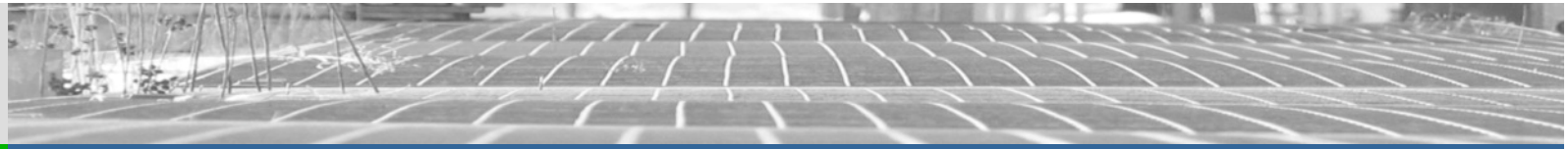

Biomass Valorisation, Regional Material Flow Management, Renewable Energy, Water-Soil-Energy-Nexus, Sustainability Management, Business Competitiveness, Integrated Water Resource Management,….

Biomass based Business Opportunities

Arab Forum for Renewable Energy and Energy Efficiency
3rd ARFREE Conference, Cairo, Egypt, 01th of June, 2016

Biomass as a versatile oil-equivalent and cornerstone for balanced renewable energy provision

M.Sc., Dipl.-Econ.

Felix Flesch

Institute for applied Material Flow Management

HOCHSCHULE TRIER
Umwelt-Campus Birkenfeld
Umwelt macht Karriere.

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ECB – Short Profile

- Trier University of Applied Sciences
  - More than 6.400 students (Founded in 1810)
  - More than 150 professors
  - More than 150 international universities
- Environmental Campus Birkenfeld (ECB)
  - Inaugurated in 1996
  - More than 2.500 students (2010)
  - More than 50 professors
  - Students from more than 30 nationalities
- Educational focus on environmental studies
  - Faculty of Environmental Economics and Law
  - Faculty of Environmental Engineering
- State conversion project

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Aerial View of the Past

US Military Hospital in Birkenfeld from 1953 until 1994

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Zero Emission Campus Concept

- 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
- Maximised Energy Efficiency
  - ✓ Passive and Plus-Energy Buildings
  - ✓ Energy efficient lighting (indoor and street lighting)
  - ✓ Efficiency and building automation system (heating and lighting)

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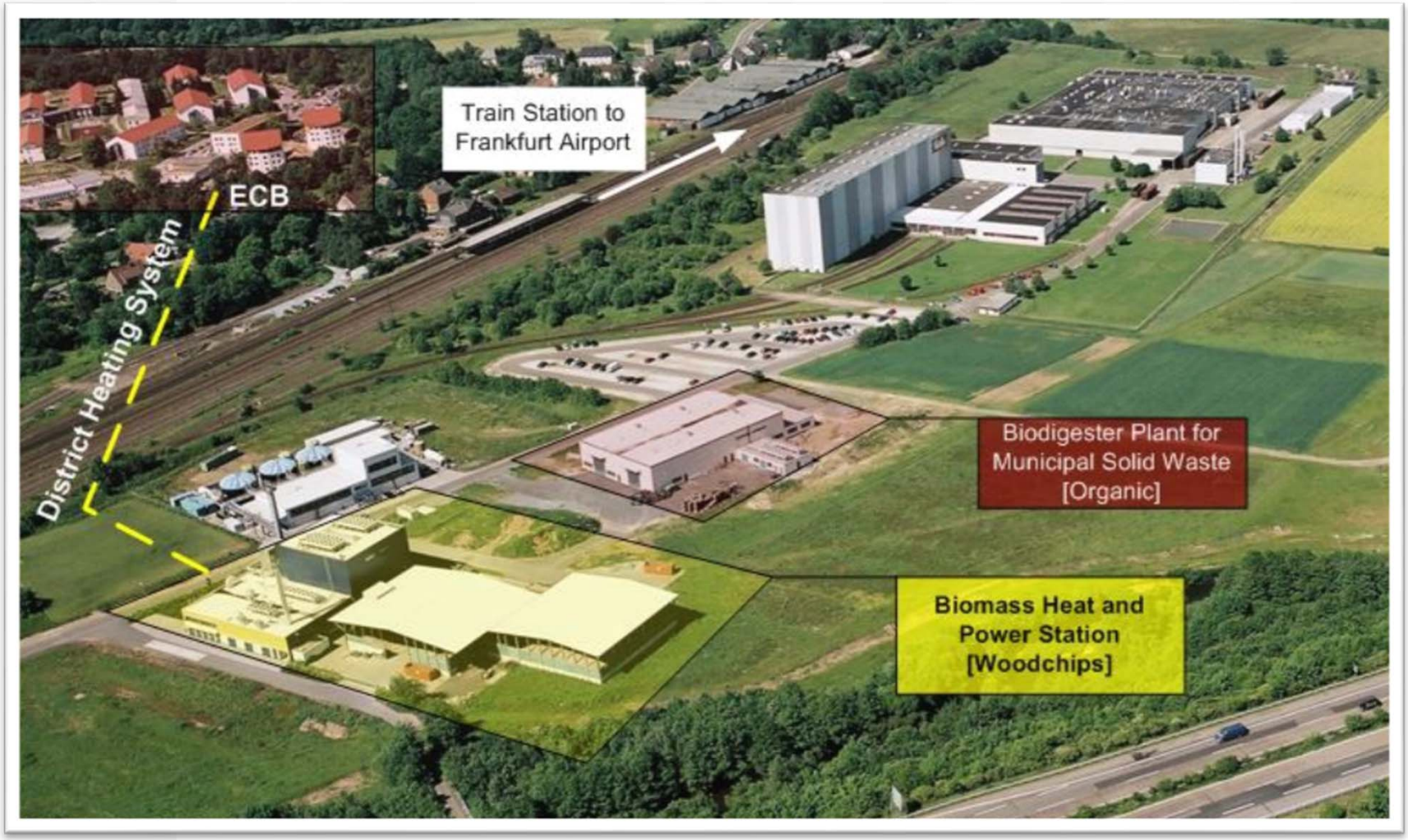
Neighbouring Eco-Industrial Park



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More than a Decade of IfaS:

Think Tank for sustainable economic promotion strategies

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One Team – plenty of Ideas and Visions...

- Non-Profit Institute
  - Foundation in 2001
  - 9 Professors
  - 60 Employees
- Interdisciplinary Team:
  - Ecological Economics
  - Mechanical and Electrical Engineering
  - Policy Science
  - Spatial Planning
  - Agriculture & Forestry Engineering
  - Environmental Law
- Large (Inter-) national network of highly specialised technology provider and planer

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IfaS – Departments & Fields of Activity

International Project Management

Study and Qualification

Fundraising

Biomass and Cultural Landscape Development

Energy Effciency & Renewable Energies

E-mobility

Material Flow Management and Zero Emission

PR – Communication and Participation

- (Regional) MFM consultancy
  - Material Flow Analysis
  - Project design
- Capacity development
- Biomass potential studies
- Zero-Emission Design & Circular economy concepts
- Climate protection strategies
- Technical and economical feasibility studies
- Eco-efficiency consultancy
- Carbon Management & Carbon Footprinting

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Global Network: Worldwide IfaS projects

Weltweite Projekte des IfaS

IfaS entwickelte einen SSM-Masterplan für das Reservat der First Nation Cree Band nahe Edmonton

IfaS developed a MFM Masterplan for the reserve of the First Nation Cree Band near Edmonton

1. Österreich
2. Frankreich
3. Polen
4. Luxemburg
5. Litauen
6. Slowenien
7. Schweiz
8. Irland
9. Großbritannien
10. Belgien
11. Griechenland
12. Tschechien
13. Ägypten
14. Algerien
15. Argentinien
16. Bangladesh
17. Brasilien
18. China
19. Chile
20. Ghana
21. Indien
22. Indonesien
23. Japan
24. Kanada
25. Kolumbien
26. Kroatien
27. Marokko
28. Mazedonien
29. Ruanda
30. Rumänien
31. Russland
32. Serbien
33. Sri Lanka
34. Taiwan
35. Türkei
36. Ungarn
37. Cape Verde
38. Martinique

Brasilien/Paraná:
Biomasse-und Landnutzungsprojekte, unter anderem für den Iguacu National Park, unter Einbindung von Kleinbauern und Abfallsammlern (catadores)
Kolumbien, Chile und Argentinien:
Entwicklung nachhaltiger Abfallwirtschaftskonzepte

Brazil/Paraná:
Biomass and land use management concepts e.g. Iguaçú National Park, involving local farmers and waste pickers (catadores)
Colombia, Chile and Argentina:
Development of integrated waste management concepts




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Global Network: Worldwide IfaS projects



China: Kreislaufwirtschaftskonzepte und Erneuerbare Energie-Anlagen auf Biomasse-Basis u.a. in Fujian, Yunnan, Lanzhou
Taiwan: Stoffstrommanagement Taichung und Kaoshiung
Russland/Jaroslawl: Regionales Stoffstrommanagement
Japan/Beppu: Deutsch-Japanisches Masterprogramm in Intern. Stoffstrommanagement (IMAT) in Kooperation mit Ritsumeikan/APU

Morocco/Rabat:
Büro IfaS Maghreb,
Konzept „Energie-Plus-Stadt" Lakhiaita,
Biomasse-Masterpläne in Kooperation
mit der GIZ und Konzepte zur nachhaltigen
Abwassernutzung
Ruanda: Strategie zur solaren Elektrifizierung auf Basis
eines revolvierenden Fonds
Ägypten/Quena: Forschungsprojekt zur nachhaltigen
Nutzung von Abwasser in der Landwirtschaft

China: Circular Economy strategies and biogas plants in Fujian, Yunnan, Lanzhou
Taiwan: Material Flow Management in Kaoshiung and Taichung
Russia/Jaroslawl: Regional Material Management Study
Japan/Beppu: The first German-Japanese Dual Master Degree in Intern. Material Flow Management in cooperation with Ritsumeikan/APU

Morocco/Rabat: IfaS Maghreb office, „Energy-plus"-concept for the City Lakhiaita, Biomass master plans in cooperation with GIZ; concepts for integrated waste water reuse
Ruanda: Strategy for solar rural electrification based on a revolving fund
Egypt/Quena: Research study for waste water reuse



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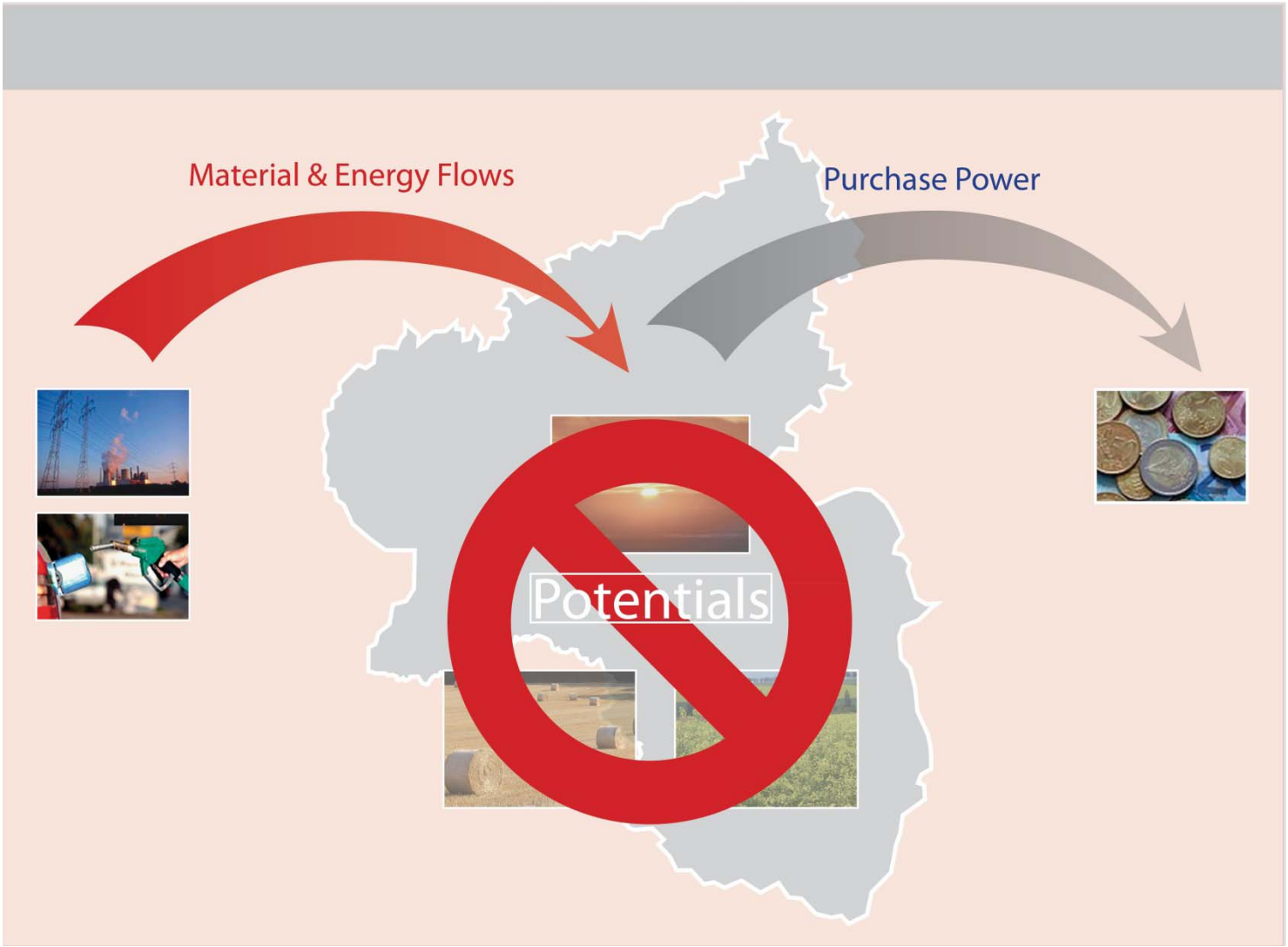
Present Throughput Society
(without MFM approach)



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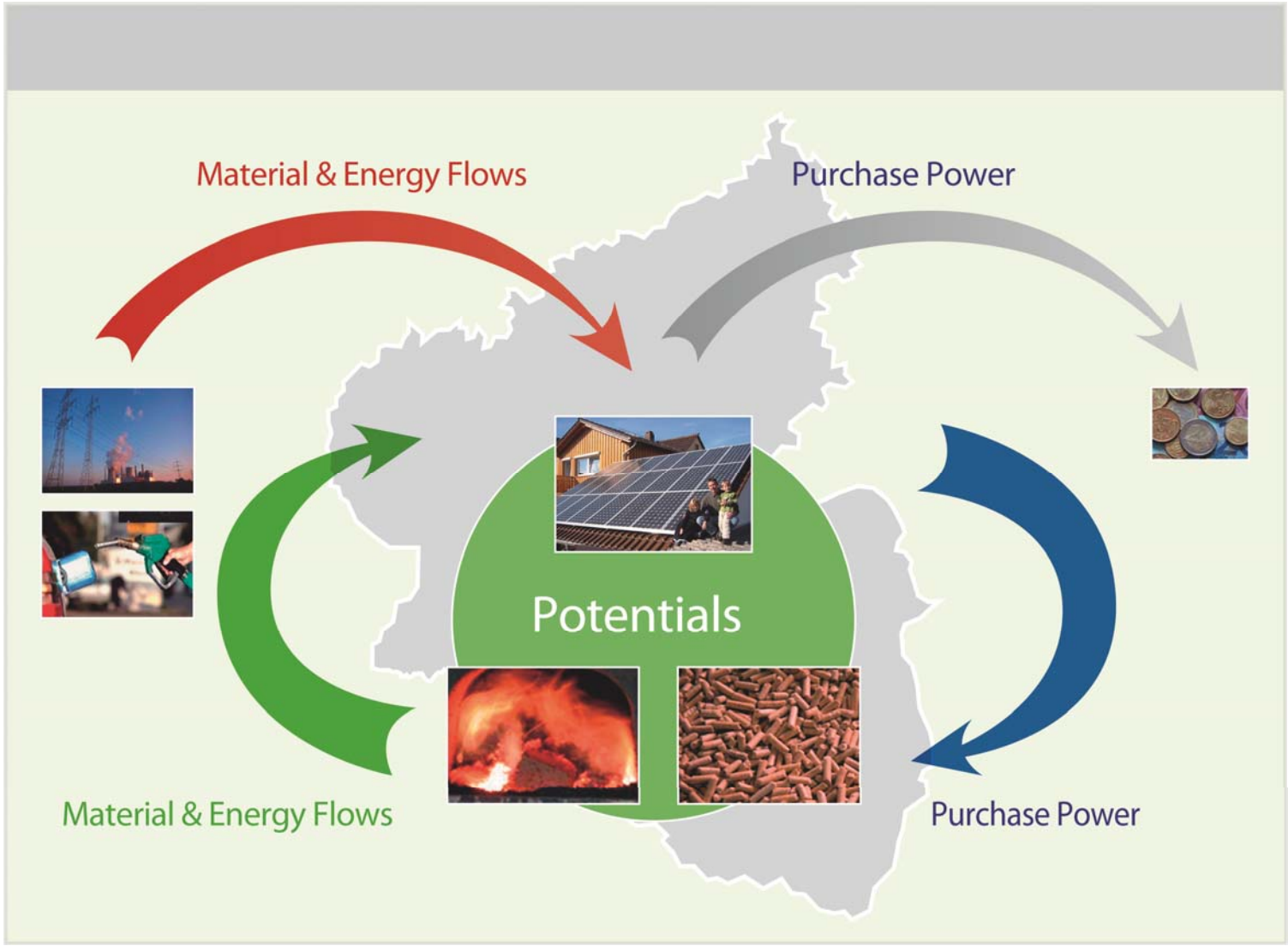
Circular Economy with MFM approach



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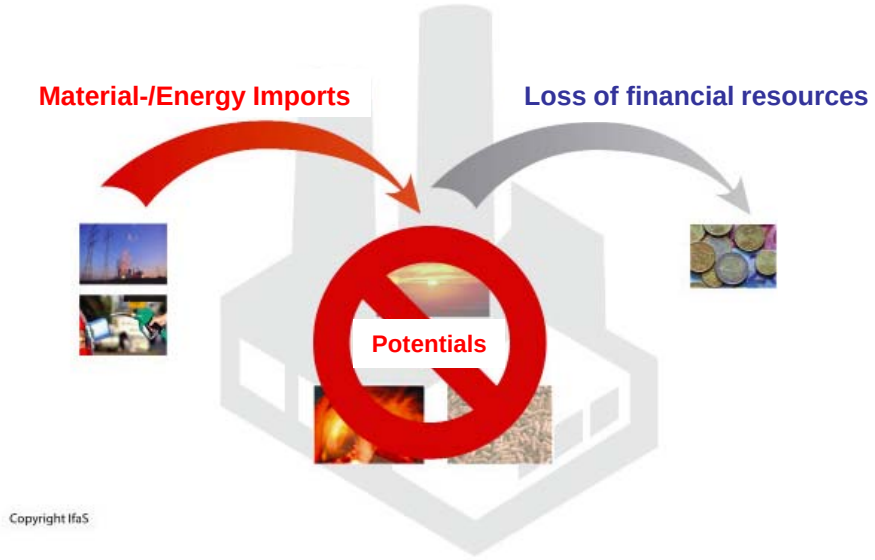
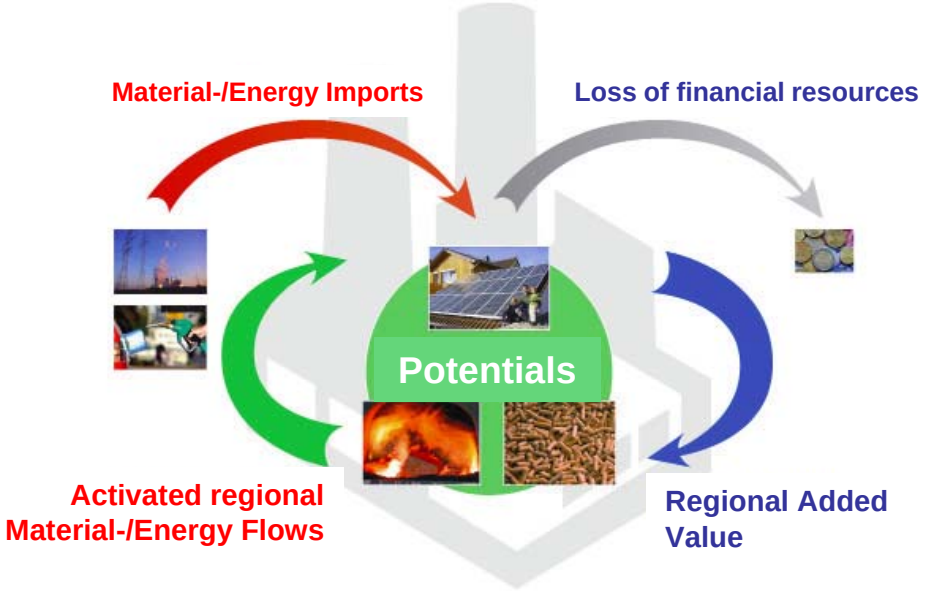
Creating business options and RAV by MFM

Nowadays “throughput society”



- Inefficient
- Cost intensive
- High Environmental impact

Vision and Goal – Zero Emission!



Optimised Material Flow Managemen

- Efficient
- Value adding
- Future-oriented

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Further Biomass Streams

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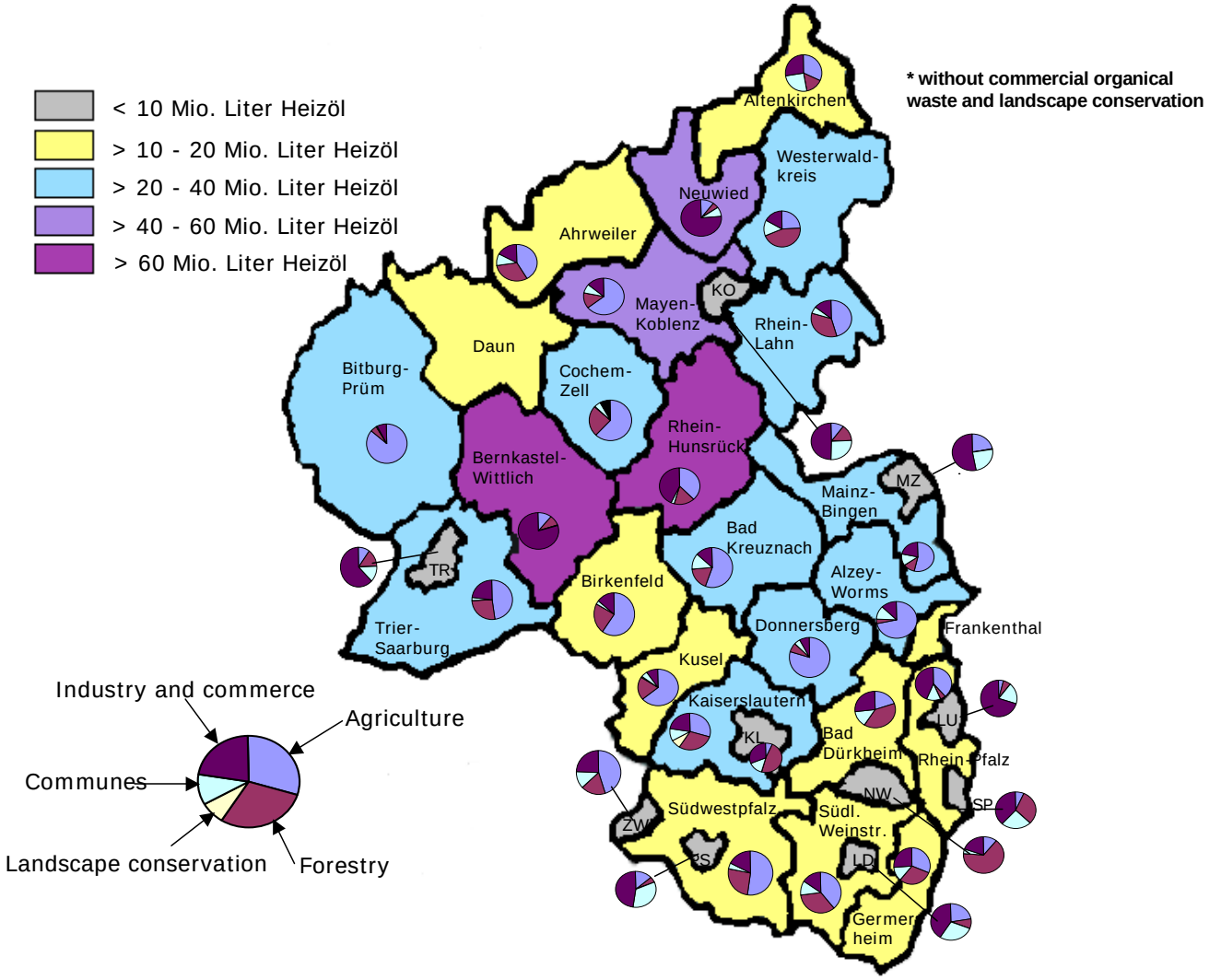
Available Potentials from Biomass in RLP (in million liter oil equivalent per year*)



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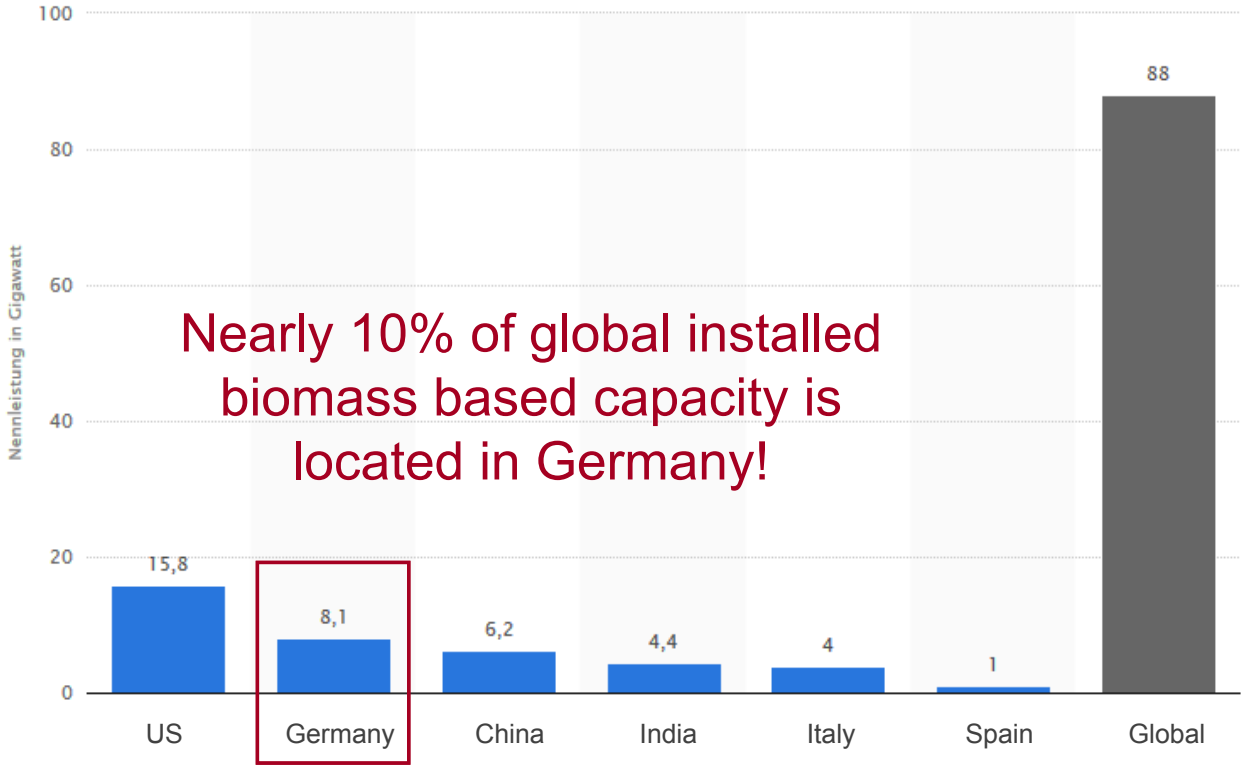
Global Biomass Power Production
(Source: Statista, 2014)

Globally (selected countries) installed electrical capacity of biomass power stations in 2013 (in Gigawatt)



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Biogas Power Production in Germany, 2012
(Source FNR, 2013)

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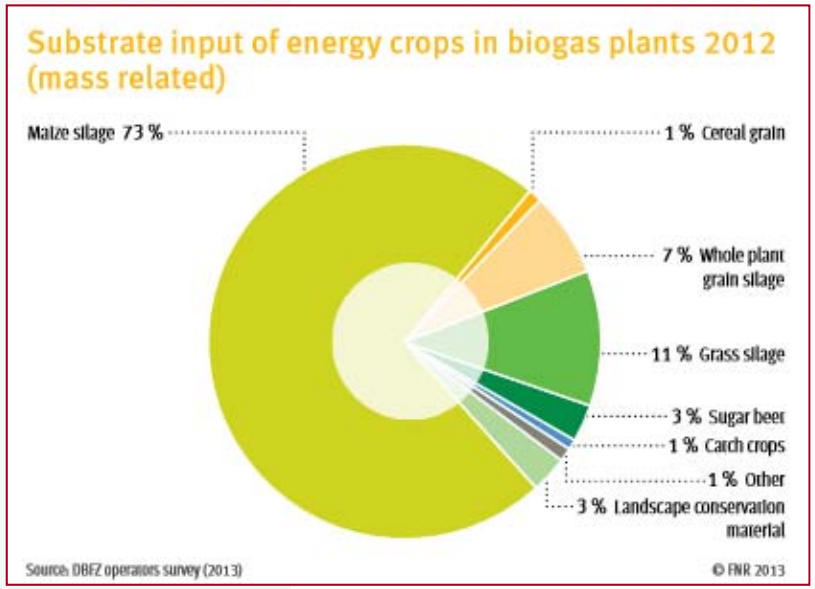
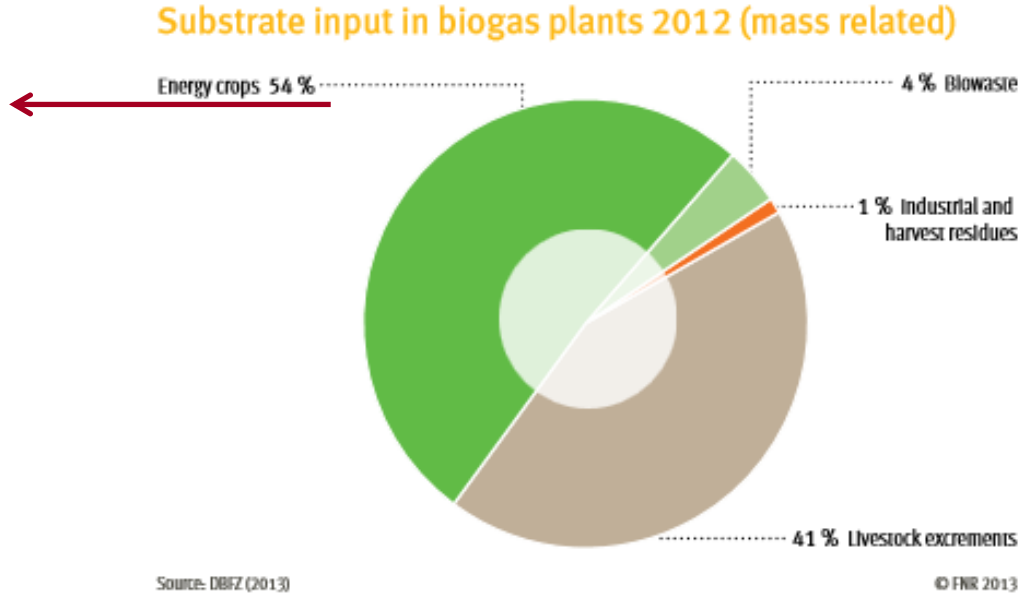
Biogas Substrates in Germany, 2013
(Source: FNR, 2013)

- In 2012, RE resources were grown on approx. 2.4 million of the roughly 12 million hectares of arable land (Germany)
  - Energy crops account for around 2.1 million hectares.
  - Energy crops for biogas account for around 1.1 million hectares.
  - Biomass generated from forestry activity on more than 11 million hectares of woods comprises the largest share of renewable resources (mainly heat energy).





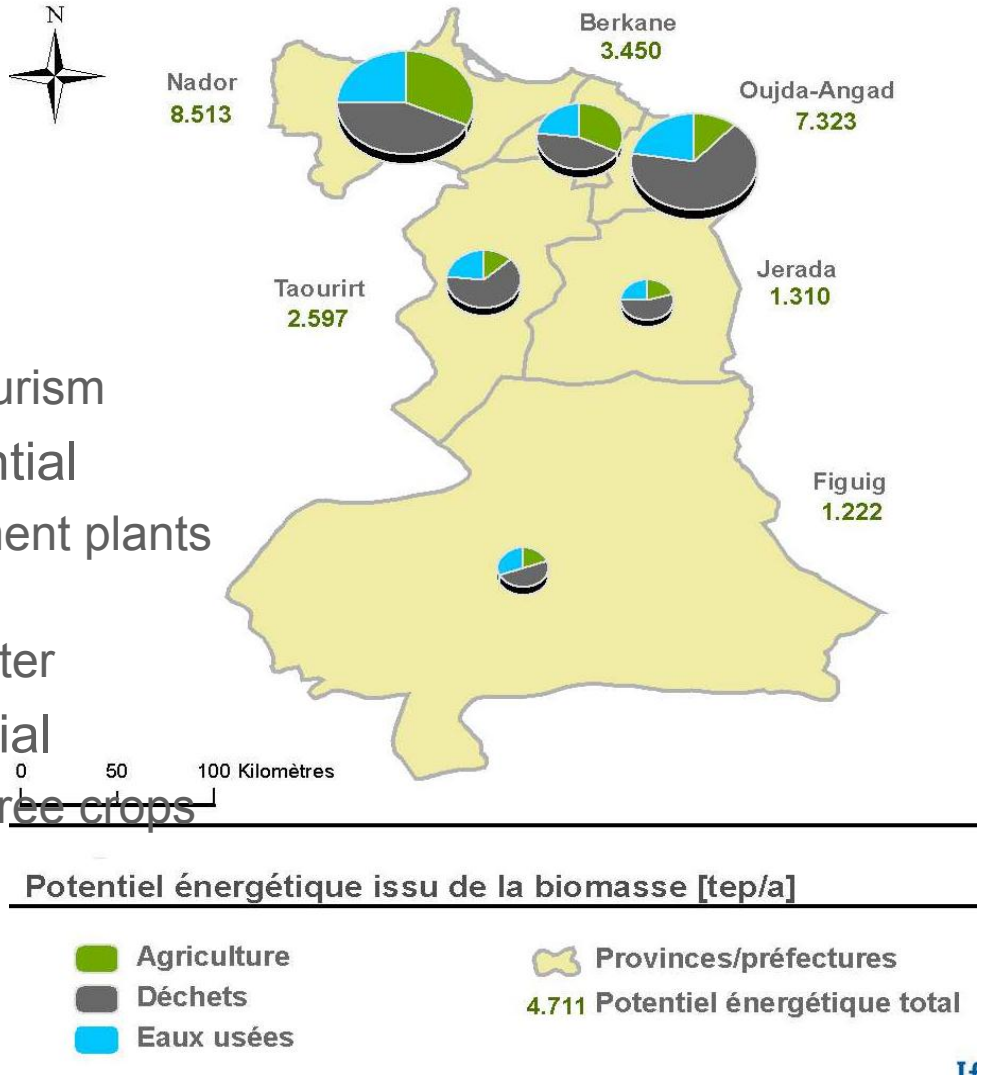
Resource or Problem?!

Waste? or 50 litres of oil equivalent and 600 kg fertilizer! (1 ton of organic MSW)

Biomass potential Study Oriental, Morocco

24,500 tons of
untapped oil equivalents

- Waste = 53 % of the total potential
  - Organic household waste
  - Organic waste from industry and tourism
- Wastewater = 24 % of the total potential
  - Modernization of established treatment plants
  - Early consideration of appropriate technologies for recycling waste water
- Agriculture = 23 % of the total potential
  - Dominance of fruit trees and other tree crops (90%)
  - Animal Husbandry = 8 %
  - Greenhouse crops = 1%



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MFM: Biomass Resource Management

Objectives: Creation of bioenergy and organic fertilizer from biomass residues

- MFA of current biomass waste production (qualitative and quantitative)
  - Product-Residue-Ratio of different crops
  - Production residues
  - Sewage Sludge from WWTP operation
- Evaluation of different biomass treatment technologies and product utilisation
  - Anaerobic Digestion (biogas, digestate)
  - Pyrolysis (biochar, thermal energy)
- Economic evaluation of different biomass utilisation scenarios

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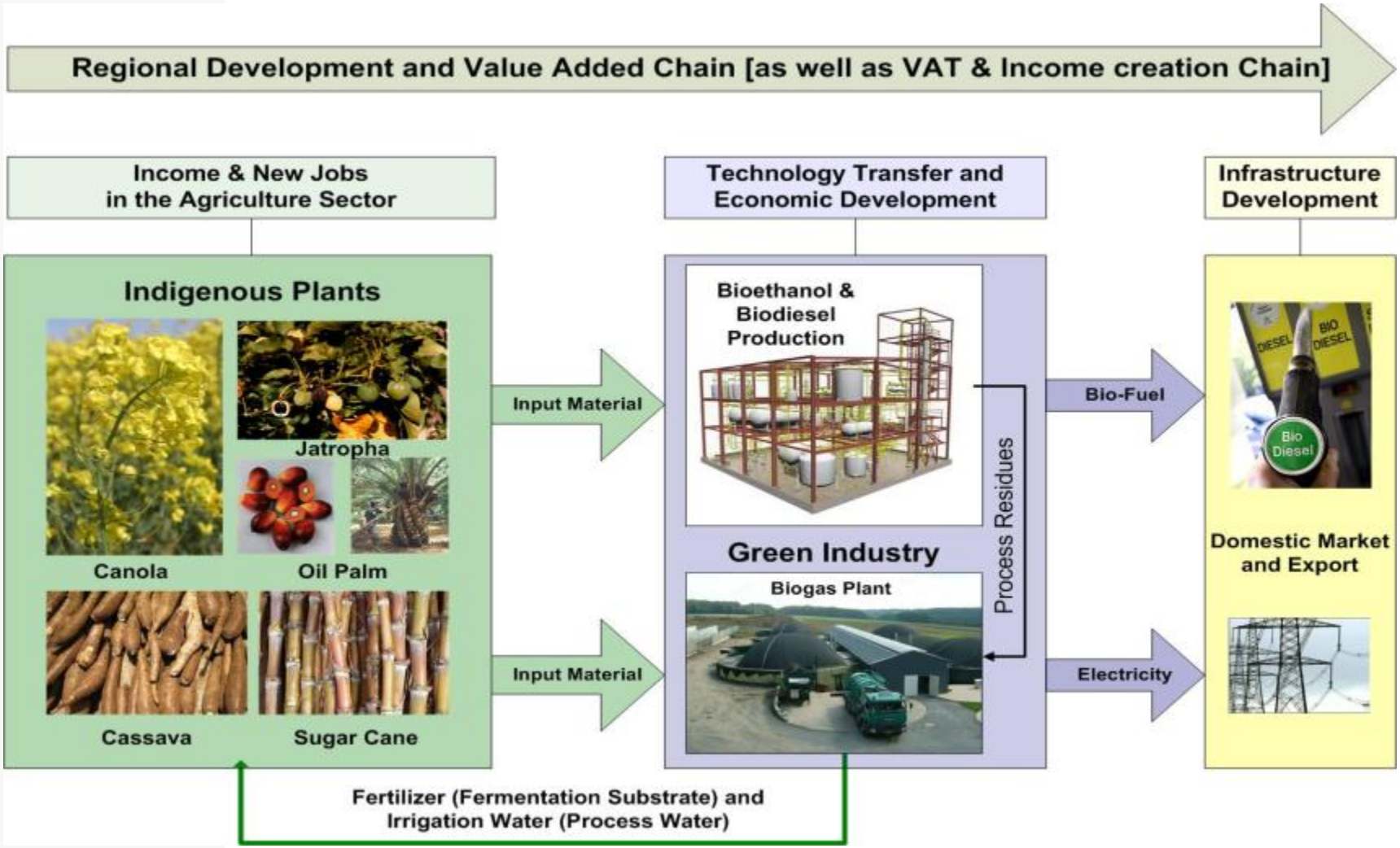
Local potential and local added value



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Moroccon National strategy for the energetic valorisation of biomass

Stratégie nationale pour la valorisation énergétique de la biomasse

Goal and Scope

- Development of a national strategy for the energetic valorisation of biomass
  - Set goals and develop action plans to achieve those goals
  - Consolidate sectoral national plans already launched
- Evaluation of biomass resources (material flows analysis) → evaluate the theoretical potential, technical and economic energy potential from biomass
  - Agriculture
  - Forestry
  - Waste management (including the potential of existing or programmed controlled landfills)
  - Wastewater treatment (including the potential of existing or planned treatment plants)
- Develop investment portfolios
- Define various possible paths of biomass promotion

  (legal, technical operating and recovery, governance ...)
- Impact Assessment (Soil, Air, Water, Regional Added Value)

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Anaerobic Digestion (Beta San Miguel, Mexico)

Anaerobic Digestion Potential

overall potential calculation

Biomass	„Cachaza“ 60,000 t_{FM}/a	Ceniza 15,000 t_{FM}/a	Lodos 11,000 t_{FM}/a	**Total Material 86,000 t_{FM}/a**
Gas Yield per Unit	52 m^3/t_{FM}	10 m^3/t_{FM}	34 m^3/t_{FM}	10% Gas 85% Digestate
Gas Yield	3,120,000 m^3/a	151,200 m^3/a	374,000 m^3/a	
	55% CH_4			
Product	40% Elec. 7,500 h/a	**Total CH_4 Yield 2,004,860 m^3/a** 10kWh/m^3 CH_4	45% Ther. 7,500 h/a	**Digestate 73,100 t_{FM}/a**
Capacity	**Power = 8,000 MWh_{el}/a Capacity = 1,000 kW_{el}**		**Heat = 9,000, MWh_{th}/a Capacity = 1,200 kW_{th}**	**Solid 18,200 t/a Liquid 54,800 t/a**
Investment	Turn-key Investment = 4,000 EUR/kW_{el} *(Excluding Customs)* **4,800,000 EUR**			

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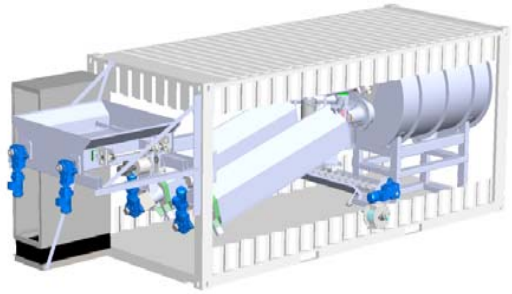
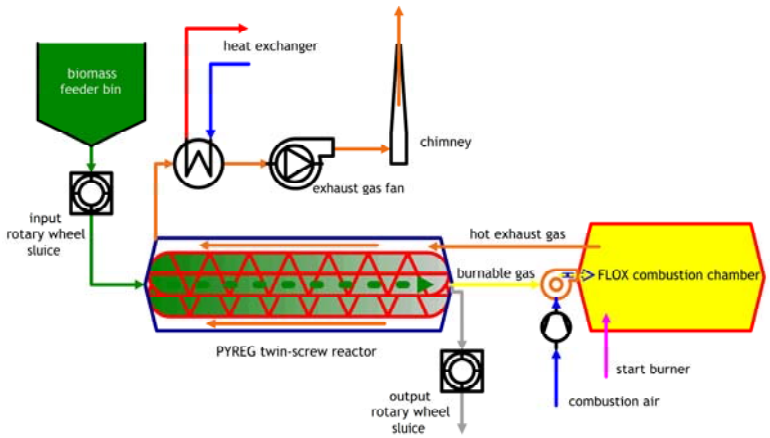
Business Options: Biochar & Pellets



Source: www.pyreg.com

- Biochar / Activated Carbon Granulate
  - PYREG Technology – 0,5 MW Pyrolysis Reactor (Energy Autarky Container Solution)
  - Water Content <50% , Particle Size <30 mm / Dissolve heavy metals
  - Suitable of various forms of organic (lignose) residues
  - “Phosphorus ashes” out of sewage sludge
  - Storable and higher NCV (18 - 26 MJ/kg)



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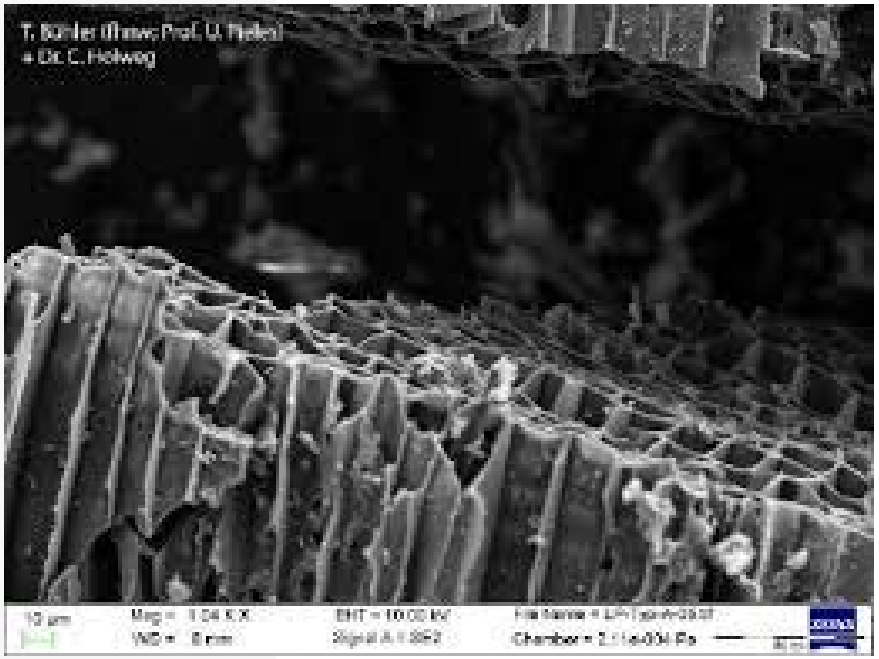
The Secret of El Dorado

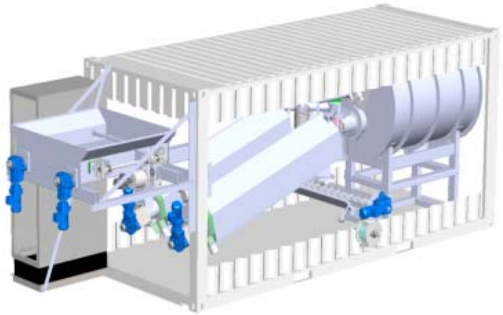
- Production of **Terra Preta**
  - Utilising organic residues and digestate from anaerobic digestion plants
  - Terra Preta humus substrate could be used for improvement and fertilization of soils and long-term humus accumulation

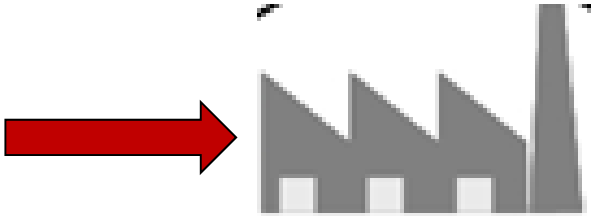


Organic Residues to Biochar and Heat

1,200 t_{MS}/a

Pyrolysis



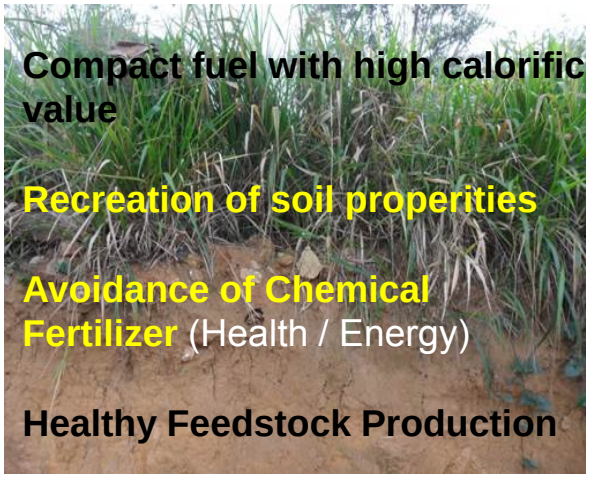


1,080 MWh/a calor

Saving:
1,600 t CO_{2e}/a heat
840 t CO_{2e}/a carbon

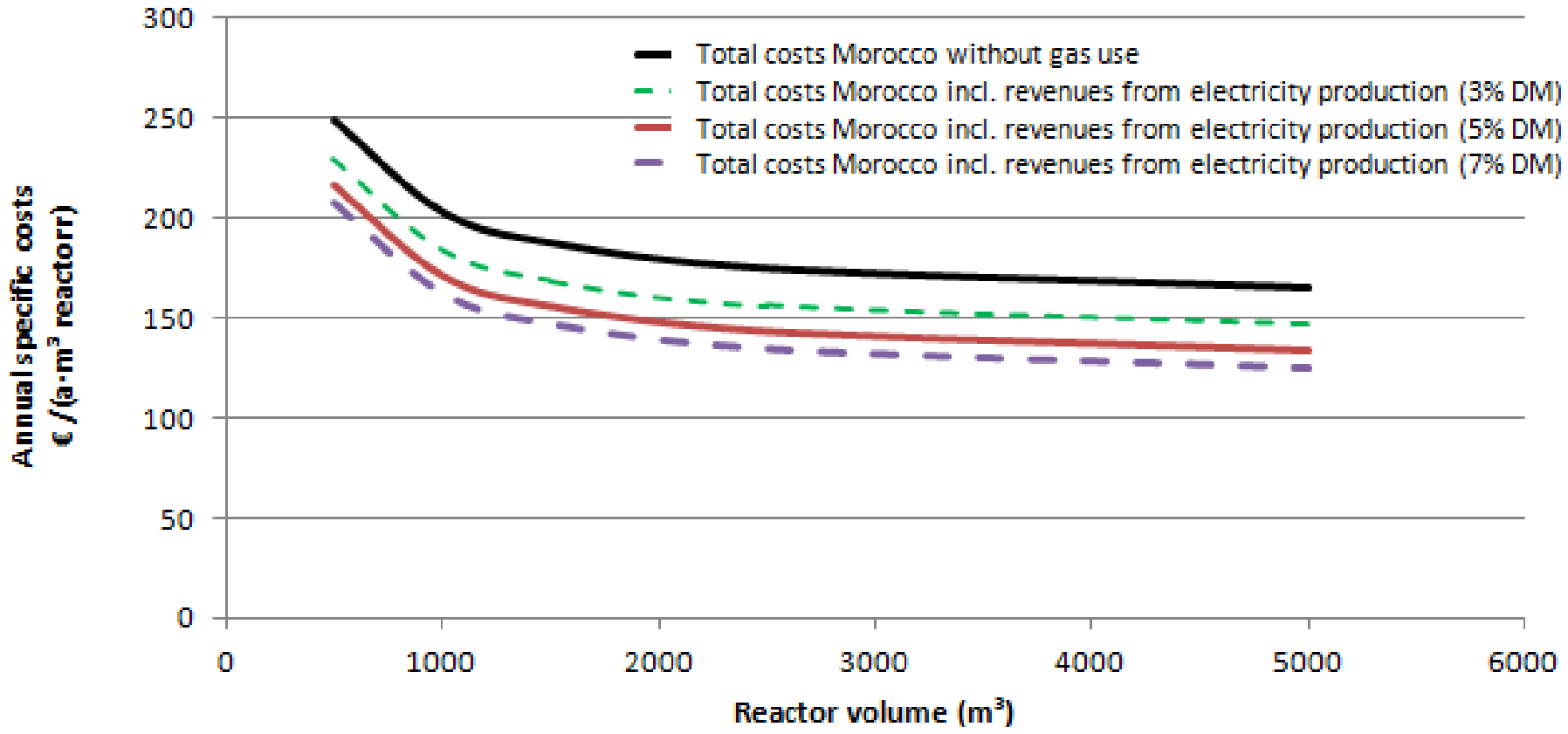
300 t/a

Potential Values:
Energy: 20,400 USD/a
Soil: 90,000 USD/a
Feed: 360,000 USD/a



Treatment and valorisation of sewage sludge

- Anaerobic treatment of sewage sludge



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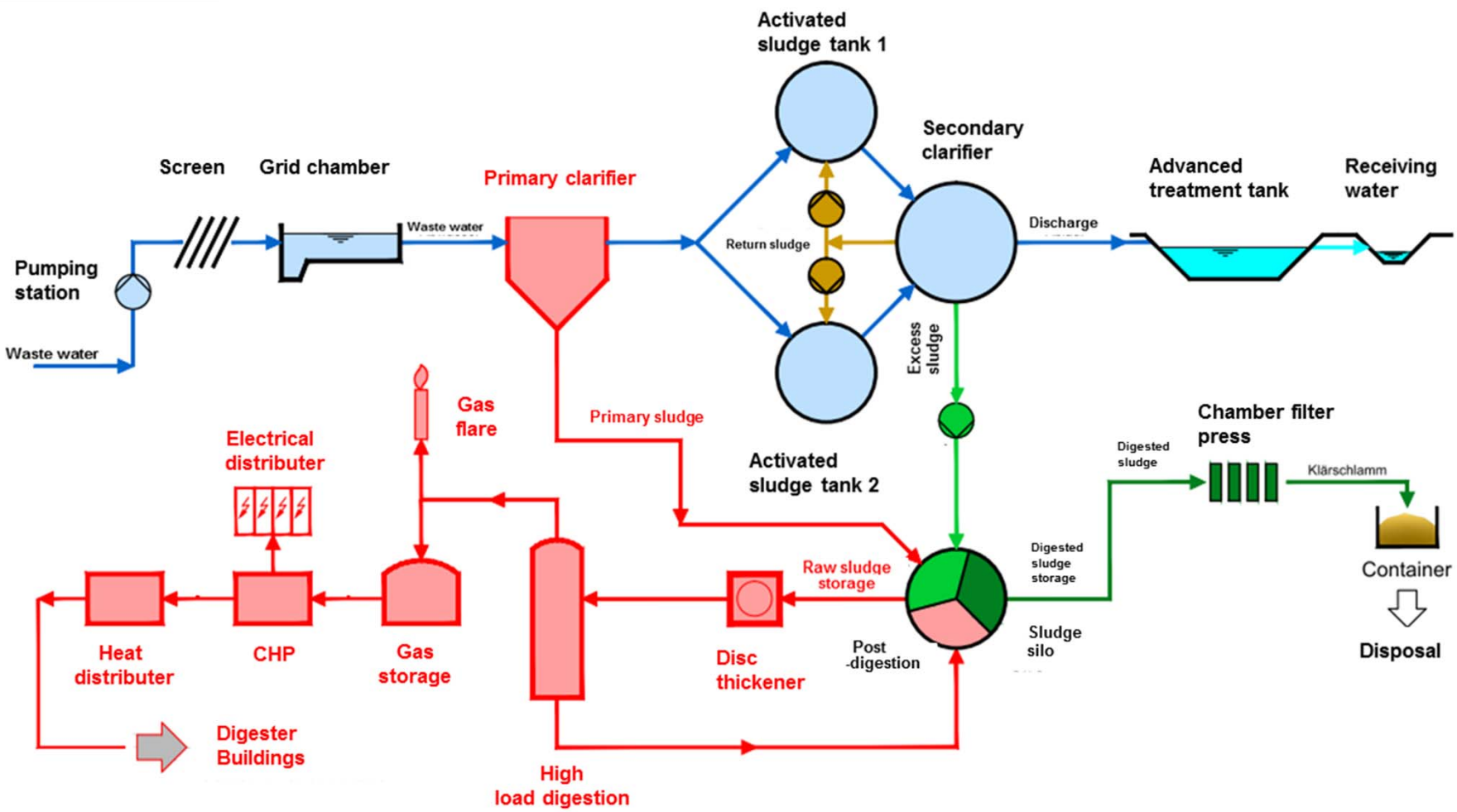
Example Energy-independent WWPT
(Weilerbach, Germany)



Source: HYDRO-Ingenieure Energie & Wasser GmbH, 2011

Hydrothermal Carbonisation (HTC)

- TerraNova Energy (HTC):
  - Treatment of primary and secondary sewage sludge to biochar
  - Reduction of Volume
  - Increase of calorific value of sludge
  - Flocculation of heavy metals
  - Hygienisation of sludge

Source: TerraNova Energy, 2010

Sustainable Resource Management as Economic Promotion Strategy….

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

Ressource Center instead of landfill!!

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

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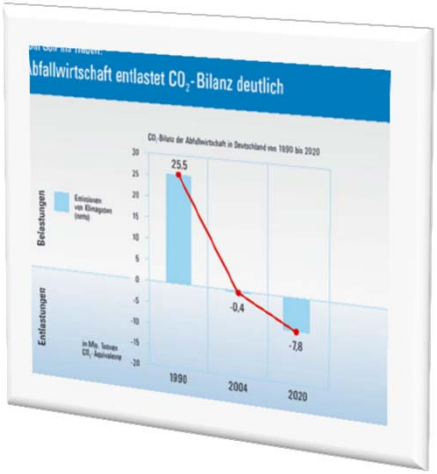
Circular Economy vs Throughput Economy

Expenses of conventional Waste Management Systems

Waste Management without Material and Energy Recovery:
Low Initial Investment
Continuing Expense Factor
Continuing Environmental Stress



Reference-Scenario

Optimisation with MFM Strategies

Expected Development

Business-as-usual-Scenario

Resource Management with Material and Energy Recovery:
High Initial Investment
Regional Added Value
Environmental Protection

Best Case - Scenario

Zeit

Growth Potentials:
CO2equ. - Allowances
Secondary Raw Material
New Products (Fertilizer, etc)

Benefits of Circular Economy Systems

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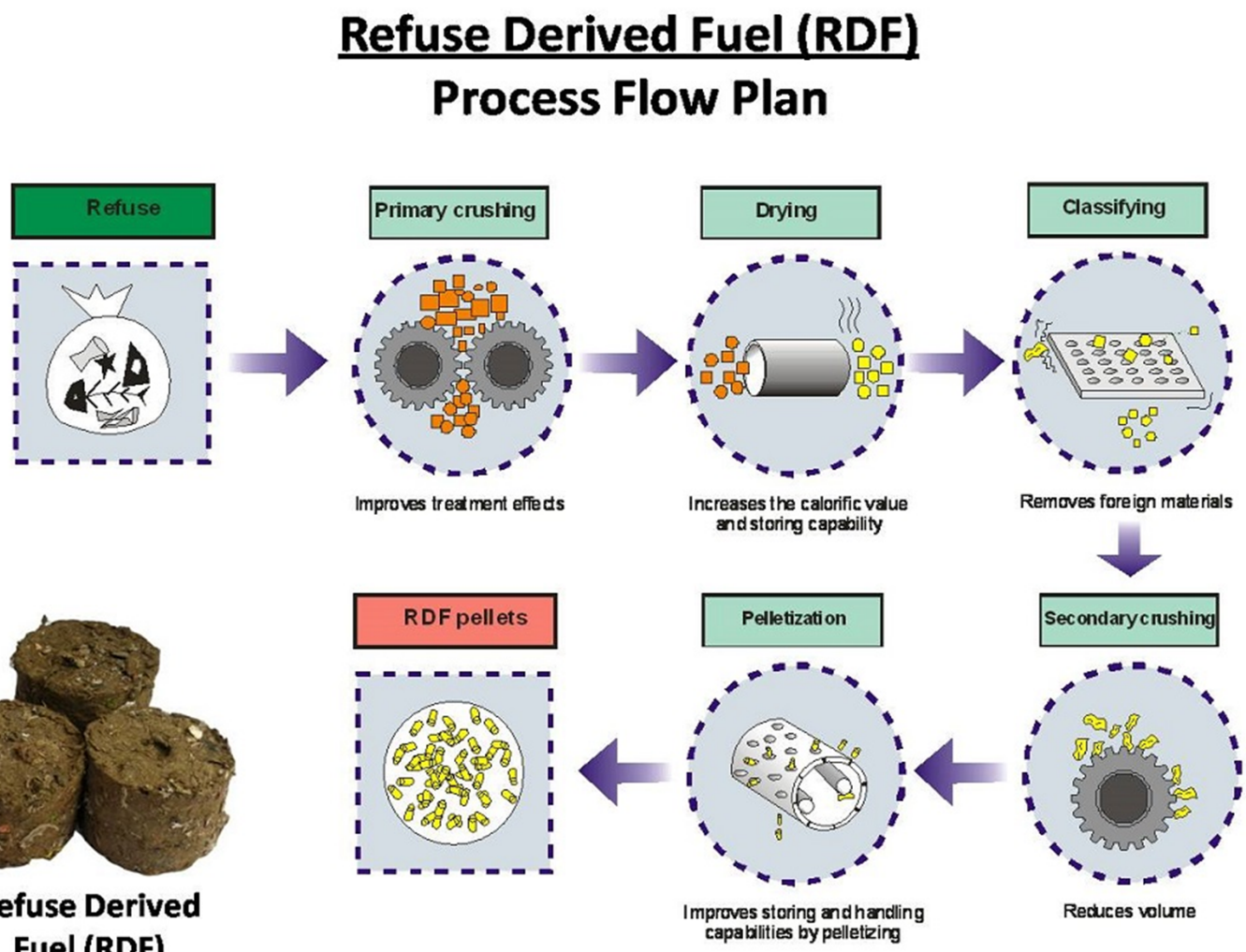
Refuse Derivided Fuel

Refuse Derived Fuel (RDF)



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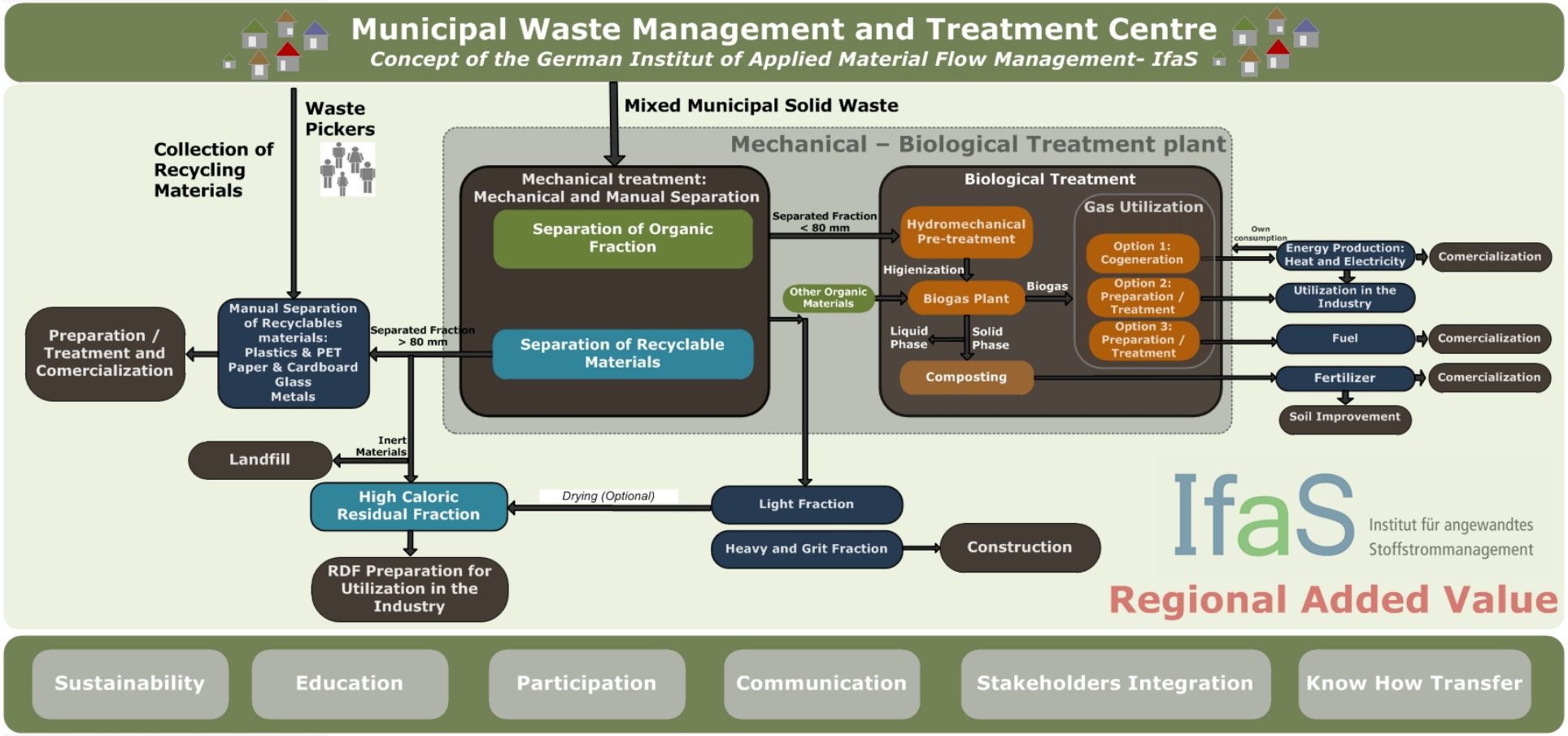
BERC Technology Design (MBT-Approach)



Source: Martínez- IfaS, 2013

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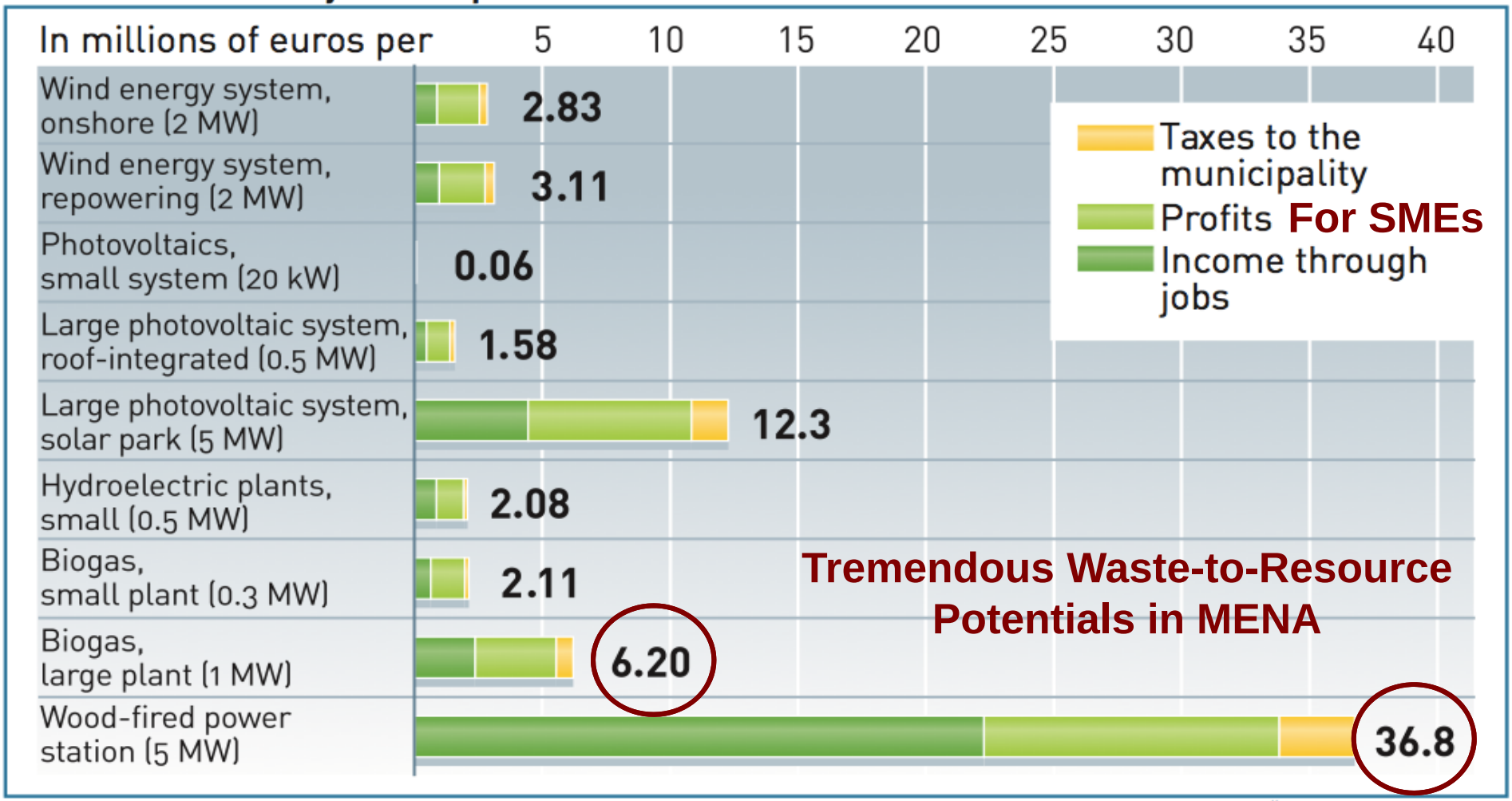
Regional Added Value Creation Potential

The value creation effects of typical renewable power generation systems

over the course of 20 years of operation



Source: IÖW, current as of Aug. 2010

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Sustainability Advisory Services for *Desert Rose*

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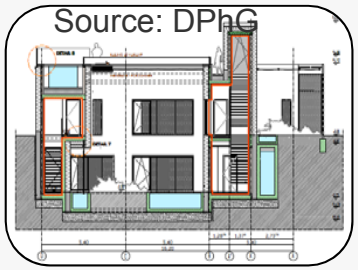
Sustainable and Smart City Concept



- 100% Renewable Energy Concept
  - Electricity and Cooling
  - Technology Design and Economic Evaluation
- Sustainable Resource Management
  - 100% Water Re-use and Water Efficiency
  - Waste-to-energy and waste-to-soil
  - Support
- Modern Oasis Concept (Multi-use) for Greenbelt
  - Source for food and energy
  - Sink for nutrient, water and fertilizer

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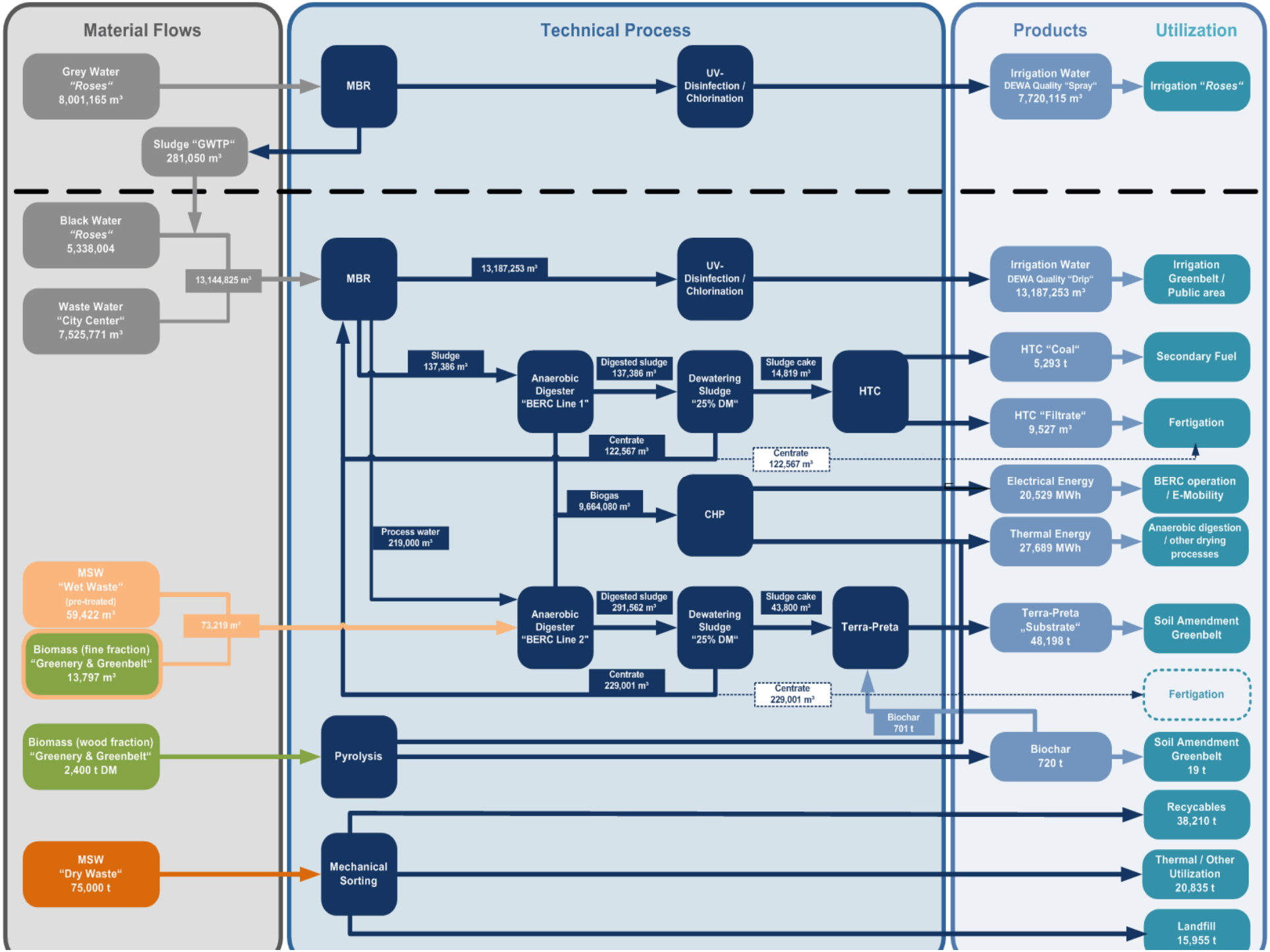
Material Flows
Technical Process
Products
Utilization
Grey Water "Roses" 8,001,165 m³
Sludge "GWTP" 281,050 m³
Black Water "Roses" 5,338,004
13,144,825 m³
Waste Water "City Center" 7,525,771 m³
MSW "Wet Waste" (pre-treated) 59,422 m³
73,219 m³
Biomass (fine fraction) "Greenery & Greenbelt" 13,797 m³
Biomass (wood fraction) "Greenery & Greenbelt" 2,400 t DM
MSW "Dry Waste" 75,000 t
MBR
MBR
UV-Disinfection / Chlorination
UV-Disinfection / Chlorination
13,187,253 m³
Sludge 137,386 m³
Anaerobic Digester "BERC Line 1"
Digested sludge 137,386 m³
Dewatering Sludge "25% DM"
Sludge cake 14,819 m³
HTC
Centrate 122,567 m³
Centrate 122,567 m³
Biogas 9,664,080 m³
CHP
Process water 219,000 m³
Anaerobic Digester "BERC Line 2"
Digested sludge 291,562 m³
Dewatering Sludge "25% DM"
Sludge cake 43,800 m³
Terra-Preta
Centrate 229,001 m³
Centrate 229,001 m³
Biochar 701 t
Pyrolysis
Mechanical Sorting
Irrigation Water DEWA Quality "Spray" 7,720,115 m³
Irrigation "Roses"
Irrigation Water DEWA Quality "Drip" 13,187,253 m³
Irrigation Greenbelt / Public area
HTC "Coal" 5,293 t
Secondary Fuel
HTC "Filtrate" 9,527 m³
Fertigation
Electrical Energy 20,529 MWh
BERC operation / E-Mobility
Thermal Energy 27,689 MWh
Anaerobic digestion / other drying processes
Terra-Preta „Substrate" 48,198 t
Soil Amendment Greenbelt
Fertigation
Biochar 720 t
Soil Amendment Greenbelt 19 t
Recycables 38,210 t
Thermal / Other Utilization 20,835 t
Landfill 15,955 t

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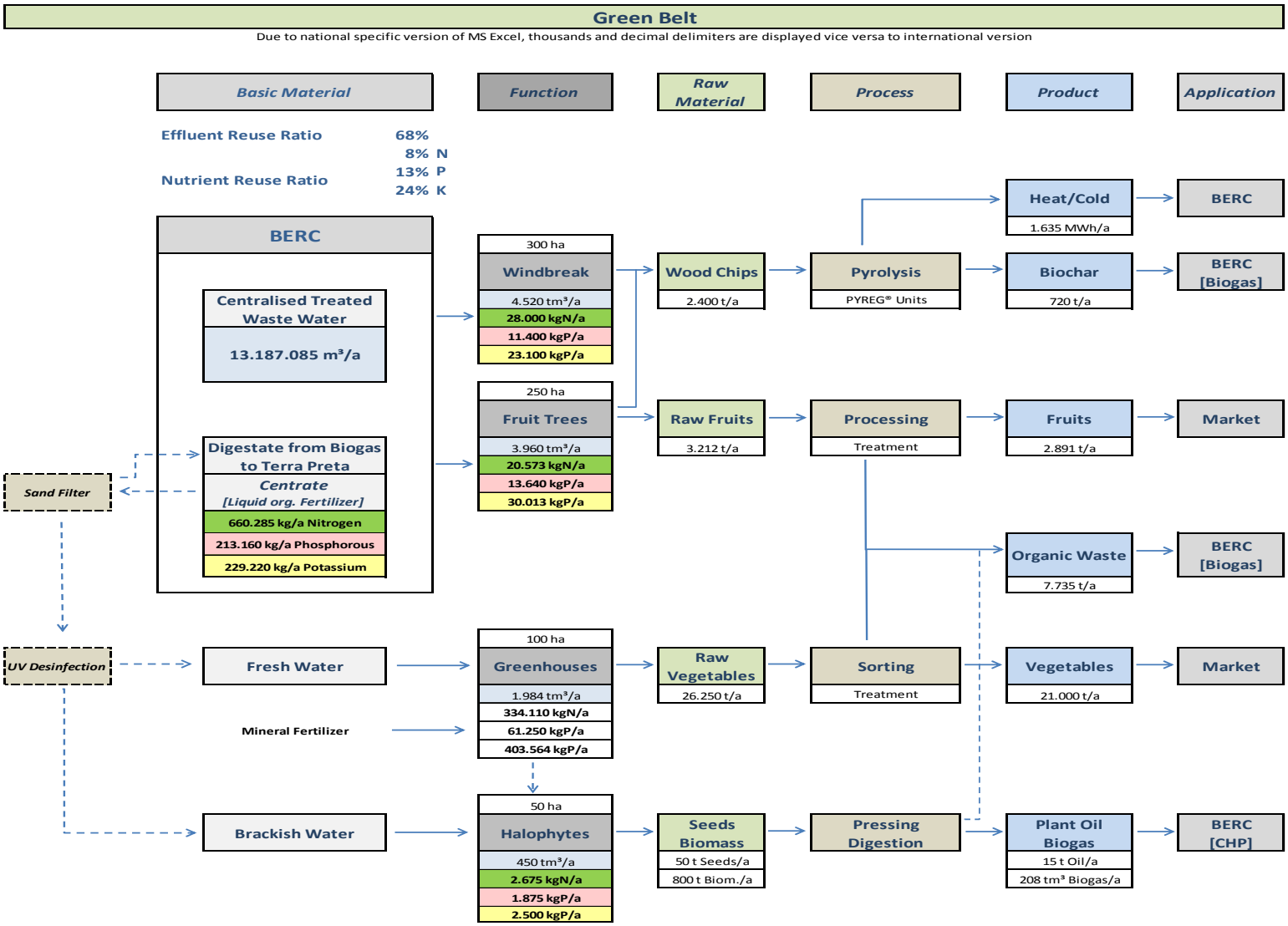
Desert Rose – Dubai - Greenbelt



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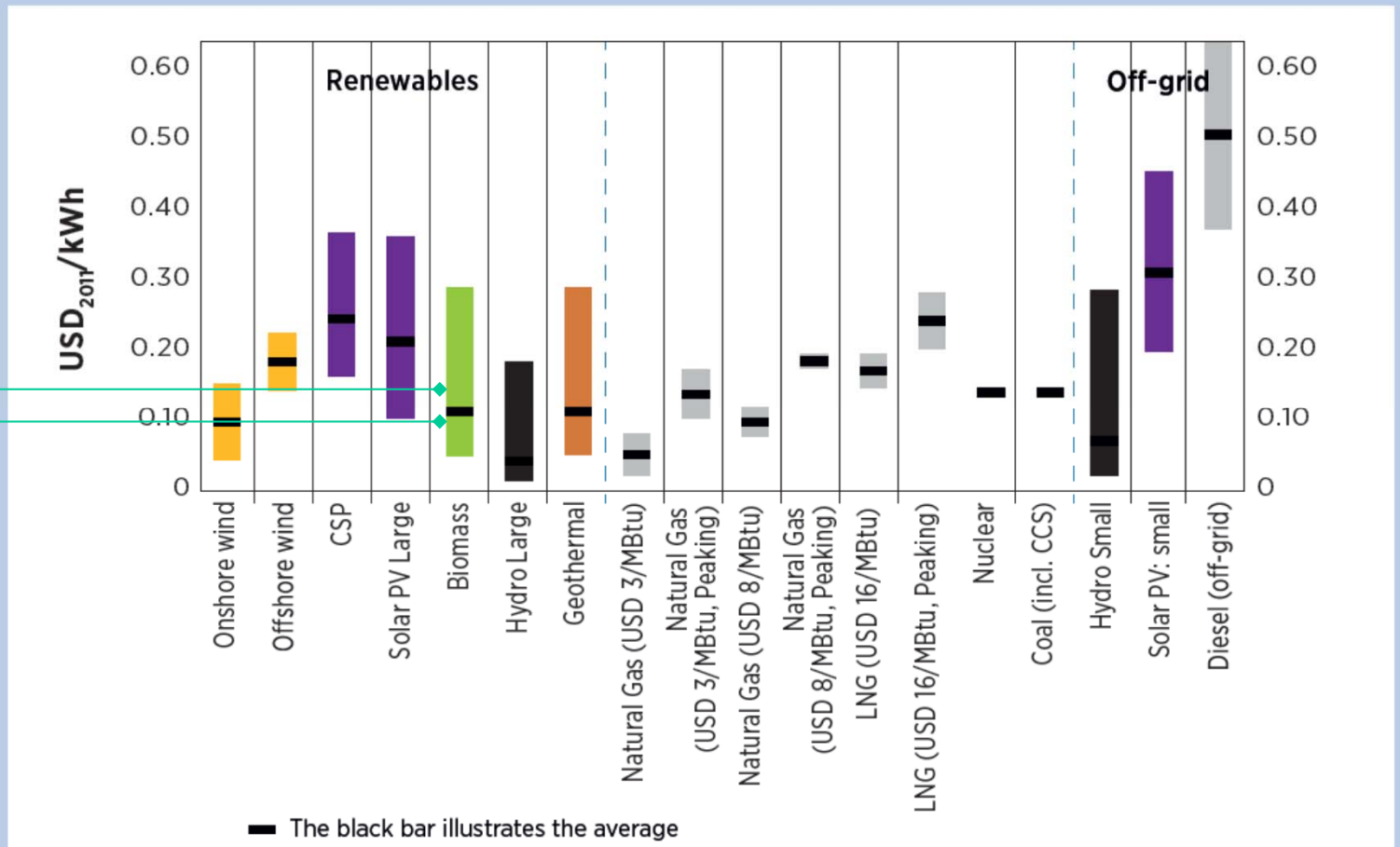
Levelized Cost of Electricity (LCoE)

actual cost level in Germany

10 kW_p

>1 MW_p

Figure 11: Levelised costs of electricity: Utility and off-grid power in OECD countries



source: IRENA

Energy and Mass Balance BERC

“Zero Emission” and “Energy Autarky”

Total		Production	Plant demand	Output
Biogas	Nm^3/a	9,664,080		
	MWh/a	55,395		
Thermal energy	MWh/a	26,069	31,772	
Electrical energy	MWh/a	20,529	17,522	3,007
Digestate / Sludge total	m^3/a	428,948		428,948
Digestate / Sludge liquid	m^3/a	351,568		351,568
Digestate / Sludge solid	m^3/a	58,619		58,619
Irrigation water	m^3/a	13,406,253	219,000	13,187,253
HTC coal	m^3/a	5,293		5,293
HTC filtrate (liquid fertilizer)	m^3/a	9,527		9,527
Thermal energy	MWh/a		1,186	
Electrical energy	MWh/a		207	
Terra-Preta Soil	m^3/a	48,198		48,198
Electrical energy	MWh/a		21	
Biochar	t/a	720	701	19
Thermal energy	MWh/a	1,620		1,620
Electrical energy	MWh/a		72	
Thermal energy balance	MWh/a	27,689	32,957	-5,269
Electrical energy balance	MWh/a	20,529	17,823	2,706

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ZE Results of BERC

Environmental Indicators		
Solid Resource Management (MSW)	Total Amount of MSW treated	142.350 t/a
	Amount of organic residues treated by anaerobic digestion	74.825 t/a
	Utilisation ratio of organic residues	100%
	Amount of dry MSW treated	75.000 t/a
	Production of Secondary Raw Material from dry MSW fraction	32.810 t/a
	Production of Secondary Fuel from dry MSW fraction	20.835 t/a
	Amount of MSW to be disposed (excl. Contingency Reserve)	11.313 t/a
	Utilisation ratio of dry MSW fraction (including Contingency Reserve)	85%
Integrated Water Resource Management	Total Amount of Waste Water treated	20.907.368 m^3/a
	Production amount of irrigation water in the quality: "spray"	7.720.115 m^3/a
	Production amount of irrigation water in the quality: "drip"	13.187.253 m^3/a
	Total Amount of Sewage Sludge Treated in Anaerobic Digestion	418.436 m^3/a
	Total Utilisation ratio of Sewage Sludge	100%
	Current Utilisation rate of N (excl. Terra-Preta) - 52%	732 t/a
	Current Utilisation rate of N (excl. Terra-Preta) - 69%	245 t/a
Total energy recovery	Biogas	9.664.080 m^3/a
	Electrical Energy	20.529 MWh/a
	Thermal Energy	27.689 MWh/a
	Secondary Fuel	120.348 MWh/a
Total energy demand	Electrical Energy	29.022 MWh/a
	Thermal Energy	32.957 MWh/a
Space Demand BERC		78.750 m^2
Space Demand GWTPs (incl. Vacuum Stations)		14.000 m^2

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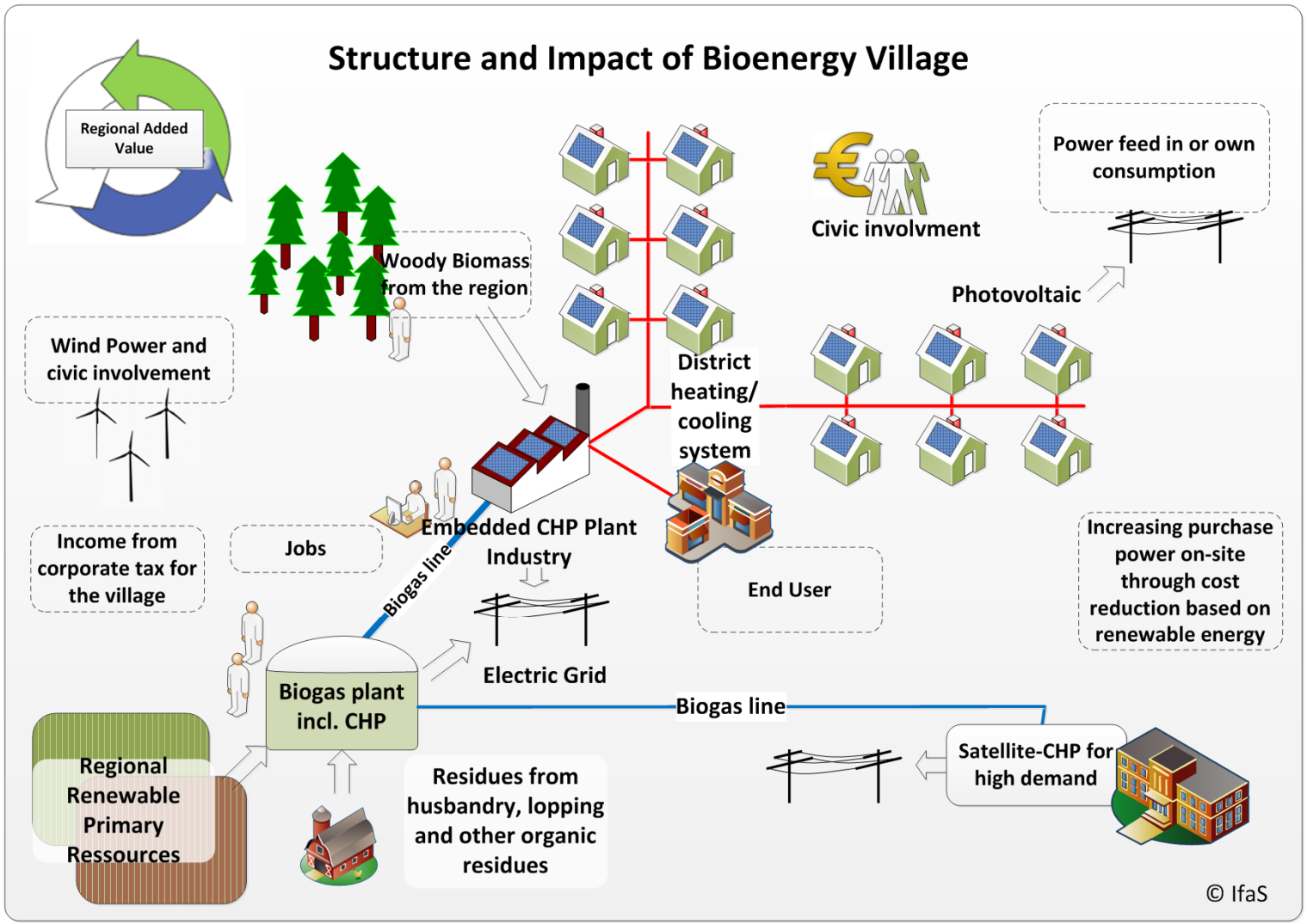
Bioenergy Village – Smart Villages



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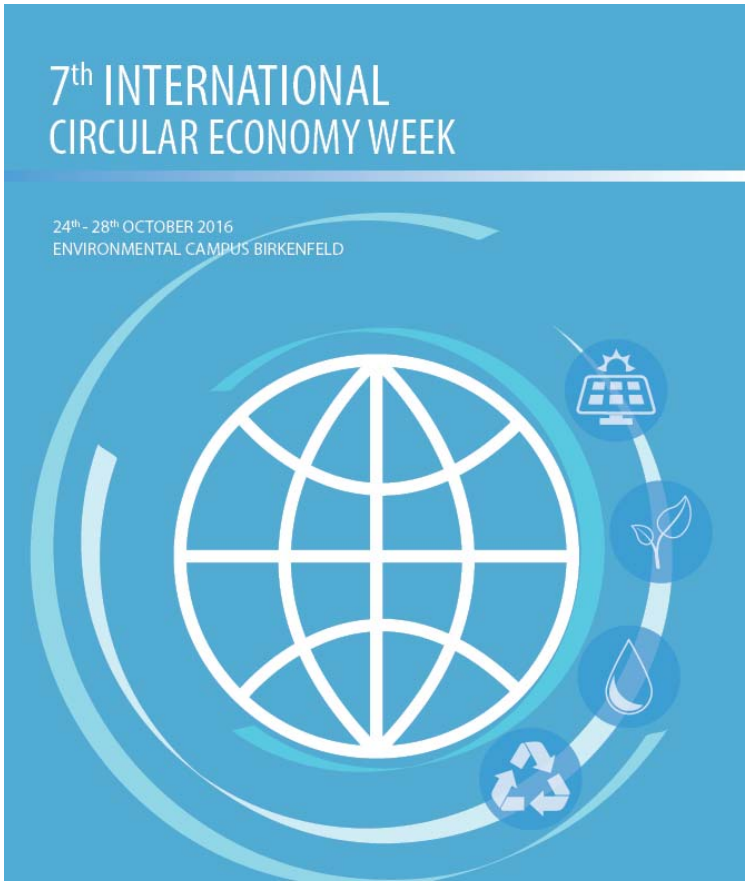
7th International Circular Economy Week

IMAT Master Int. MFM



24th-28th October 2016

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All it needs is a deeper look!

IfaS Institut für angewandtes Stoffstrommanagement

100% Renewables and Resource Economy
based on **regional Zero Emission and MFM**

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