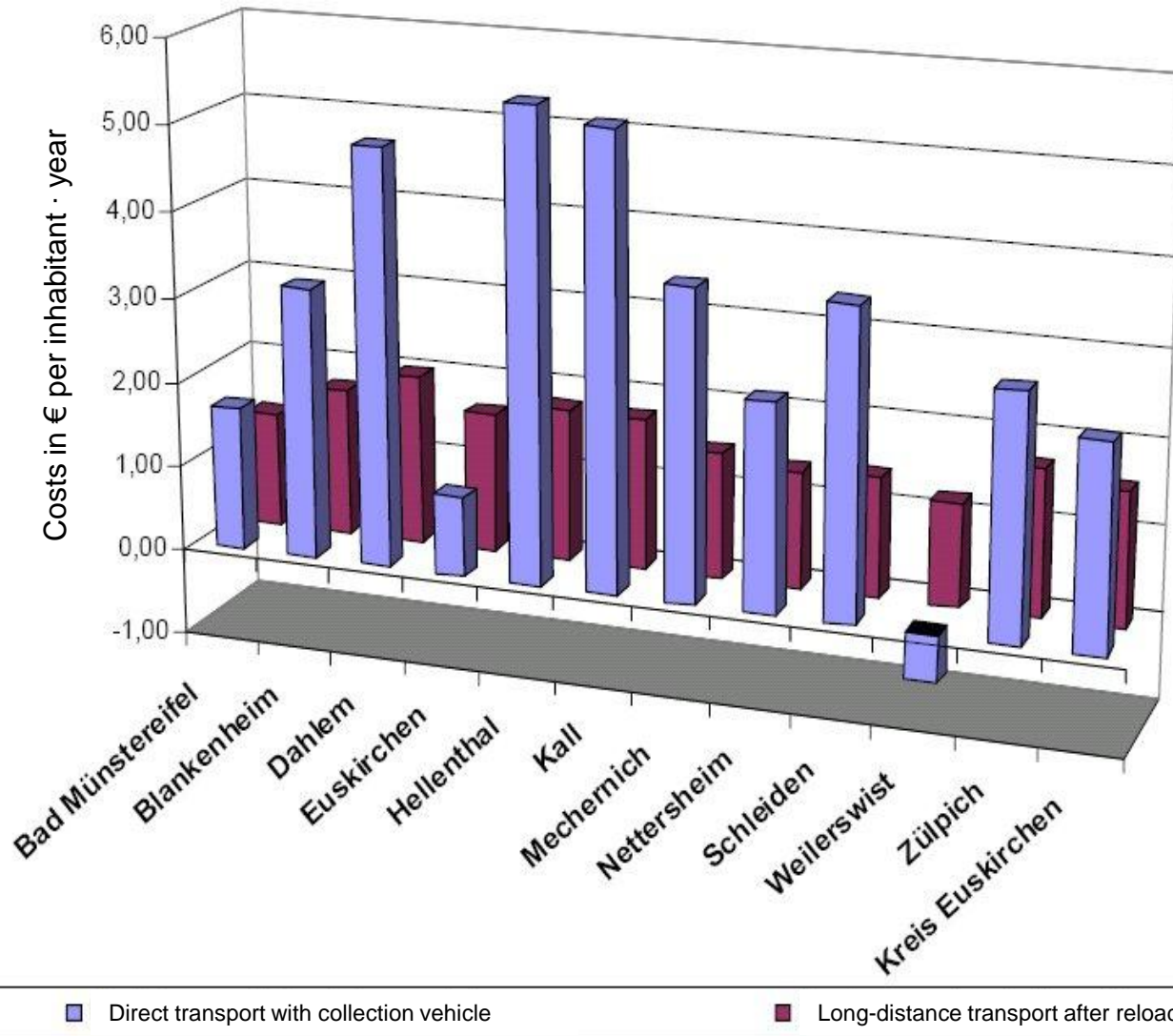
| Operation costs for a collection vehicle | | | |
|--|----------------|--------------------|------------------|
| Purchase | | | 170.000 € |
| Vehicle | | | 110.000 € |
| Superstructure | | | 60.000 € |
| Use | 7 Jahre | 10.000 km/a | 70.000 km |
| Interest | 6% | | |
| Annuity | 0,1791 | | 30.447 € |
| Tax | | | 2.000 € |
| Insurance | | | 7.000 € |
| Overheads | | | 39.447 € |
| Tyres/Mileage | 10 unit | 80.000 km | |
| Tyres front | 2 unit | 375 €/unit | 94 € |
| Tyres rear | 8 unit | 350 €/unit | 350 € |
| Fuel | 40 L/h | 0,70 €/L | 56.000 € |
| Lubricants | 5% | | 2.800 € |
| RWU | 9% | | 15.300 € |
| Sum Maintenance | | | 74.544 € |
| Driver's wage | | | 28.000 € |
| Personnel reserves | 20% | | 5.600 € |
| Employer's share | 25% | | 8.400 € |
| Sum personnel | | | 42.000 € |
| Sum Costs | | | 155.001 € |
| Administration | 5% | | 7.800 € |
| Risk/Profit | 10% | | 15.599 € |
| Total costs | | | 179.389 € |
| Mileage costs | | | 17,94 €/km |
| Daily costs | 250 d/a | | 718 €/d |
| Hourly costs | 8 h/d | | 90 €/h |

Personnel costs for each further loader
 ~ 25.000 €/a plus bonuses

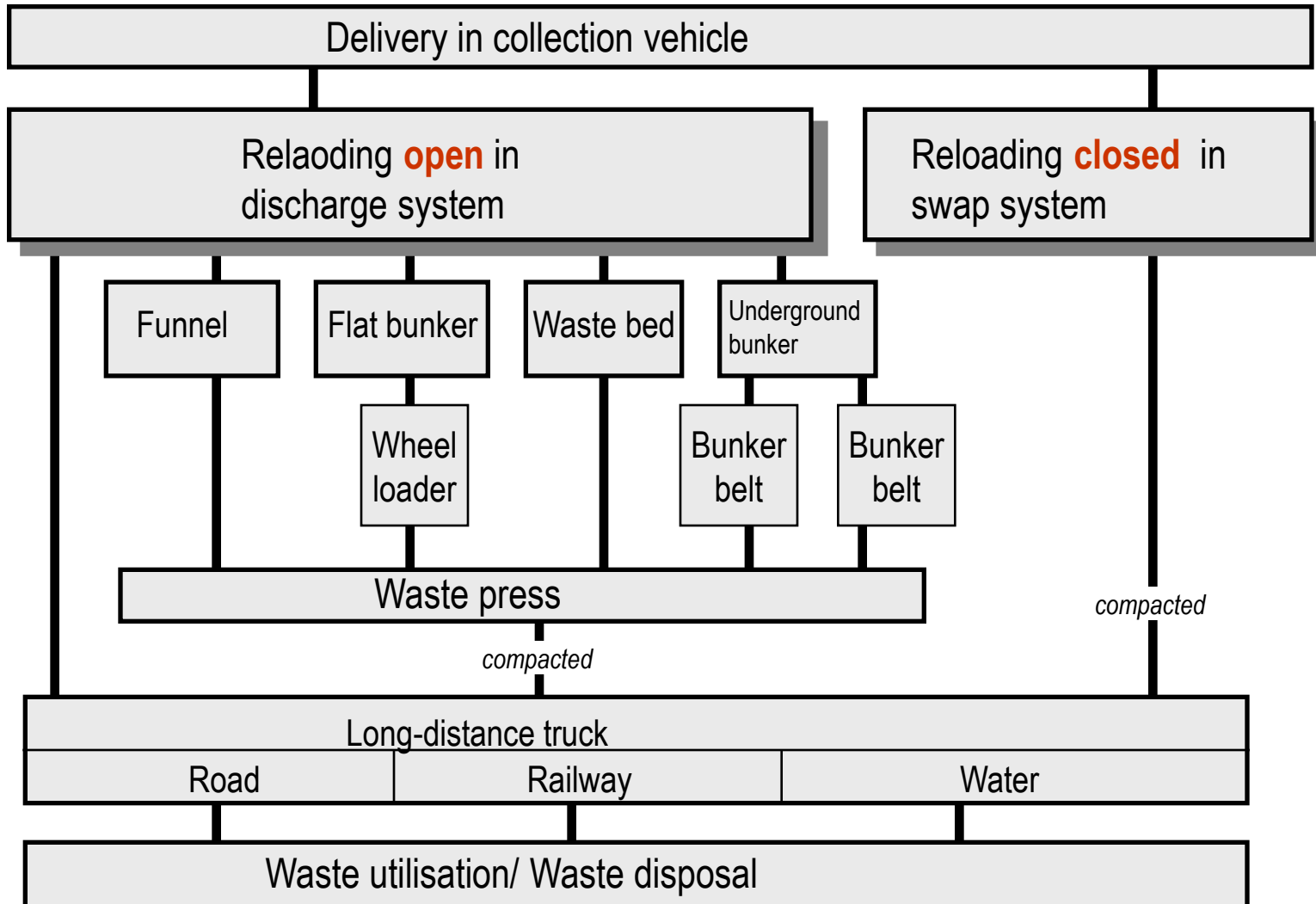
Operation Costs for an Articulated Truck/Reloading and Long-Distance

| Operation costs for an articulated truck | | | | Fixed | Variable |
|--|-------------|-------------|------------------|-----------------|-----------------|
| Purchase | | | 123.000 € | | |
| Vehicle | | | 95.000 € | | |
| Superstructure | | | 28.000 € | | |
| Use | 7 Jahre | 50.000 km/a | 350.000 km | | |
| Interest | 6% | | | | |
| Annuity | 0,1791 | | 22.029 € | 22.029 € | |
| Tax | | | 2.000 € | 2.000 € | |
| Insurance | | | 7.000 € | 7.000 € | |
| Overheads | | | 31.029 € | 31.029 € | |
| Tyres/Mileage | 12 unit | 80.000 km | | | |
| Tyres front | 2 unit | 375 €/unit | 469 € | | 469 € |
| Tyres rear | 10 unit | 325 €/unit | 2.031 € | | 2.031 € |
| Fuel | 42 L/100 km | 0,70 €/L | 14.700 € | | 14.700 € |
| Lubricants | 5% | | 735 € | | 735 € |
| RWU | 9% | | 11.070 € | | 11.070 € |
| Sum Maintenance | | | 29.005 € | | 29.005 € |
| Driver's wage | | | 28.000 € | 28.000 € | |
| Personnel reserves | 20% | | 5.600 € | 5.600 € | |
| Employer's share | 25% | | 8.400 € | 8.400 € | |
| Sum personnel | | | 42.000 € | 42.000 € | |
| Sum Costs | | | 102.034 € | 73.029 € | 29.005 € |
| Administration | 5% | | 10.203 € | 7.303 € | 2.901 € |
| Risk/Profit | 10% | | 10.203 € | 7.303 € | 2.901 € |
| Total costs | | | 122.441 € | 87.635 € | 34.806 € |
| Mileage costs | | | 2,45 €/km | | 0,696 €/km |
| Daily costs | 250 d/a | | 490 €/d | 351 €/d | |
| Hourly costs | 8 h/d | | 61 €/h | 44 €/h | |

Cost Comparison – Model Calculation from NRW



Waste Reloading Systems



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Links

Anfahrt

Welcome to the internet presentation of

MITTOUR



the software for collection vehicle administration
and tour planning/optimisation for small and mid-size disposal companies

supported by the Federal Ministry for Education and Research



**Federal Ministry
of Education
and Research**

Layout and programming **Stecon data** info@stecon-web.de

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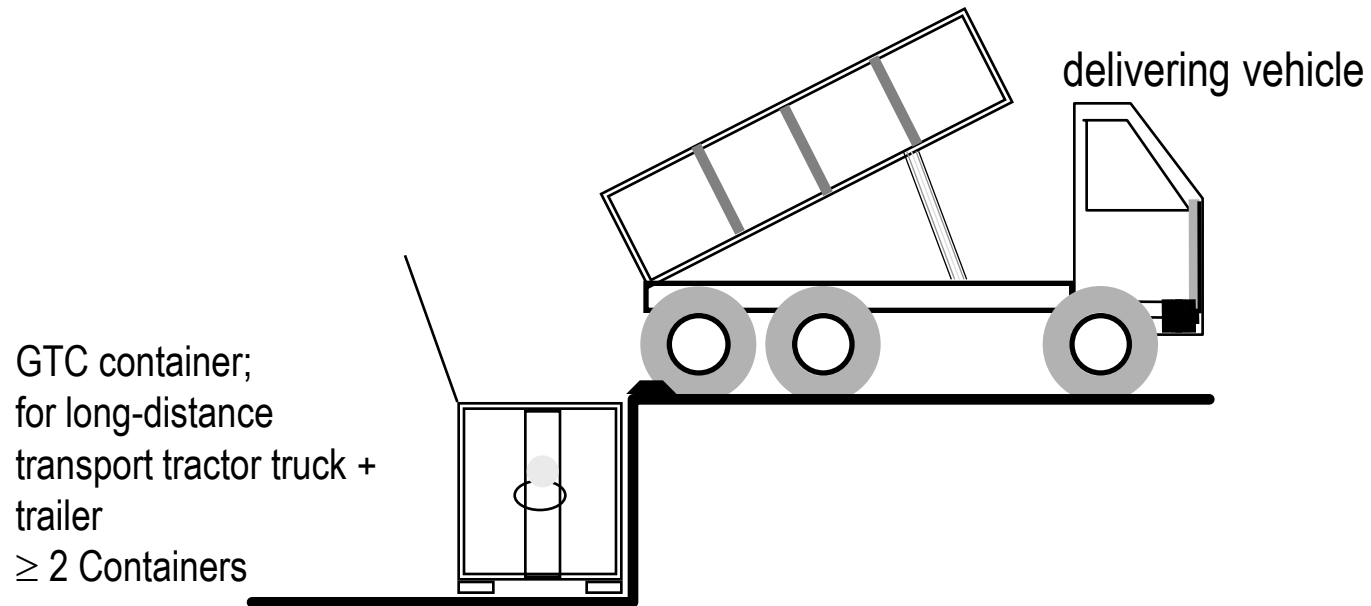
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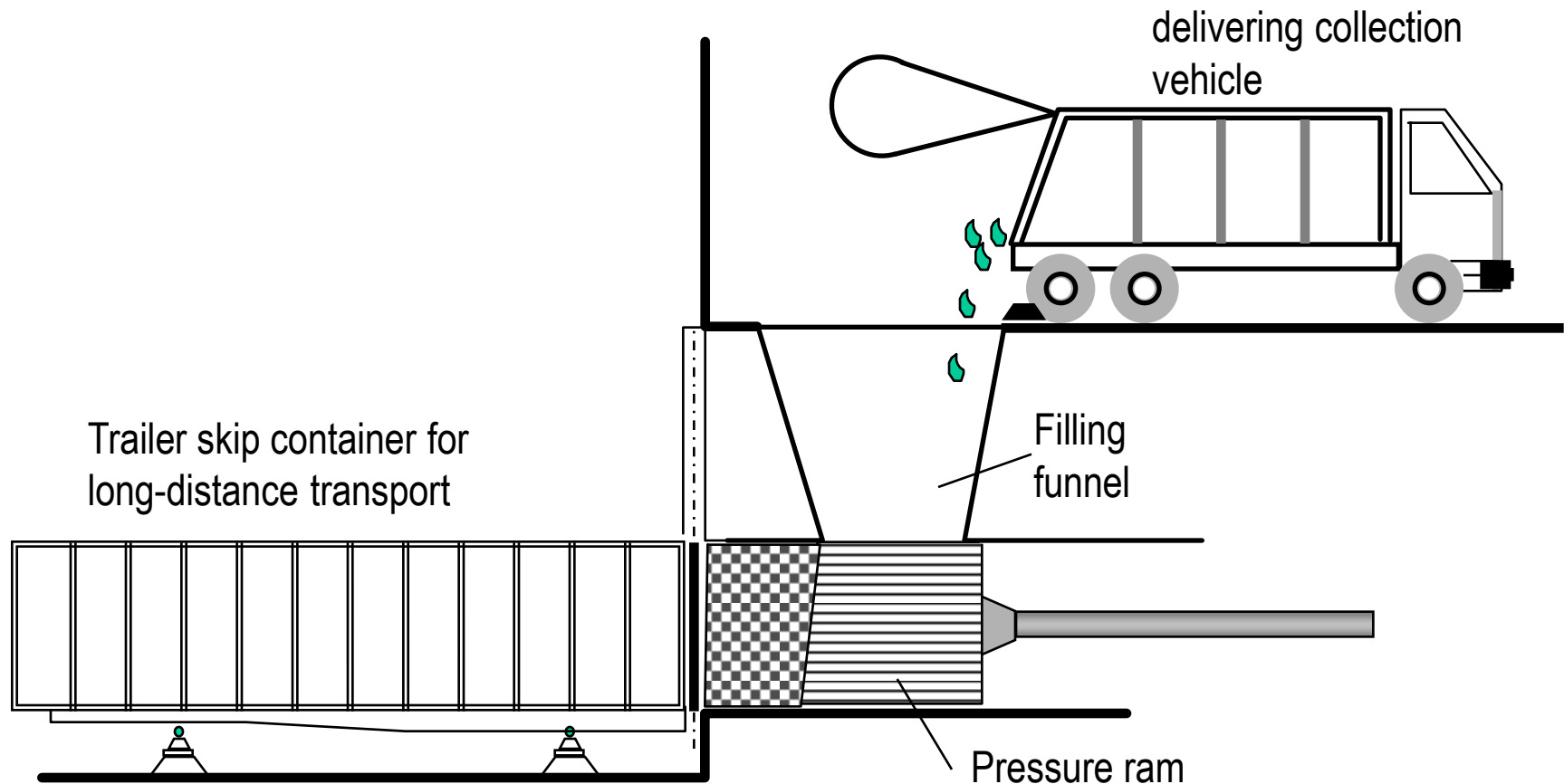
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HRB 6144
Amtsgericht Dresden
St.-Nr. 201/111/03470

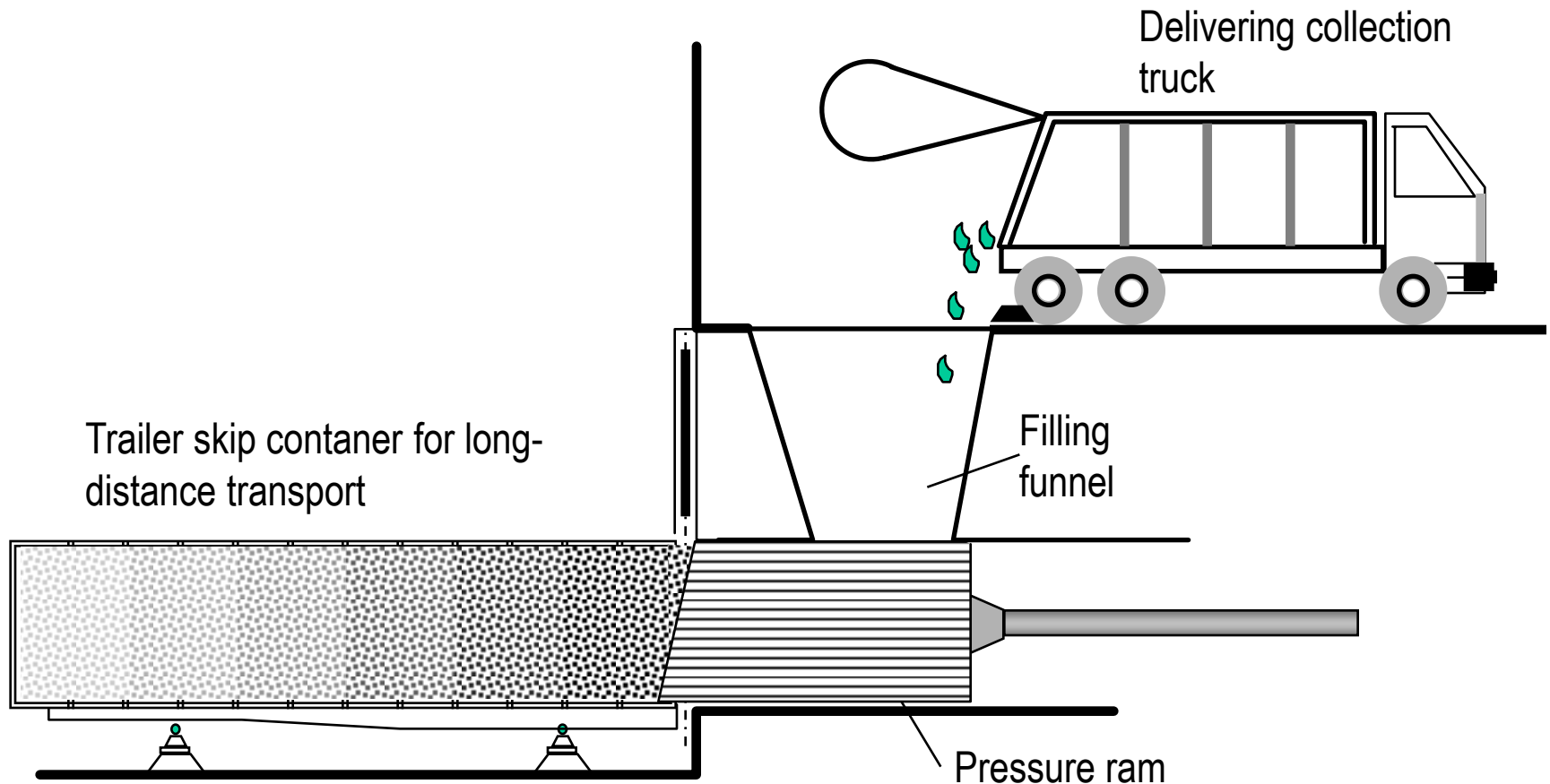
Reloading Plants for Uncompacted Containers



Waste Reloading with Antechamber Press

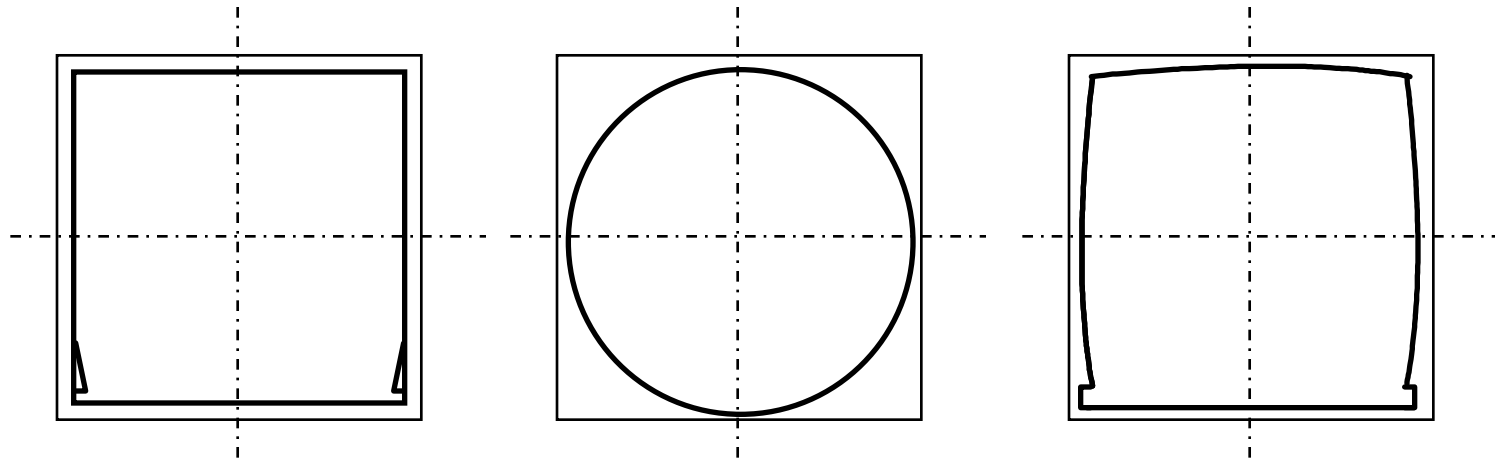


Waste Reloading with Stationary Plugging Press



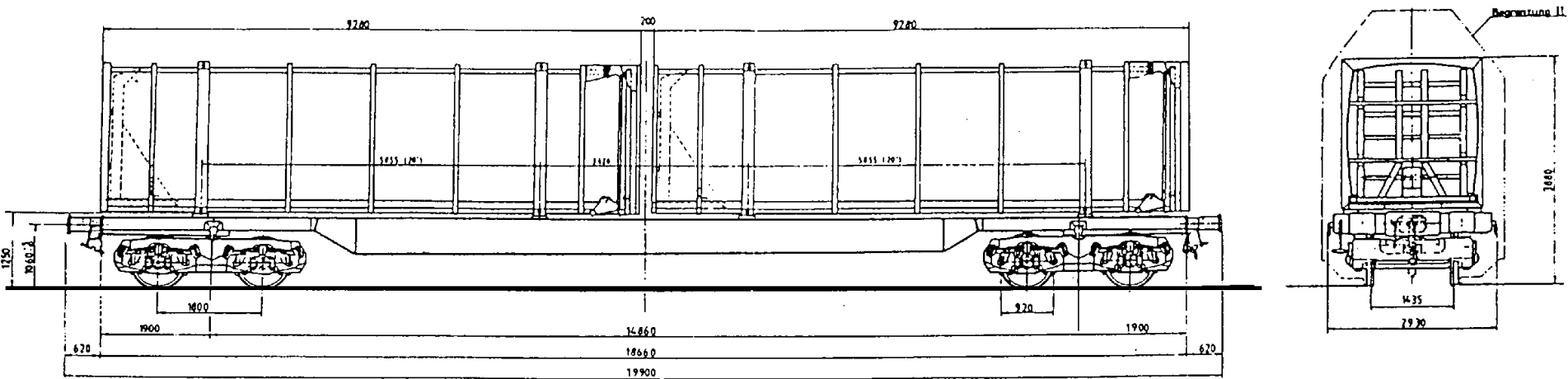
Cubic, Cylindrical or Shell Containers for Long-Distance Waste Transport

according to Rocholl, 1989



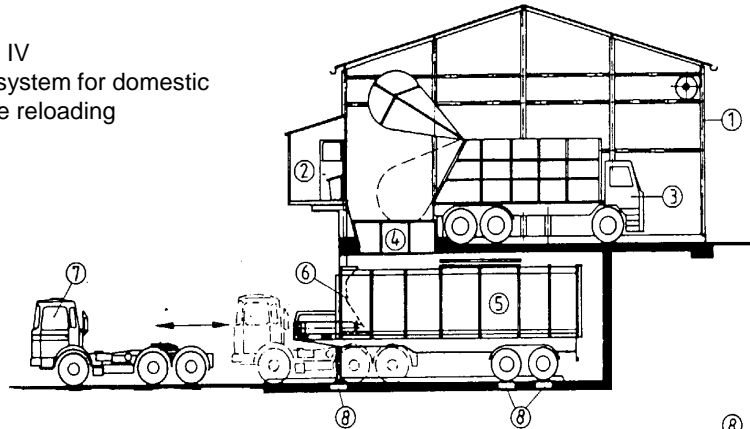
Containers and German Rail Carriages

- Reloading Road → Rail preferably with fixed discharge locations



Reloading Plant for Road or Rail Transport

RMA IV
The system for domestic waste reloading

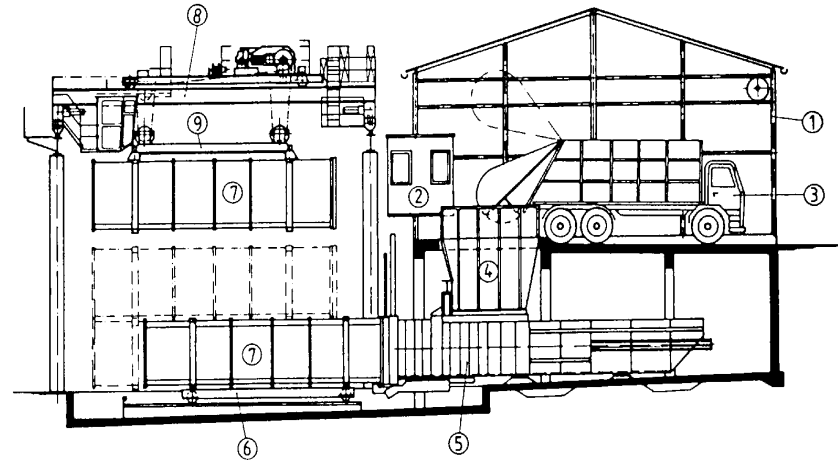


- Legend**
- 1 Hall
 - 2 Switch Room
 - 3 Delivery vehicle
 - 4 Funnel
 - 5 Container trailer
 - 6 Compacting device
 - 7 Tractor truck
 - 8 Weighing scales

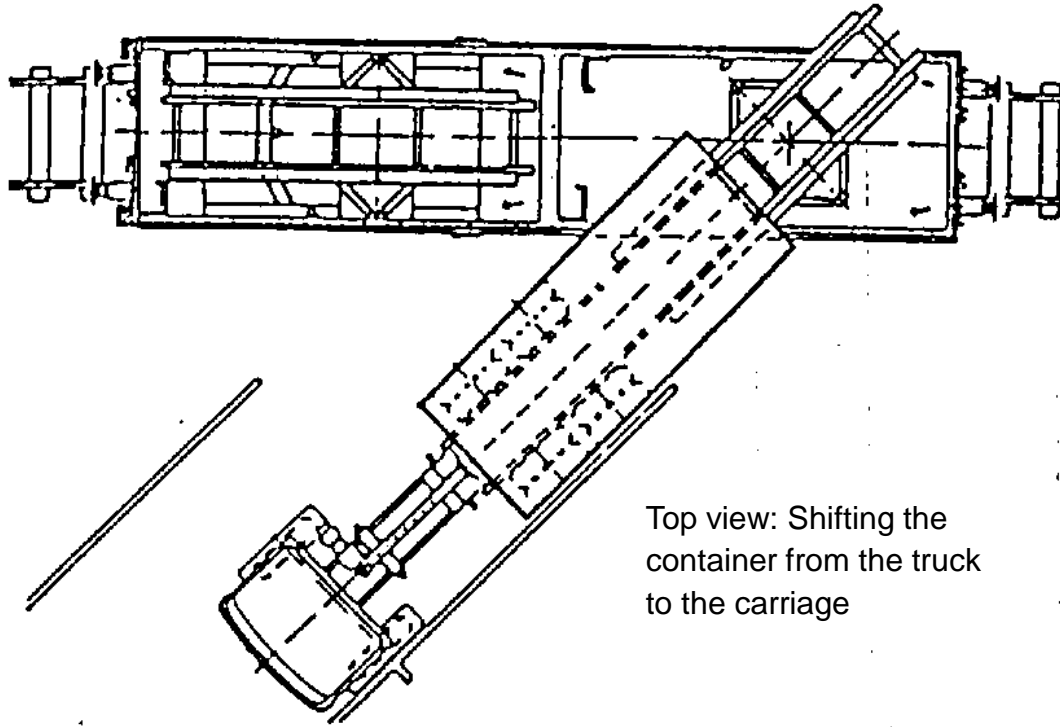
RMA II
The system for universal processing of commercial, industrial and domestic waste

Legend

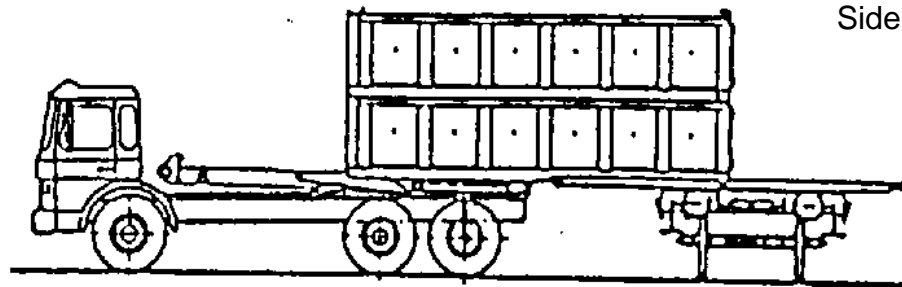
- 1 Hall
- 2 Switch Room
- 3 Delivery vehicle
- 4 Funnel
- 5 Antechamber press
- 6 Docking vehicle
- 7 Container
- 8 Crane
- 9 Spreader



ACTS Reloading System Truck >> Railway

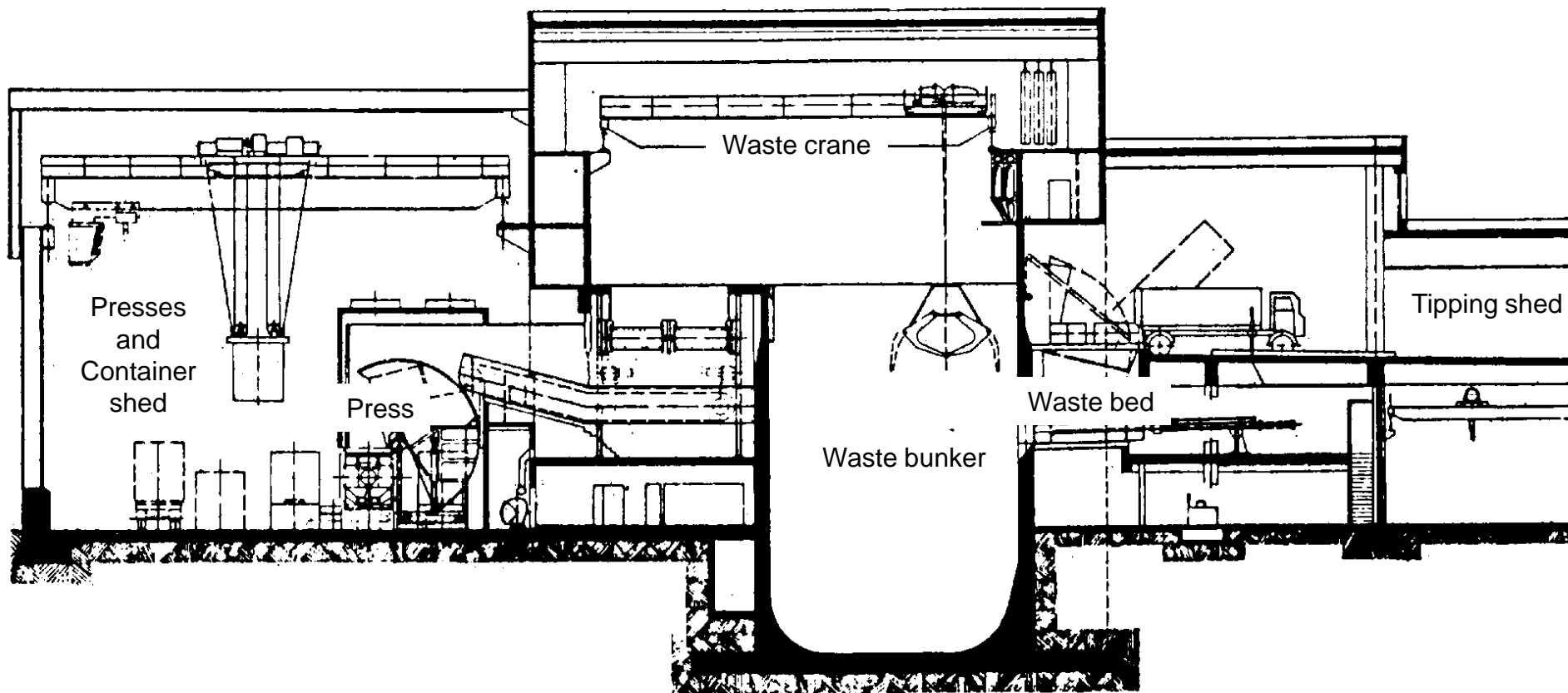


Top view: Shifting the container from the truck to the carriage



Side view

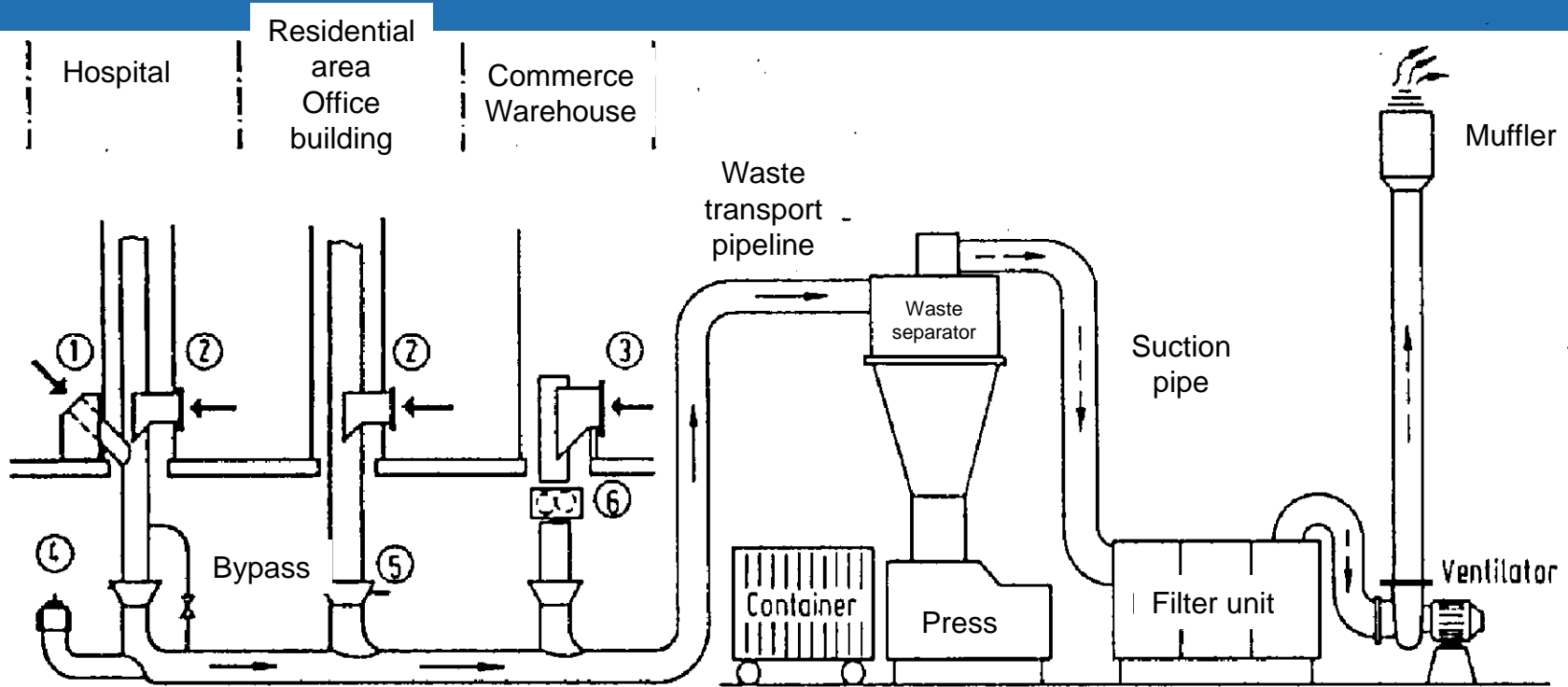
Reloading Station Berlin-Gradestraße



Reloading Road → Ship

- In Germany hardly used due to ice drifts
- Abroad, more frequently used (Geneva, London, Amsterdam, Rotterdam)
- The ship hold can also be used as bunker

Pneumatic Transport



- | | | | |
|-------------------|-----------------------|---------------|------------------------|
| 1 Sterilisator | 3 Cardboard feeding | 5 Shaft valve | → Waste transport pipe |
| 2 Feeding station | 4 Transport air valve | 6 Comminutor | - - - Suction pipeline |

- Due to limited transport ways (<300m) in S also with mobile suction truck
- Waste dumping shafts problematic for separate collection