IfaS

From Circular to Economy!

Ressources instead of waste!

Prof. Dr. Peter Heck, CEO IfaS
Cacak, 11.02.2025

Professor Dr. Peter Heck
Managing Director
Institute for Applied Material Flow Management

Office: 9926/027
eMail: p.heck@umwelt-campus.de
Appointments: Ms. Evi Hubig | 9926/026

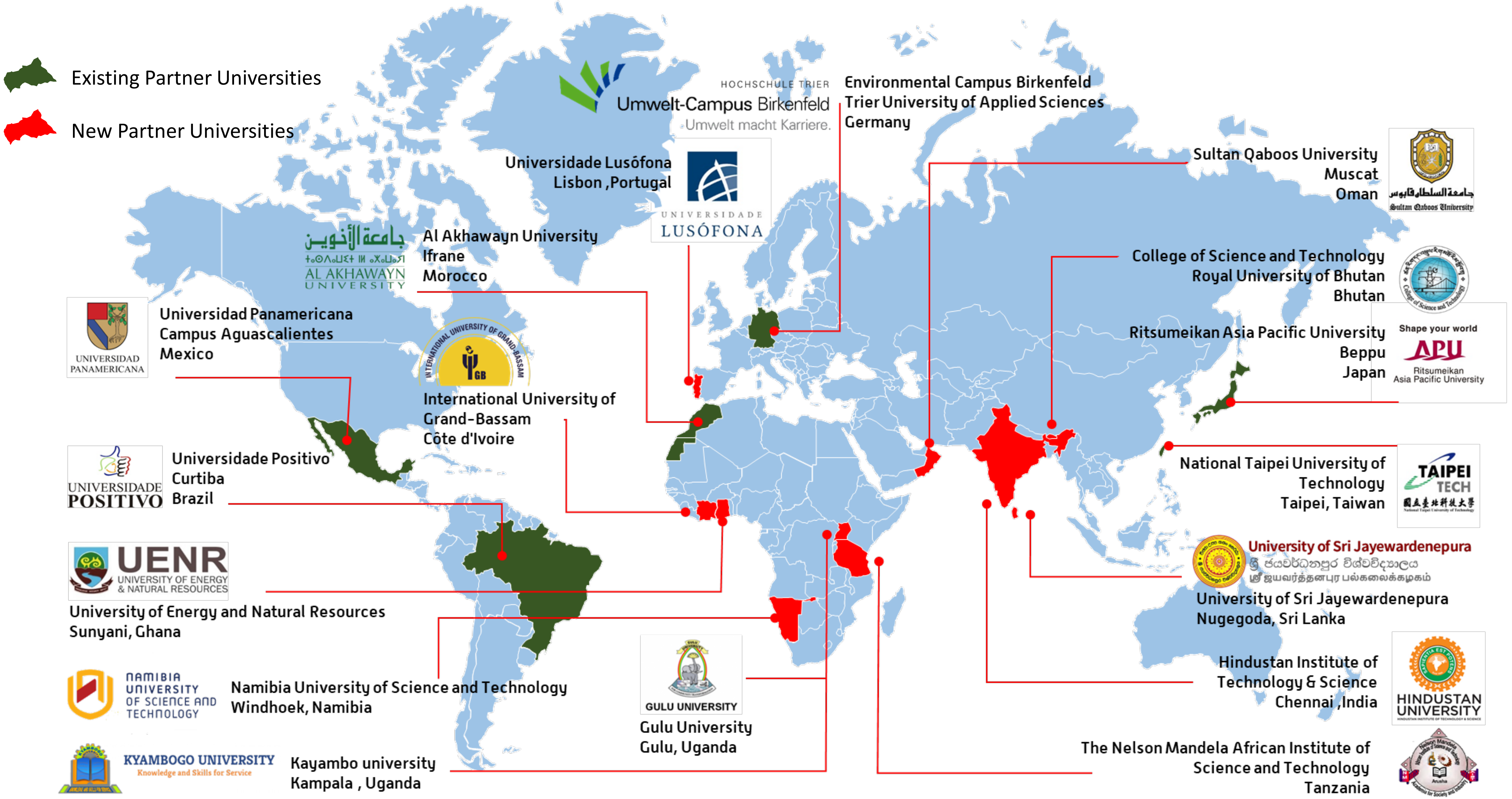
IfaS is the largest university-based-not-for-profit material flow management think-tank in Germany

- Foundation in 2001
- 9 Professors and 80 Employees
- Interdisciplinary Team
  - Ecological Economics
  - Environmental Engineering
  - Policy Science
  - Landscape Planning
  - Agriculture & Forestry Engineering
  - Environmental Law

IfaS Third Party funds: 5,79 Mio € in 2023

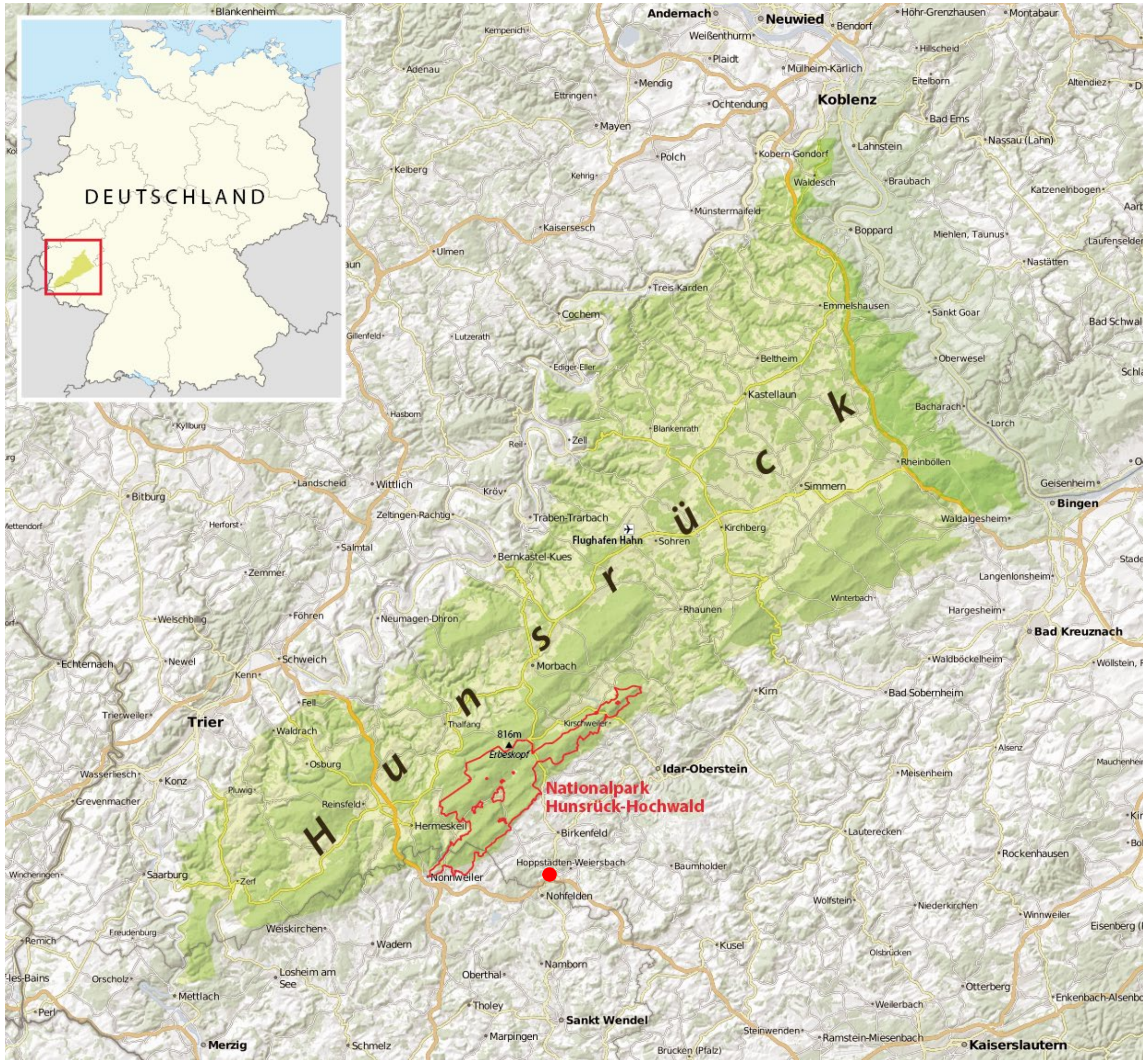
IMAT| Combining Education, Research and Export Promotion

IfaS



University of Applied Sciences Trier - Umwelt-Campus Birkenfeld

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER



Environmental Campus Birkenfeld

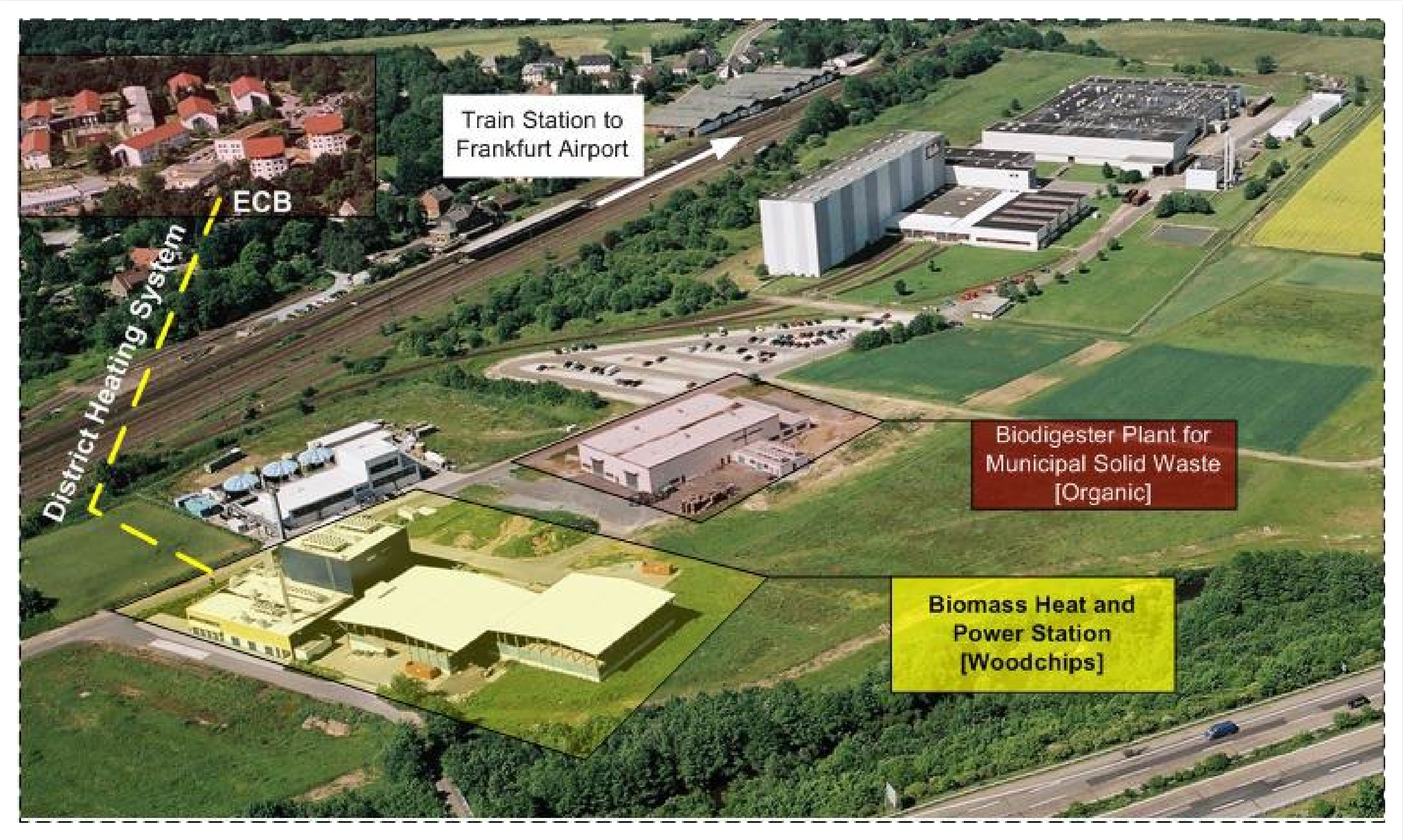
Zero-Emission Campus Birkenfeld: Germany´s Number One Green University

One of the greenest universities of the World!

- **100%** renewable heat supply based on waste wood, biogas (co-generation) and solar thermal
- **100%** renewable electricity based on cogeneration & PV
- **100%** renewable cooling supply based on geothermal, biomass and solar adsorption
- **100% Rain water capture and use**

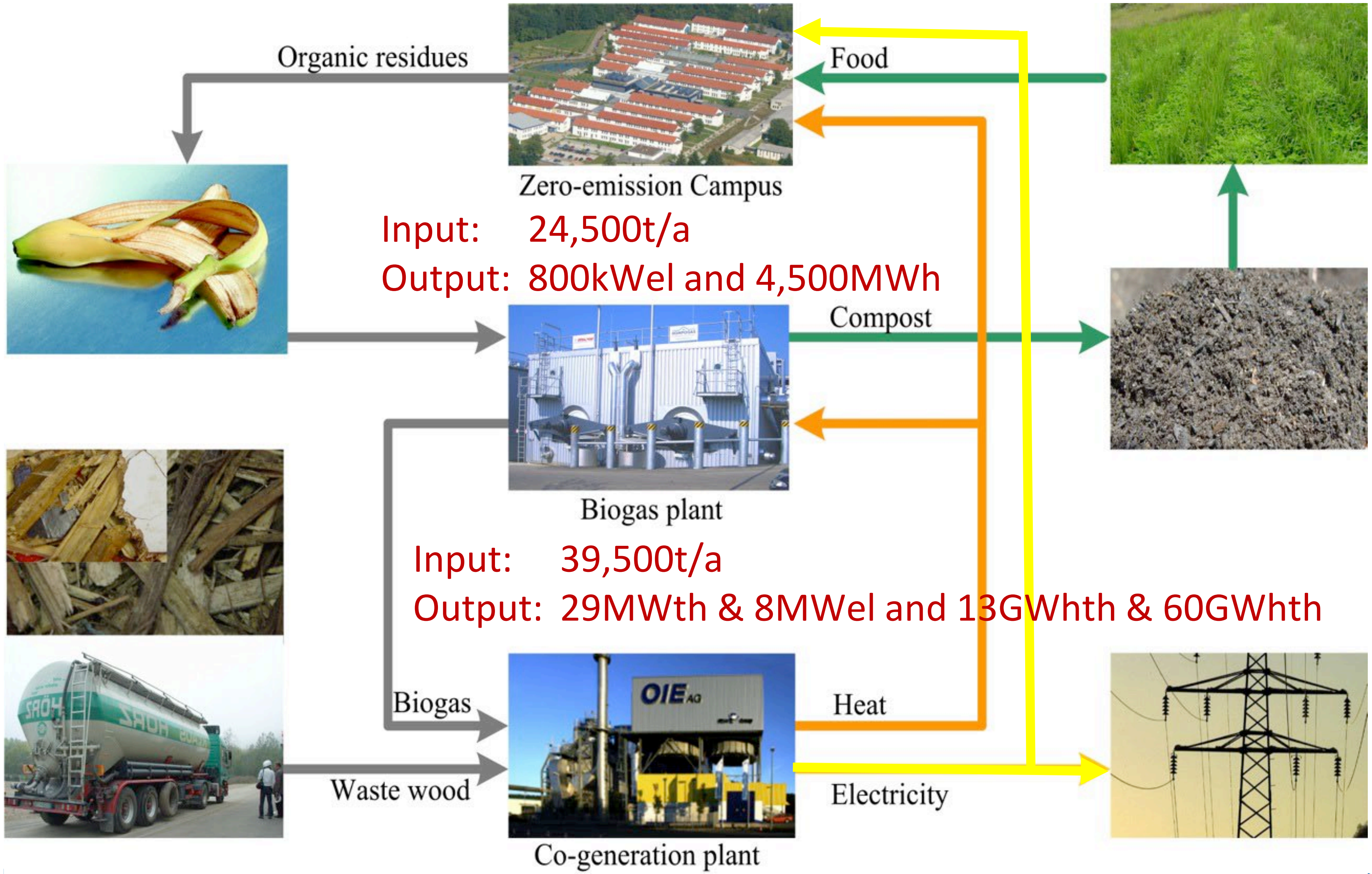
Eco-Industrial Park (Waste-to-Energy)

IfaS Institut für angewandtes Stoffstrommanagement



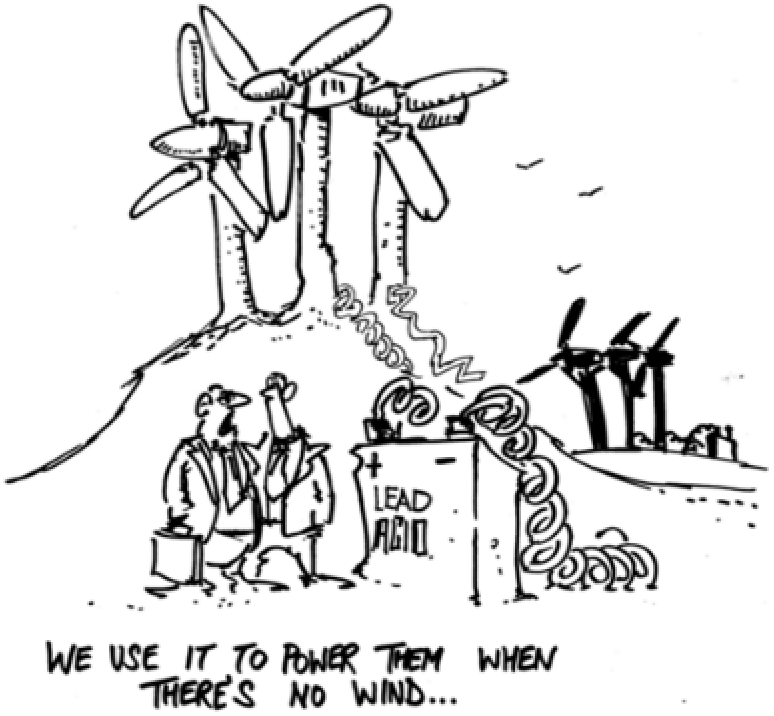
- **100%** Private investments (40 Mio. EUR CAPEX) in Public-Private-Partnership
- **100%** Regional Added Value (35 new jobs, GHG abatement, long-term affordable energy security)
- **100%** waste problems solved without second pollutions

Eco-Industrial Park (Waste-to-Energy)



Adding value by:

- Zero Waste
- Zero Wastewater
- 100 % Renewable Energies
- Participatory Finance
- Optimized material flows



Source: google.com/images

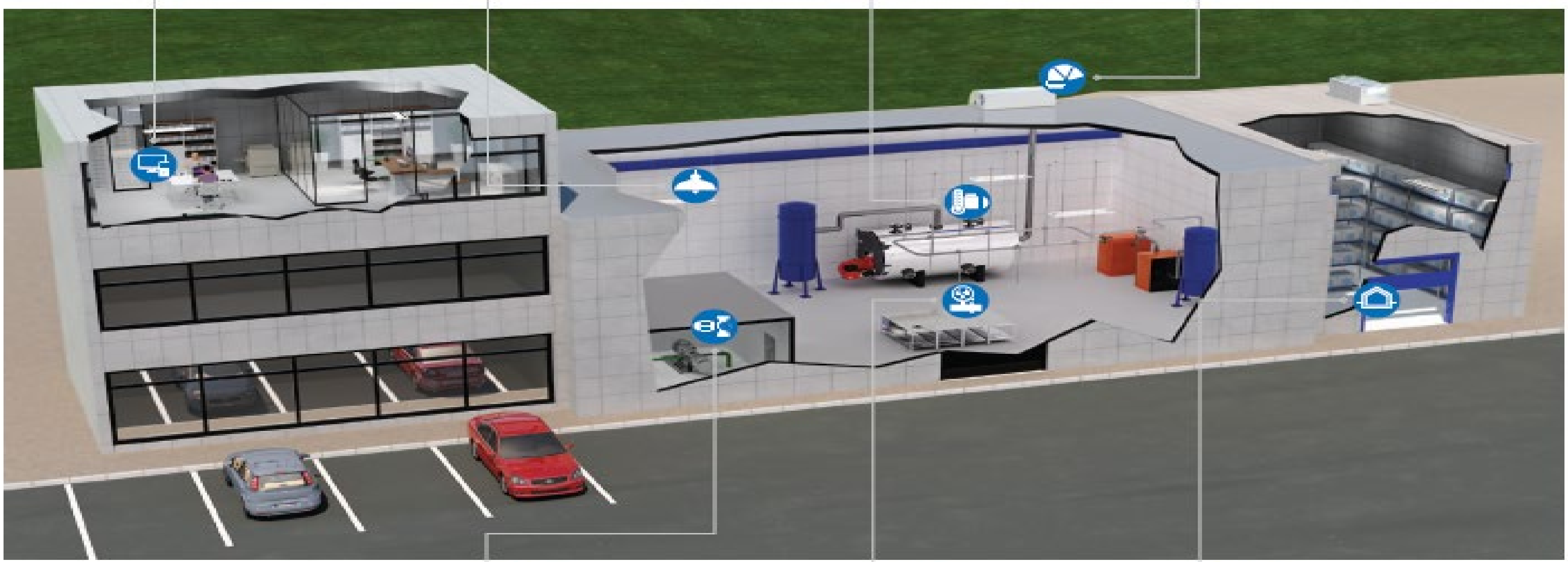
Examples: Energy efficiency potentials

IT up to **75%**

Lighting up to 70%

Heat Processes up to **30%**

HVAC up to **65%**



Pump systems up to **30%**

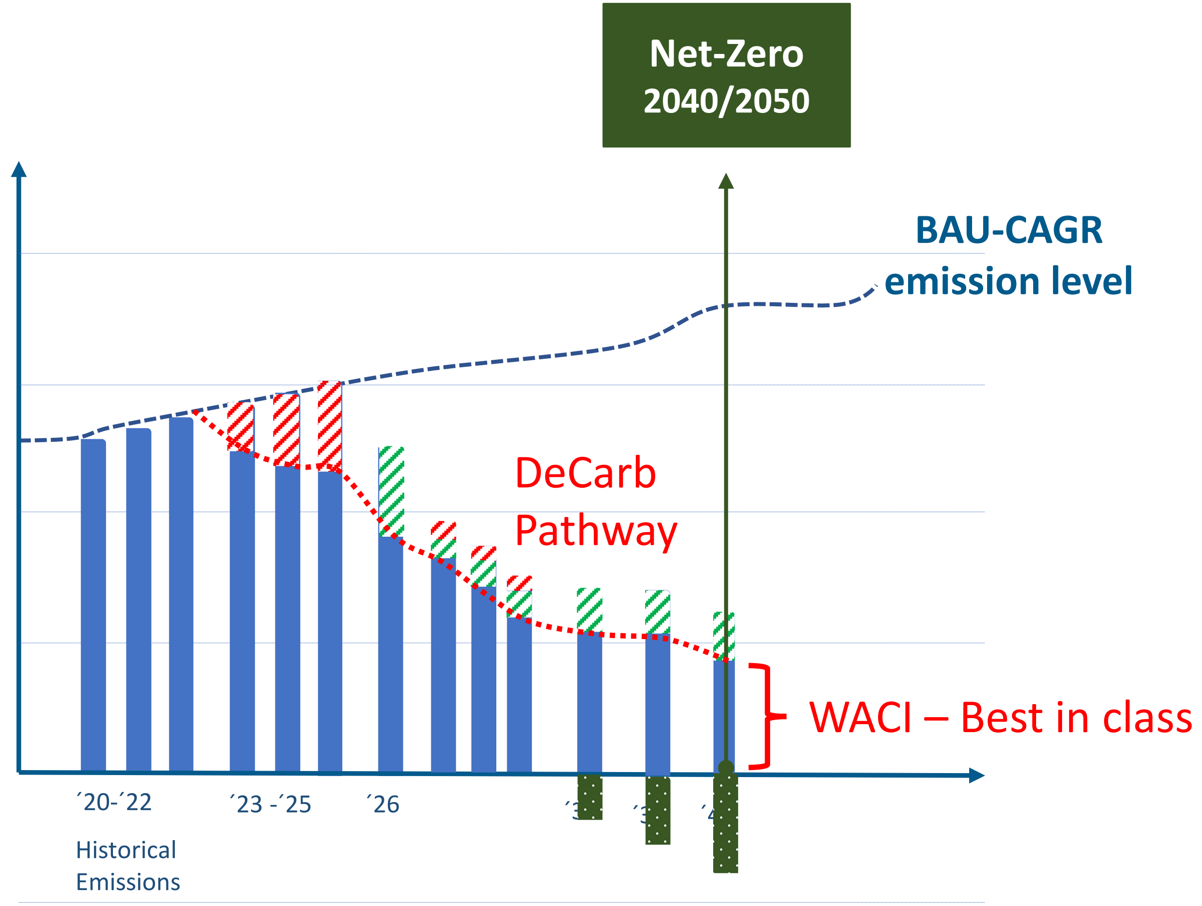
Compressed Air up to **50%**

Building Envelope up to **80%**

Source: DENA

GHG Management

| Exemplified net-zero trajectory



2023-25: Production increase & constant WACI

"Must have" efficiency projects reducing WACI and continuous efficiency improvement

Strategic projects:
Expansion of RE (biogas & PV);
Stepwise HFO-steam replacement powered by RE;
Expansion of e-mobility based distribution
Securing carbon removal certificates
Battery based peak load shaving
Green Hydrogen and Wind energy

Start (partly) neutralising GHG (sourcing until 2024)
(MAC internal > cost of removal)

KFW DEG Impulse

Business Support Services

Advisory Services from DEG

Resource and Energy Efficiency Check developed by IfaS

Resource and Efficiency Check (REC) - Advisory for industries

IfaS

- Resource and Energy Efficiency Check (REC) is a complimentary service by the DEG Business Support Service to financing partners

- Assessment of resource and energy efficiency within **multilevel production cycles and any industry's complex energy and material flows!**

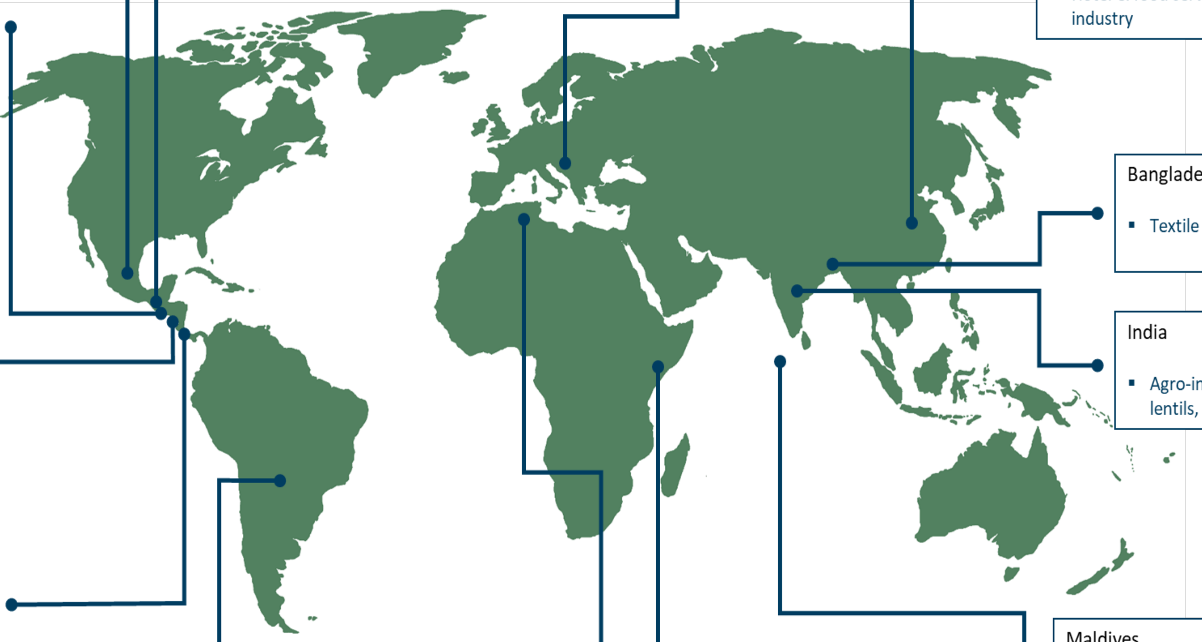
  - <u>Coaching</u> program – REC as a starting point!
  - Create <u>transparency</u> on own optimization potential
  - <u>Knowledge transfer</u> based on collaborative work
  - Starting point for <u>continuous improvement processes</u>

Source: IfaS, 2023

REC- Resource and Energy Checks
8-years of Industrial Energy and Resource Efficiency Optimization

IfaS

KFW DEG



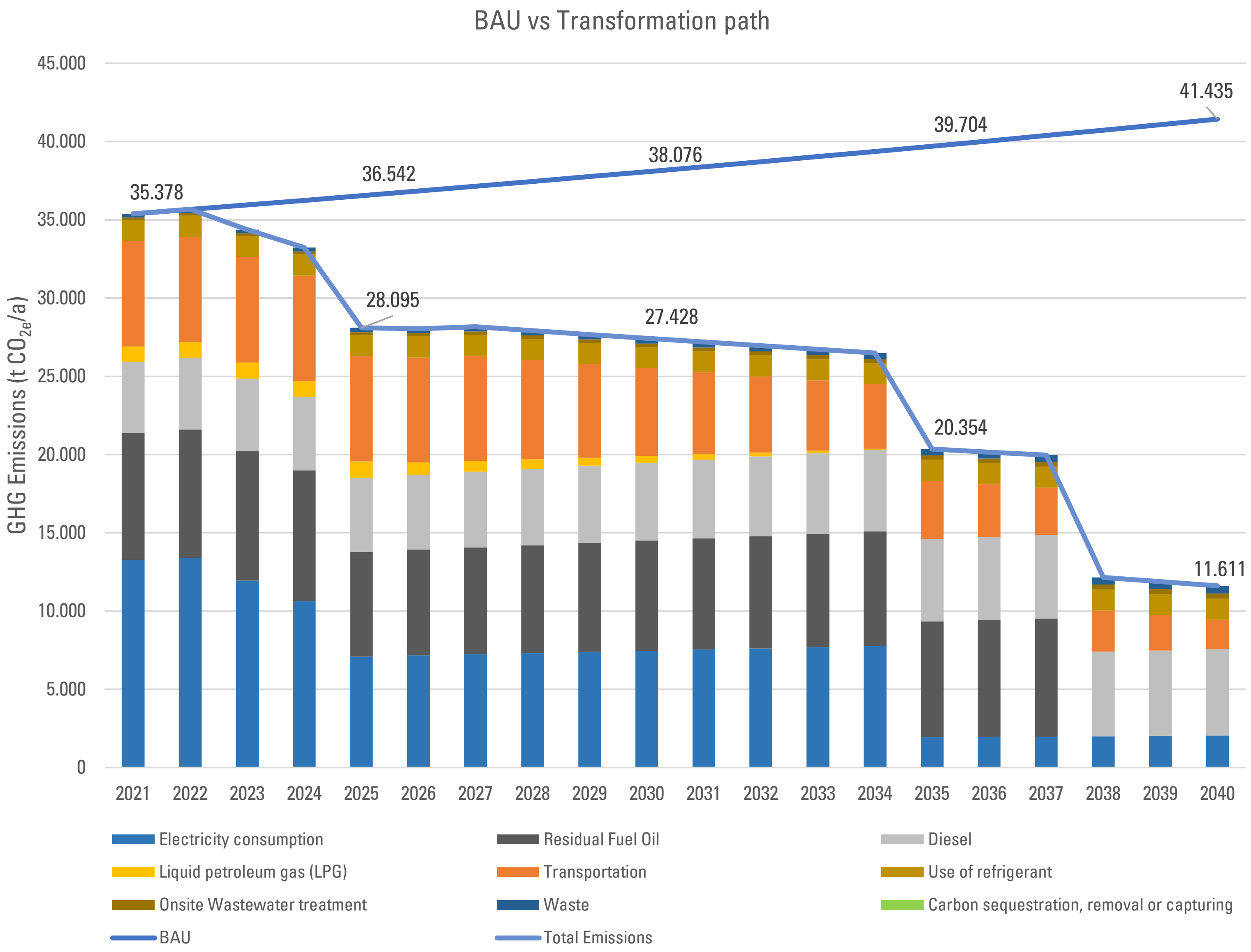
Accumulated Potentials

Renewable Energies	263,661	MWh
Energy savings	1,510,159	MWh
Cost savings	50,962	Mio. USD
GHG Mitigation	349,221	t CO_2eq.
CAPEX	148,007	Mio. USD

Decarbonisation Pathway through Resource & Energy Efficiency

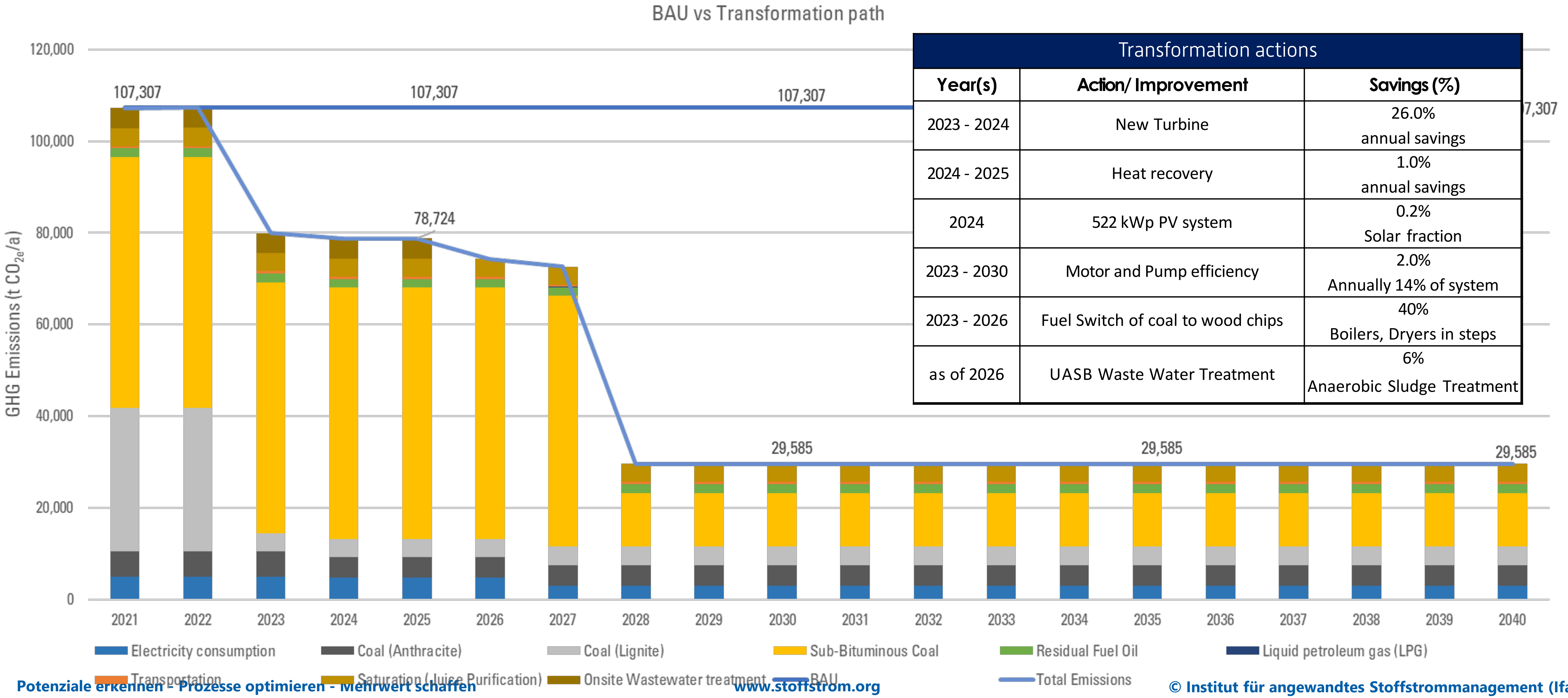
Transformation actions (Example of Brewery)		
Year(s)	**Action/ Improvement**	**Savings (%)**
2023 - 2025	Motor and Pump efficiency	10% annual savings
2023 - 2025	Improved Illumination	2.55% Over three years
2025	1 MWp PV system	10% Solar fraction
2025	1.5 MW Biogas (1,500 hours full load operation)	14.2% RE supply
2025	Reduce HFO use for Stem	20% from rapid stem generation
2025	Rapid steam generation	-2% from electricity
2026	LPG savings due to E - Forklifts	25% Savings in 2026
2026 - 2035	LPG savings due to E - Forklifts	100% over 9 years (LPG ZERO)
2028 - 2040	Fuel savings in Transport	70% Over 12 years time
2035	10 MW Wind and PV	75% of Grid electricity
2038	HFO Zero – By green H_2	100% HFO consumption

Assumptions: Increase of electricity consumption for E-Forklifts will be covered through RE. Load balance, Demand-side-response and Batteries



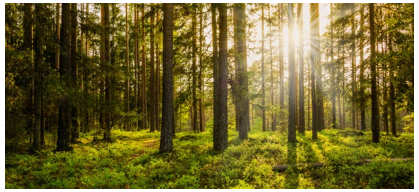
Business driven de-carbonisation pathway – Agro-Industry

CAGR estimated to stagnate: Potential increase of electricity consumption for e.g. electrification of fuel related emission from Scope 3 to be covered through RE. Load balance, Demand-side-response and Batteries (Hydrogen)



Transformation actions		
Year(s)	**Action/ Improvement**	**Savings (%)**
2023 - 2024	New Turbine	26.0% annual savings
2024 - 2025	Heat recovery	1.0% annual savings
2024	522 kWp PV system	0.2% Solar fraction
2023 - 2030	Motor and Pump efficiency	2.0% Annually 14% of system
2023 - 2026	Fuel Switch of coal to wood chips	40% Boilers, Dryers in steps
as of 2026	UASB Waste Water Treatment	6% Anaerobic Sludge Treatment

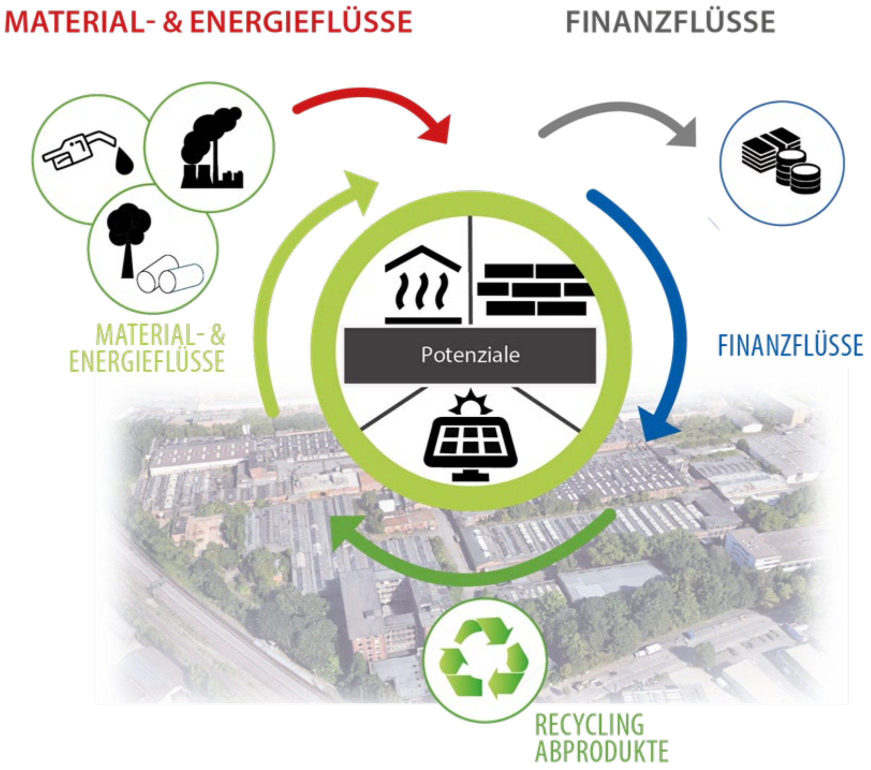
Are we acting or watching? It is Economy!



Sustainability is the better economy

Circular value addition

Monetarizing of unused potentials: increase purchase power, open new regional value chains



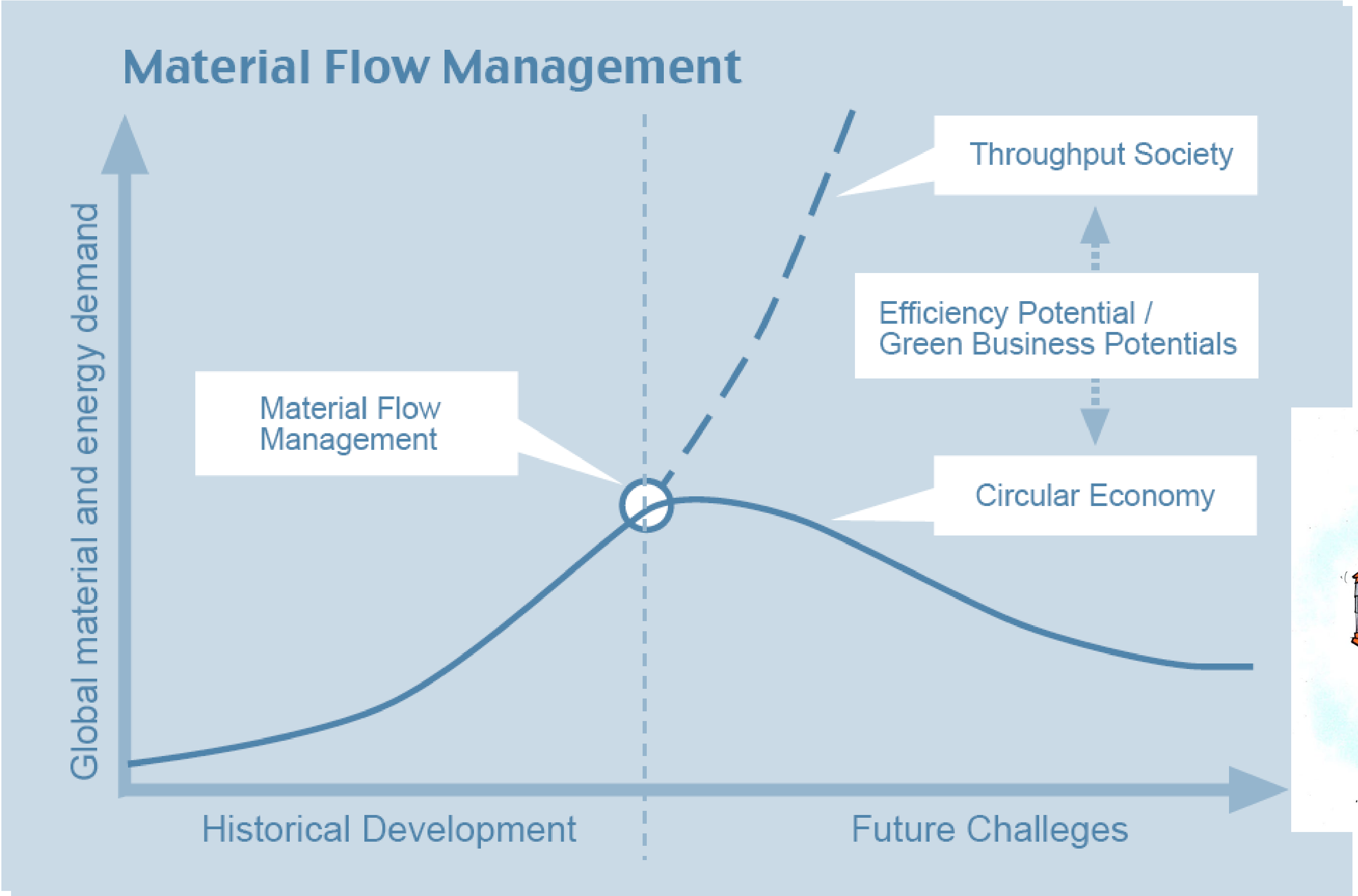
Creating and sustaining values

- **Regional/circular value added:**

  Sum of all additional values in a given system (builiding, company, town, city, county, state) within a defined time span

- ***Value*** means: new money, new jobs, eductaion, socialsecutity, resilience, environmental aspects, cultural aspects etc.

Official (but widely unknown) German policy since 1994



Material Flow Management,

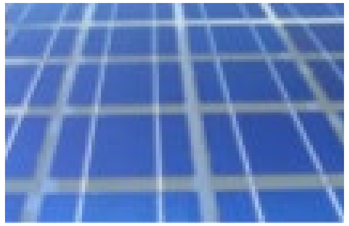
*Saving **money** on energy and resources and ..*
using it for adding value to our people!

Zero Emission

MFM Key Material Flow Potentials in Regions

Foto: H.-G. Oed

Foto: IfaS

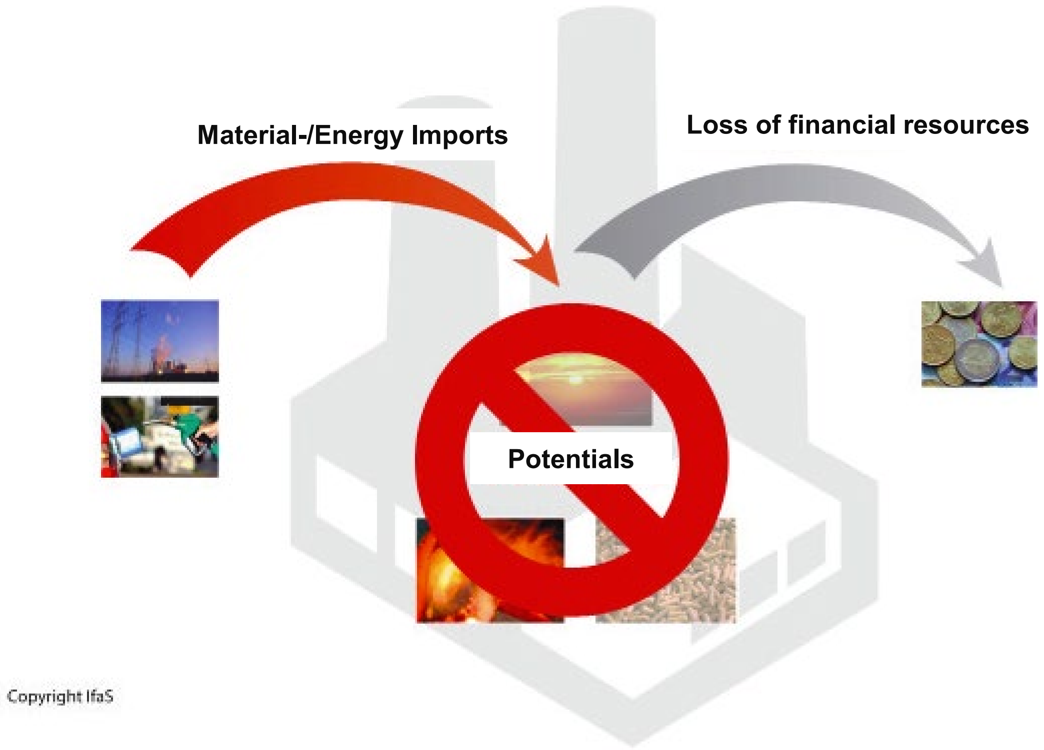


- Water/Wastewater,
- Municipal Solid Waste
- Sewage Sludge
- Fossil End energy (electricity, heat, cold, mobility)
- Renewable Energies,
- (all sorts of) Biomass (residues)
- Buildings and Infrastructure
- Waste Fats and Oils
- Traffic and Mobility
- Special aspects like e. g. tourism
- etc.....

Regional Potentials

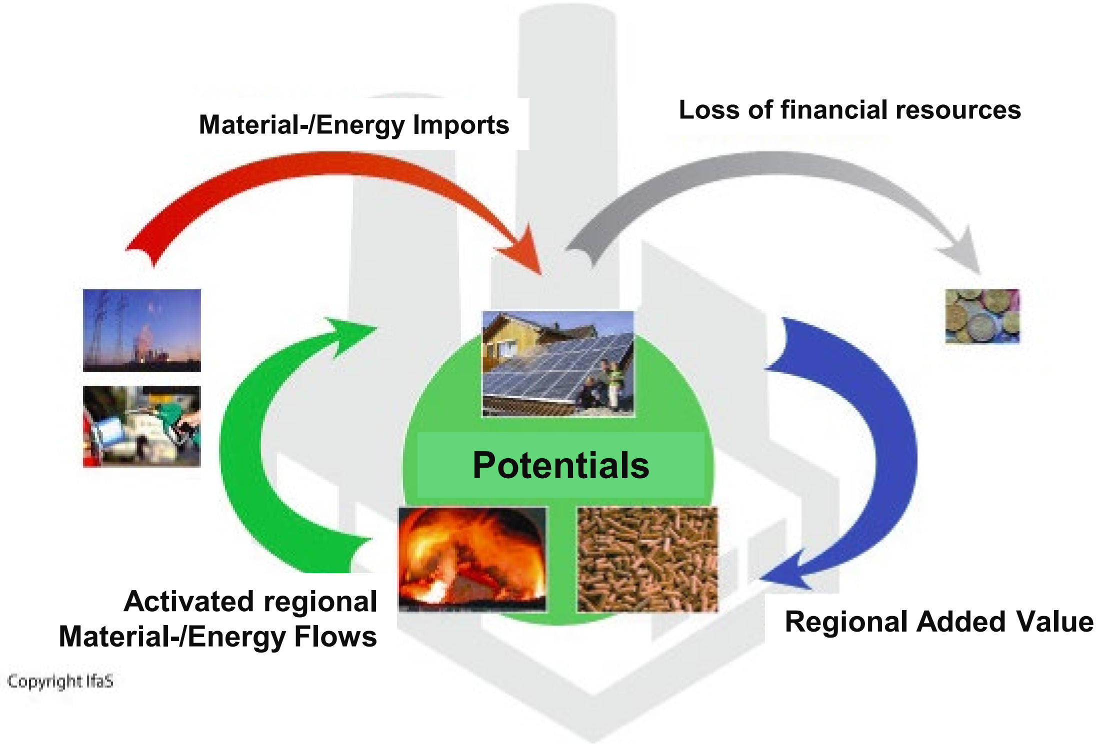
Material Flow Management & Regional Added Value

Nowadays “throughput society”



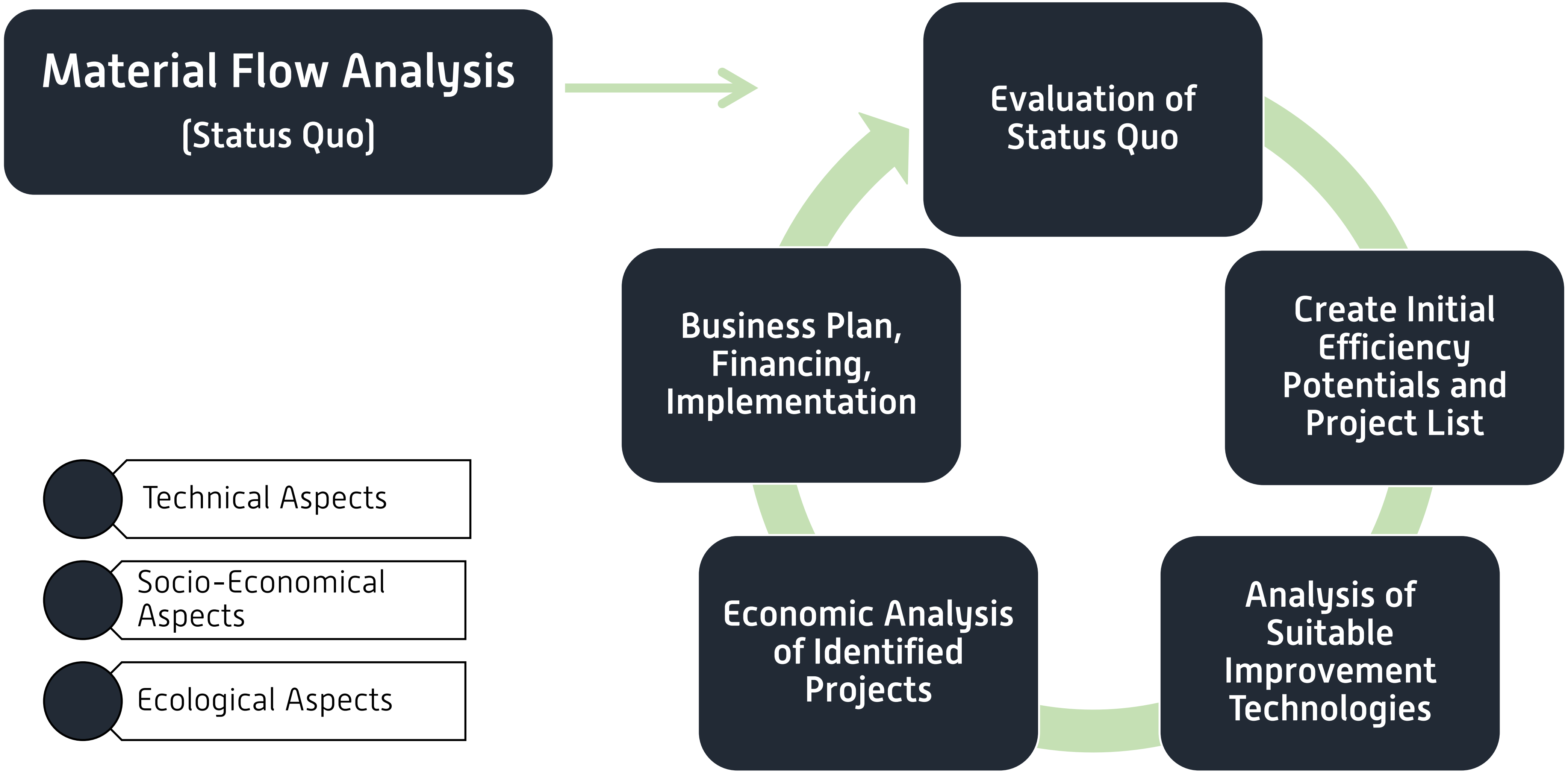
- Low CAPEX – High OPEX
- Negative Environmental impact

Vision and Goal – Zero Emission!



- High CAPEX but improved Project-IRR
- Environmental Protection and Regional Added Value, Green Investment

IfaS Workflow



Source: IfaS, 2022

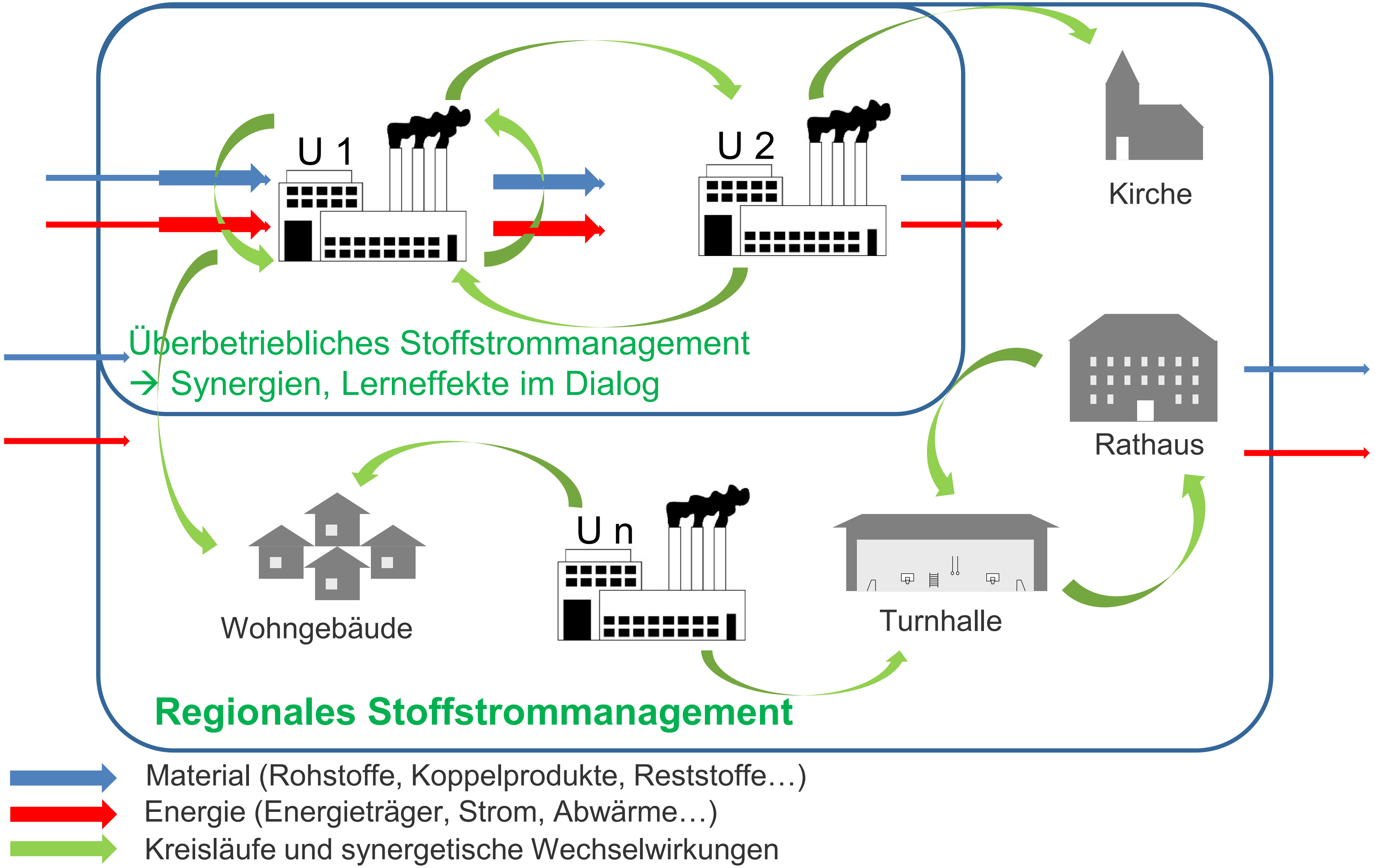
Regional economy has a long tradition!

IfaS

Friedrich Wilhelm Raiffeisen
(1818 - 1888)

The money of the Region for the Region

From inta corporate to inter corporate to regional Material Flow Management



MFM – The new economic development paradigm

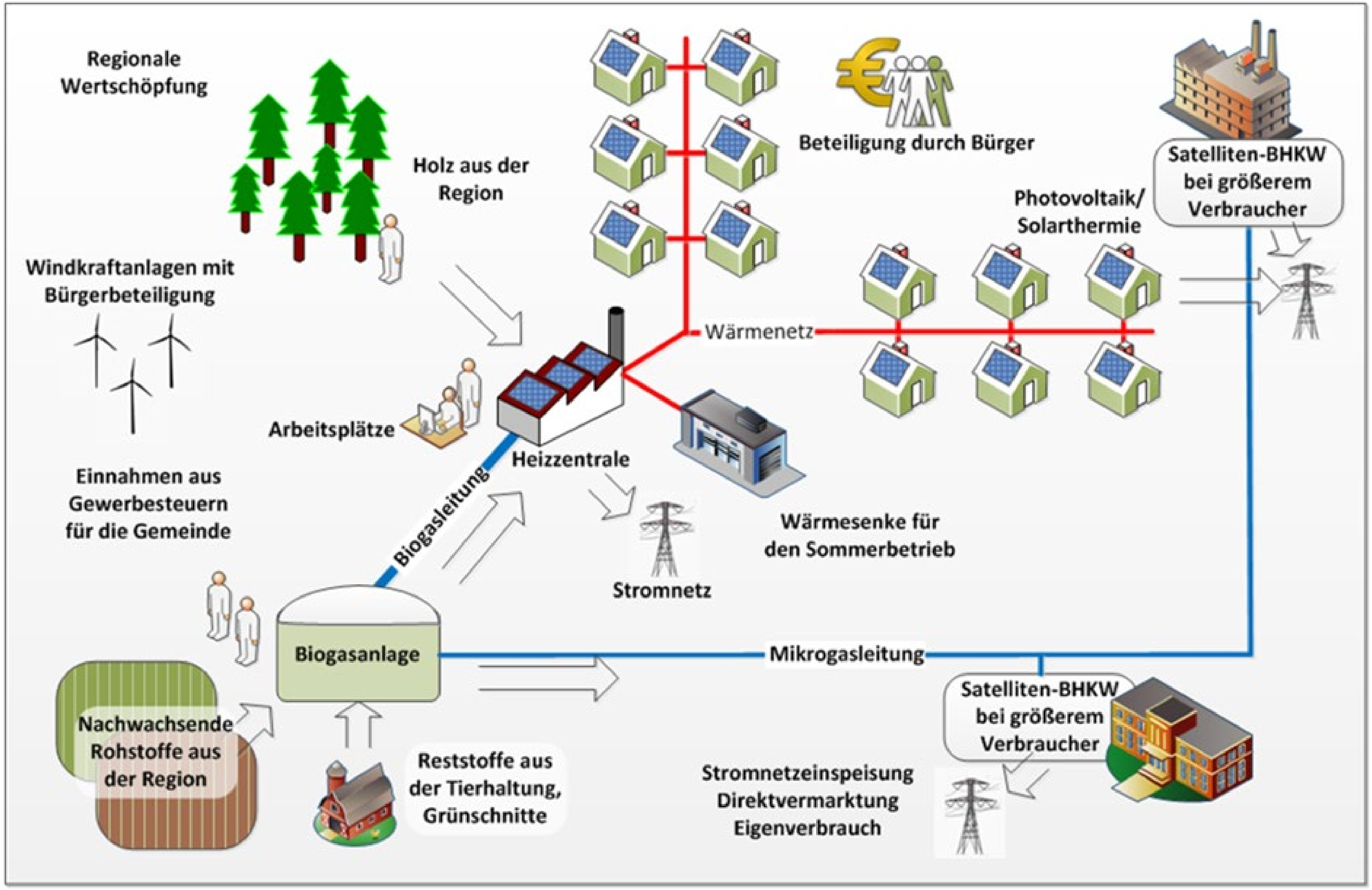
MFM helps to understand transformation towards resilient and sustainable societies as a chance

MFM as a tool to operationalize Circular Economy

MFM as a starting point for a global Green Deal

BioEnergy Villages: Being independent

- **Goals:**
  - To become Energy Independent
  - To reduce CO_2 Emissions
  - Create local jobs
  - Keep money in the region



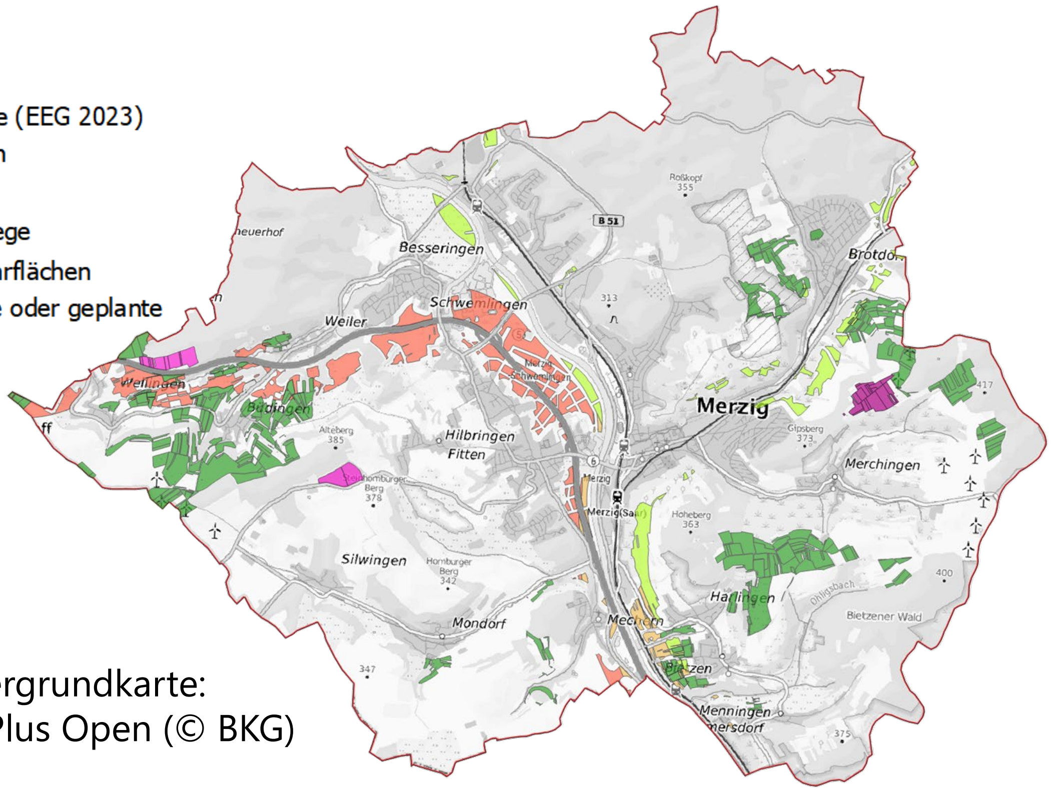
More than 400 Bioenergy Villages in Germany being basically energy independent

Potentials PV on free land

- 500 m area along highways and railways
  - Ausschlussgebiete und Restriktionen (Datengrundlage u. a. ALKIS, OpenStreetMap, Geoportal SL)
- Photovoltaic on agricultural land (Geoportal Saarland – „benachteiligte Gebiete“)
- Existing pV plants

PV FFA

PV FFA Korridore (EEG 2023)
- Autobahnen
- Gemischt
- Schienenwege
- PV auf Agrarflächen
- Bestehende oder geplante PV FFA



Hintergrundkarte:
Top Plus Open (© BKG)

PV-Freiflächenanlagen (PV-FFA)			
Flächenkulisse	Flächenkulisse [ha]	Leistung $[MW_p]$ [2]	Stromerträge [MWh/a] [3]
Autobahn	257	171,0	163.000
Schienenwege	129	86,0	81.000
Autobahn und Schienenwege	33	22,0	21.000
Agrarflächen	564	376,0	357.000
bestehende FFA [1]	*ca. 20 ha*	*8,4*	*8.000*
geplante FFA [4]	*ca. 25 ha*	*14,0*	*13.300*
Summe	**1.028**	**677,4**	**643.300**

1) MaStR (Stichjahr 2020)

2) Annahme Installierbare Leistung: 15 m² / kW_p

3) Annahme Stromertrag: 950 kWh/kW_p*a

4) Erweiterung Solarpark Wellingen und Fitten sowie Errichtung einer PV-FFA Merchingen

➢ PV FFA-Potential covers **445%** of actual demand

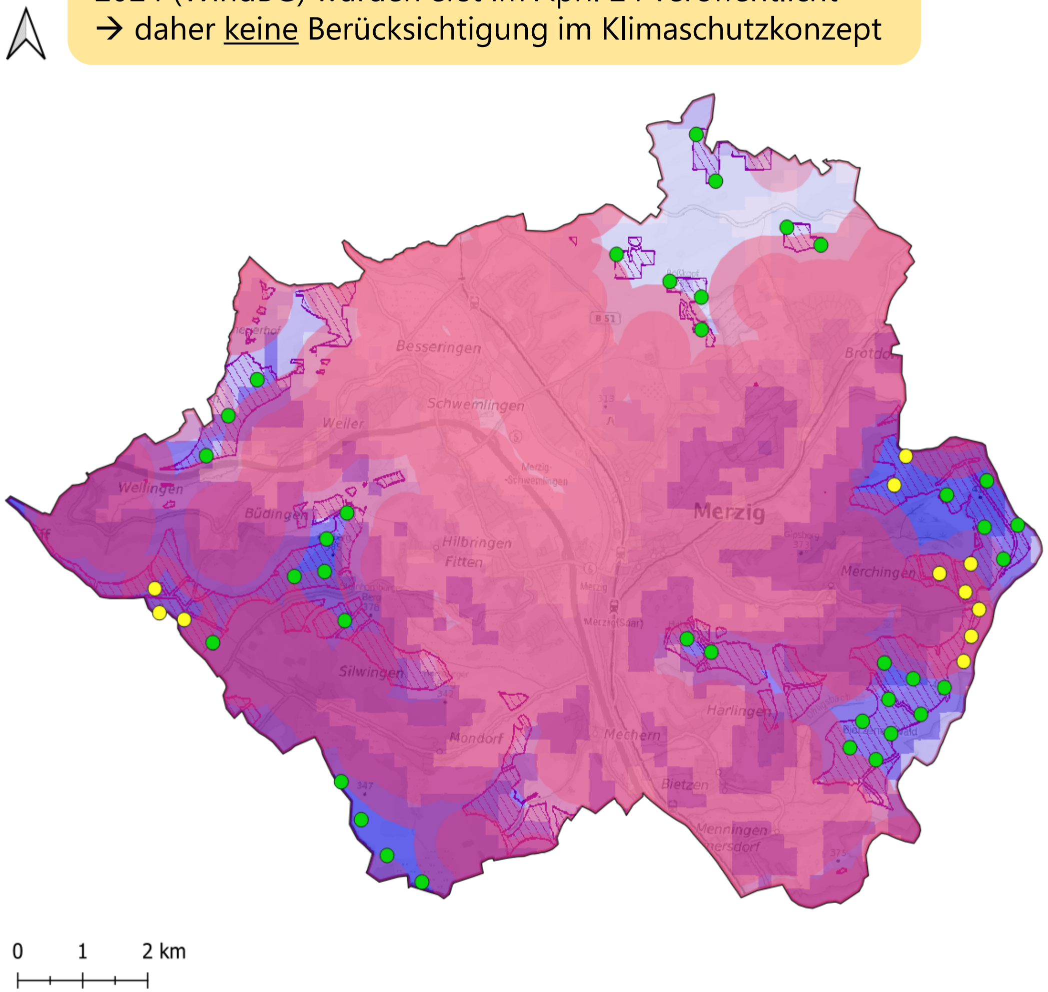
Potentials – Wind power

- Geodata
- Existing wind power

  WEA mit insg. 31,1 MW Leistung
- Bewertung des maximalen Gesamtpotenzials nach Umsetzungswahrscheinlichkeit (Steuerungsgruppe, Stadtwerke)
  - Ausbaupotenzial innerhalb Potenzialflächen
  - Theoretisches Repoweringpotenzial
  - Ableitung von zwei weiteren Ausbauszenarien
- Maximales Gesamtpotenzial im Jahr 2045
  - 45 Windenergieanlagen
  - Gesamtleistung ca. 272 MW
  - Jährliche Stromerträge ca. 631.000 MWh/a

➢ Wind covers **460%** of today electricity dema

Ergebnisse der Windflächenpotenzialstudie Saarland 2024 (WindBG) wurden erst im April 24 veröffentlicht
→ daher <u>keine</u> Berücksichtigung im Klimaschutzkonzept



Potenzialanalyse Windenergie

Windenergieanlagen (WEA)
- Bestehende WEA
- Ausbaupotenzial WEA

Zusätzliche Abstandsannahme
- Abstand zu Wohngebäuden (900 m)
- Abstand zu sonst. Gebäuden (500 m)

Windenergieatlas Saarland
- Potenzialfläche AI-PRO (MW3_NH150)

Mittlere jährliche Wind-geschwindigkeit (150 m NH) in m/s
- 3,8 - 4,5
- 4,5 - 5,0
- 5,0 - 5,5
- 5,5 - 6,0
- 6,0 - 6,5

Datenquellen

Windenergieatlas Saarland:
© LVGL, Geoportal Saarland

ALKIS:
© LVGL, bereitgestellt durch Stadt Merzig

Hintergrundkarte TopPlusOpen:
© Bundesamt für Kartographie und Geodäsie (BKG 2024)

When you are poor… you should invest in your potentials

Annual Energy Import and Loss of Purchas Power in the County District: approx. 290 Million €

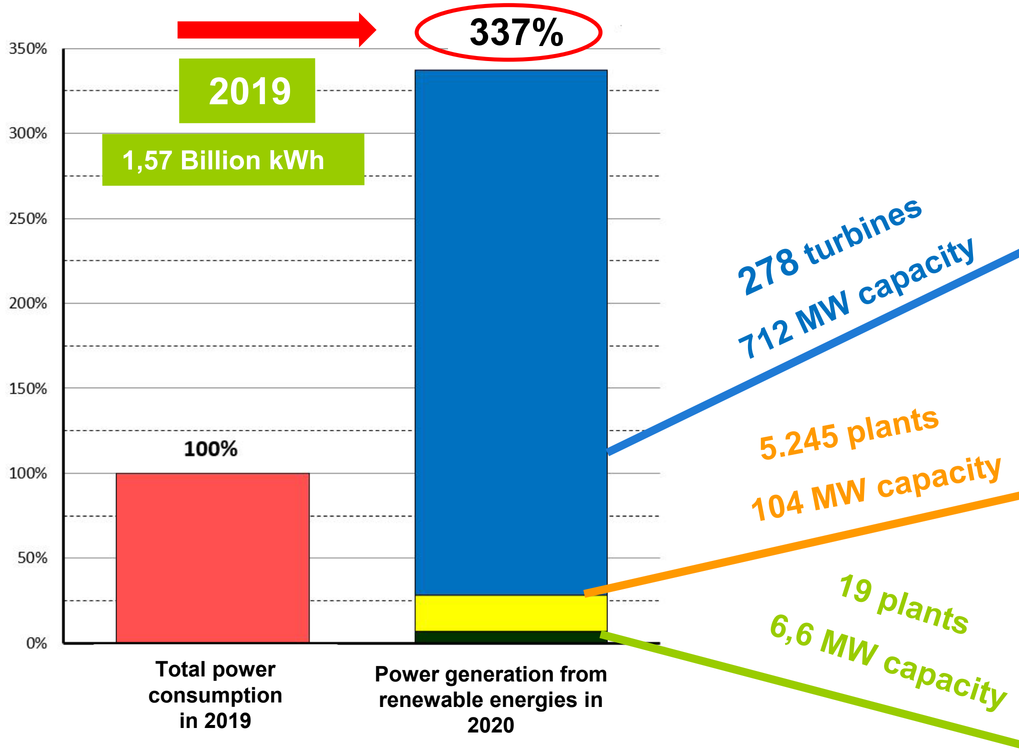
Das bedeutet:

Total expenditure on energy imports in the Federal Republic of Germany in **2011:**
87 Mrd. €
23% more than 2010

Objective of Zero Emission:
Through improvements in energy efficiency and introduction of renewable energies we convert energy import costs into regional jobs and value added!

The share of renewable electricity in the district will probably be at 337% by the end of 2020

Total power consumption 466 Mio. kWh in 2019



informational:
Hydro power

Ø Federation 3,3 %

since 2010: Pilot project river turbines in the Rhine at St. Goar

Wind energy
308,88 %
Ø Federation 18,2 %

Photovoltaic
21,03 %
Ø Federation 8,9 %

Biomass
7,20 %
Ø Federation 8,9 %

Share of renewable energies: 337% **Ø Federation 45%**

At the end of 2020, 278 wind power stations have been operating in the district

District administration of the district of Rhein-Hunsrück

Source picture: juwi Energieprojekte GmbH

End of 2020:

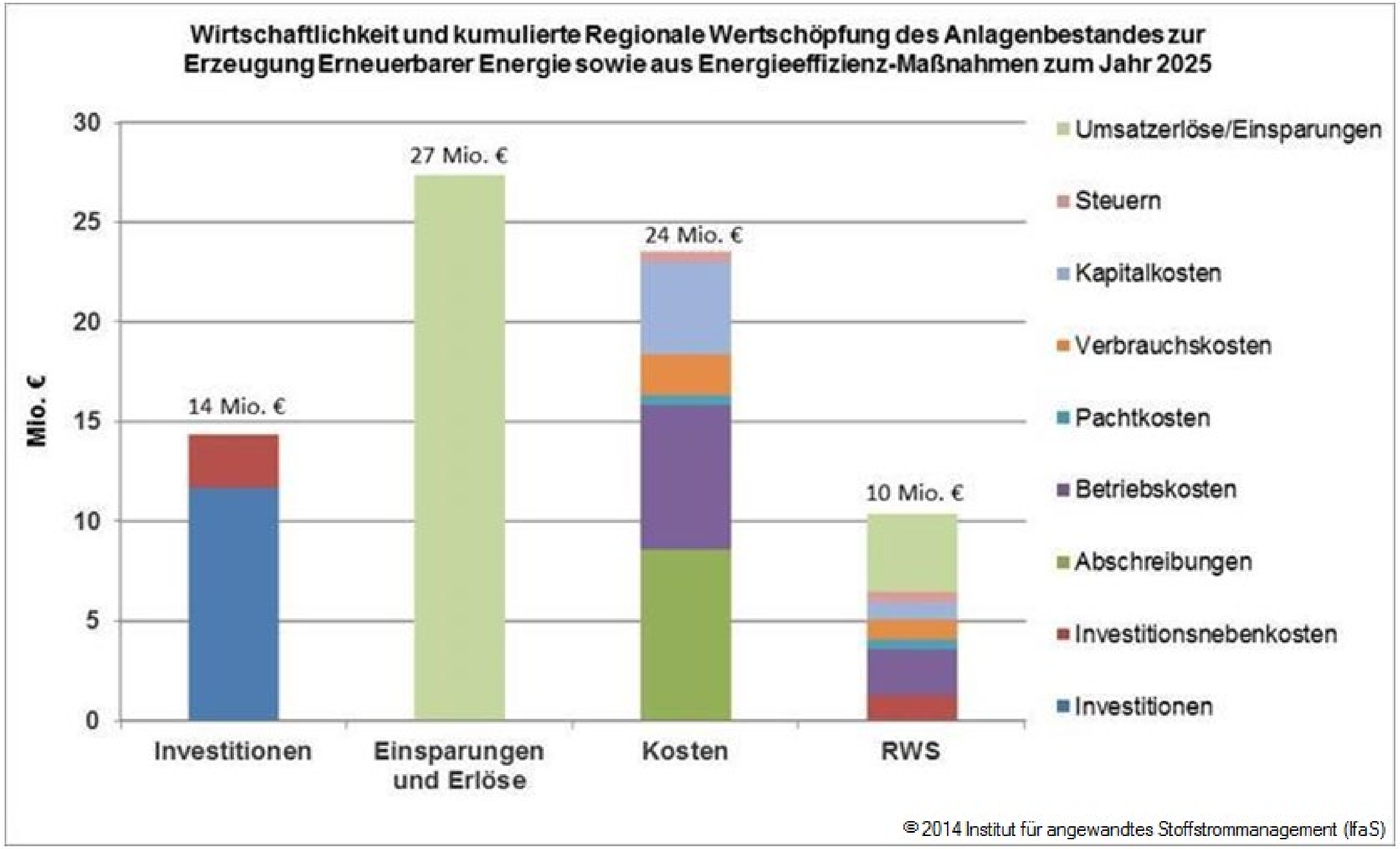
278 wind power stations with a power of 712 MW are producing more than 1,57 billion kWh of renewable power per year

7,8 Million € of annual leasing income for the municipalities
1,6 Million € servicing costs
2,2 Million € feed-in tarif (only regional), 65 Million € regional invest costs
in 20 years 216 Million € regional added value

Example village (Added value in 12 years)

Approx. 10 Mio. € RAV till 2025 (today 400.000 €)!

- **Investi:**
  ca. 14 Mio. €
- **Savings and revenues:**
  ca. 27 Mio. €
- **costs*:**
  ca. 24 Mio. €
- **RAV*:**
  ca. 10 Mio. €



* Netto-Barwerte

Being rewarded…

**63 out of 137 communities are gaining rental incomes from the wind energy
64 other communities are gaining rental incomes from solidary pacts**

Rhein-Hunsrück has got the exceedingly fewest

Statistic: The budget situation in the district, its municipalities and communities is the most solid nationwide

Debts of overall community budget in 2015 (Selection)

	Sum (in Mio. Euro)	Change	Per captia
District of Rhein-Hunsrück	60,7	+ 3,4 %	594
District of Cochem-Zell	117,9	- 3,7 %	1896
District of Bernkastel-Wittlich	273,3	+ 2,9 %	2455
District of Rhein-Lahn	228,8	- 5,7 %	1879
District of Mayen-Koblenz	477,7	-2,9 %	2264
District of Birkenfeld	323,6	+5,9 %	4021
District of Bad Kreuznach	357,6	-3,0 %	2759
City of Koblenz	412,6	- 4,7 %	3698
District of Mainz-Bingen	185,5	-8,6 %	905
Rhineland-Palatinate	12 596,3	+ 0,9 %	3132

Information: Statistical State agency

Source: Rhein-Hunsrück-Newsletter, from the 22nd of August 2016

In the 19th century people emigrated to America, because the Hunsrück could not feed them any more.

Today our municipalities have liquid funds of 108 Million Euro.

36

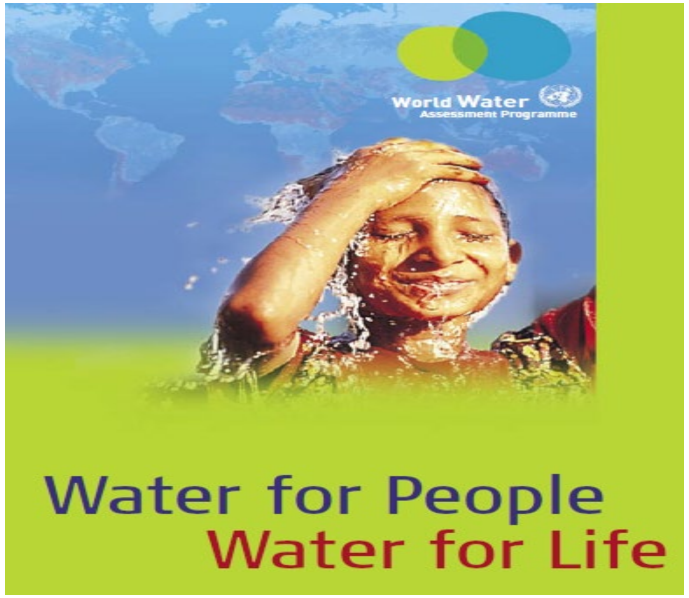
Circular Economy and Municipal Waste(s) Management

Institute for Applied Material Flow Management (IfaS)

Integrated Water Resource Management (IWRM)

Sewage sludge drying by
Thermo-System

- Intelligent new wastewater treatment designs with minimised capacity (and investment)
- Optimisation of existing WWT structures
  - Energy efficiency and energy “autarky” of existing WWTP by anaerobic digestion of raw WW/sewage sludge
  - Re-use of pre-treated water for irrigation (semi and arid area)
  - Production of fertilizer substitute by digestate



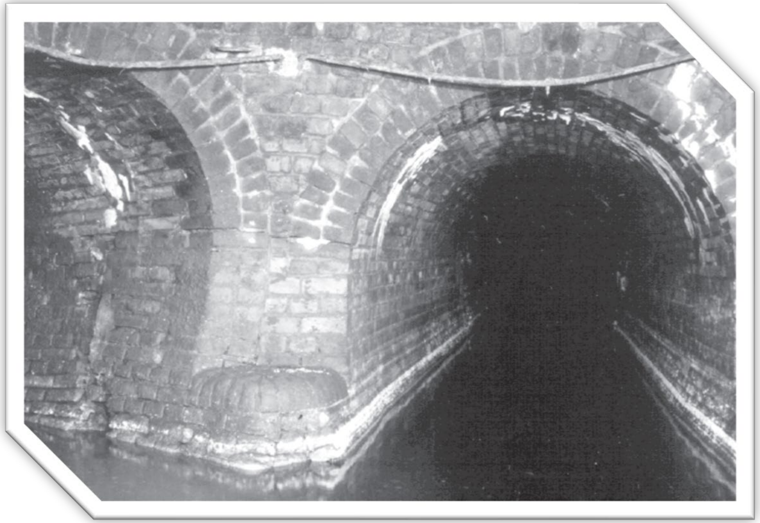
SOURCE: google.com/images, (2019.); Accessed 05.MAY.2019

SOURCE: https://blogs.worldbank.org/water/wastewater-treatment-critical-component-circular-economy

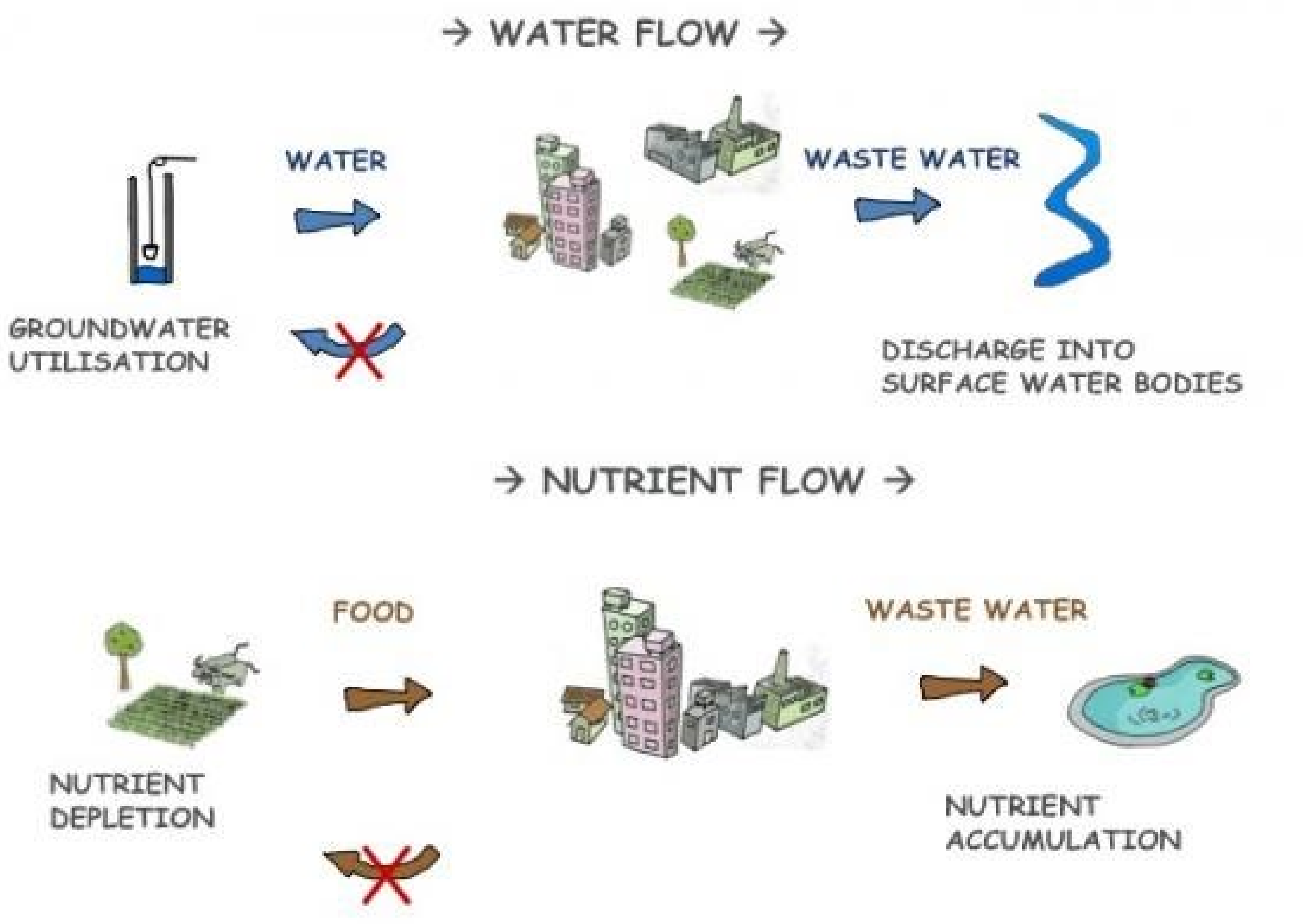
Consequences

- The German public sewage network is approximately **562,000 km** in length.
- Around **9,632** public WWTP plants are in operation and responsible for the treatment of **10 billion m^3** of waste water and the production of **1.85 Million t** of sewage sludge

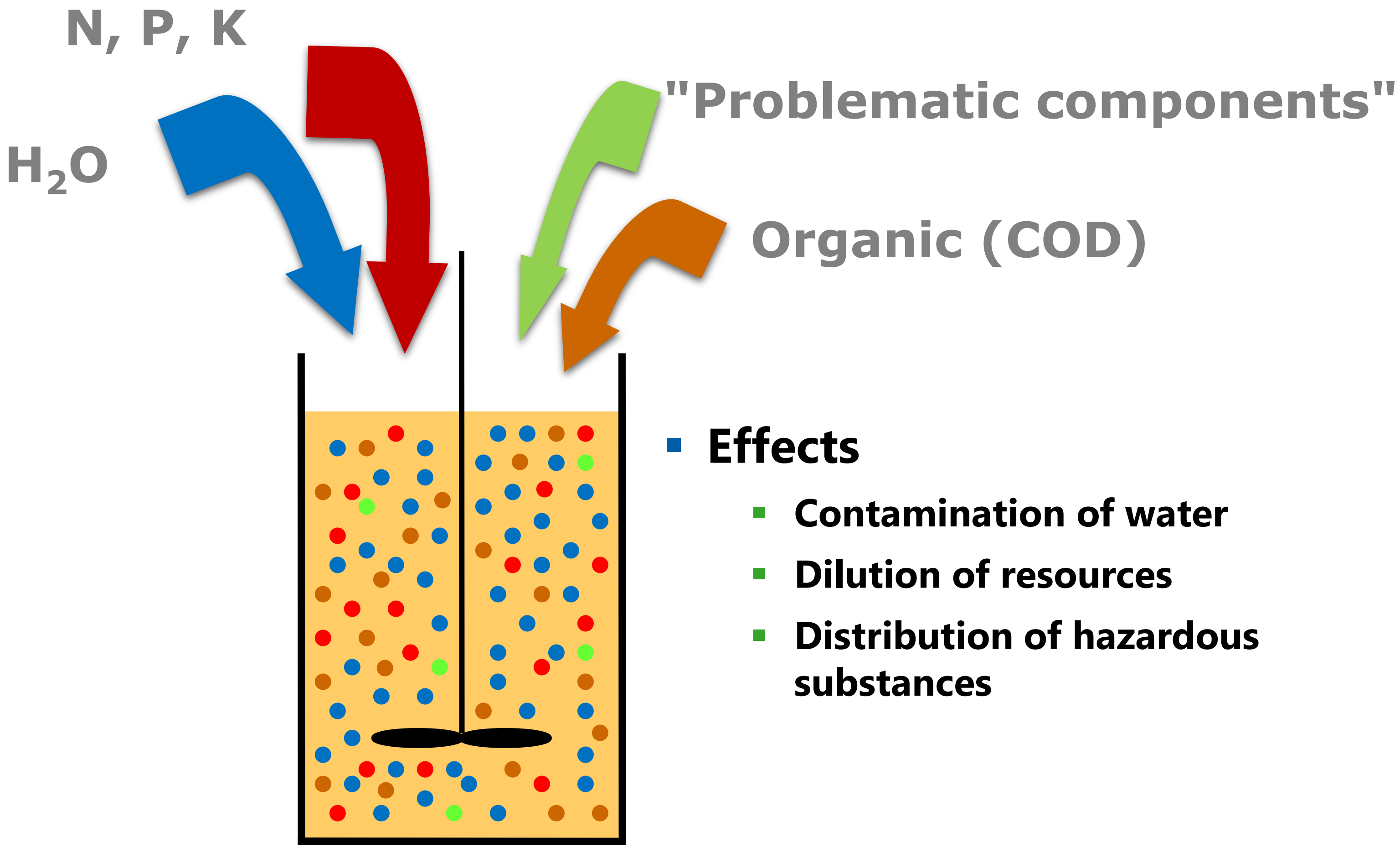
→Not sustainable, not transferable to most countries
(although a good quality of water bodies is reached in most rivers and lakes)



Current linear system



Waste water as a nutrient cocktail



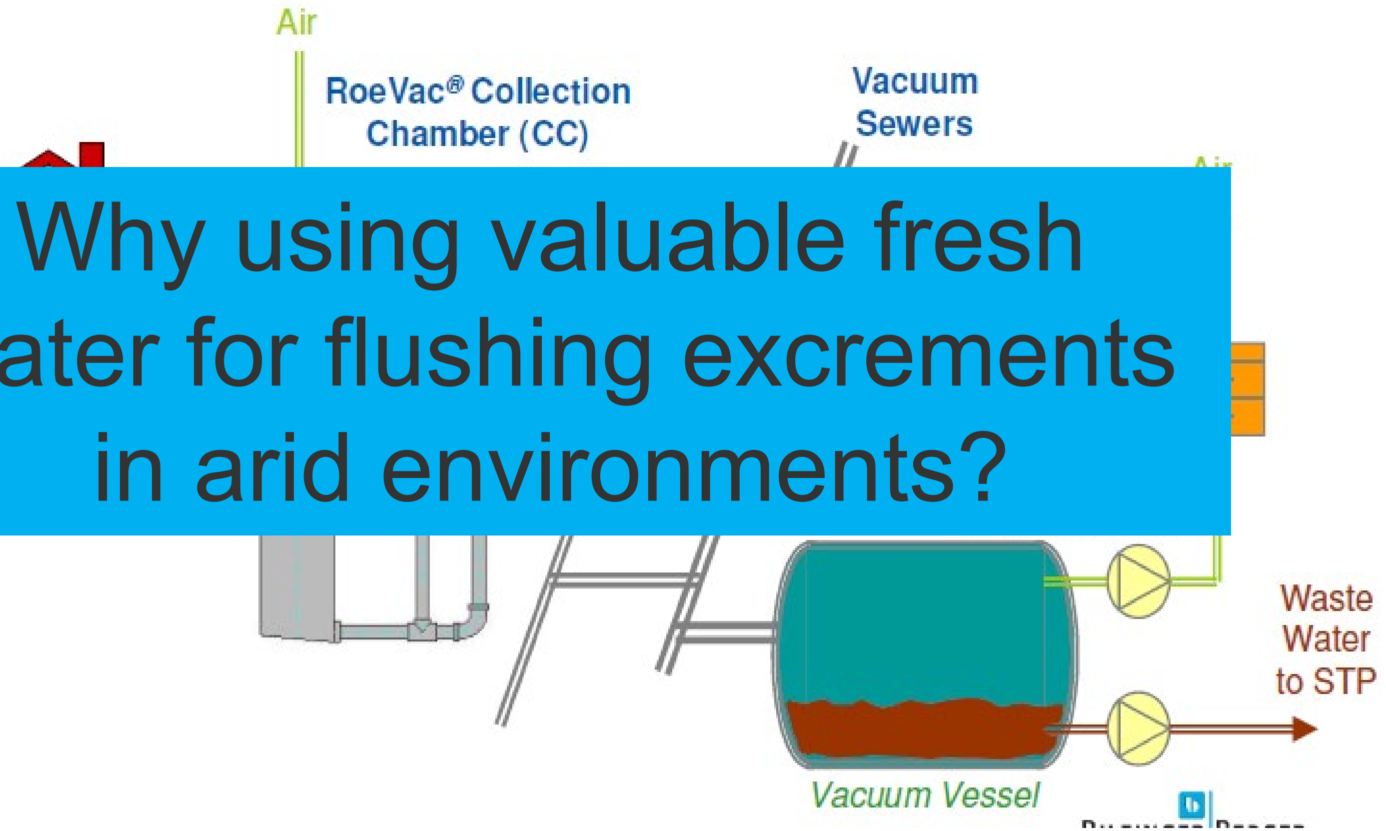
- **Effects**
  - **Contamination of water**
  - **Dilution of resources**
  - **Distribution of hazardous substances**

Separation of waste water flows

	70 % of energy demand in WWT	> 80 % of energy content	> 60% of heavy metals	
Individual Flows	Yellow Water (Urine)	Brown Water (Feces)	Gray Water (Household)	Rainwater
Process	Drying Process Nitrate	Anaerobic treatment Drying Composting	Constructed Wetland, Menbrane technology	Infiltration
End Product	Fertilizer	Biogas Soil conditioner	Irrigation Reutilization	Recycling to irrigation and Sanitary usage
	More than 60% of N and P			

Innovative drainage systems

Vacuum drainage system for the transport of waste water

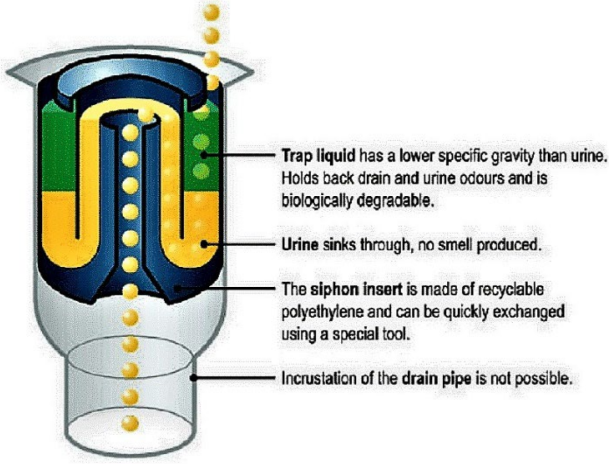


Why using valuable fresh water for flushing excrements in arid environments?

Source: Roediger Vacuum, 2010

Use case – Waterless urinals

	Conventional urinals	Waterless Urinals
		
CAPEX (€)	180	250
Water demand	3.7 l/flush	none
Water price	0.0016 €/liter	
Usage (per day)	100 times/day	100 times/day
Odor trap usage		7000 times (average)
Odor trap price		18 €/trap
OPEX (€/day)	0.6 (water cost)	0.0026 (Depreciation of the odor trap)
Water use	135 m^3/a (+10% for cleaning)	0.3 m^3/a (only for regular maintenance)



Water Resource | Urine as material source

IfaS

Collection	Convertion	Cleaning / Treatment	Evaporation	Fertilisation
Collection of urine using waterless urinals or separation toilets	Stabilization of nitrogen (nitrification)	The activated carbon filter removes pharmaceuticals and hormones	The distiller eliminates pathogens and reduces the volume	The process provides distilled water and Aurin-Vunas liquid fertilizer for plants (NPK + Trace nutrients)

Model	Unit	NX-200	NX-500	NX-1000
max. Vol. of urine processed	l/d	**200**	**500**	**1.000**
Average fertilizer production (7%)	l/d	**14**	**35**	**70**
Production of distilled water (93%)	l/d	**186**	**465**	**930**
Electricity demand				
Specific demand	kWh/l Urine	0,15	0,15	0,15
Daily demand	kWh/d	30	75	150
Investments /Costs / Revenue (net)				
Treatment Plant	€	**120.000 €**	**230.000 €**	**350.000 €**
Maintenance	€/a	5.000 €	5.000 €	6.000 €
Energy (0,28€/kWh)	€/a	3.066 €	7.665 €	15.330 €
Sales Revenue (4€/l fertilizer)	€/a	**20.440 €**	**51.100 €**	**102.200 €**
Payback period	a	10	6	4

Source: https://vuna.ch/aurin/; 2021

Water Resource | Urine as material source

1m³ of Urin contains:

9.2	kg	Nitrogen
1.0	kg	Phosphorous
2.2	kg	Potassium

- Treatment (elimination of nutrients and energy) of 1 m^3 wastewater takes on average 0.5 $kWh_{El.}$
- The Production of 1 kg Nitrogen takes approx. 10 $kWh_{El.}$
- The Exploration of 1 kg Phosphorous takes approx. 10 $kWh_{El.}$

→ Conventional wastewater treatment destroys valuable raw materials and energy by using fossil energy and **money!**

From waste water treatment station to power station

IfaS

From WWTP to Power Plant!

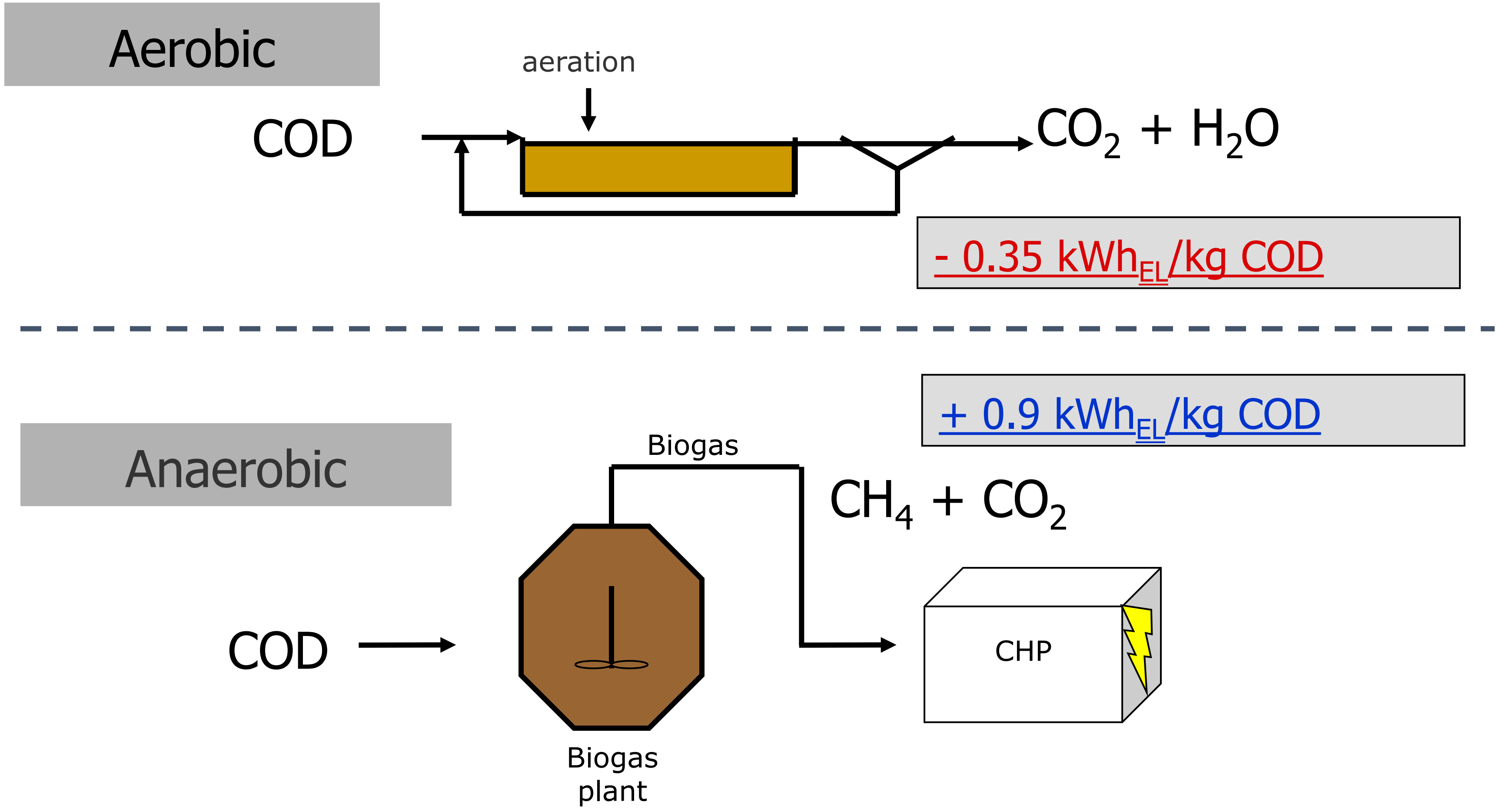
- Reduction of energy use
- Increase of own power production
- Decrease of operation costs
- Synergies between waste water and waste treatment (co-fermentation)

GHG reduction

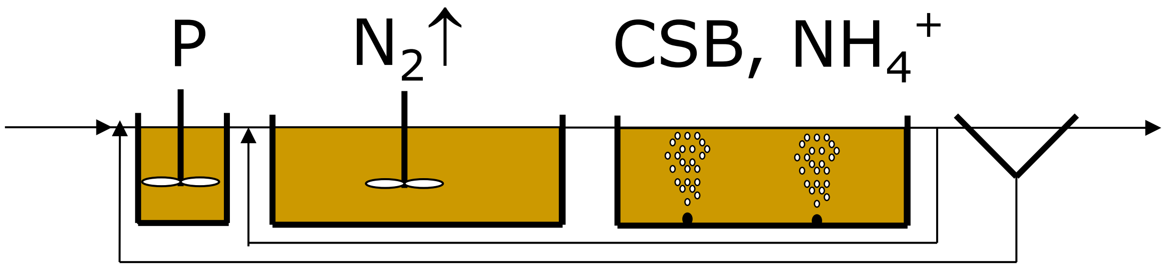
Economic revenues

Bildquelle: https://www.ste-kl.de/

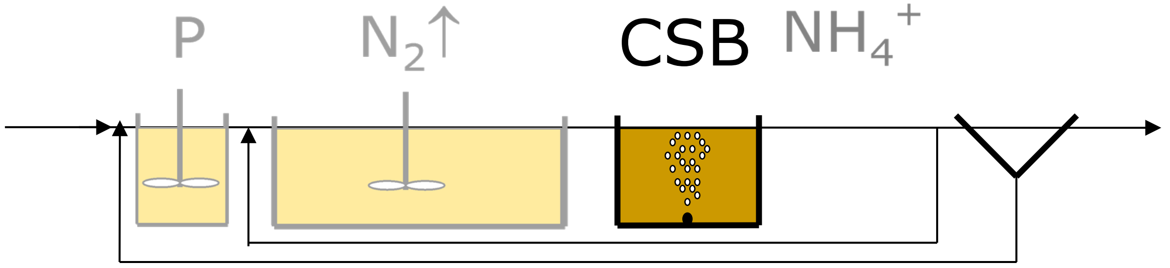
Aerobic versus Anaerobic process



BAU (herkömmliches Abwasser)



After separation of yellow water



Vergleich

V_{BB} -75%

O_2 -50%

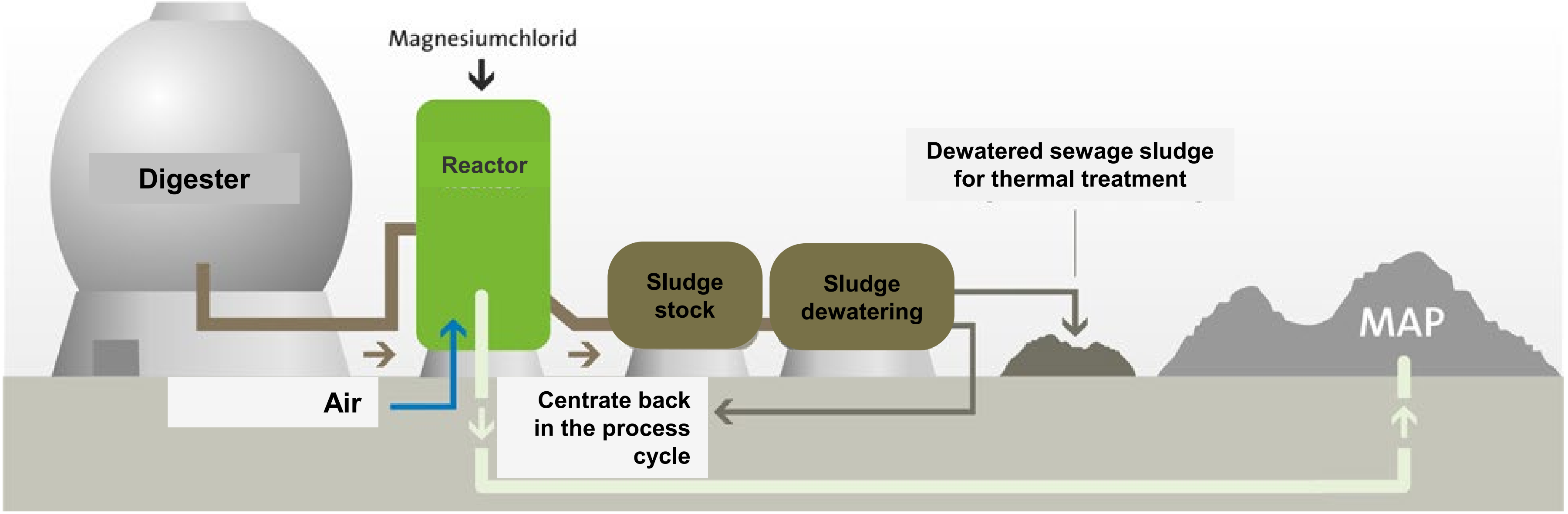
$ÜS_d$ +5%

Fe^{3+} -80%

→ Urin (0,8 % of waste water amount but 87% of N) responsible for 75% of total costs in waste water treatment!!!

Technical conception for recycling of nutrients

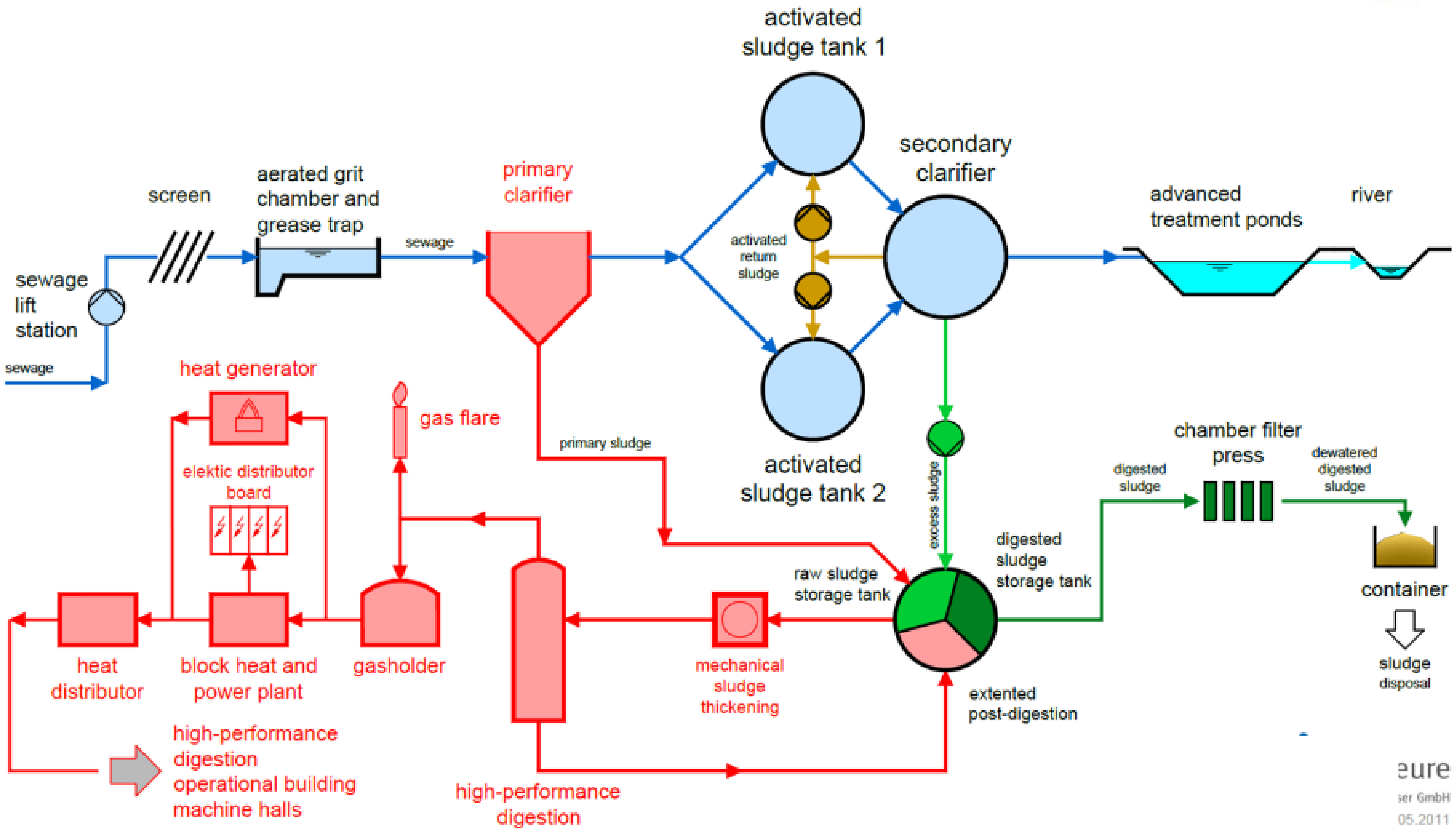
- Magnesium Ammonia Phosphate (MAP)



- Products:
  - e.g. Berliner Pflanze®
  - 0,5 kg 2.50 EUR
  - 2 kg 4,00 EUR
  - 5 kg 10,00 EUR

Source: Berliner Wasserbetriebe, 2016

Energy positive WWTP



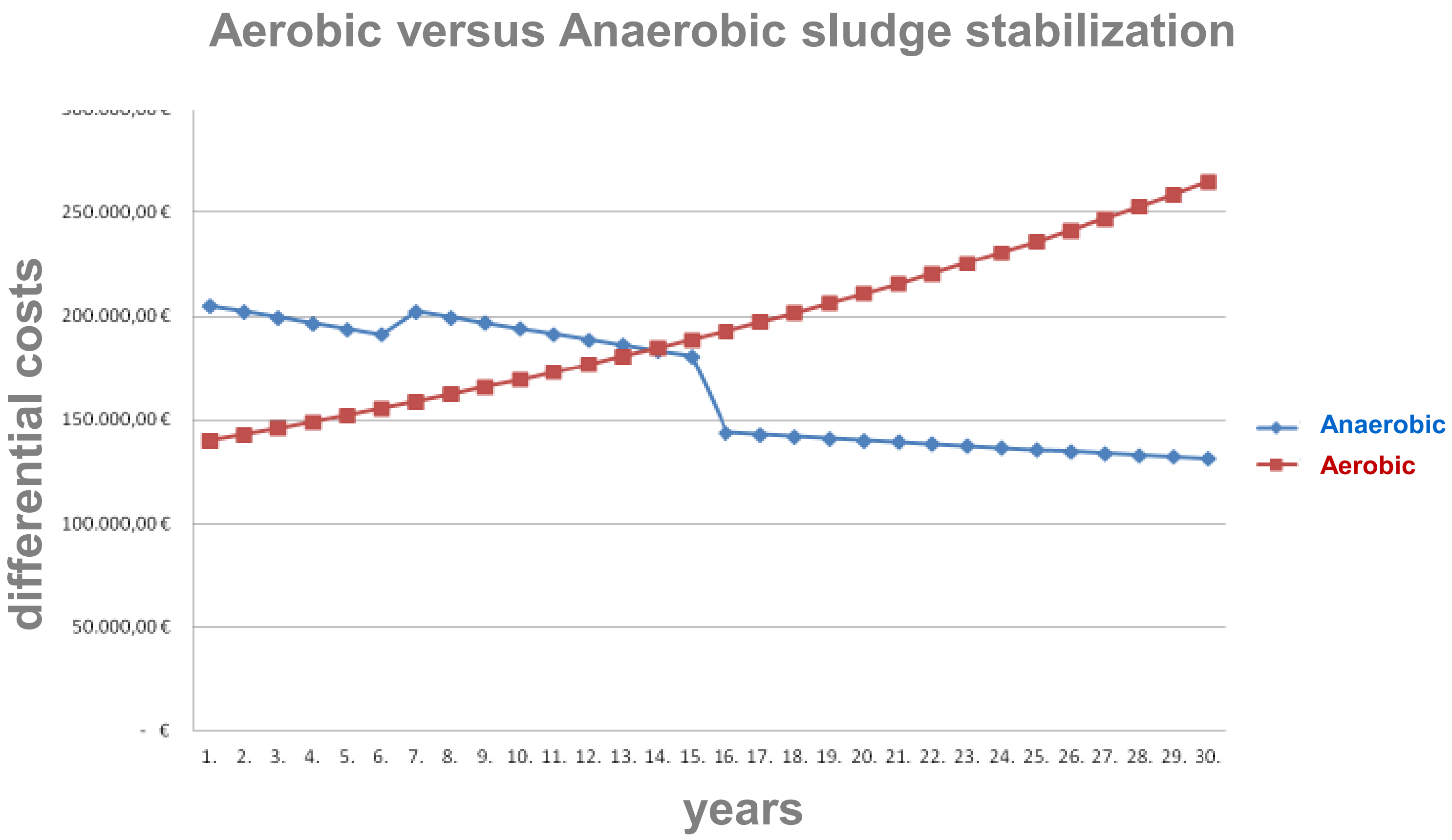
Source: Dipl.-Ing. Stefan Krieger, HYDRO-Ingenieure Energie & Wasser GmbH, 2011

Cost comparison old status and optimized

Parameters	Old status	Energy independent
Average size of WWTP	24.000 EW	24.000 EW
Total power consumption	**480.000 kWh/a**	**425.000 kWh/a**
Specific power consumption	20 kWh/(PE*a)	17,6 kWh/(PE*a)
Power production	**0 kWh/a**	**470.000 kWh/a**
Consumption of liquid gas	3.800 l/a	0 l/a
Sewage sludge	1.200 t/a	840 t/a
Lime addition for drainage	157 t/a	105 t/a
Fe³Cl addition for drainage	87 t/a	58 t/a
Investement		1.709.500 €
Running costs (energy, maintenance, others)	**137.300€/a**	**57.000€/a**

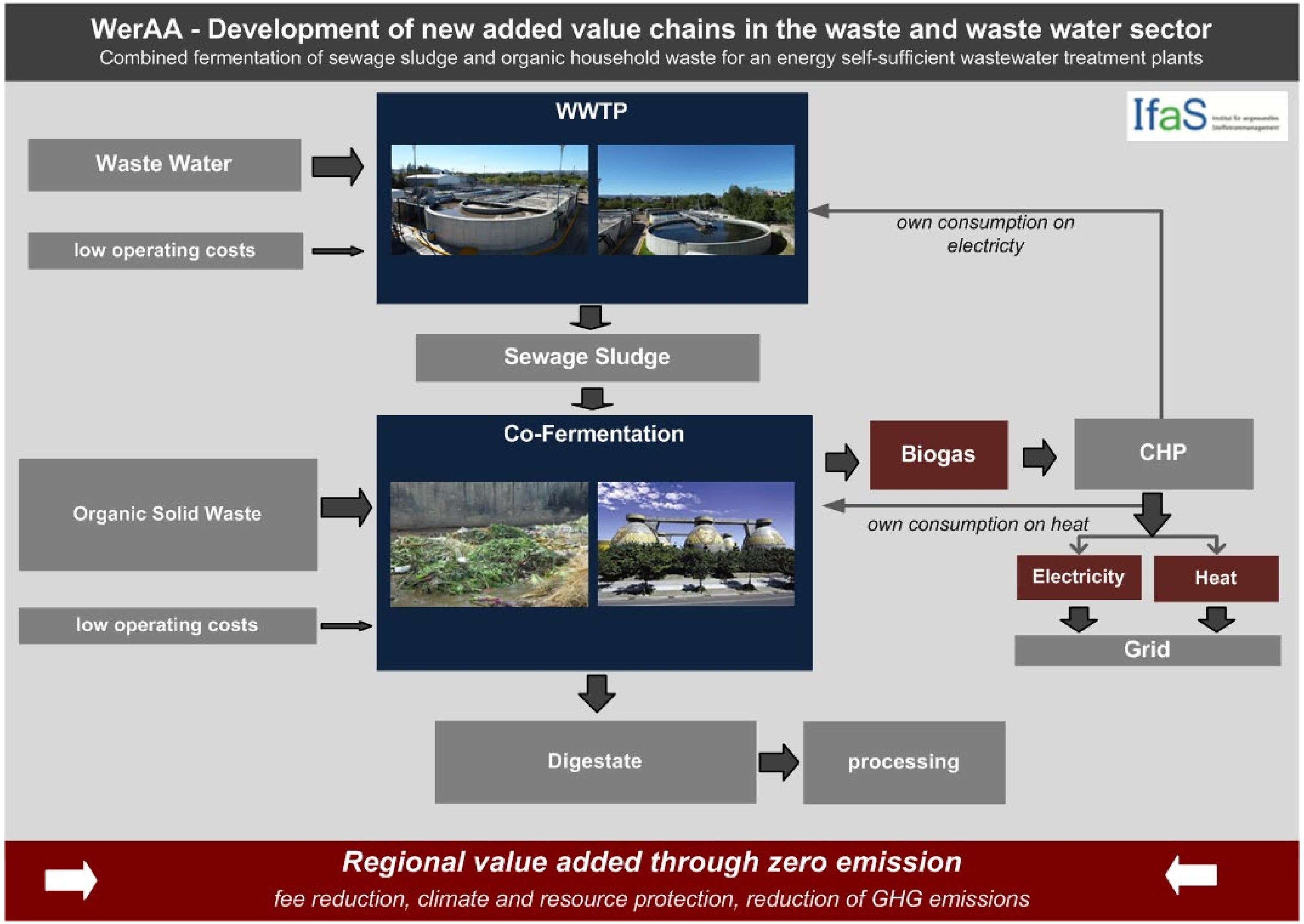
Source: Dipl.-Ing. Stefan Krieger, HYDRO-Ingenieure Energie & Wasser GmbH, 2011

Economic comparison



Source: Dipl.-Ing. Stefan Krieger, HYDRO-Ingenieure Energie & Wasser GmbH, 2011

Co-Fermentation



SPONSORED BY THE

Federal Ministry of Education and Research

FKZ 03FH046PX5

Waste as a management failure
No waste strategy
Ressource Centers

From Waste to Resource Management



Municipal Waste Fractions - Resource Waste

- Municipal solid waste: organic and non-organic materials like paper, cardboard, plastics, metals textiles.
- Municipal wastewater
- Agricultural and greenery waste
- Waste from food industry
- Etc.

Potentials

Definition:

„Material-Flow-Management means the goal oriented, responsible, integrated and efficient influencing of material systems.

The goals are given by ecological and economical areas and by observing social aspects."

Enquête-Commission of the German Bundestag: „Protection of human beings and environment", 1994, p. 259

Introduction to the Legal Framework of Circular Economy in Europe & Germany

Legal Framework in Germany

European Laws

<u>EU Waste Framework Directive</u>
Waste hierarchy
Waste prevention & recycling
Polluter pays principle & producer responsibility
Waste Management Plans & Waste Prevention Programs

European waste catalogue
Designation and classification of waste

German Federal Law

<u>Circular Economy Law</u>

- Basic obligations of the circular economy
- Measures & strategies
- Obligations of the federal state and municipalities

State Law of German Federal States

- Laws
- Administrative Regulations
- Municipal Code

The Municipal Disposal Law

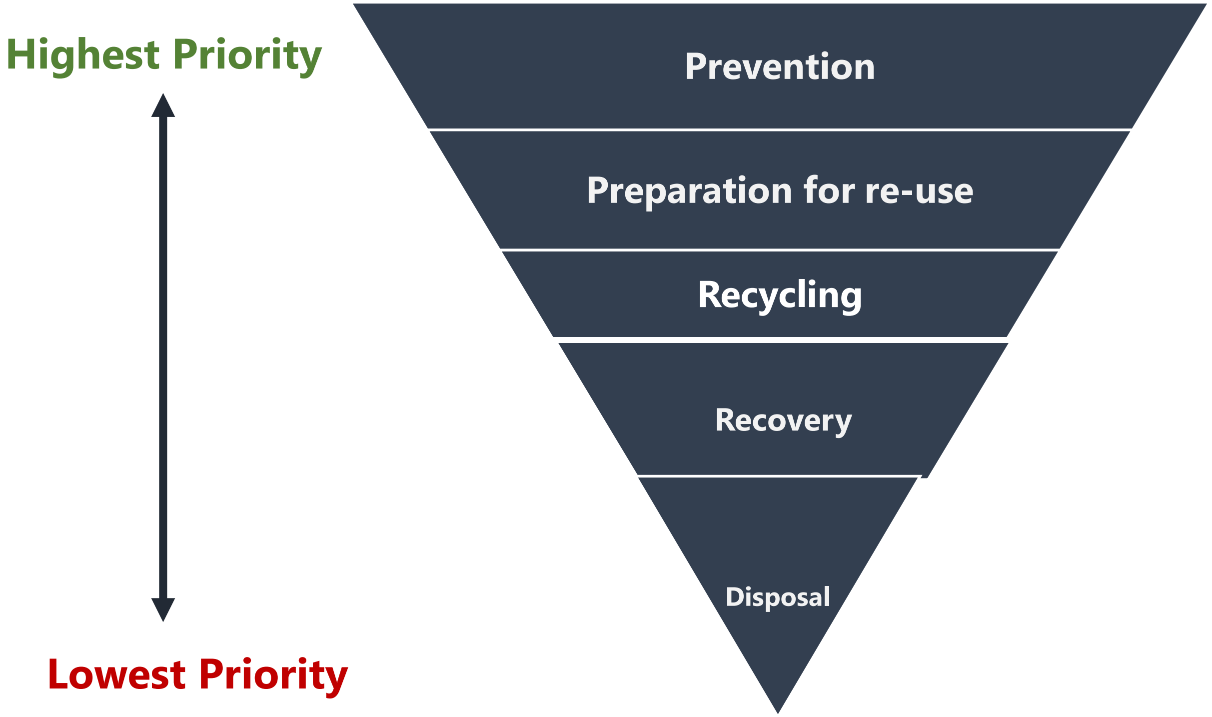
Specification of implementation-related matters on the municipal level

Source: Own Elaboration According to European and German Laws

Waste Management Hierarchy

- The Five-Step “Waste Hierarchy”, is established in the Waste Framework Directive.
- **Priority order in waste prevention and management** (Art. 4)

Waste Management Hierarchy:



- Waste **prevention**
- Reduction of **miss throw** (residual waste etc.) → **More recycling**
- **Reduction** of food wasting
- **Anaerobic treatment** instead of composting
- **Reduction** of incineration
- **Reduction** of disposal

Source: Own Elaboration According to European Waste Directive

Legal Framework of European Union: The Waste Framework Directive

The Waste Framework Directive sets the **basic concepts** and **definitions** related to waste management, including definitions of waste, recycling and recovery.

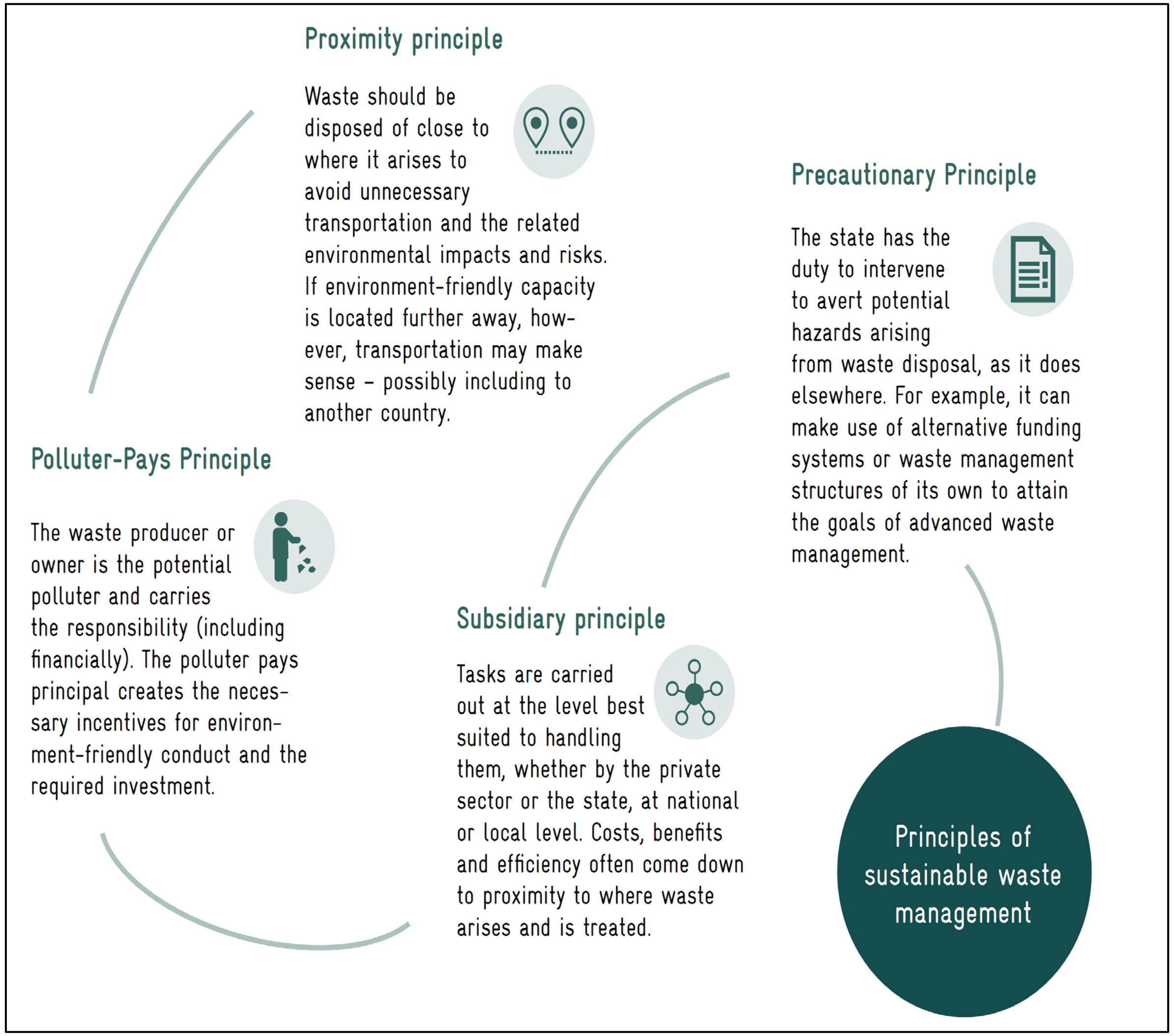
The Waste Framework Directive lays down some **basic waste management principles**. It requires that waste be managed:

- without endangering human health and harming the environment
- without risk to water, air, soil, plants or animals
- without causing a nuisance through noise or odors
- and without adversely affecting the countryside or places of special interest.

Source: European Commission [DG ENV–Unit C2], Use of Economic Instruments and Waste Management Performances, Final Report, 2018

Principles of Sustainable Waste Management

- **Waste Hierarchy Principle:** Waste prevention, reuse, recycling, (energetic or other) recovery, disposal.
- **Polluter-Pays Principle:** those generating waste also pay for its treatment – this is needed in order to create necessary investments and incentivize environmentally friendly behavior.
- **Precautionary Principle: T**he government has the duty to intervene in order to prevent possible damage to the environment and/or human health.
- **Proximity Principle:** waste should be treated/ disposed of as close as possible to the place of its origin in order to avoid unnecessary transportation as well as associated environmental pollution and risks.
- **Subsidiarity Principle:** who is doing the job, depends on who is doing it best. Cost, benefit, and efficiency are often determined by proximity to waste generation and treatment.



Source: GIZ, 2019

EU action plan for the Circular Economy

Transition towards a circular economy

On 18th April 2018, the EU Parliament adopted the EU Circular Economy Package:

- Increase the processing and recycling rate: **70%** packaging waste and **65%** municipal waste
- Restriction of landfilling of municipal waste to 5%
- Reduction of food waste
- Strengthening cooperation between EU countries

2020 → **2030** → **2050**

EU Waste Framework Directive:

- Reprocessing and Recycling
- At least 50% municipal waste
- At least 70% of construction and demolition waste

Resource-efficient Europe:

Strengthening economic performance & reducing the use of resources

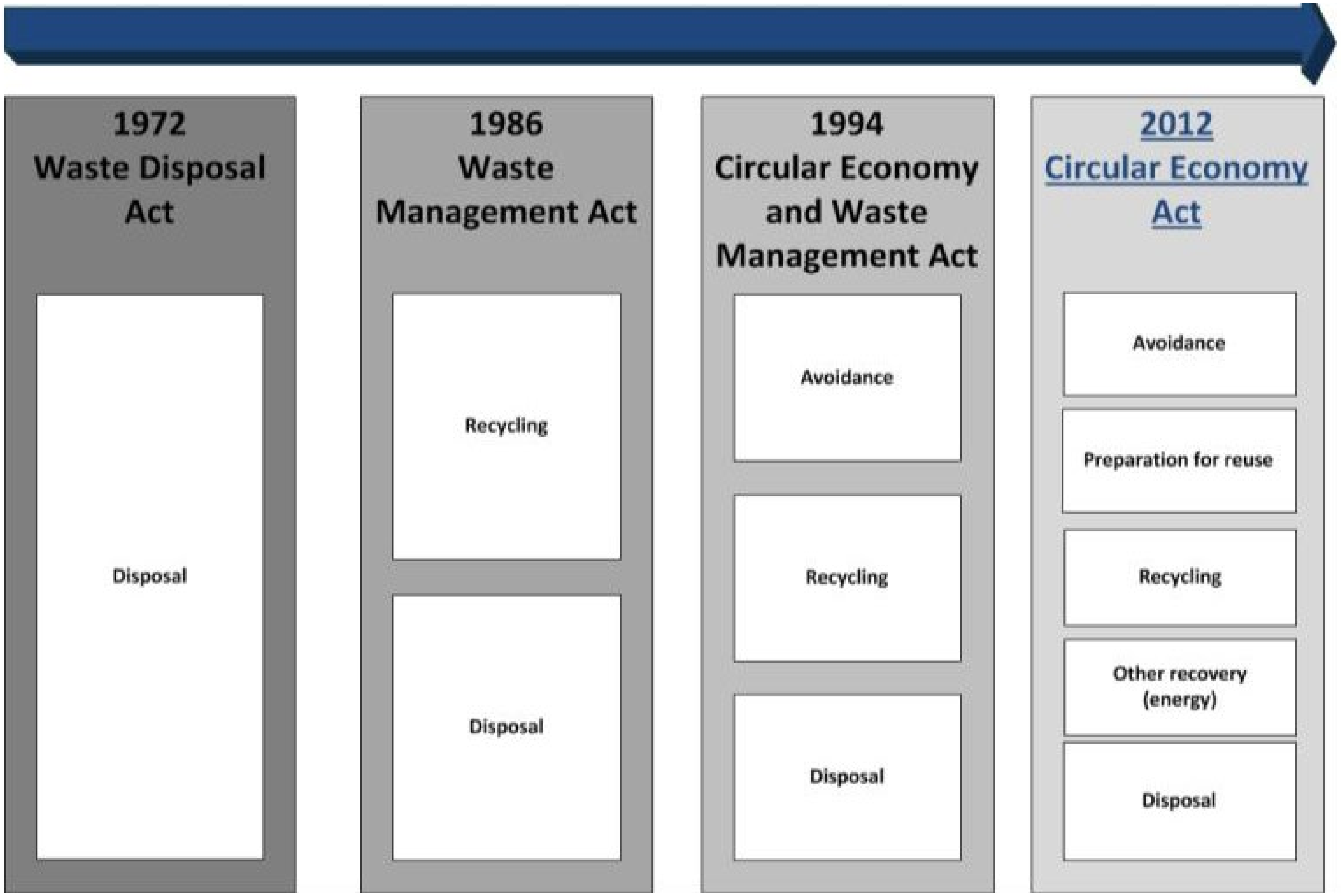
Securing the supply of resources

Combating climate change & controlling the environmental impact of resource use

Source: IfaS, 2019, in Anlehnung an die EU-waste framework directive, EU Action Plan / Circular economy package

Historical Development of the German Waste Management / Circular Economy Law

IfaS



Source: Own Elaboration According to German Laws

Waste Management in Germany

Waste management in Germany has evolved into a large and powerful economic sector.

More than 270,000 people work in about 11,000 companies, with an annual turnover of around **70 billion euros**.

More than **15,500 waste management facilities** help to conserve resources through recycling and other recovery operations.

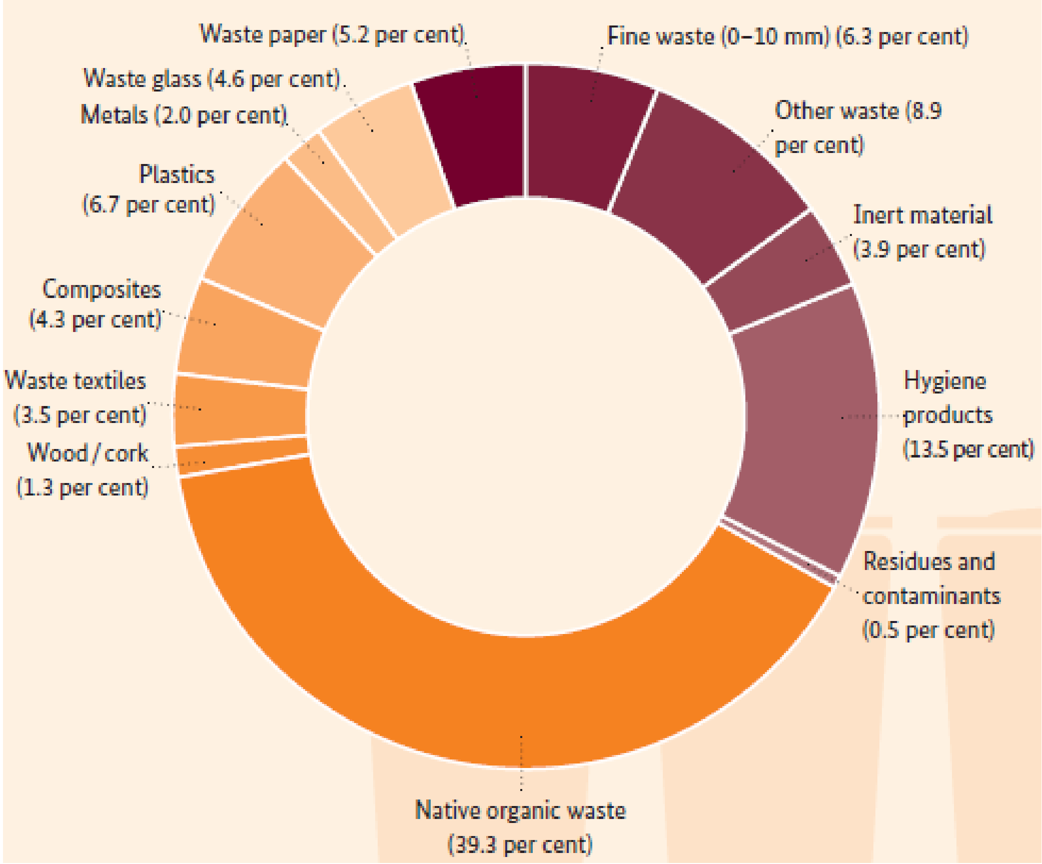
Germany's **high recycling rates of per cent for household waste**, around **70 per cent for production and commercial waste**, and almost **90 per cent for construction and demolition waste** speak for themselves.

Source: BMU, 2018

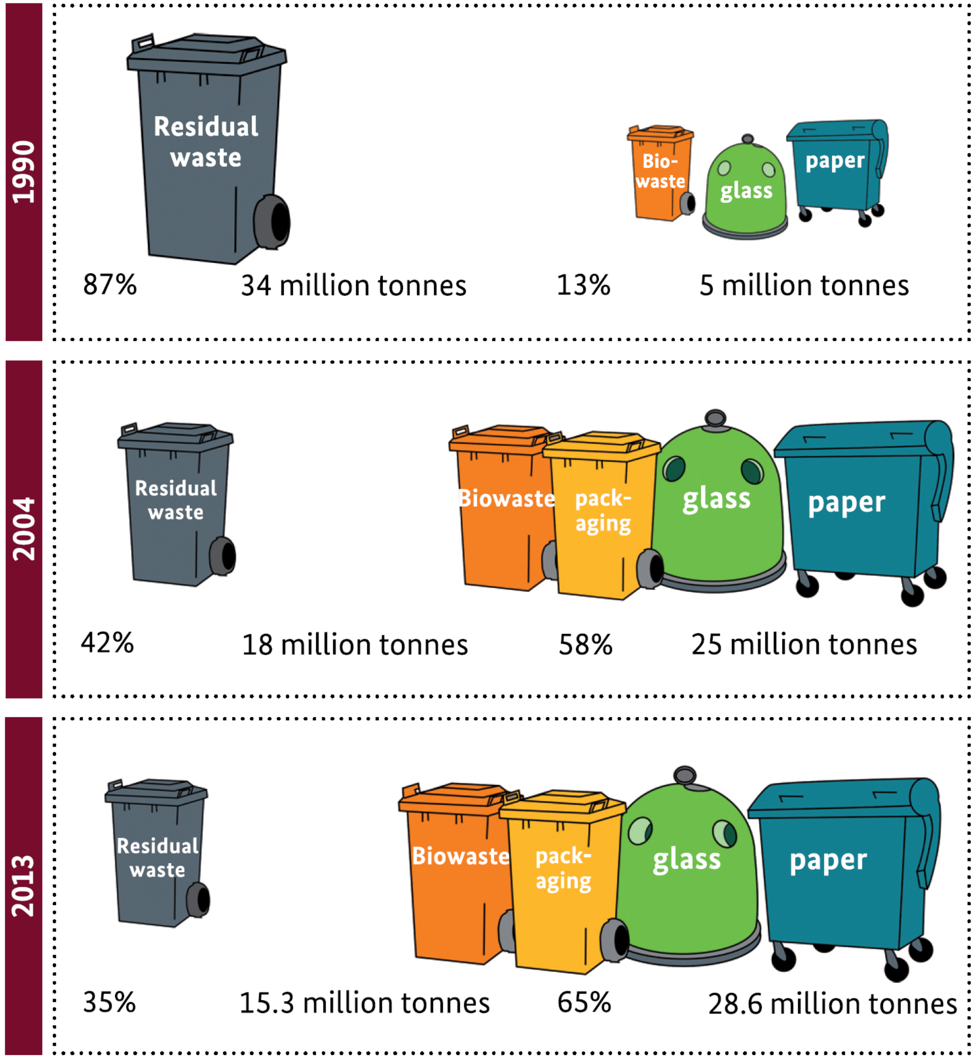
More Recyclables than Residual Waste

The contribution of the waste management sector to a sustainable economy in Germany is shown by the **high recycling quota**

Composition residual houshold waste in Germany



Source: Federal Environment Agency, 2020



Source: Federal Statistical Office (Statistisches Bundesamt) 2015, own calculations

Treatment of Separated Selected Municipal Solid Waste Fractions

Separated Municipal Solid Waste Fractions:

Plastics	Papier Cardboard	Glass	Organic Waste	Residual Waste
				

Transport to the Different Treatment Plants:

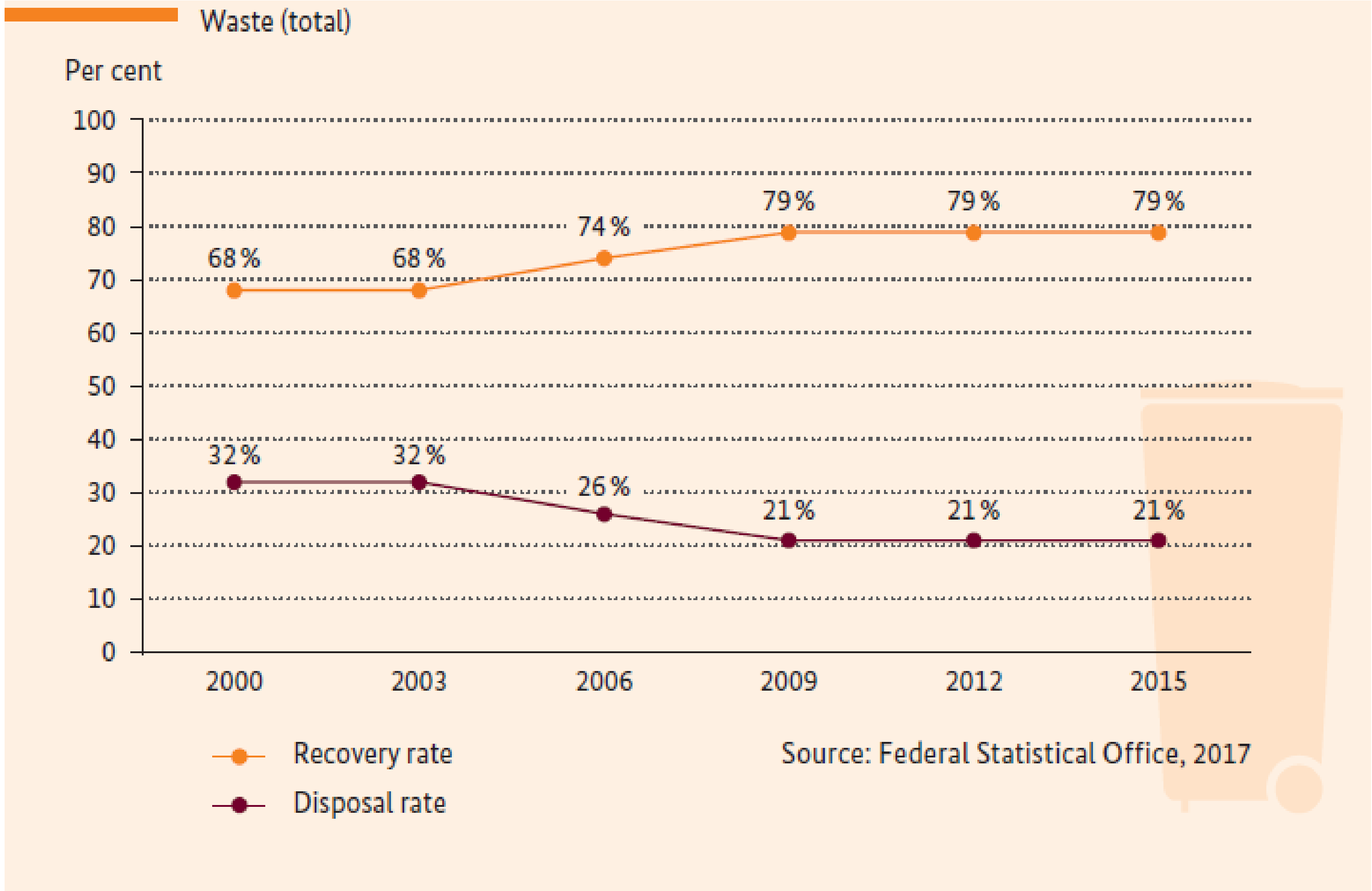
Plastic Recycling Plant	Paper & Cardboard Recycling plant	Glass Recycling Plant	Fermentation or Composting Plant	Mechanical Biological Treatment Plant

Source of the Diagram: Martínez, 2023
Source of the container pictures: https://kaufbauer.de

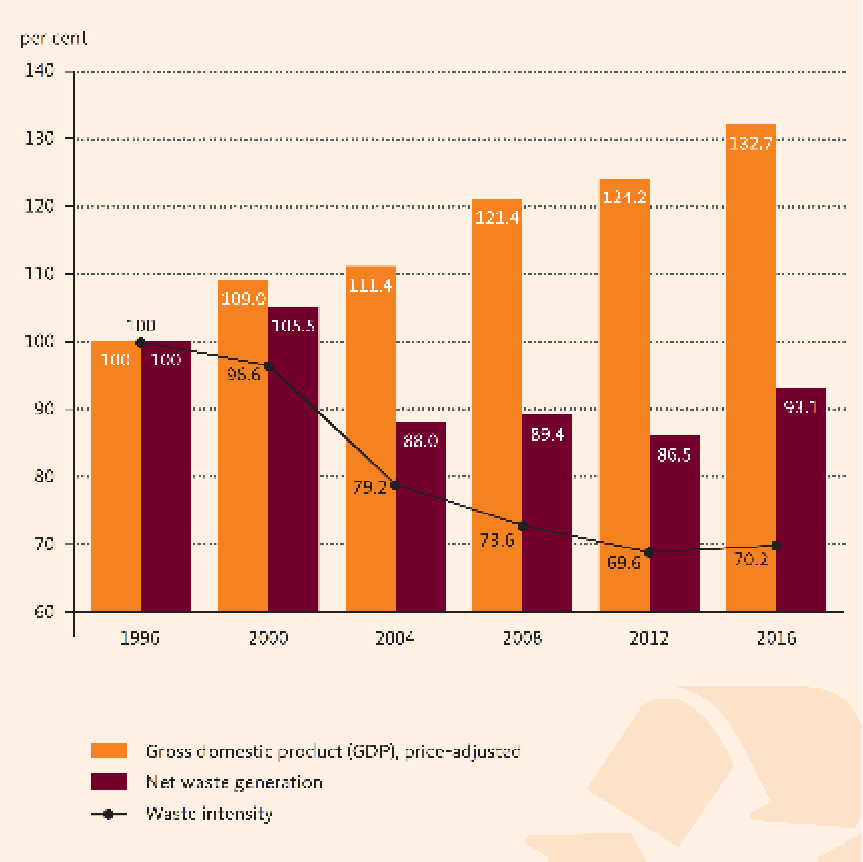
Municipal Waste in Germany

Source: NABU, 2019: „Wege unseres Hausmülls“, https://www.nabu.de/umwelt-und-ressourcen/abfall-und-recycling/20810.html, Data: 30.06.2019

Recovery & Disposal Rates (%) of MSW (2000 – 2018)



Decoupling Waste Generation from Economic Output (1996 – 2016)



Prohibition of Untreated Waste Disposal, since 2005

Source: Waste Management in Germany 2020, BMU, 2020

Bio-Waste Container
Door-to-door collection

IfaS

- In **2017** the volume of biowaste collected separately from private households increased by more than **500,000 tonnes.**
- About **14,2 million tonnes** of biodegradable waste were treated in composting and anaerobic digestion plants or biogas installations.
- Of this, 4.9 million tonnes were collected in organic waste bins and 5.4 million tonnes were garden and park waste. This corresponds to an average collection rate of 125 kilograms per capita per year.

Biowaste

<u>Organic solid waste is a resource</u>

1 Tonne of organic waste:

- 100 m³ biogas
- 200 kWh Electricity+ 250 kWh Heat
- 45 -60 L Fuel eq.
- 600 Kg organic fertilizer

Source: Waste Management in Germany 2020, BMU, 2020

Organic Waste Valorization & Treatment

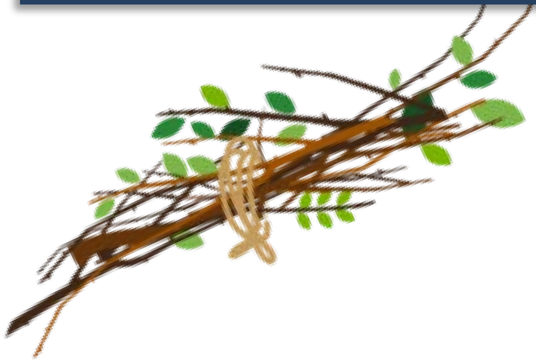
- Resource Center: Utilization of Organic Waste

Separate bio waste collection

Fertilizer

Energy

Green waste



Energetically and material utilization

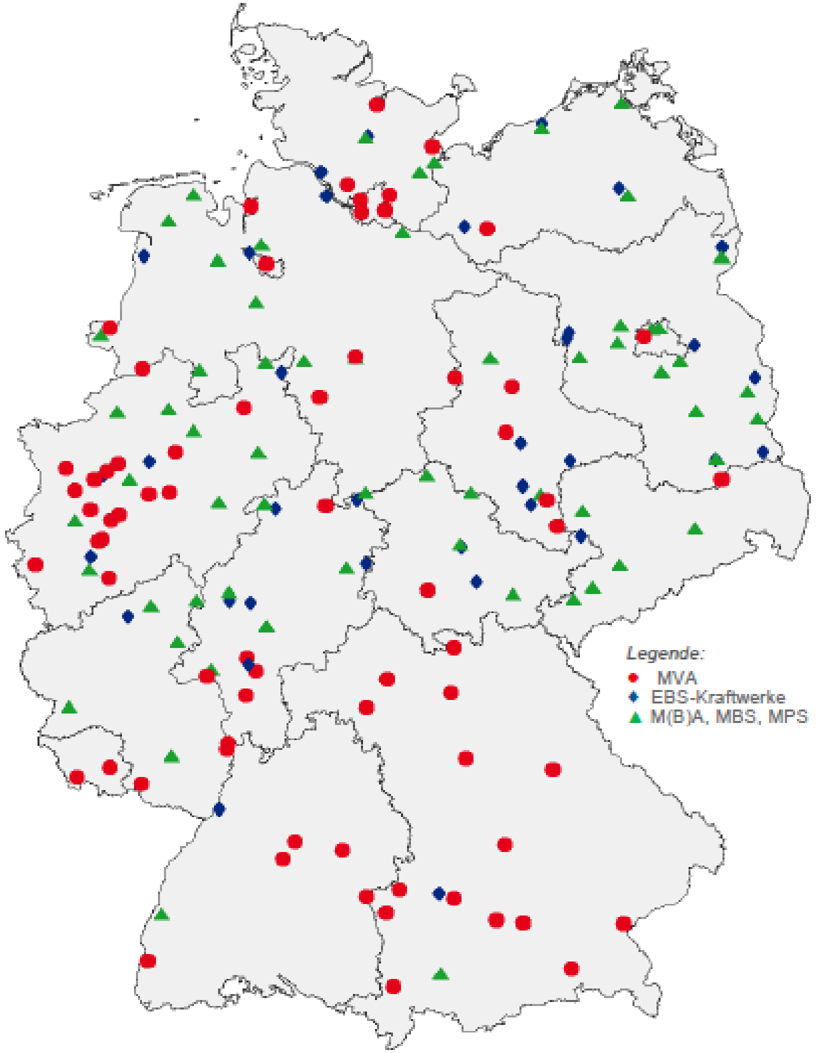
Advantages of the Biological Treatment

High investments … but;

- Environmental and climate protection
- Regional added value
- Production of renewable energies (heat and electricity)
- Compost production
- CO_2 Neutral
- Hygenization of the biomass
- Technology transfer
- New jobs

Waste Treatment Capacity in Germany

IfaS



Quelle: ITAD, ASA, Prognos ergänzende Eigenrecherchen und Analyse

Source: Prognos, 2014

- 68 MVA
- 19,6 Mio. Mg/2013

- 61 M(B)A / MBS/ MPS
- 6,1 Mio. Mg/2013

* Aßlar wurde zum 31.12.2013 geschlossen

- 35 EBS-Kraftwerke (Mittelkalorik)
- 5,4 Mio. Mg/2013**

** eine weitere Anlage im Bau

Nachrichtlich:

- 39 Mitverbrennungsanlagen (Mittel- und Hochkalorik)
- 2,8 Mio. Mg/2013

Ressource Center instead of landfill!!

- Biowaste is seen and treated as a resource!
- Industrialised (space efficient) design
- Serving as base load power plants

Sustainable Resource Management = Economic Promotion Strategy + Environmental Protection

Source: Prices IfaS, 2010; MSW-composition OECD, 2002

From linear to circular...

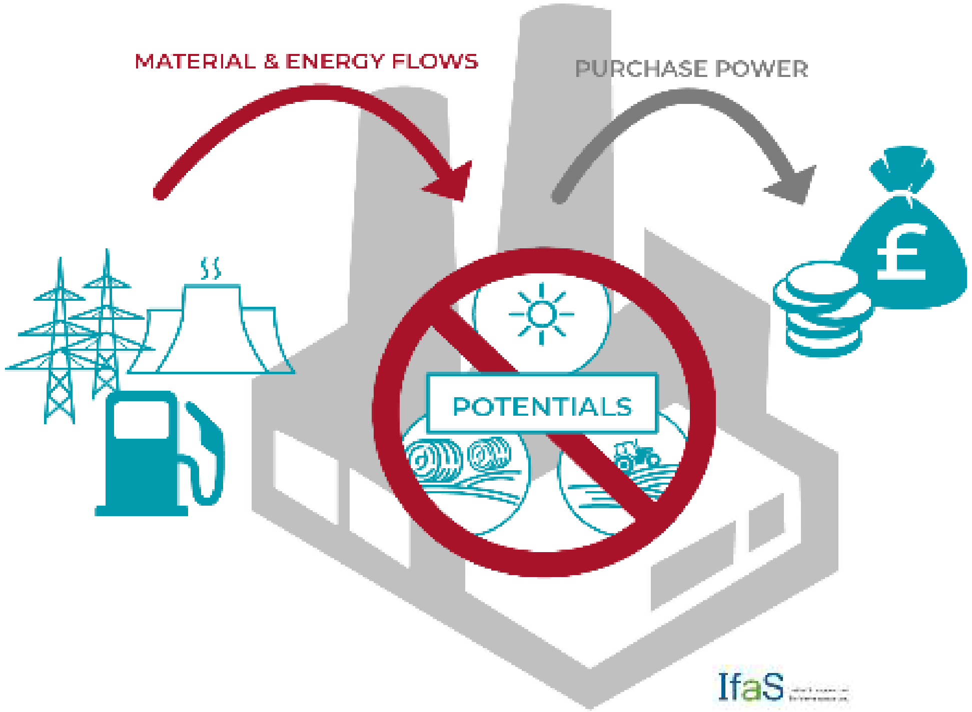
Landfill Foz do Iguacu, Brazil. Source: Martínez, 2019

✓ Resource Centers

Rhein-Hunsrück Entsorgung. Source: RHE, 2022

Linear Economy - Nowadays “Throughput Society”

Vision and Goal – Zero Emission!



Linear Economy

- Inefficient system
- Cost intensive
- High Environmental impact
- No regional added value

Source: IfaS, 2020

Just a deeper look!

- Understand the system
- Review data provided
- Mapping and sampling
- Pricing the unprized
- Comparison to BAT
- Listen to weak signals

→ Communicate!

Energy – soil – fertilizer nexus

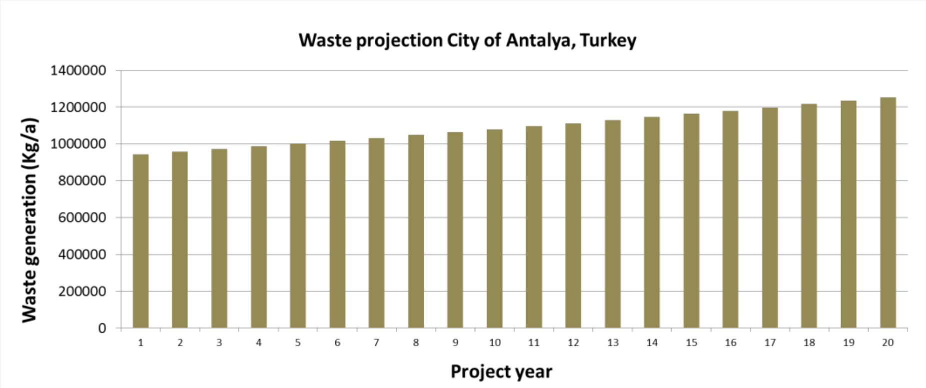
Waste „Management“ ?...

Impressions of the Landfill “Kizilli”

Determination of Waste Quantities

The estimated MSW amount to be processed in the resource centre of Antalya within its first year of operation (expected 2015) is **943.366 t/a**

MSW Composition		1 2015	5 2019	10 2024	15 2029	20 2034	Total in the project period	Average per year in 20 years of the project
Glas	7,35%	69.268,13	73.518,67	79.200,49	85.321,42	91.915,40	1.601.733	80.087
Metals	1,34%	12.628,48	13.403,40	14.439,27	15.555,20	16.757,37	292.017	14.601
Paper and cardboard	7,45%	70.210,56	74.518,93	80.278,05	86.482,26	93.165,95	1.623.526	81.176
Plastics	9,47%	89.247,51	94.724,06	102.044,71	109.931,14	118.427,05	2.063.730	103.186
Organic materials	48,80%	459.902,71	488.123,97	525.848,15	566.487,80	610.268,24	10.634.637	531.732
Other materials	13,69%	129.017,79	136.934,78	147.517,65	158.918,40	171.200,25	2.983.364	149.168
Inert Materials and ashes	12,00%	113.090,83	120.030,48	129.306,92	139.300,28	150.065,96	2.615.075	130.754
Total	**100%**	**943.366**	**1.001.254**	**1.078.635**	**1.161.996**	**1.251.800**	**21.814.081**	**1.090.704**



Source

Initial situation of the solid waste management

IfaS

Cachimba Landfil

Landfills in Turkey
Example: Antalya and Kumluca

Source:
IfaS

IfaS

Current situation of waste management: Praia und Sao Vicente, Cape Verde

Lixiera Praia, Santiago

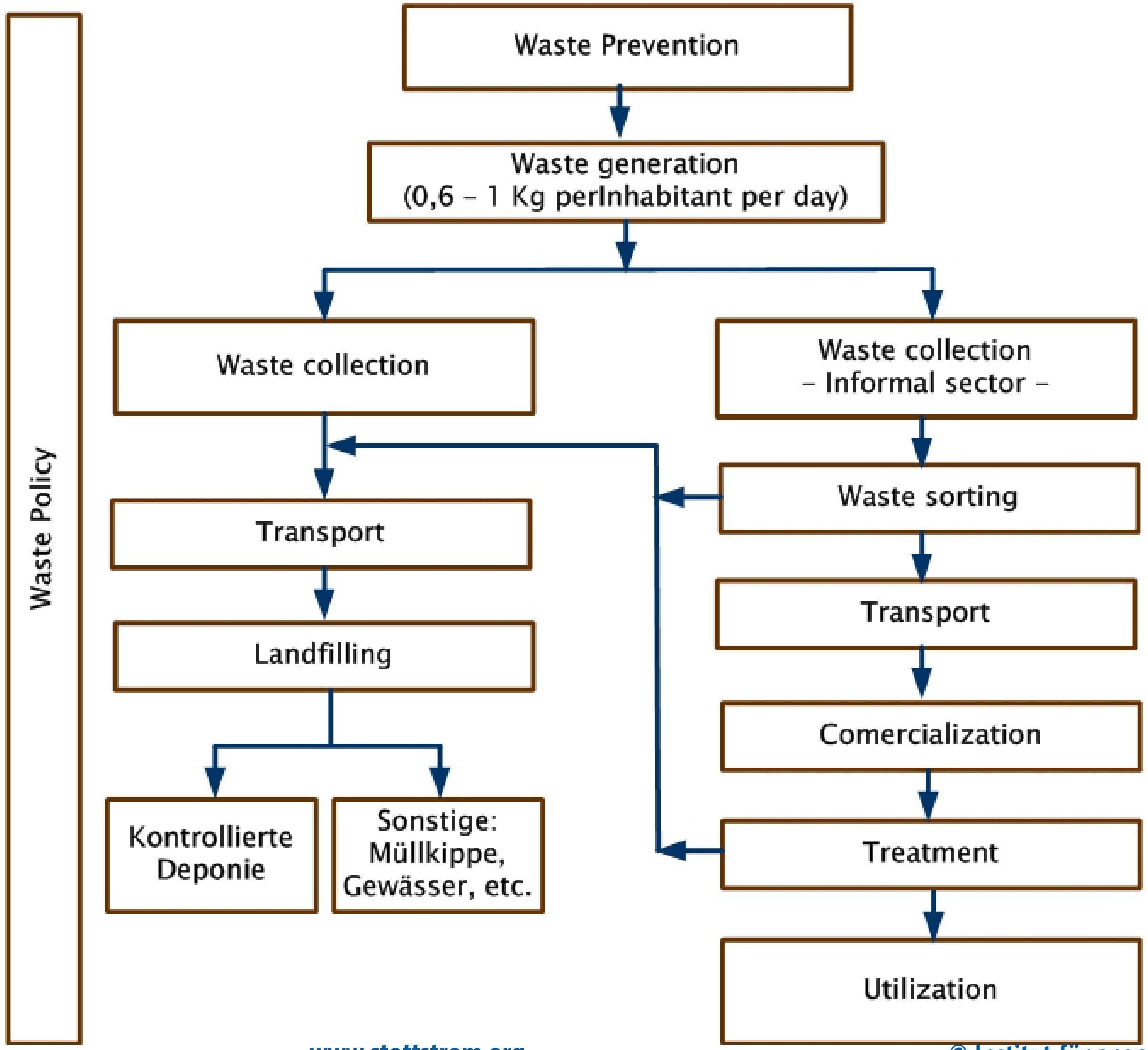
Lixiera Mindelo, Sao Vicente

Source:
IfaS, April 2012

Summary: Current situation of waste management

- The energy potentials from waste are not used
- Low recovery of recyclable materials (only 10%)
- Inadequate work conditions for the informal waste pickers
- Lack of information (quantity, quality and operational costs of the current MSW management system)
- High local and global environmental pollution (by importation and uncontrolled burning of materials)
- High transport costs
- No added value
- Etc.

Current situation of the MSW in DC / LDC



Source: Martínez, 2011

Actual effects from waste treatment in landfills

- Large transportation efforts
- Treatment costs for leachate
- Global warming
- Additional energy required for treatment on landfill
- External effects by methane emissions, water pollution
- Energy content in waste is not being used
- No creation of new jobs
- Landfill space will be used up (additional investment costs)
- Difficulties in finding new landfill space

- → negative added value!!!

Landfills in Turkey
Example: Antalya & Kumluca

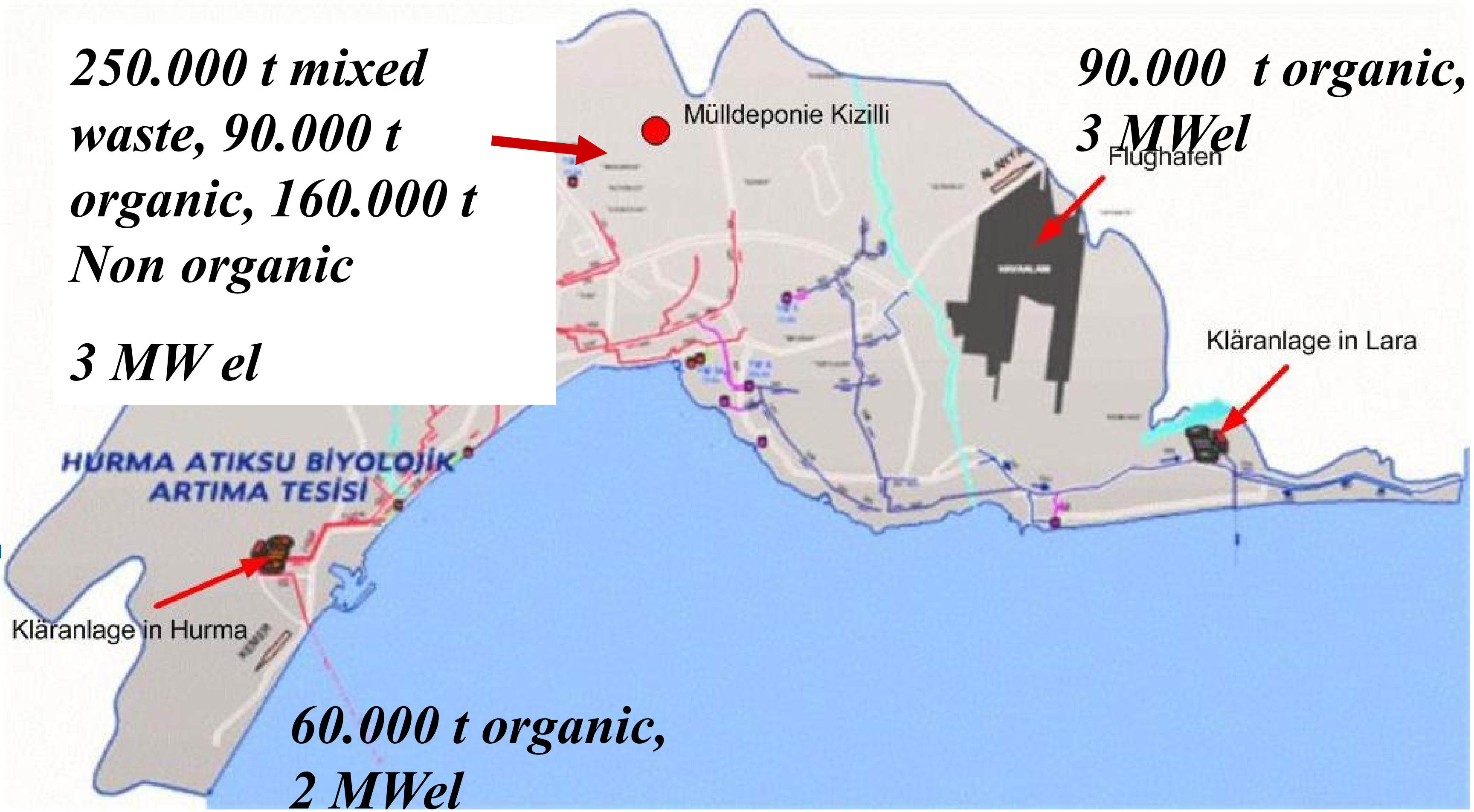
Source: IfaS, 2006

Case study Turkey City of Antalya

250.000 t mixed waste, 90.000 t organic, 160.000 t Non organic

3 MW el

90.000 t organic, 3 MWel



60.000 t organic, 2 MWel

Waste water treatment plant: potential heat customer for sludge drying

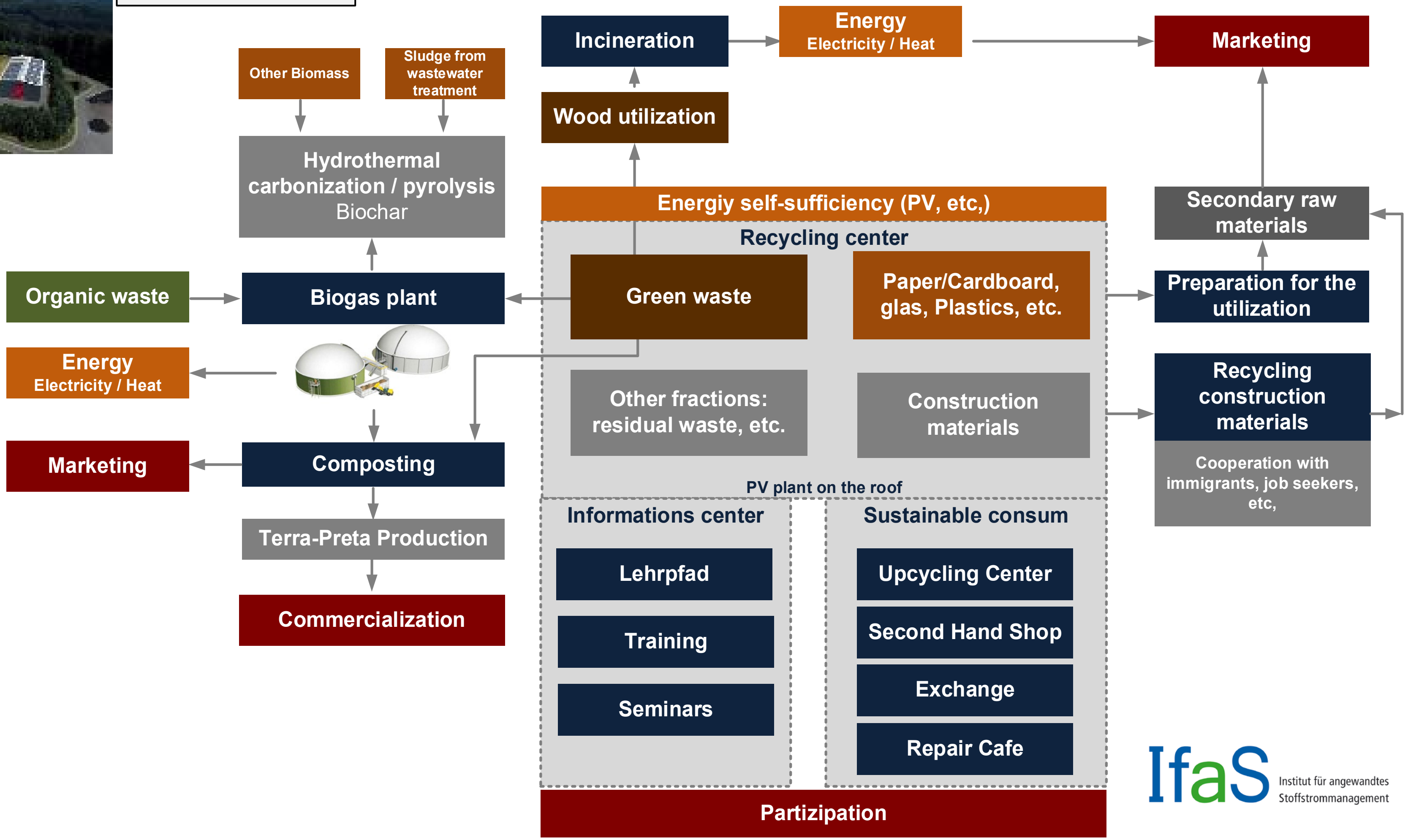
Resource Center / Center for Circular Economy – Resource Management

Innovative Ressource Center

Regional Added Value

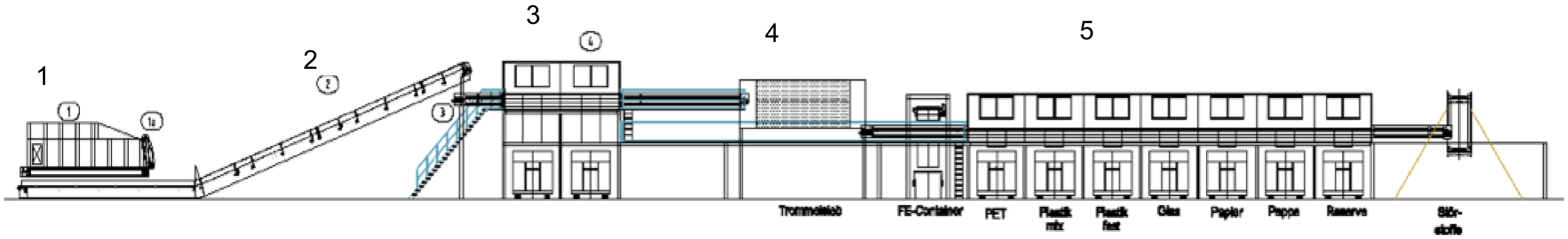
No landfills
No incineration

- **Recycling** points, sorting, processing, and commercialization of recyclable materials
- Energetical utilization of organic waste fractions
- New products: Organic fertilizer, Electricity, and heat generation
- Information center and capacity building
- Social inclusion and joint work with the informal sector
- New jobs
- New Circular Economy models: Upcycling, Second-hand shop etc.



IfaS Institut für angewandtes Stoffstrommanagement

Mechanical treatment



1. Reception
2. Transport Band
3. Cabins 1: for separation of disturbing materials
4. Trommel for separation of waste fractions: <80mm and >80mm
5. Cabins 2: for separation of waste fractions (paper, plastics, metals, etc)



Reception of materials

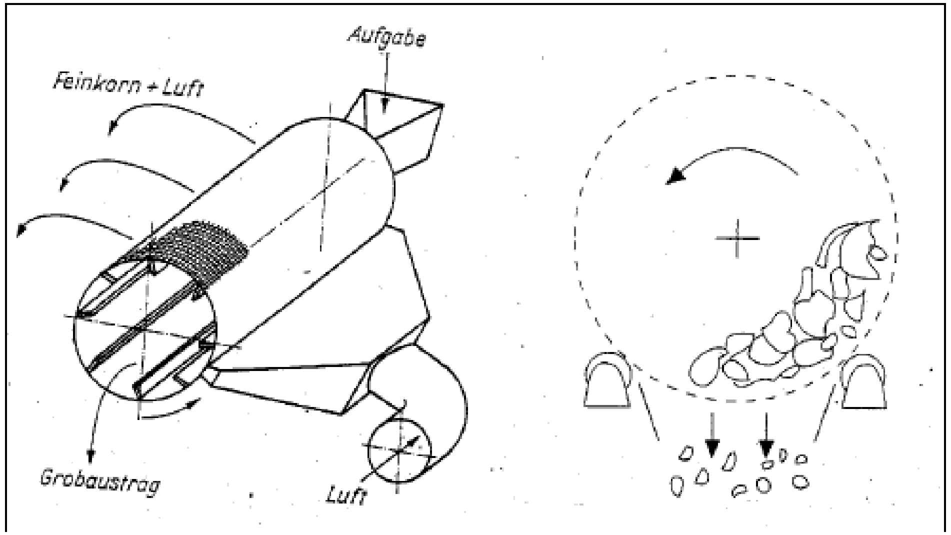
Rudnick & Enners
Maschinen- und Anlagenbau GmbH

Mechanical treatment Rudnick & Enners
Example: separation cabins and trommel

IfaS

Rudnick & Enners
Maschinen- und Anlagenbau GmbH

Sieving drum



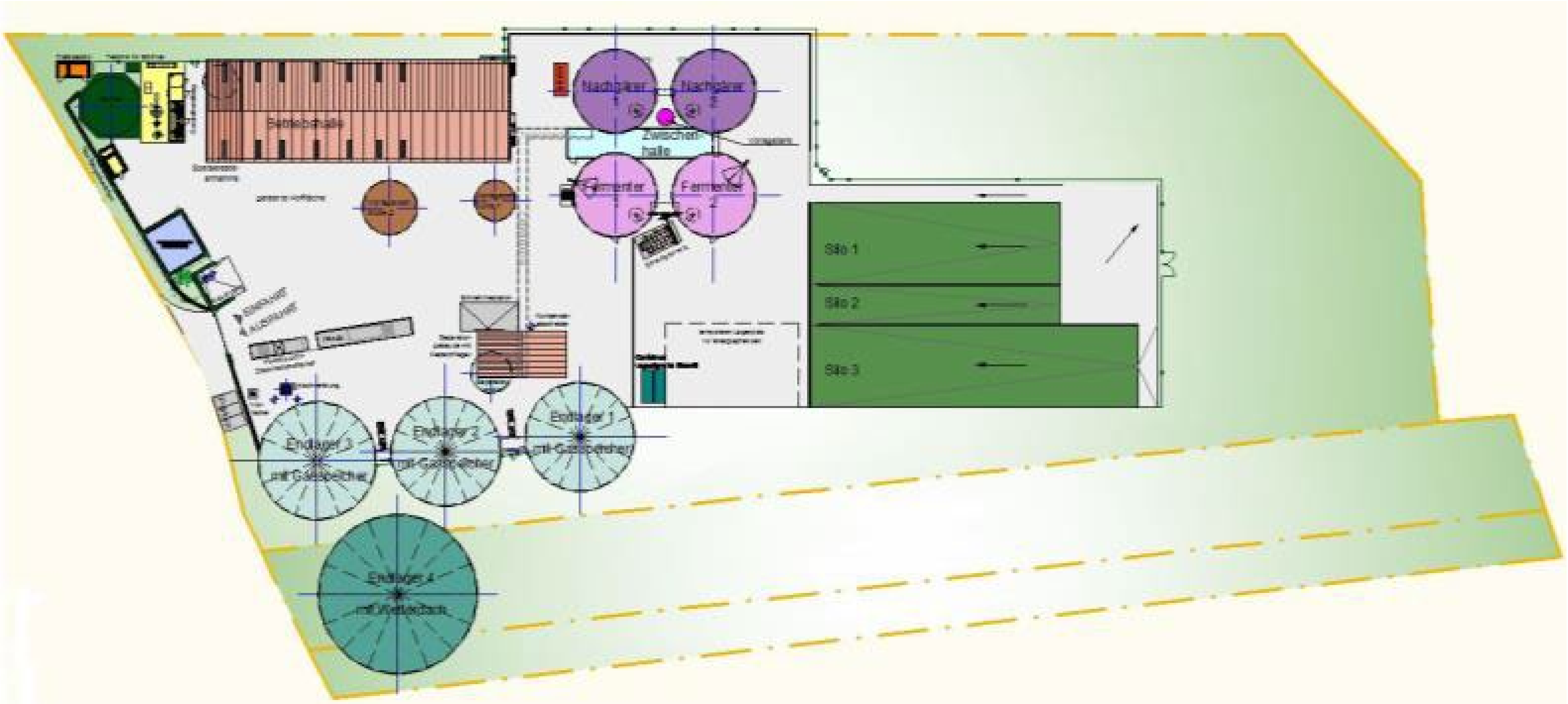
Source: TU Dresden

Separated materials

Source:
Rudnick & Enners

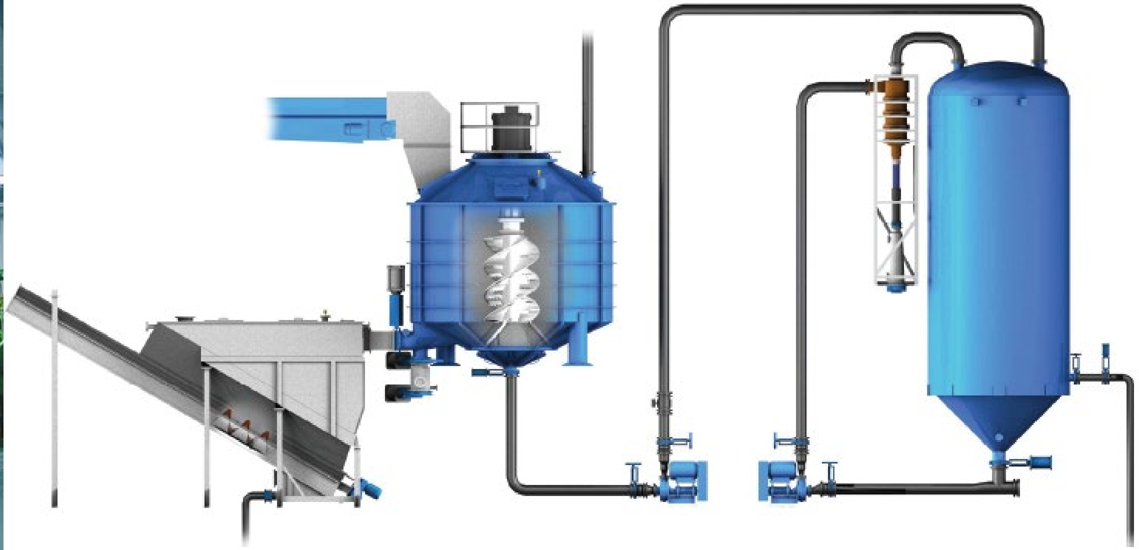
Conceptual technology design

- Pre-treatment: manual separation, hydro mechanical waste treatment (Pulper) and grit removal system (GRS)
- Biogas plant, including fermentation and composting
- Combined Heat and Power Unit- CHP



Source: LEE

Hydro-mechanical Pre-treatment
BTA-Pulper



Ligth fraction

Heavy fraction

Grit Fraction

agraferm technologies

Revenues of the project

Products generated from MSW	Chilean Market Values
Electricity	65 €/MWh
Heat	35 €/MWh
Ferrous Metal	58 €/t
PET	137 €/t
Plastics light	115 €/t
Plastics heavy	115 €/t
Paper	29 €/t
Cardboard	22 €/t
Glass	33 €/t
Soil Conditioner	1 €/t
Certified Emission Reductions (CERs)	10 €/t

→ **Conservative Scenario**

Waste Treatment Fee (Example for a Municipality with 100.000 t/a – at year 1)

In comparison to BAU-Scenario

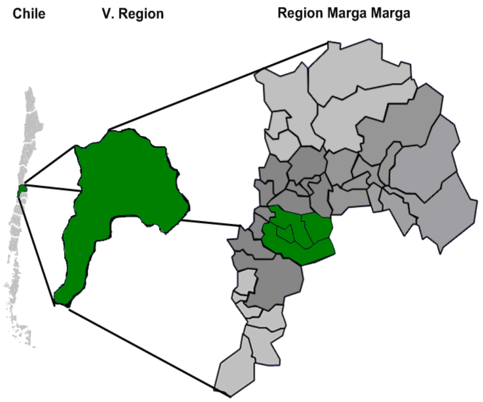
Socio-Economic Indicators	Project evaluation	
	Alternative 1	Alternative 2
	Resource center	Transfer Station and landfill (BAU Scenario)
Investment Total	**25.443.429 €**	**7.270.470 €**
TTT –Total Tonnes Treated	**3.301.681**	**3.301.681**
CTT- Costs per Tonne Treated	***11,51 €***	***12,20 €***
Job Creation	***133 - 177***	***54 - 79***
Tradable Emission Reductions in t CO_{2e}	***1.666.064***	***- Transport Emissions***

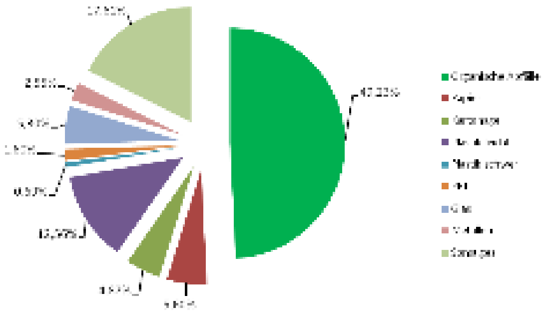
Creation of Regional Added Value
Example for a Municipality with 100.000 t/a

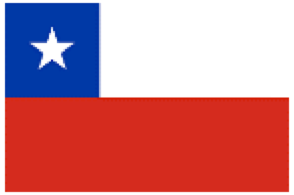
IfaS

Added Value	Within 20 Years	
Direct Jobs	>170	Positions
Emission Reduction	1,666,064	t CO_{2e}
Investment in Education	2	Mio. €
Soil Conditioner Production	203,391	Tonnes
Recycling	260,427	Tonnes
Net Electricity Production	130,442	MWh_{el}
Net Heat Production	202,588	MWh_{th}
RDF Production	1,096,315	Tonnes

Municipal Waste Treatment Center, V. Region, Valparaiso, Chile: Practical Example







4 Municipalities:
Limache, Olmué, Quilpué and Villa Alemana

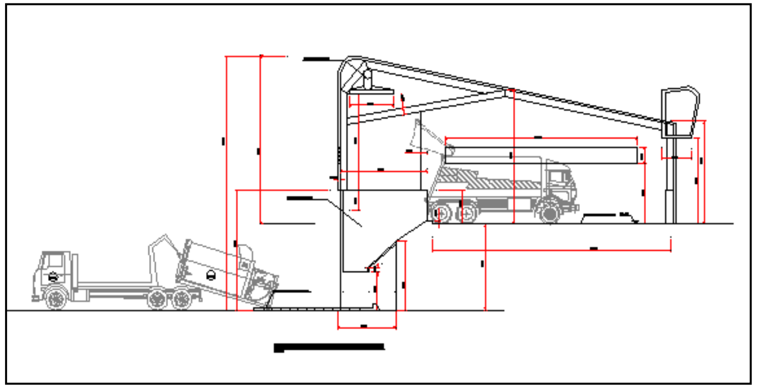
Approx. **100.000 tons** of solid waste yearly, increasing by **2.7% yearly**

50% of the waste is organic

High costs of transportation and final disposal

Source: IfaS, 2009

Example: Situation in the V. Region, Chile



Source: IfaS, 2010

- Planning of new landfills and transfer stations with high transportation costs and emissions
- Low technical "know-how" in MSW recovery and disposal
- No material or use of MSW for energy generation
- No waste prevention strategy
- No added value

Location


Olmué
Viña del Mar
14 Km
Limache
8 Km
Villa Alemana
Valparaíso
40 Km
19 Km
Resource center
Quilpué
Current Landfill in Valparaiso

Initial Situation of the Solid Waste Management







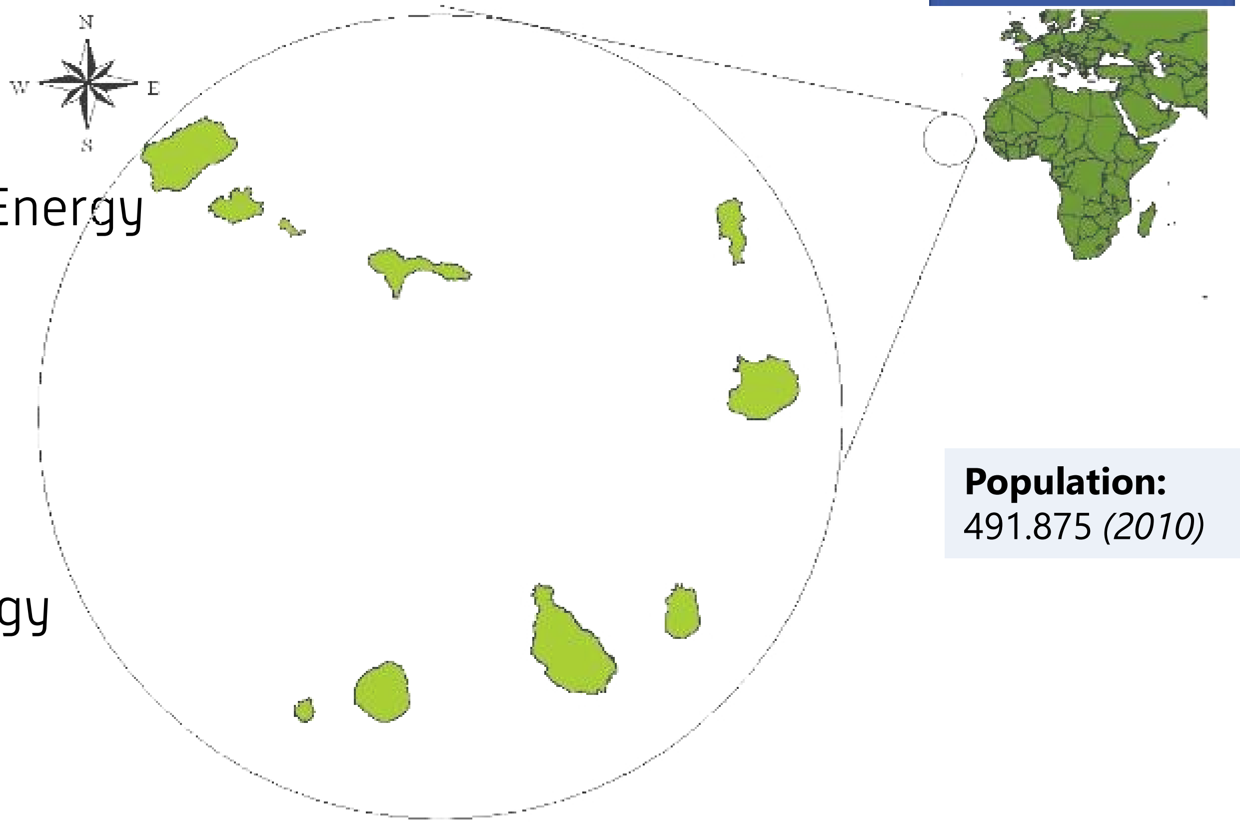
Source: IfaS, 2010

Informal Waste Pickers

Source: GPR-IfaS, 2010 / ILIX, 2011

Zero Emission Concept: 100% RE Cape Verde

- **Project: Cape Verde 100% Renewable**
- **Project Content:**
  - Energy Efficiency
  - Renewable Energy
  - Network Management
  - Sustainable Waste Management – Waste to Energy
  - Climate Protection



- **Project volume:** EUR 499,656.00 (net value**).**

Population:
491.875 *(2010)*

- **Client:** Ministry of Tourism, Industry and Energy of Cape Verde

- **Project partner:** BELIA

Source: IfaS, 2012

Waste Disposal in Praia, Cape Verde
Praia und Sao Vicente





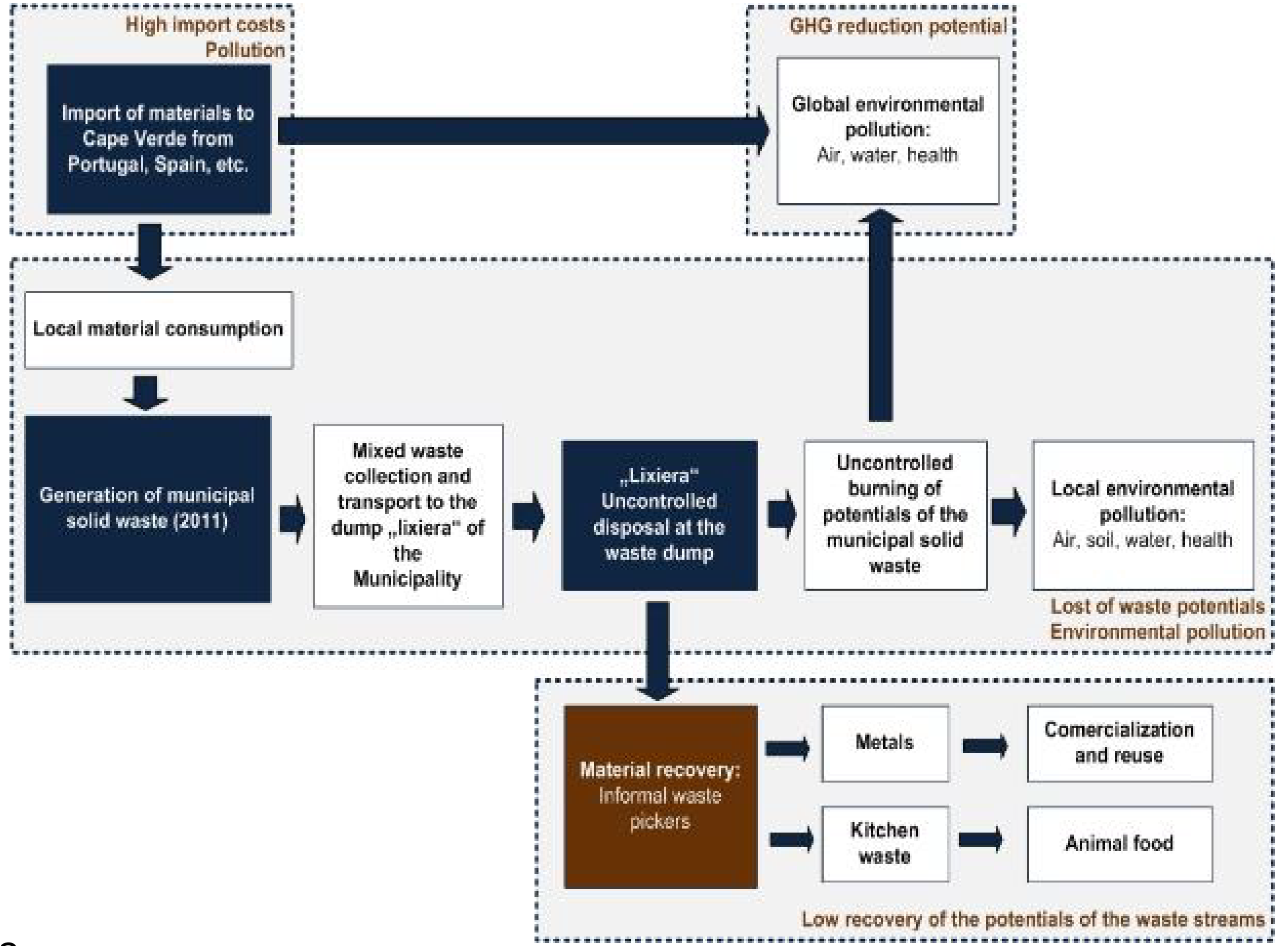


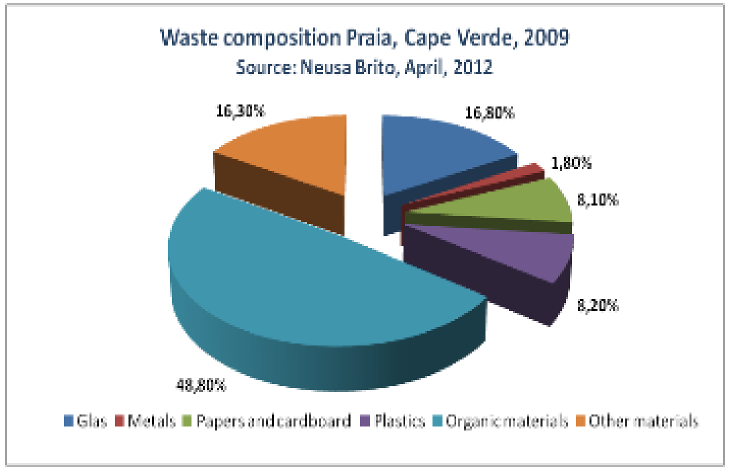

Source: Martínez, 2012

Resource Center in Praia, Cape Verde
Material Flow Analysis of Current MSW Management

Landfills in Praia and
Sao Vicente

Ca. 45,000 t/a Municipal Solid Waste
0.8 kg/EW*a





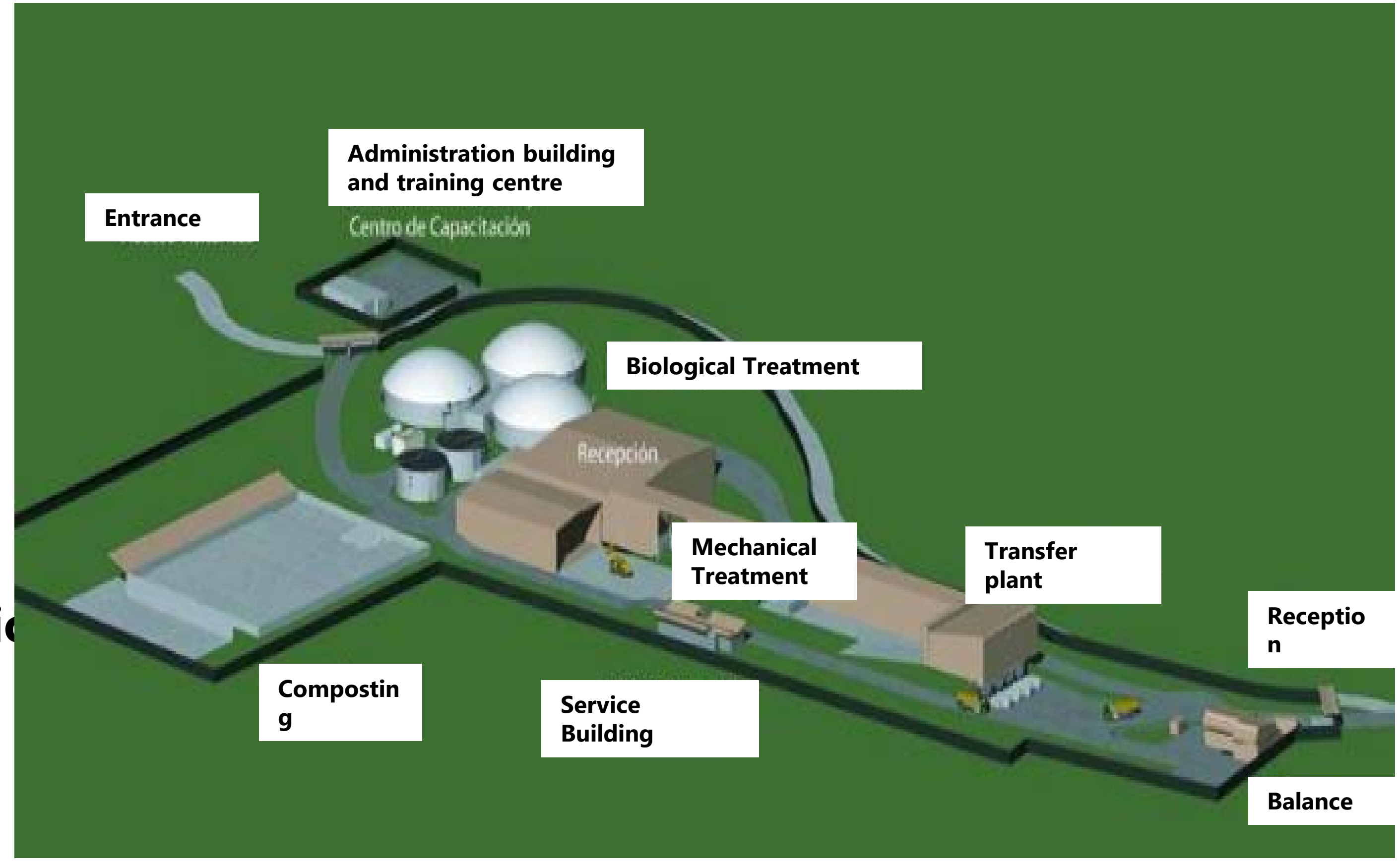
Source: Martínez, IfaS, 2012

Waste Disposal in China

Source: IfaS, 2009

Management Concept & Technology
Mechanical- Biological Treatment

- **Waste prevention and education**
- **Separation of waste fractions (in the households, etc.)**
- **Mechanical treatment:**
  - Manual sorting
  - Trommel
- **Biological treatment**
  - Hydro mechanical pre-treatment
  - Anaerobic digestion
  - Composting
- **RDF Production with the residual fracti**
- **Disposal of stabilized materials**



Source: IfaS, 2010

Mechanical Treatment Rudnick & Enners

IfaS

- **Example: Reception of Materials**

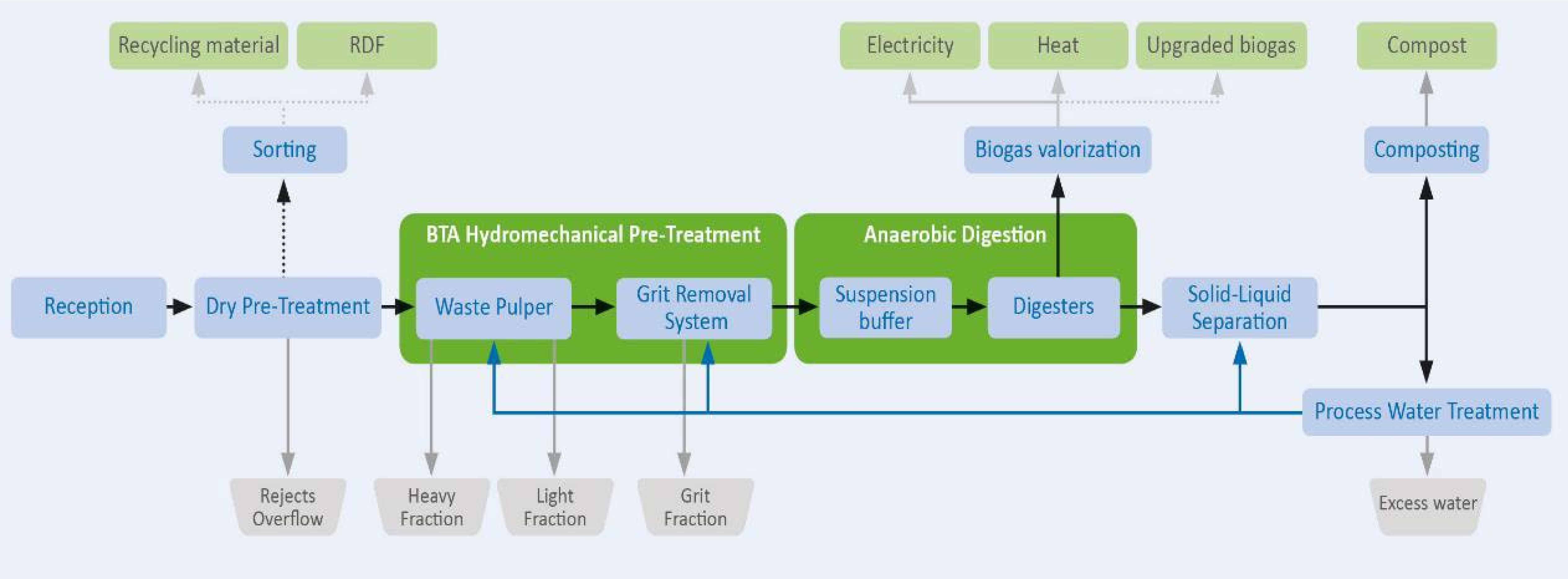
- **Separated Materials**

- **Example: Separation Cabins and Trommel**

Rudnick & Enners
Maschinen- und Anlagenbau GmbH

Source: Rudnick & Enners, 2010

Hydro-Mechanical Waste Treatment
The BTA Process



Source: BTA International, 2013

Biogas Utilization Possibilities

Co-Generation plant (CHP)

Biogas is conducted to a CHP- Combined heat and power plant to generate heat & electricity

Conditioning / Utilization of the Biogas as a Fuel

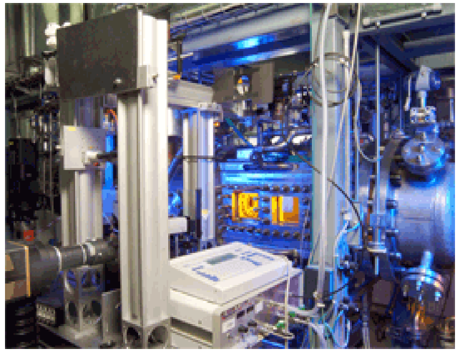
Example in Switzerland

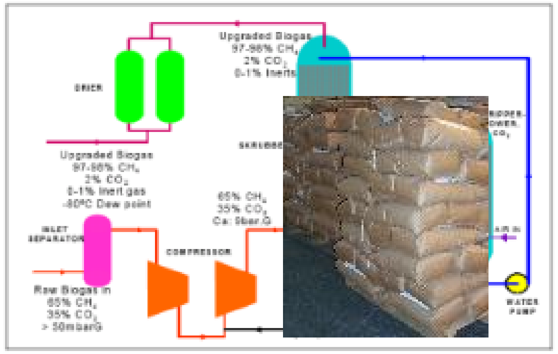
Biogas from municipal solid waste in Malmö, Sweden

Biogas Utilization in Drying process


Sacking plant for pellets to big bags or sacks

Conditioning/ Feeding of the Biogas into the Natural Gas Net





Products of the resource center

Recycling materials → **Commercialization**



Liquid and solid fertilizer → **Utilization in the agriculture**

Energy (Thermal and Electrical) → **Own consumption and/or commercialization**


Optional: RDF; Reuse derived fuels from the high caloric fraction / residual materials → **Development of Marketing strategy**

Regional added value!!!

Waste Treatment Fee
(Example for a Municipality with 100.000 t/a – at year 1)

In comparison to BAU-Scenario (Example Chile)

Socio-Economic Indicators	Project evaluation	
	Alternative 1	Alternative 2
	Resource center	Transfer Station and landfill (BAU Scenario)
Investment Total Area, Excavations, Periphery, Pre-treatment, Biogas Plant Training and Information center, Overhead and Planning (5-10% of the total investment) etc.	25,443,429 €	7,270,470 €
TTT –Total Tonnes Treated	3,301,681	3,301,681
CTT- Costs per Tonne Treated Administration, Maintenance, Raw Materials and Supplies, Monitoring and Analysis, Insurance, Landfilling of Waste, External Advice / Training etc.	*11.51 €*	*12.20 €*
Job Creation	*133 - 177*	*54 - 79*
Tradable Emission Reductions in t CO_{2e}	*1,666,064*	*- Transport Emissions*

Creation of Regional Added Value
Example for a Municipality with 100.000 t/a

Added Value	Within 20 Years	
Direct Jobs	>170	Positions
Emission Reduction	1,666,064	t CO_{2e}
Investment in Education	2	Mio. €
Soil Conditioner Production	203,391	Tonnes
Recycling	260,427	Tonnes
Net Electricity Production	130,442	MWh_{el}
Net Heat Production	202,588	MWh_{th}
RDF Production	1,096,315	Tonnes

Socio-Economic Parameter	Evaluation Results	
	BAT concept	BAU Scenario
Total Investment	25.443.429 €	7.270.470 €
VAC- Net present cost value (in €)	-1,333,364 €	-1,357,258 €
CTT- Treatment costs per unit (in €)	-11,39 €	-11,67 €
Creation of new Jobs	120 - 188	40 - 64
Emission Reduction Potential in t CO_{2e}	2,827,309	Transport Emission
Operating Costs in € per t of MSW including transportation and disposal	10.16 €	18.55 €
Value Added Tax Potential (VAT 19%)	3.346.560 €	+ /- 0

Status Quo of organic household waste treatment in Bad Kreuznach

Baujahr der AWB-Anlage
Bad Kreuznach
Investition: 20-25 Mio. DM

1985

1987

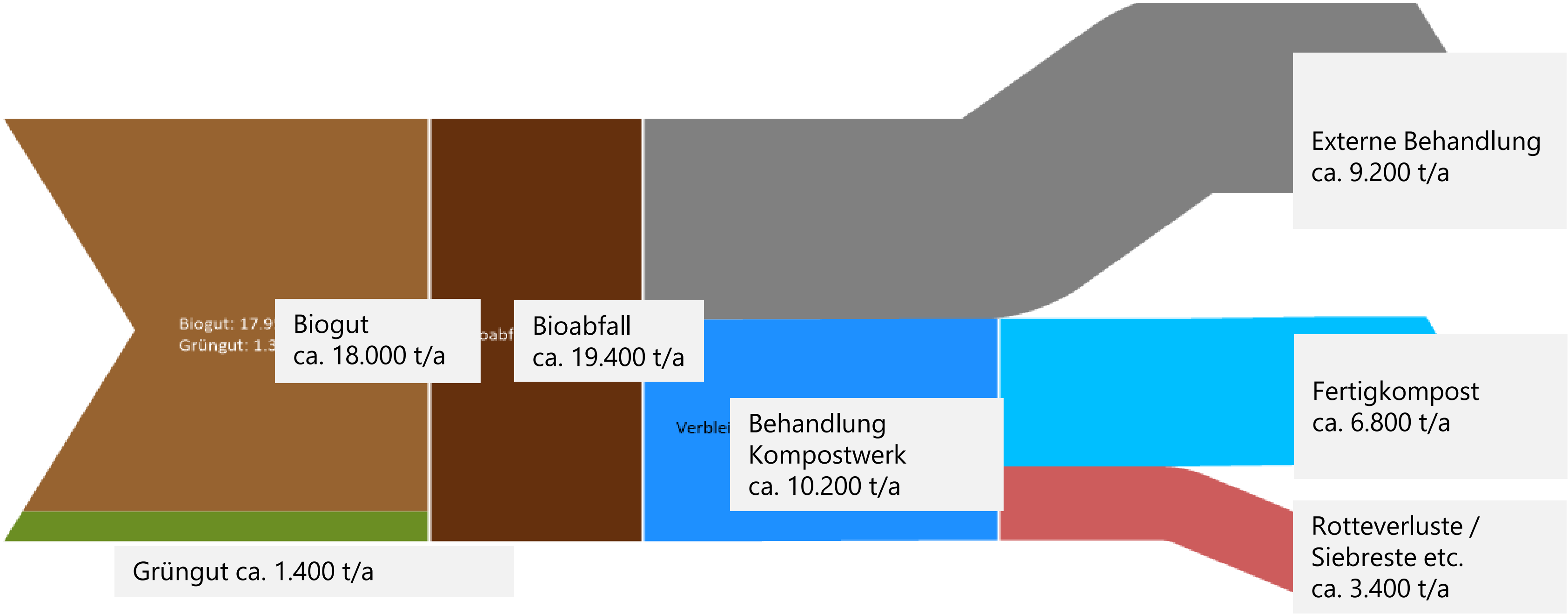
Inbetriebnahme
Behandlung gemischter
Restabfallfraktion
genehm. Kapazität:
35.000 t/a Restabfall

1990

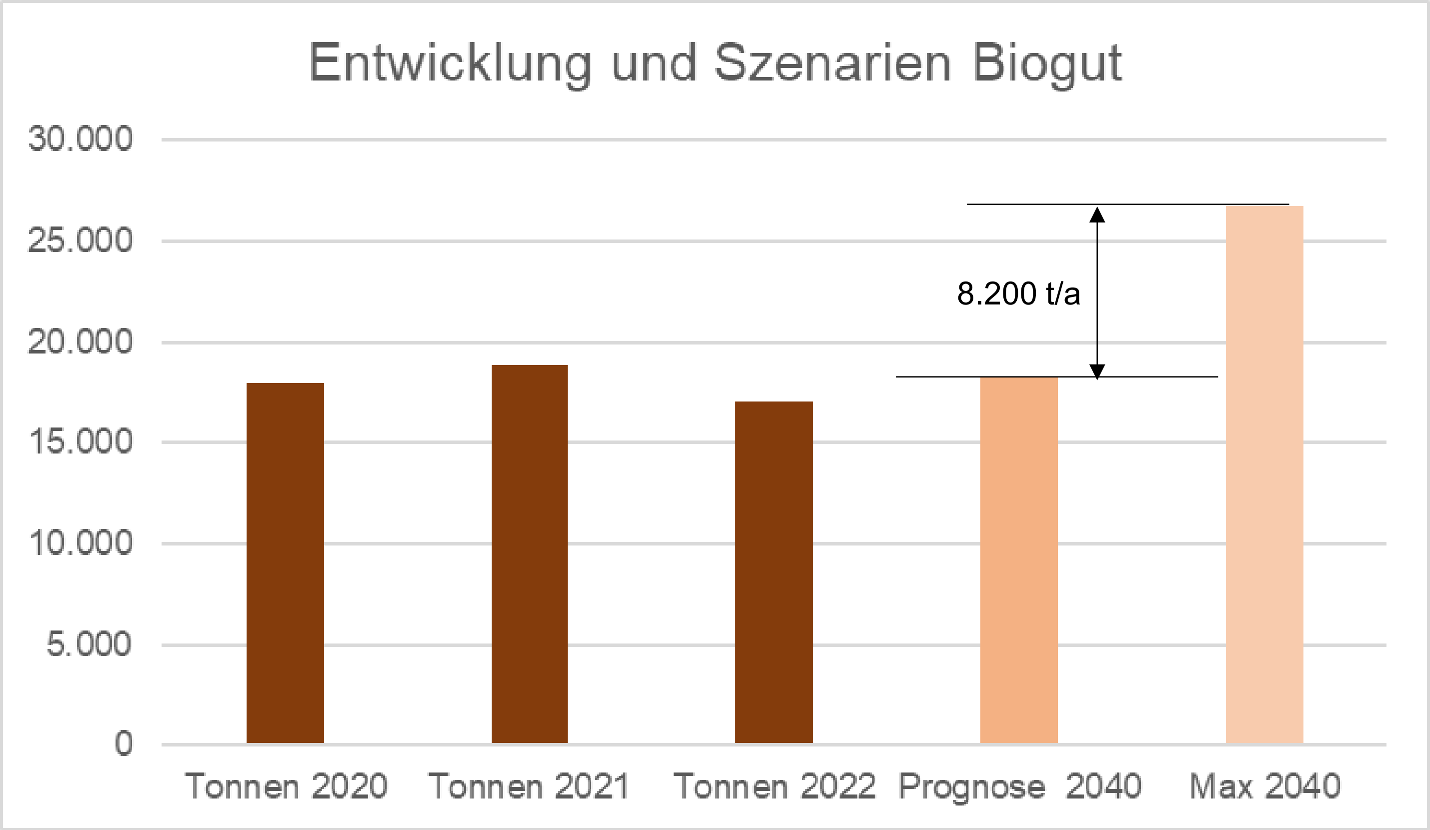
Einführung der
Braunen Tonne
Umwidmung zu
Kompostierungsanlage
mit offener Nachrotte
Kapazität:
18.000-19.000 t/a Bioabfall

2000

Umstellung der offenen
Nachrotte auf geschlossene
Containerkompostierung
genehm. Kapazität:
10.000 t/a Bioabfall



Szenario organic waste development



- Prognosis based on population development

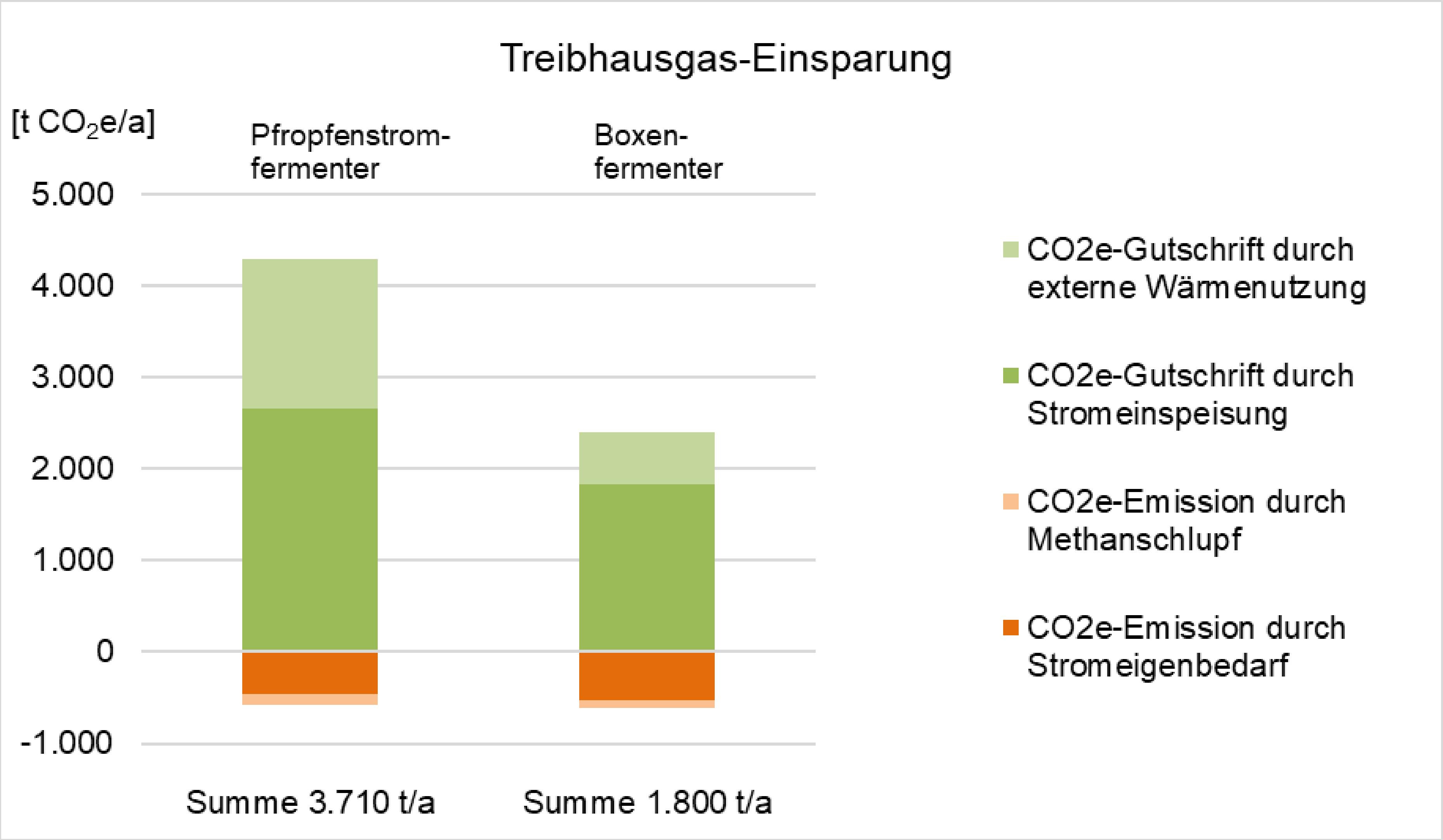
Technical options for biodigestion

Berechnungsgröße	Pfropfenstrom-verfahren	Boxen-verfahren	Einheit
Biogutmenge	19.400		t/a
Biogasertrag	2.425.000	1.552.000	Nm³/a
Biogasertrag (netto)	13.644.100	4.749.100	kWh/a
BHKW elektr. Leistung	970	540	
BHKW Stromproduktion	4.753.000	3.266.000	
BHKW Wärmeleistung	1.390	490	kWth
BHKW Wärmelieferung	6.811.000	2.401.000	kWh_{th}/a
Flüssiger Gärrest	4.200	700	t/a
Fester Gärrest	10.900	9.200	t/a
CO2e-Einsparung netto	3.710	1.800	t/a

- **Annahmen**
  - Flexibler (diskontinuierlicher) BHKW-Betrieb anhand eines Standardstromlastprofils (→ Direktvermarktung)
  - Biogaskessel als Fermenter-Heizung bei Pfropfenströmer, zweites BHKW bei Boxenverfahren
  - Pufferspeicher für Biogas und Heizwasser

- Rückmeldung der Kompostabnehmer (Abfrage durch AWB, Hr. Schwinn)
  - Markt für feste Gärreste in der Region vorhanden (Flächen)
  - Erfahrung mit festen Gärresten vorhanden
  - Weinbau ist für feste Gärreste grundsätzlich geeignet (im Gegensatz zu flüssigen Gärresten)

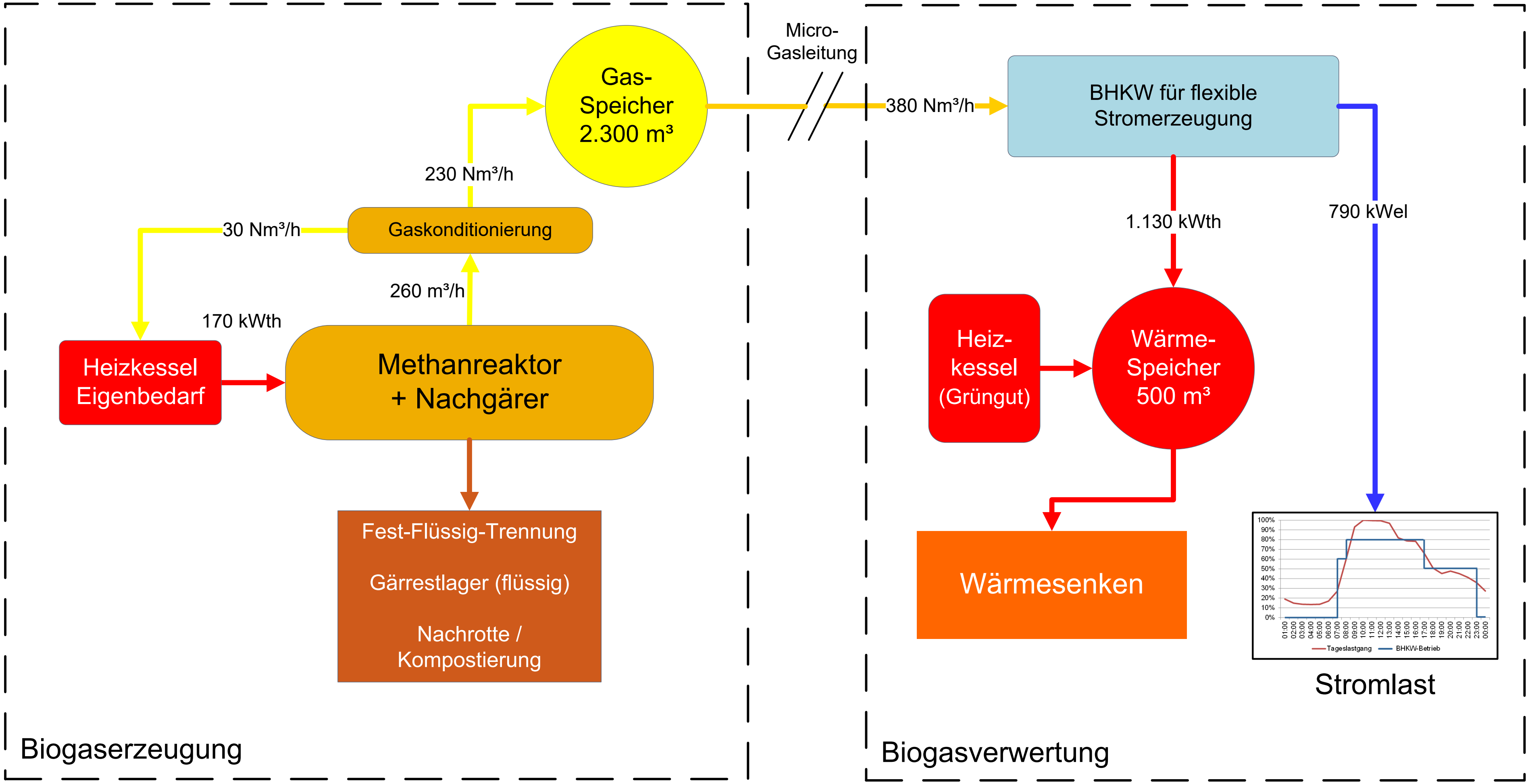
GHG Balance



- Higher gas yield leads to more GHG savings und more green energy
- Higher own energy consumption leads to lower GHG reduction

➢ As a result we have a high reduction of GHG compared to composting

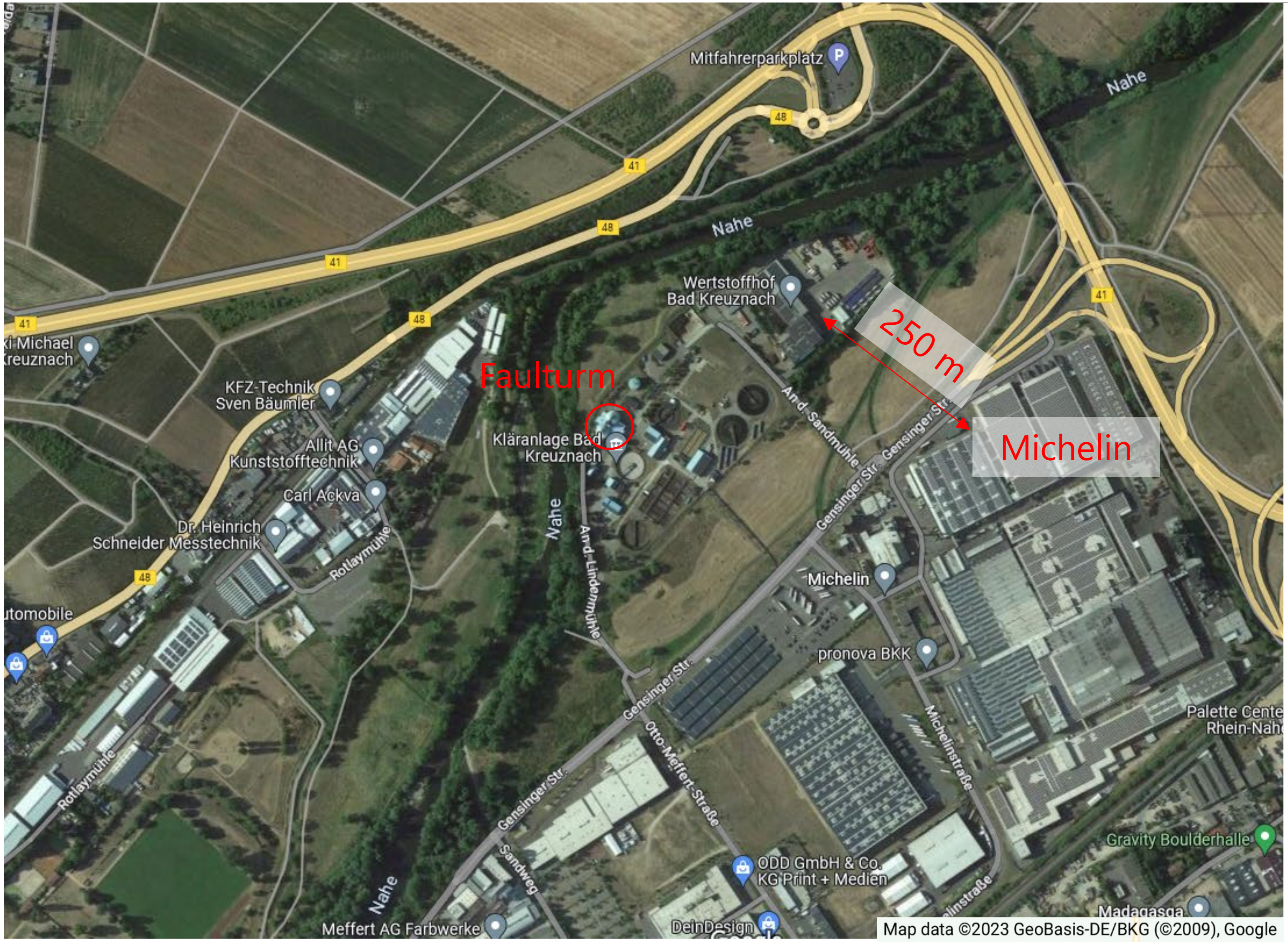
Technical set up for biodigestion and cogeneration heat and power



- Flexibility options through a large gas and/or heat storage

Location Bad Kreuznach – Heat customers and waste water treatment plant

IfaS



- Potential sale of heat to Michelin tyre plant
  - Strombedarf ist sehr hoch und durch Elektrifizierung weiter ansteigend
  - Wärmebedarf im Sommer gering, aber KWKK möglich
  - Denkbar wäre eine Veräußerung des Biogases oder der erzeugten Strom- und Wärmeenergie
- cooperation mit WWTP possible but unlikely due to legal requirements

Potential CAPEX estimation (ca. 20.000 t/a)

Alle Angaben netto

Investitionsschätzung [€]	Pfropfenstrom-verfahren	Boxen-verfahren
Vergärung	9.737.700	13.200.000
Kompostierung	3.500.000	enthalten
Mobile Aggregate	368.600	368.600
Gasspeicher	enthalten	enthalten
Microgasleitung	60.000	60.000
BHKW	960.000	535.000
Wärmespeicher	858.000	308.000
Nebenkosten [5%]	774.000	724.000
Unvorhergesehenes [5%]	774.000	724.000
Summe	**17.032.300**	**15.919.600**

Costs and revenues (ca. 20.000 t/a)

Alle Angaben netto

Basis Szenario 20.000 t/a			
Berechnungsgröße	Pfropfenstrom-verfahren	Boxen-verfahren	Einheit
Biogutmenge	**19.400**		**t/a**
Behandlungskosten	**2.615.000**	**1.994.000**	**€/a**
Kapitalgebundene Kosten	*1.253.000*	*1.171.000*	*€/a*
Betriebsgebundene Kosten	*926.000*	*659.000*	*€/a*
Verbrauchsgebundene Kosten	*436.000*	*164.000*	*€/a*
Erlöse	**-1.082.000**	**-474.000**	**€/a**
Erlöse aus Wärmelieferung	*-409.000*	*-144.000*	*€/a*
Erlöse aus Stromverkauf	*-673.000*	*-330.000*	*€/a*
Erlöse aus Kompostverkauf	*0*	*0*	*€/a*
Verwertungskosten	**1.533.000**	**1.520.000**	**€/a**
Spezifische Verwertungskosten	**79**	**78**	**€/t**

- Pfropfenstromverfahren:
  - Investitionsbedarf **ca. 17 Mio. €**
  - **Anmerkungen:**
    - Erlöse höher → Höherer Biogasertag
    - Geringen Eigenenergiebedarf → Kein Energiebedarf der Nachrotte berücksichtigt
- Boxenverfahren:
  - Investitionsbedarf **ca. 16 Mio. €**
  - **Anmerkung:**
    - Investitionen wurden auf eine Anlagengröße von 20.000 t/a abgeschätzt
    - Hoher Eigenwärmebedarf → zwei BHKWs berücksichtigt
      1. Kleines BHWK am Standort (Strom- Wärmeversorgung am Standort)

Kosten und Erlöse der Verfahren (ca. 20.000 t/a)

Szenario 25% höhere Investitionen

Alle Angaben netto

Szenario 25% höhere Investitionen 20.000 t/a			
Berechnungsgröße	Pfropfenstrom-verfahren	Boxen-verfahren	Einheit
Biogutmenge	**19.400**		**t/a**
Behandlungskosten	**2.929.000**	**2.287.000**	**€/a**
Kapitalgebundene Kosten	*1.567.000*	*1.464.000*	*€/a*
Betriebsgebundene Kosten	*926.000*	*659.000*	*€/a*
Verbrauchsgebundene Kosten	*436.000*	*164.000*	*€/a*
Erlöse	**-1.082.000**	**-474.000**	**€/a**
Erlöse aus Wärmelieferung	*-409.000*	*-144.000*	*€/a*
Erlöse aus Stromverkauf	*-673.000*	*-330.000*	*€/a*
Erlöse aus Kompostverkauf	*0*	*0*	*€/a*
Verwertungskosten	**1.847.000**	**1.813.000**	**€/a**
Spezifische Verwertungskosten	**95**	**93**	**€/t**

- Höhere Investitionen in die Anlage (25%)
  - Behandlungskosten liegen im oberen Bereich

- Pfropfenstromverfahren:
  - Investitionsbedarf **ca. 21,3 Mio. €**
  - **Anmerkungen:**
    - Erlöse höher → Höherer Biogasertag
    - Geringen Eigenenergiebedarf
      → **Kein Energiebedarf** der Nachrotte
      berücksichtigt
- Boxenverfahren:
  - Investitionsbedarf **ca. 20 Mio. €**
  - **Anmerkung:**
    - Investitionen wurden auf eine Anlagengröße von 20.000 t/a abgeschätzt
    - Hoher Eigenwärmebedarf
      → zwei BHKWs berücksichtigt
      1. Kleines BHWK am Standort
      (Strom- Wärmeversorgung am Standort)
    - Personal für den Betrieb wurde für eine 20.000 t/a Anlage abgeschätzt

Kosten und Erlöse der Verfahren (ca. 30.000 t/a)

Alle Angaben netto

Basis Szenario 30.000 t/a			
Berechnungsgröße	Pfropfenstrom-verfahren	Boxen-verfahren	Einheit
Biogutmenge	**30.000**		**t/a**
Behandlungskosten	**3.862.000**	**2.771.000**	**€/a**
Kapitalgebundene Kosten	*1.888.000*	*1.612.000*	*€/a*
Betriebsgebundene Kosten	*1.300.000*	*905.000*	*€/a*
Verbrauchsgebundene Kosten	*674.000*	*254.000*	*€/a*
Erlöse	**-1.683.000**	**-725.000**	**€/a**
Erlöse aus Wärmelieferung	*-635.000*	*-218.000*	*€/a*
Erlöse aus Stromverkauf	*-1.048.000*	*-507.000*	*€/a*
Erlöse aus Kompostverkauf	*0*	*0*	*€/a*
Verwertungskosten	**2.179.000**	**2.046.000**	**€/a**
Spezifische Verwertungskosten	**73**	**68**	**€/t**

- **Beide verfahren liegen in einem vergleichbaren Preisniveau**
  - Aufwendungen sind beim Pfropfenstromverfahren höher
  - Erlöse fallen beim Boxenverfahren niedriger aus
- **Insgesamt erste Annäherung, aufgrund volatiler Bau- und Maschinenkosten vorläufig!!**

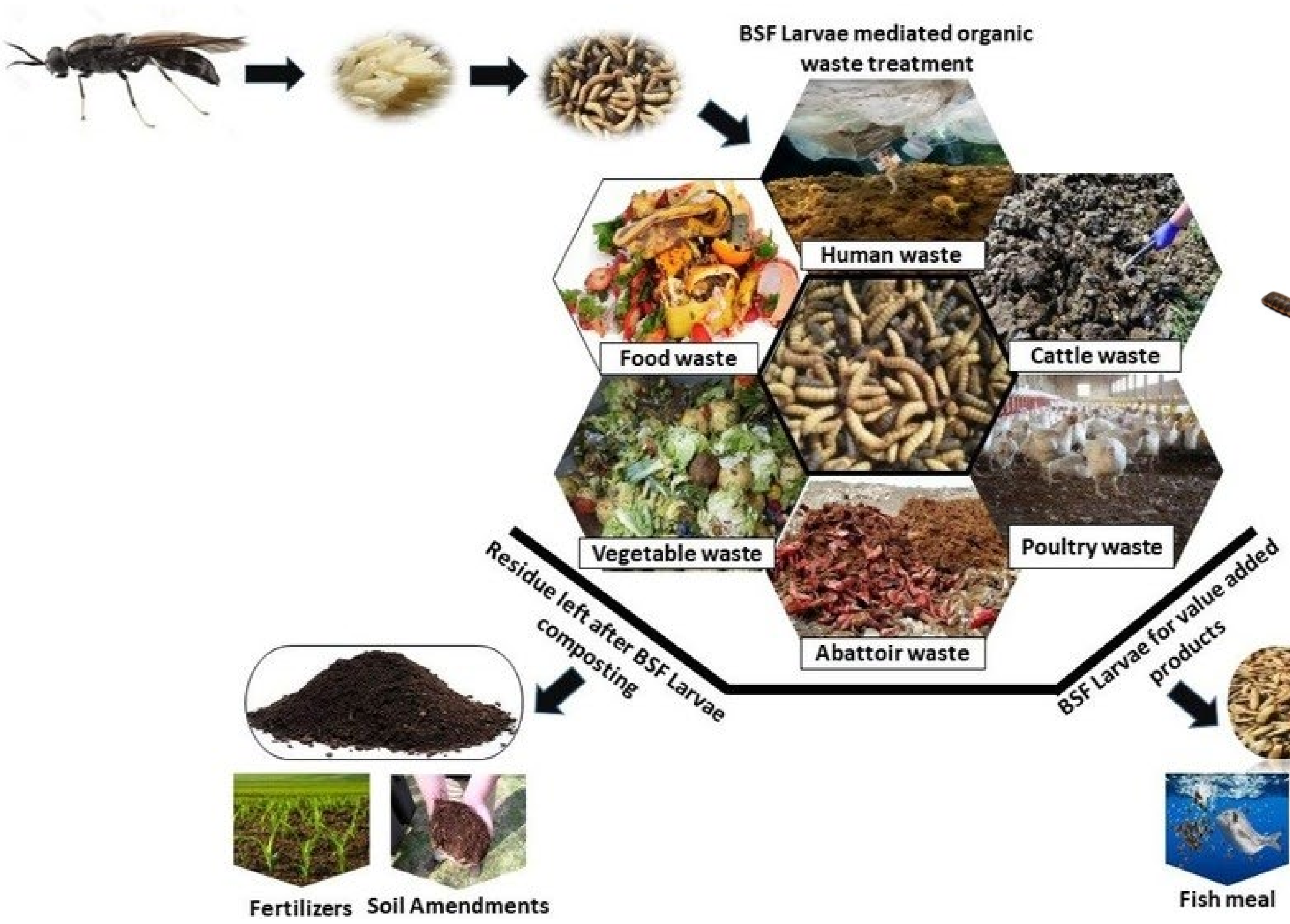
- Pfropfenstromverfahren:
  - Investitionsbedarf **ca. 25,7 Mio. €**
  - **Anmerkung:**
    - Investitionen wurden auf eine Anlagengröße von 30.000 t/a hochgerechnet
    - Personal für den Betrieb wurde für eine 30.000 t/a Anlage nicht verändert (relativ hoher Automatisierungsgrad)
- Boxenverfahren:
  - Investitionsbedarf **ca. 22 Mio. €**
  - **Anmerkungen:**
    - Hoher Eigenwärmebedarf
      → zwei BHKWs berücksichtigt
      1. Kleines BHWK am Standort
      (Strom- Wärmeversorgung am Standort)

New fermentable plant for biomass of the district own waste management company

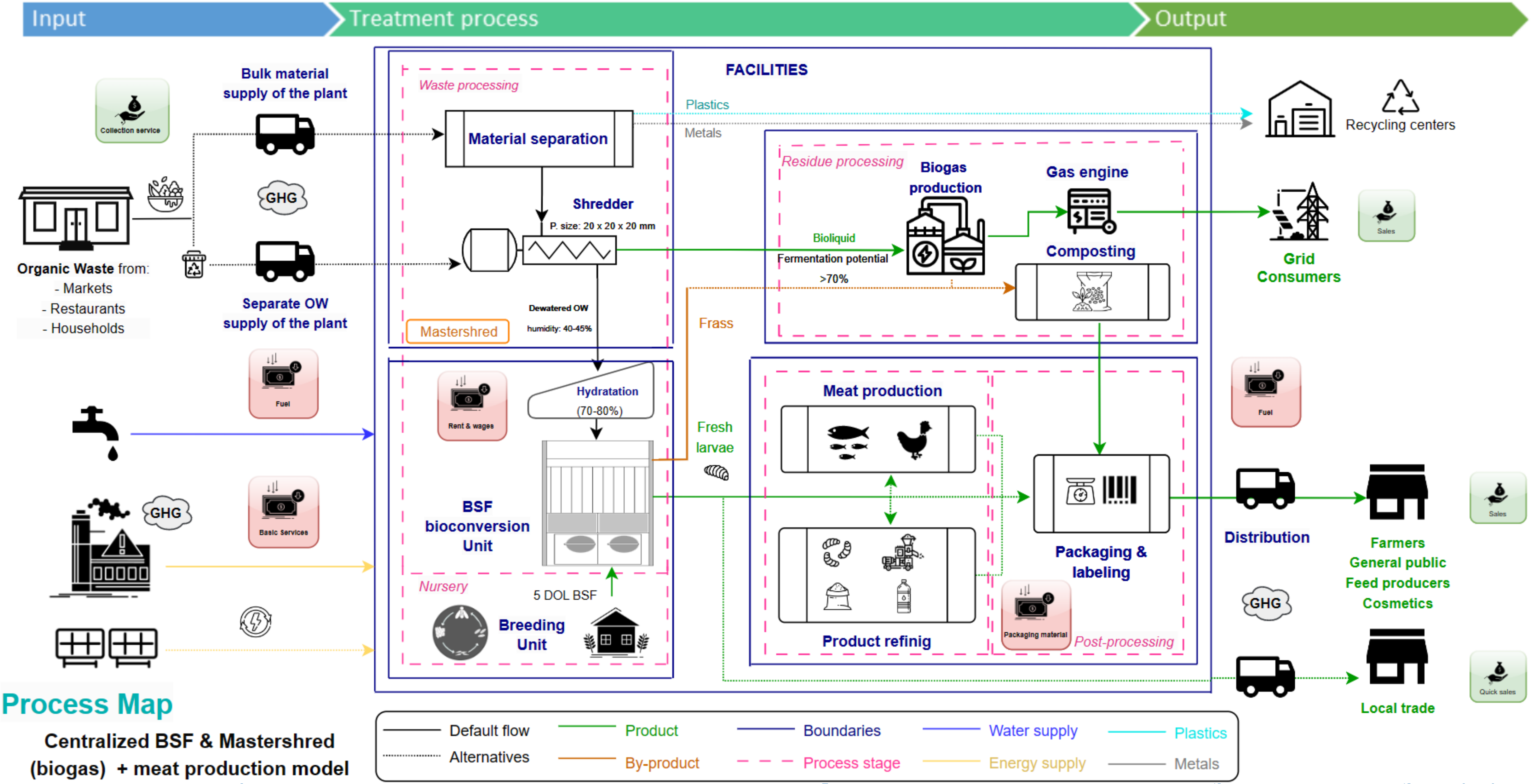
Launch in the year 2021

- Use of the biomass of the kitchens 15,000 tons per year from private households
- Production of 10,500 tons of digestate/fertiliser
- Flexibel production of about 4,5 Million kWh electricity power per year (3,4 Million kWh feed in the grid)

Next practice: Black soldier fly for waste treatment



Waste- Energy – Feed and Food Nexus: Black



Process Map

Centralized BSF & Mastershred (biogas) + meat production model

International Circular Economy Week and Conference

At the Environmental Campus in Birkenfeld (ECB)

IfaS

3th - 7th November 2025

5th November: ICE-Conference

More than 100 international participants

Aims

- Provide an understanding on the challenges, strategies, technologies and opportunities offered by Circular Economy, Zero Emission and Material Flow Management
- Provide an understanding on the IfaS´ regional Material Flow Management and Circular Economy approach methods
- Provide an overview on innovative CE & ZE technology and services offered by German SME´s
- Encourage you to establish new international networks with companies, public sector participations from Germany and other delegations

Technical visits

- Energy efficiency
- Renewable Energy
- Waste treatment systems (energetically and material utilization)
- Wastewater treatment systems
- Etc.

It always seems impossible until it´s done !

Nelson Mandela

Prof. Dr. Peter Heck, Managing Director

Institut für angewandtes Stoffstrommanagement (IfaS)

Umwelt-Campus Birkenfeld
Campusallee
55768 Hoppstädten-Weiersbach

Telefon: +49 6782 17-1221

p.heck@umwelt-campus.de