Circular Economy:
More business and more environmental protection through Material Flow Management!

IV. International Conference on Circular Economy 2014
Environmental Campus Birkenfeld
6th of November, 2014

Prof. Dr. Peter Heck
Managing Director
Institute for applied Material Flow Management

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    - Material Flow Management (MFM)
    - Zero-Emission (ZE) System Design
  - (Inter-) National IfaS Next Practice Examples

Zero-Emission Campus Birkenfeld:
An innovative model for education and research!

 Formerly a US Military Hospital
Between 1953 – 1994

Zero Emission Campus

- 100% Renewable heat/cooling supply based on waste wood, biogas and solar thermal
- 100% Renewable electricity based on cogeneration and photovoltaic
- 100% Energy efficiency
  - Waste Heat Recovery
  - Cooling system based on geothermal and solar adsorption
  - Rain water utilization
  - Passive and Plus-Energy Buildings
  - Campus as a Biotope
- Zero Waste Water and Nutrient recovery in planning

Zero Emission Building Design
17. April 2007

Zero Emission University by Waste to Energy

- Circular Economy Concept
- The Zero Emission University
  - In terms of energy

ZE = Waste-to-Resource

Discover Potentials
Optimize Processes
Create Regional Added Value

Innovative Waste Water Management
at the Environmental Campus Birkenfeld

- Recycling plant for the treatment of organic solid and biological waste
- Recovery of Nutrients
- Natural waste water treatment with service water recirculation and biomass production
- Natural water pond for recreation

Solar Energy Utilisation

- Photovoltaic: Facade-Integrated & Art
- Solar Thermal Applications

Integrated Water Resource Management

- Natural water ponds for ground water recharge
  - Avoidance of rain water run off to sewer system
- Rain water collection and valorisation as service (grey) water (toilet flushing)
- Green roofs to reduce rainwater runoff

New UCB-Communication Centre

- Passive house standard
  
- PV installation with an installed capacity of 40 kWp
- 40 cm exterior insulation
- Triple-glazed windows
- Air conditioning with 80 % heat recovery
- Adiabatic cooling of the conference room
- High efficient electric motors
Other Innovations

- Zero-Heat-Energy Student Dormitory
  [Passive House Standard]
- Modular Boarding House
  [Timber frame – less embedded energy]
- LED based public lighting
  Test area with different lamp pole types

IfaS in Numbers

- Non-Profit Research Institute
  - Foundation in 2001
  - 9 Professors
  - 80 Employees from various disciplines
- 5 Departments:
  - Renewable Energy & Energy Efficiency
  - Biomass and Cultural landscape Management
  - Zero Emission and MFM Research
  - Education
  - International MFM

Core Competences

- Creation and Marketing of the Circular Economy Strategy for the State Government Rhineland-Palatinate
- Climate Protection and Zero-Emission Strategies and Projects for Regions, Universities and Industries in Germany, China, Turkey, Chile, Brazil, Morocco
- (Inter-) national Capacity Building and Consultancy for Energy Transition and Zero Emission
- Sustainable Water, Waste and Resource Management projects in Europe, Asia and Latin America
- Carbon Footprint, Carbon Management and CDM Project Development and Capacity Building
- Community Debt Relief Advisory Services
- Innovation Projects for the EU (e.g. ZECONS)
- IfaS as a coach for Zero Emission System Design

IfaS at „home“ (RLP)

More than 300 community projects in RLP since 2004
Discover Potentials
Optimise Processes
Create Added Value

Global Network: Worldwide IfaS projects

Weltweite Projekte des IfaS

MFM in prehistoric and modern times

Definition Material Flow Management

Material Flow Management and Zero-Emission:
The future-oriented research area

Circular Economy with MFM approach
Conventional linear model vs. CE-Model

Zero Emission: the global perspective

Material Flow Management and Zero Emission

Zero Emission (ZE) : A Management Approach

ZE-MFM Master Planning

- Balance Approach: Quantitative CO₂-Neutrality avoiding, compensating and off-setting emissions from electricity, heat and cooling energy consumptions
- Material Flow Analysis: Thorough (qualitative and quantitative) analysis of existing consumption (demand) patterns and existing (or to be activated) potentials
- Commitment: Ambitious and measurable targets
- Participation: Motivation, awareness and participation schemes for citizens and industry creating innovations and local stakeholder networks.
- Economic Promotion: as a result of Zero Emission as a systemic and sustainable community/regional development approach.

Procedural Steps:
1. Energy- and CO₂-Balance (incl. Target Scenario)
2. Potential Analysis (Saving, Efficiency, RE)
3. Participation Management
   a) Stakeholder Analysis & Management
   b) Participation and local Financing Models
4. Catalogue of Measures/Projects
5. Controlling and Monitoring Concept (Implementation)
6. Fundraising and Financing Concept
7. Public Relation Concept
Optimization of energy flows

- Electricity
  - Energy source: natural resource
  - Heat loss: wastewater
- Heat
  - Energy source: natural resource

Energy Efficiency and User Behavior

- Capacity Building and Awareness of staff is crucial to tap “non-investment” related energy saving potentials
  - Switch off unnecessary light sources
  - Closing doors and windows (if AC is operating)
  - Only short intermittent ventilation

Heat & Cooling | Insulation of Pipes and Armatures

- High losses due to constant usage
- Steam-, condensate-, cooling and warm-water pipes

Example:
- 30 Armatures, 150 m Pipes (50mm) at 70°C
- 10 Armatures, 30 m Pipes (50mm) at 110°C
  - Energy Saving: ca. 247,700 kWh/year
  - Saving: ca. 8,700 €/year
  - Investment: ca. 17,400 €
  - Stat. Amortization / IRR: 2 a / 50%

Bandapsel | Insulation of Buffer Storage Socket

- Buffer Storage Socket not insulated

Example:
- Energy Saving: ca. 59,300 kWh/year
- Saving: ca. 2,080 €/year
- Investment: ca. 1,070 €
- Stat. Amortization: 0.5 years
- IRR: 191%
Electricity | High Efficiency Pumps

- Replacement of (old) over-dimensioned pumps by high efficiency pumps
- Energy Saving: 58,200 kWh/year
- Saving: 7,000 €/year
- Investment: 23,000 €
- Stat. Amortization: 3.1 years
- IRR: 31%

Compressed Air | Waste Heat Re-Utilisation

- Example: Compressor for Cooling Engine with 800kW Cooling Capacity
- Heat Recovery and Usage for process water pre-heating
  - Energy Saving (natural gas): 685,000 kWh/year
  - Investment: 20,600 €
  - Dyn. Amortization / IRR: 0.6 years
  - IRR: 180%

Sustainable Buildings: Energy Producer of the Future

Producing energy!


Guiding Principles MEDA Low Energy House

- Energy Efficient HVAC (heating, ventilation, air conditioning)
- Solar and/or geothermal energy

Summary of Results:
- 5-10% additional incremental cost
- 40-50% energy saving
- Increase in comfort and living quality

EE Buildings: Life cycle cost analysis

- Higher initial investment but lower life-cycle costs
- Higher craftsmanship services during construction than (imported) fuel bills during lifetime
- Preferable for lending institutions
- Higher lending volume and improved cash flow of debtors

Lighting | Street Lighting (SAL, Cape Verde)

- Replacement of mercury-vapor-bulbs and sodium-vapor-bulbs to LED-lamps (~1,550 lamps)
- Energy Saving: 31,682 kWh/year
- Saving: 7,000 €/year
- Investment: 795,600 €
- Stat. Amortization: 8.0 years
- Cost saving (15 years): 1,158,000 €

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17. April 2007

**Auftaktveranstaltung Biomasse-Masterplan LK MYK**

### Lighting | Street Lighting (Rhineland-Palatinate)

- **Residential Street**
  - 10 Light Poles
  - Street Length: 300 m

  **IST:** 10 x 125 W HQL  
  **EE-Potential:** 90%  
  **Target:** 10 x 13 W LED

- **Communal Main Street**
  - 42 Light Poles
  - Street length: 1.1 km

  **IST:** 6 x 250 W HQL  
  **EE-Potential:** 50%  
  **Target:** 8 x 78 W LED  

### Tri-Generation | Power, heat and cooling production

- **Example:**
  - Energy production: 7.825 MWh/year
  - Coldness production: 4.035 MWh/year
  - Heat production: 3.228 MWh/year
  - Invest overall: 1.235.000€
  - (100 % own consumption of electricity)

### ZE-MFM Master Plan: Renewable Energies

- **Objective:** Activate and increase locally available renewable energies
- **Task:** Determine short and mid-term RE potentials (technical and economical)
  - Wind and solar energy (roof-top) cadastre, biomass potentials, geothermal, run-off hydro, etc.
  - Review of existing analysis & studies
  - Statistical default values and interpolations
  - Determination of LCOE for all projects / RE sources
  - (Regional) utility structure and financing concept

### ZE-MFM: Energy Management in Buildings

- **Objective:** Energy (Efficiency) Management for (Public) Building (ISO 50001, EEA)
  - Determination of short and mid-term energy efficiency potentials (technical and economical)
  - Heating and cooling efficiency by upgrading equipment and building envelope
  - Appointment of communal Zero Emission Building Manager
  - (continuous) Definition of projects and calculation of energy efficiency/energy saving per unit investment
  - Municipality building as starting point
  - Awareness and financing program for domestic households
  - Round table program for industry

### ZE-MFM: District heating and cooling concepts

- **Objective:** Valorising local resources for district heating and cooling concepts
  - MFA of current energy demand (qualitative and quantitative)
  - Map excess heat sources and heat (cooling) sinks
  - Re-utilisation of industrial (process) excess heat
  - Re-utilisation of excess heat from power station (combined heat, cooling and power)
  - Utilisation of local residues (e.g. wood chips) as primary fuel
  - Creation of local logistic structures
  - Development of business models (e.g. contracting)
  - Determination of LCOE for heat and cold services
Cooperatives and Participatory Financing: Old (financing) ideas for a new (sustainable) world!

Energy Cooperatives in Germany: A success story
covering the last 5 years: the number of energy cooperatives quadrupled.

New Trend: (Community) Workshops
Based on various topics (heating, cooling, RE, etc)
Based on different stakeholders (public, industry, citizens, etc)

Academic Capacity Building
IMAT (International Material Flow Management)
Topic-based training courses and technology site visits

Non-Academic Capacity Building
Training program for craftsmen
Training program for community advisors
Training and qualification program for informal sector participations (e.g. in waste technologies)
Fundraising and Business Planning

Stakeholder Management
(Academic) Workshops
Based on different topics (heating, cooling, RE, etc)
Based on different stakeholders (public, industry, citizens, etc)

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Training and qualification program for informal sector participations (e.g. in waste technologies)
Fundraising and Business Planning


- Objective: Re-use and recovery of nutrients and embedded energy
  - Optimisation of existing WWTP structures and intelligent new designs
- Determination of short and mid-term energy efficiency, energy autarky as well as water re-use and nutrient recovery potentials (technical and economical)
  - Energy efficiency and energy autarky: existing WWTP by anaerobic digestion of sewage sludge
  - Recovery of heat within waste water
  - Recovery of nutrients (e.g. phosphorus) within waste water
  - Waste water avoidance by water re-use (on-site) and water minimisation strategies and technologies
  - Re-use of pre-treated water for irrigation (semi- and arid area)

Current linear system

What means “to collect WW in sewers” and treat it in centralized plants?

The classical comprehension of waste water leads to the following “technical solutions”:
- Collection in sewers and treatment in centralized WWTP
- Out of sight – out of mind

Germany collects and transports wastewater within a network of 486,000 km² sewer.

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

Separation of waste water flows

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Rain Water Management

- Rainwater harvesting & valorisation
  - Installation in new and existing buildings
  - Use for applications not requiring drinking water quality
  - Potential Replacement of up to 50% of the drinking water demand in private household
- Infiltration and retention of rain water
  - Groundwater recharge
  - Reducing the risk of floods
- Retention of rain water by green roofs

Rain water management

- Inconveniences of centralised rain water management systems
  - Sealed surfaces → Increase of rain water discharge
  - Increase of the costs by:
    - Huge sewage networks (high diameter)
    - Treatment of rain water in WWTP (overdimensioned WWTPs)
  - Low performance of the WWTPs through high hydraulic load
  - Degradation of the quality of the surface water by punctual discharges of the overflow
  - Increasing risk of floods through rapid overload of the evacuation systems
  - Reduction of groundwater recharge
  - Decrease of evaporation

Childrens playground

Rain Water Reuse
(Examples: Toilets and Air Conditioning)

Aerobic versus Anaerobic

- Aerobic
  - COD → CO₂ + H₂O
  - + 0.35 kWh/kg COD
- Anaerobic
  - CDD → Biogas Plant
  - Biogas → CH₄ + CO₂
  - + 0.9 kWh/kg COD

Analysis of separated waste water flows

Water
Nitrogen
Phosphorus
Potassium
Organic material (COD)

Based on Otterpohl u. Oldenburg 2002 (modified)
### Adapted Technology

**BAU (Conventional Waste water)**

- P
- \(N_2\uparrow\)
- CSB, NH\(_4^+\)

**Comparison**
- \(V_{\text{BB}}\) - 75%
- \(O_2\) - 50%
- US\(d\) + 5%
- \(Fe^{3+}\) - 80%

After separation of yellow water:
- P
- \(N_2\uparrow\)
- CSB, NH\(_4^+\)

→ Urine (0.8% of waste water amount but 87% of N) responsible for 75% of total costs in waste water treatment!!!

### 1 m\(^3\) Urine contains on average:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>1.0 kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>2.2 kg</td>
</tr>
</tbody>
</table>

Treatment (elimination of nutrients and energy) of 1 m\(^3\) waste water demand (on average) 0.5 kWh Energy.

Exploration and Production of 1 kg Nitrogen demand 10 kWh energy per each.

De Facto, conventional waste water treatment destroys valuable raw materials and energy by using fossil energy and money.

### Black water and biological waste treatment

Black waste water with kitchen residues in the vacuum duct.

- 60% biogas
- 6-8 fold organics
- >99% fecal germs

Anaerobic-aerobic treatment

Biological waste and fermentation:

- 1/3 HCU's

### Power Balance WWT

**Power Balance WWT**

- Amount: LPUE/d
- Organic Matter in Water: g/PE/d
- Organic Waste in Water: g/PE/d
- Energy in generated Biogas (kWh/m\(^3\))
- Heat from Biogas (85% efficiency)
- Heat Required for Digestion
- Heat Required for Sludge Drying
- Heat Value of dried Sludge

### Heat Balance of WWT

**Heat Balance of WWT**

**Best Practice to Next Practice:** sustainable biomass production in desert areas

© Ifa 2007
**Construct Wetland: Energy from waste water**

St. Alban, Germany, 1150 citizens

**Flow Chart Energy Positive WWTP**

**Cost comparison: conventional to ZE WWTP**

<table>
<thead>
<tr>
<th>Cost Positions</th>
<th>IST</th>
<th>Energy Autarkic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td></td>
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<tr>
<td>Civil Construction</td>
<td>€ 780,000</td>
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<tr>
<td>Technology</td>
<td>€ 686,500</td>
<td></td>
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<tr>
<td>Engineering Concept</td>
<td>€ 243,000</td>
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<tr>
<td>Sum Investment</td>
<td>€ 1,709,500</td>
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<tr>
<td>Operational Costs</td>
<td></td>
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<tr>
<td>Energy Costs (Electricity, Gas)</td>
<td>€ 73,800/a</td>
<td>€</td>
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<tr>
<td>Other operation and maintenance</td>
<td>€ 63,500/a</td>
<td>€ 57,000/a</td>
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<tr>
<td>Sum Operational Costs</td>
<td>€ 137,300/a</td>
<td>€ 57,000/a</td>
</tr>
</tbody>
</table>


**Cash Flow Development**

GiA Weiherbach
Wirtschaftlichkeitsvergleich Aerobe / Anaerobe Stabilisierung mit HLF (ohne Förderung)

**Waterless urinals**

- Water consumption at urinals
- Servicing infra-red controls
- Exemplary exchange of 40 urinals
- No consumption of electricity, water
- No service necessary

- Water savings: 1,620 m³/year
- Invest.: 20,000 €
- Dynamic amortisation: 4.9 years

Source: www.urimat.de

**Separate treatment of blacksoil and grey water through vacuum sewer system**

- Energy efficient combined Waste water and organic waste treatment
- Heat + 55 KWh
- Electricity +30 KWh

Quelle: Modifiziert nach Dr.-Ing. Markus Gerlach, Roediger Vacuum, 2010
Best Practice to Next Practice: sustainable biomass production in desert areas

MSW: Problem or Opportunity?

ZE-MFM: Regional Resource Management

- **Objectives**: Creation of regional resource activation strategies and management concepts
  - MFA of current waste production (qualitative and quantitative) for agriculture, industrial and municipal solid waste (MSW)
  - Determination of short and mid-term district heating and cooling potentials secondary raw material and waste-to-energy potentials (technical and economical)
  - Optimisation of waste collection logistics and introduction of separate collection of recyclables
  - Awareness campaigns for waste avoidance
  - Creation of local resource centres for centralised value adding
  - Concepts for participation of informal sector
  - Development of business models for know-how and technology transfer (e.g. BOT)
  - Determination of necessary waste gate fees

Cachimba Landfill

- Products of the resource center
  - Recycling materials → Comercialization
  - Liquid and solid fertilizer → Utilization in the agriculture
  - Energy (thermical and electrical) → Own consumption and/or PPA
  - Optional: RDF - Reuse derived fuels from the high caloric fraction / residual materials → Development of Marketing strategy
  - Regional added value for Markets
Mechanical treatment

Legend:

1. Reception
2. Conveyor Belt
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.)

RDF use in cement industry

Value from biomass

Biological treatment for organic waste fractions

1 ton organic waste: 50 liters of oil and 600 kg fertilizer or waste?

Dry Weak degradability
wet High degradability

Energy Potential of organic household waste in RLP and Saarland state

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© Institut für angewandtes Stoffstrommanagement
Discover Potentials Optimise Processes Create Regional Added Value

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**Ressource Center instead of landfill!!**

**Waste Treatment Fee**
(Example for a Municipality with 100,000 t/a – at year 1)

In comparison to BAU-Scenario

<table>
<thead>
<tr>
<th>Socio-Economic Indicators</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
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</thead>
<tbody>
<tr>
<td>Investment Total</td>
<td>22,443,429 €</td>
<td>7,275,478 €</td>
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<tr>
<td>TTT – Total Tons Treated</td>
<td>3,301,681</td>
<td>3,301,681</td>
</tr>
<tr>
<td>CTT – Costs per Tonne Treated</td>
<td>11,31 €</td>
<td>12,20 €</td>
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<tr>
<td>Job Creation</td>
<td>133 - 177</td>
<td>54 - 79</td>
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<tr>
<td>Tradable Emission Reductions in t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂e</td>
<td>1,000,000</td>
<td>Transport Emission</td>
</tr>
</tbody>
</table>

**MSW and Poverty Alleviation**

- Monthly payment for waste collectors
- Salary
- Equity capital
- Convertion
- Capital stock in fund
- Interest rate: 2.5%
- Buy out of international investors
- Transfer of equity capital to workers
- Share for fund
- Payed monthly to worker
- 10% per year
- 10th year

**Agenda of the Circular Economy Week**

- **Monday: Zero Emission County District**
  - Example of Rhein-Hunsrück District:
    - 101,000 inhabitants
    - Area: 963 km²
    - 134 settlements (75% with less than 500 inhabitants)

- Other topics:
  - Greenery Residues Management and District Heating
  - School Heating
  - Logistics

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Thank you for your attention and enjoy the Circular Economy Week!

One Team – plenty of ideas and visions...

- An interdisciplinary Team:
  - (Bio-) Geography
  - Microeconomics
  - Mechanical Engineering
  - Spatial Planning
  - Forestry Engineering
  - Agricultural Engineering
  - Environmental Law
  - …

IfaS Clients (2011)

IfaS – Project examples

- Zero Emission Strategies for Municipalities
- Development of extensive land use concepts for the production of renewables resources as potential compensation measures (ELKE)
- Sustainable Energy Management Systems (SEMS)
- Energy Efficiency Check: Energy & material flow analysis in industry
- Zero Emission Network
  - …

Zero CO₂ₑ Emission Certification System

- Project Profile:
  - 4 EU Countries (BE, D, IRL, UK)
  - 11 Partners in 8 EU Communities
  - 7 Observers
  - Budget: € 6,503,403.99
  - Duration: 2011 until 2015

- Objectives:
  - Development of an EU-wide Zero-CO₂ₑ Emission Certification and Award Scheme
  - Analysis of best-practice in communal (green) financing
  - Zero-CO₂ₑ Emission Master-Planes and Pilot projects
  - Policy Advisory for EC in Zero-CO₂ₑ Labelling and Carbon Trading for municipalities
Discover Potentials! Optimise Processes! Create Added Value!

**Energy wood: Many forms & applications**

- **Example of biogenesis solid fuels**

- **Primary products**
  - Biomass
  - Biofuel
  - Biochemicals
  - Bioelectricity

- **By-products**
  - Wood chips
  - Wood pellets
  - Wood briquettes
  - Wood dust
  - Saw dust

- **Local Value Chains of (Waste) Wood**

- **Wood Potential in Serbia**
  - Serbia is a biomass rich country:
    - Area: 2,252,400 ha (29.1%)
    - Volume: 362,5 million m³

- **Agricultural Biogas**
  - Biogas in Sri Lanka:
    - Limited to small-scale, low-tech, household (cooking gas) use
    - Limited fertilizer application (substrate) and missing quality control
  - Biogas in Germany:
    - Average installed capacity of 375kWe (up to 1.5MWel)
    - Economically profitable by selling energy (Heat, Electricity) and fertilizer

- **Current Coconut Residue Management**
  - Majority of Coconut Residues are openly incinerated without energy recovery
    - High emissions on CO₂, CH₄, N₂O
  - Less than 10% of the residues are used to produce activated carbon
    - Production volume = ~45,000 t/a [2007 data]
    - Emission = 12 - 15 kg CH₄/t CO₂
  - Outdated production technologies and processes
    - Emission intensive
    - Low regional (business) value added

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Current Rice Husk Management

- Another untapped potential
  - Rice husk only partly used for small steam production mainly in food industry
  - Total husk volume of 655,730 t/yr
  - Equal to 550,000 t/yr coal (650,000 t/yr demand at Norochcholai)

  - NCV of paddy husk = 12.1 - 15.3 MJ/kg

Product Carbon Footprint: BRTIA Fill&Go

- Results of Product Carbon Footprint for BRTIA Fill&Go Mobile Water Filter System
  - Granulated Activated Carbon from Sri Lanka is used in the BRTIA Fill&Go Filter Disks
  - Reference: 3.35t CO2eq. per t GAC (Variance 1.00t - 7.76t CO2eq. per t GAC)
  - Company is having a strong incentive to purchase low-emission GAC

Business Options: Biochar & Pellets

- 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
- Pelletizing or Briquetting Residues
  - Storable and higher NCV (18 - 26 MJ/kg)

Regional Added Value Creation Potential

The value creation effects of typical renewable power generation systems over the course of 30 years of operation

<table>
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<tr>
<th>Technology</th>
<th>In millions of euros per</th>
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<th>10</th>
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</table>

MSW in Sri Lanka

- Currently ~ 3,500 tons/d of Municipal Solid Waste are collected in Sri Lanka (60% Organic)
- Non-separated landfills is the predominant treatment
- Minor composting (window) plants and "anaerobe digestions" producing kitchen gas are tested
- No industrial "waste to energy plant" in operation

How much Energy is on your Roof?

- Local Banks are highly interested in risk-free investments
### Renewables achieve Grid Parity

- **Lower Energy Costs for SMEs in the long run**

### Total municipal value creation from renewable energies, 2009 and 2020

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>2009</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind energy</td>
<td>2.766</td>
<td>5.088</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>3.472</td>
<td>6.050</td>
</tr>
<tr>
<td>Small-scale hydrogen plant</td>
<td>0.089</td>
<td>0.165</td>
</tr>
<tr>
<td>Biogas</td>
<td>1.879</td>
<td>3.300</td>
</tr>
<tr>
<td>Biomass (wood)</td>
<td>1.363</td>
<td>2.442</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.400</td>
<td>0.700</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>0.265</td>
<td>0.450</td>
</tr>
<tr>
<td>Biofuels</td>
<td>2.131</td>
<td>3.740</td>
</tr>
</tbody>
</table>

- **Renewable energy share of total energy consumption**
  - Electric power: 43.8%
  - Renewable energy: 16.3%
- **Heat**:
  - 8.8% in 2009
  - 5.5% in 2020

### The PV Roof Top Program

- **The PV Roof Top Program**

### Solar Energy Management

- **Solar Energy Management**

- **Typical SME Business Potential**

### A complete value creation chain means more profit for the community

- The more stages of the broadly diversified value creation chain are located in a community, the more income, profits, and taxes will be generated.

#### Wind energy system with 2 MW of output:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Value (in millions of euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Stage</td>
<td>Wind energy system is produced in the community</td>
<td>0.495</td>
</tr>
<tr>
<td>2nd Stage</td>
<td>Planning and installation by a local company</td>
<td>0.137</td>
</tr>
<tr>
<td>3rd Stage</td>
<td>Operation and maintenance of the system by local companies</td>
<td>0.783</td>
</tr>
<tr>
<td>4th Stage</td>
<td>The operator of the wind energy system is a local company</td>
<td>1.414</td>
</tr>
</tbody>
</table>

**Entire value creation chain**: 2.831

*Assumption: Wind energy system, 2 MW of output – 20-year lifespan*
17. April 2007

Auftaktveranstaltung Biomasse-Masterplan LK
MYK

Tax payments to a municipality for a 2 MW wind energy system

<table>
<thead>
<tr>
<th>Value creation stages</th>
<th>Business tax</th>
<th>Municipal share of income tax</th>
<th>Total (10 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>... if system is manufactured in the community</td>
<td>€619,700/yr</td>
<td>€618,740/yr</td>
<td>€1,238,440</td>
</tr>
<tr>
<td>... if planning and installation are provided by local companies</td>
<td>€62,820/yr</td>
<td>€65,330/yr</td>
<td>€1,010,000</td>
</tr>
<tr>
<td>... if grid connection and power purchase agreement are made to the renewable energy supplier</td>
<td>€976,000/yr</td>
<td>€976,000/yr</td>
<td>€1,952,000</td>
</tr>
<tr>
<td>Total (with only 30% of business tax paid)</td>
<td>€323,290</td>
<td>€328,290</td>
<td>€654,580</td>
</tr>
</tbody>
</table>

30,000 EUR Taxes = 100,000 EUR SME Profit = 1,000,000 EUR SME Turnover

Investments in construction of renewable energy installations in Germany 2012

One-time SME business options in planning and construction

Revenues from the operation of renewable energy installations in Germany in 2011

Continuous SME business options in operation and maintenance

Municipal value creation from renewable energies, 2009 – 2011

<table>
<thead>
<tr>
<th>Energy type</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind energy</td>
<td>€2,000 million</td>
<td>€2,241 million</td>
<td>€2,246 million</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>€2,455 million</td>
<td>€3,734 million</td>
<td>€3,860 million</td>
</tr>
<tr>
<td>Small hydroelectric plant</td>
<td>€10 million</td>
<td>€10 million</td>
<td>€10 million</td>
</tr>
<tr>
<td>Biogas</td>
<td>€507 million</td>
<td>€517 million</td>
<td>€517 million</td>
</tr>
<tr>
<td>Biomass (wood)</td>
<td>€557 million</td>
<td>€553 million</td>
<td>€575 million</td>
</tr>
<tr>
<td>Geothermal heat pumps</td>
<td>€205 million</td>
<td>€224 million</td>
<td>€224 million</td>
</tr>
<tr>
<td>Solar thermal energy</td>
<td>€554 million</td>
<td>€556 million</td>
<td>€556 million</td>
</tr>
<tr>
<td>Biofuels</td>
<td>€507 million</td>
<td>€475 million</td>
<td>€475 million</td>
</tr>
<tr>
<td>Total</td>
<td>€6,785 million</td>
<td>€6,933 million</td>
<td>€6,942 million</td>
</tr>
</tbody>
</table>

We use it to fuel them when there's no wind.
17. April 2007

RE and Regional Added Value

<table>
<thead>
<tr>
<th>Total municipal value creation from renewable energies, 2009 and 2030*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion €/year: Wind energy, Photovoltaics, Small-scale hydropower, Biogas, Biomass (wood), Geothermal, Heat pumps, Solar thermal energy, Biofuels, Total municipal value creation</td>
</tr>
<tr>
<td>2009</td>
</tr>
<tr>
<td>2.792</td>
</tr>
<tr>
<td>2.420</td>
</tr>
<tr>
<td>0.049</td>
</tr>
<tr>
<td>1.679</td>
</tr>
<tr>
<td>1.343</td>
</tr>
<tr>
<td>0.400</td>
</tr>
<tr>
<td>0.944</td>
</tr>
<tr>
<td>0.157</td>
</tr>
<tr>
<td>1.845</td>
</tr>
</tbody>
</table>

*Growth of renewable energies by 2030, according to the AEE/EPE industry forecast

0.5 MW PYREG-plant, Dörth Germany

- 2-teen screw Pyrolysis reactors working in parallel
- Combustion chamber burning syngas

Suitable Input Materials

- Calorific value >10 MJ/kg, water content <50%, particle size <30 mm / Dissolve heavy metals
- Green waste, sewage sludge, slaughterhouse waste, paper sludge, bark, pine needles, foliage, cereal production waste, straw, rapeseed, sugar beet waste, olive production waste, nutshells, digestate, screenings, coffee production waste, compost, beer barley residues, miscanthus, silphium, rubber, ...

ZE Business Sector: Energy Saving Contracting

- Preparation phase: energy costs of contractor and energy costs of customer
- Main contract phase: refinancing and profit of contractor
- End of contract: return of profits to enlarge ZE system

Investment in Windpower in Germany (2012)

- Development of electricity production and installed capacity of wind energy plants in Germany

Revolving Fund!

- Initial Community Development Fund
- Community Development Master Plan
- Apply for lost grant based on Business Plans
- Create a Local Energy / ZE Service provide
- Job Creation, Local Services
- Environmental Improvement

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Current solid waste management in Colombo

Comparison of Anaerobic Digestion with Composting

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Anaerobic Digestion</th>
<th>Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space requirement (footprint)</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>Odours</td>
<td>20%</td>
<td>100%</td>
</tr>
<tr>
<td>Energy balance</td>
<td>Energy Surplus</td>
<td>Energy Demand</td>
</tr>
<tr>
<td>Biogas production</td>
<td>100 – 150 m³/Mg</td>
<td>none</td>
</tr>
<tr>
<td>Process time required to produce mature compost</td>
<td>3 weeks digestion, plus 5 weeks composting</td>
<td>12 weeks</td>
</tr>
</tbody>
</table>