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REEF 2W

INCREASED RENEWABLE ENERGY AND ENERGY EFFICIENCY BY INTEGRATING, COMBINING URBAN WASTEWATER AND WASTE MANAGEMENT SYSTEM

TAKING COOPERATION FORWARD

REEF 2W Final Conference

REEF 2W APPROACH

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BACKGROUND

Climate change is one of the great challenges of our times.

Wastewater is coming more and more into focus.

Different options to generate energy from wastewater/waste:

- Electric and thermal energy from digester gas combustion
- Thermal energy from wastewater heat recovery
- Solar energy, hydropower (and wind power)

Different options to supply energy from wastewater/waste:

- in the premises of the wastewater infrastructure
- in the adjacent settlement structures

BASIC CONCEPT

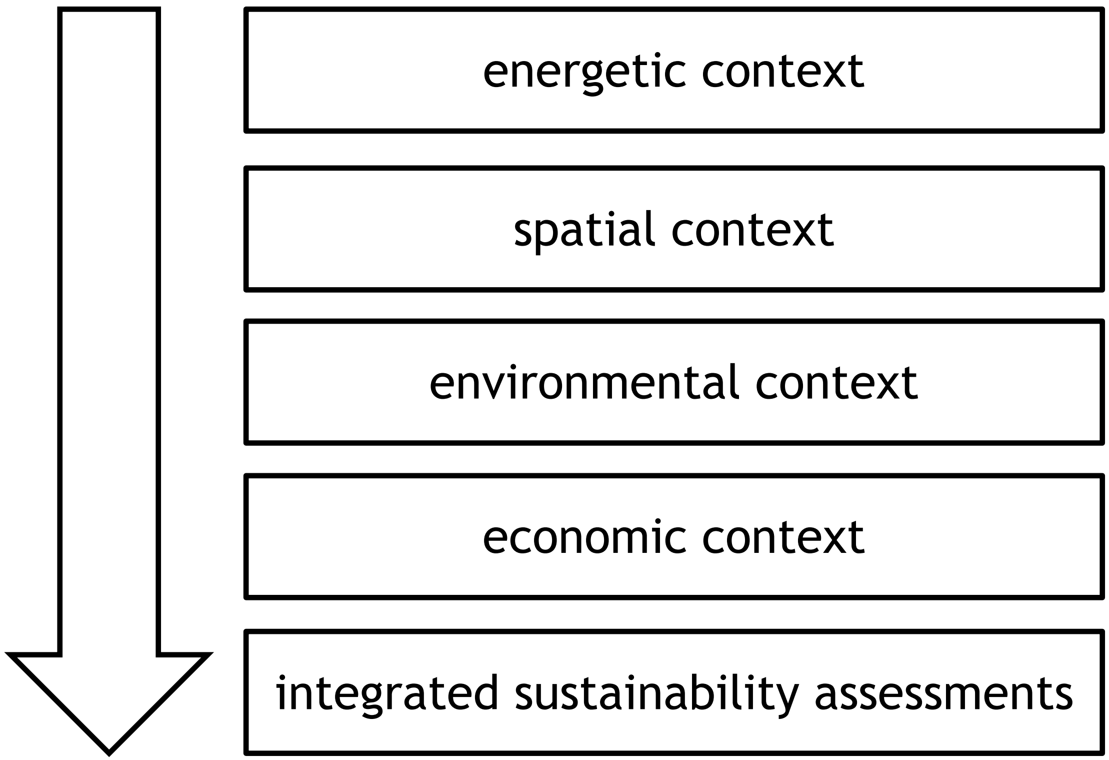

Figure: The REEF 2W approach (own illustration)

ENERGETIC CONTEXT

Energy efficiency

Identification of optimisation potential in the efficient use of electric and thermal energy at a WWTP.

Renewable energy generation

Identification of available (and so fare untapped) renewable energy sources at a WWTP.

Alternative energy approaches

Application of “novel” energy technologies at WWTPs.

Above evaluations provide an idea on surplus energy potentials at a WWTP.

ENERGETIC CONTEXT

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Energy efficiency

Comparison of the

- electric and thermal energy consumption
- of an entire WWTP and/or selected treatment technologies
- with standard ranges based on Austrian experiences.

		standard range	
WWTP total	**kWh/PE$_{120}$/a**	**20**	**50**
1) inflow pumping station and mechanical pre-treatment	**kWh/PE$_{120}$/a**	**2,5**	**5,5**
1.1 pumping stations	kWh/PE$_{120}$/a	1,5	3,5
1.2 screening	kWh/PE$_{120}$/a	0,5	1
1.3 sand trap and primary clarifier	kWh/PE$_{120}$/a	0,5	1
2) mechanical-biological treatment	**kWh/PE$_{120}$/a**	**14,5**	**33**
2.1 aeration	kWh/PE$_{120}$/a	11,5	22
2.2 stirrers	kWh/PE$_{120}$/a	1,5	4,5
2.3 return sludge pumps	kWh/PE$_{120}$/a	1	4,5
2.4 miscellanious (sec. clarifer)	kWh/PE$_{120}$/a	0,5	2
3) sludge treatment	**kWh/PE$_{120}$/a**	**2**	**7**
3.1 thickening	kWh/PE$_{120}$/a	0,5	1
3.2 digestion	kWh/PE$_{120}$/a	1	2,5
3.3 dewatering	kWh/PE$_{120}$/a	0,5	3,5
4) infrastructure	**kWh/PE$_{120}$/a**	**1**	**4,5**
4.1 heating	kWh/PE$_{120}$/a	0	2,5
4.2 misc. infrastructure	kWh/PE$_{120}$/a	1	2

		standard range	
WWTP total	**kWh/PE/a**	0	30
sludge heating	kWh/PE/a	8	12
transmission loss, digester tower heating	kWh/PE/a	0	4
generation, storage and distrivution loss	kWh/PE/a	0	2
heat for buildings	kWh/PE/a	0	2
heat for supply air unit	kWh/PE/a	0	10

Table: Standard ranges for electric and thermal energy consumption in Austria (Lindtner, 2008, adapted)

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Renewable energy generation

Electric energy generation (from sludge/waste, wastewater, solar):

- Digester gas (biogas) combustion
- Hydropower
- Photovoltaics
- (Wind power)

Thermal energy generation (from sludge/waste, wastewater, solar):

- Digester gas (biogas) combustion
- Wastewater heat recovery
- Solar thermal (and hybrid systems PVT)

ENERGETIC CONTEXT

Alternative energy approaches

Increase biogas yield/digestion performance (co-digestion of organic waste in anaerobic digestion, hydrolysis of sludge/waste)

Energy generation from sludge (anaerobic digestion, gasification, incineration)

Biogas upgrading for feed-in to public gas supply networks

Urban compatibility assessment

Consideration the energetic context of the settlement structures in the surroundings of the WWTP.

Integration of WWTP surplus energy generation and energy demand in the adjacent settlement structures.

Different types of heat consumers ("hotspots" of thermal energy consumption) with specific heat demands and settlement internal grid lengths are distinguished:

- Village or town centres
- Multi-storey buildings
- Commerce and industry
- Agriculture and forestry

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Urban compatibility assessment

Figure: Examples of heat consumer types: village Centre (left) and multi-storey buildings (right) (own illustration)

Environmental benefits

Consideration of the environmental (climatic) benefits of the intended WWTP-based renewable energy supply - C02 emissions (global warming potential) of the investigated scenario.

A suitable method to analyse the potential environmental impacts in the context of REEF 2W is the approach of Life Cycle Assessment (LCA).

GWP factors are defined/applied to account for the related GHG emissions (use of energy carriers and other processes) of an investigated application enabling the comparison with other scenarios.

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Environmental benefits

Table: Examples of GWP factors based on LCA database ecoinvent (s. a.)

Material / Process	GWP (IPCC 2013 for 100a)	Unit	Ecoinvent v3.4 dataset
Electricity mix EU	0,39	kg CO2-eq/kWh	market group for electricity, medium voltage [RER]
Electricity mix DE	0,627	kg CO2-eq/kWh	electricity, medium voltage [DE]
Electricity mix AT	0,295	kg CO2-eq/kWh	market for electricity, medium voltage [AT]
Electricity mix IT	0,381	kg CO2-eq/kWh	market for electricity, medium voltage [IT]
Electricity mix HR	0,286	kg CO2-eq/kWh	market for electricity, medium voltage [HR]
Electricity mix CZ	0,69	kg CO2-eq/kWh	market for electricity, medium voltage [CZ]
Gas	0,23	kg CO2-eq/kWh	natural gas, burned in gas motor, for storage [RoW]
Heat	0,202	kg CO2-eq/kWh	market for heat, district or industrial, natural gas [Europe without Switzerland]
FeCl3	0,949	kg CO2-eq/kg FeCl3 (100%)	market for iron (III) chloride, without water, in 40% solution state [GLO]
Polyaluminum chloride	1,389	kg CO2-eq/kg PACl (100%)	market for polyaluminium chloride [GLO]
Polymer	2,087	kg CO2-eq/kg polymer	market for acrylonitrile [GLO]
Acetate	1,584	kg CO2-eq/kg acetate	market for acetic acid, without water, in 98% solution state [GLO]
Methanol	0,659	kg CO2-eq/kg methanol	market for methanol [GLO]

ECONOMIC CONTEXT

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Economic opportunities

Consideration of economic aspects of the intended WWTP-based renewable energy supply.

Determination of costs for investment and operation of the investigated scenario under consideration of additional “income” due to energy generation and energy saving

Cost ranges are defined/applied to facilitate a first estimation.

The derived costs and incomes allow the application of economic indicators such as return on investment (ROI) to compare different scenarios.

INTEGRATED SUSTAINABILITY ASSESSMENT

Combination of the information collected during the four previous steps.

Apart from energetic, spatial, environmental and economic indicators this assessment further includes additional social and technical parameters.

The comparison of the different indicators with pre-defined scales allows a final evaluation of the intended WWTP-based energy supply from a holistic and integrated perspective.

INTEGRATED SUSTAINABILITY ASSESSMENT

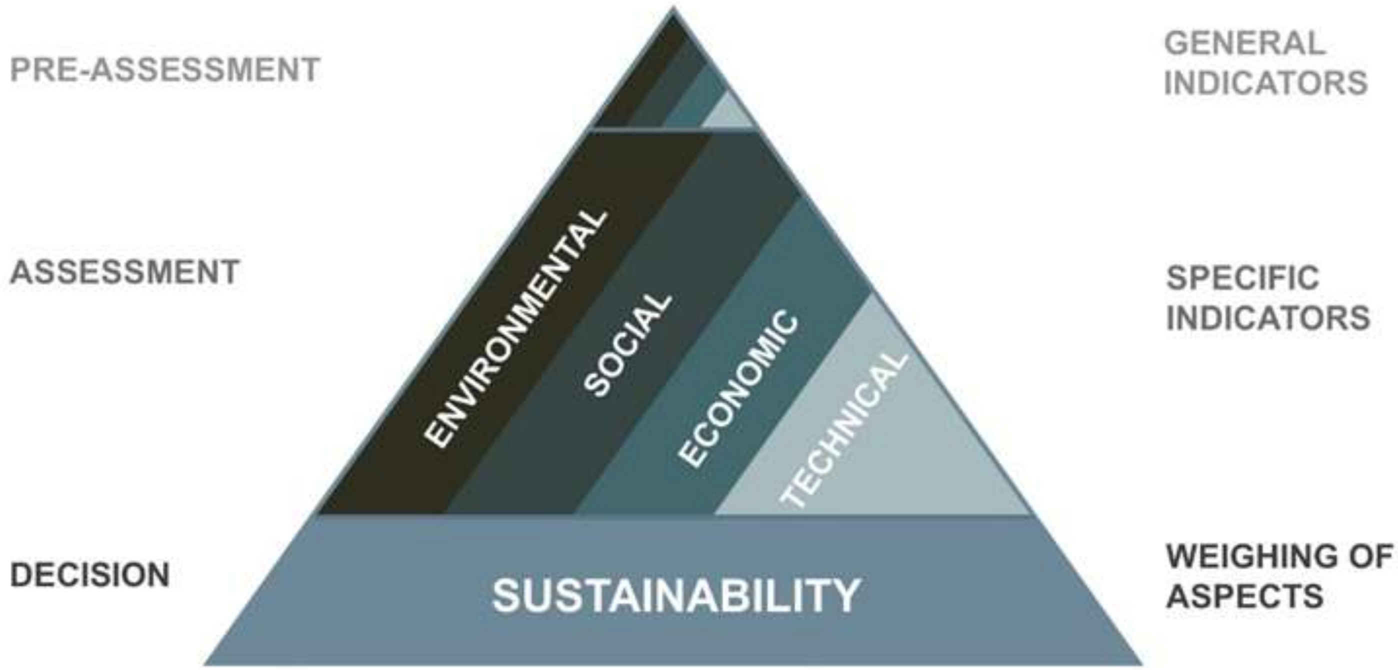

Figure: Illustration of indicators from a pre-assessment to the final decision (adapted after Stoeglehner and Narodoslawsky, 2008)

INTEGRATED SUSTAINABILITY ASSESSMENT

Table: Examples on general indicators for integrated sustainability assessment (own illustration)

	General indicator	Measurement	Categories	Graduation
Availability of excess energy	Electric excess energy provision	Difference between electric energy production and consumption in kWh	> 0 ≤ 0	A B
	Thermal excess energy provision	Difference between thermal energy production and consumption in kWh	> 0 ≤ 0	A B
	Excess digester gas provision	Difference between digester gas production and consumption in m^3	> 0 ≤ 0	A B
Availability of energy consumers	Excess electricity demand	Electricity demand in the vicinity of the WWTP and in kWh	> 0 = 0	A B
	Excess heat demand	Heat demand in the vicinity of the WWTP and in kWh	> 0 = 0	A B
	Excess digester gas demand	Digester gas demand in the vicinity of the WWTP and in kWh	> 0 = 0	A B

CONCLUSIONS

The REEF 2W approach integrates energetic, spatial, environmental and economic perspectives as well as technical and social aspects to evaluate energy supply from wastewater/waste.

Its rather open concept shall provide guidance (in a most flexible manner) to support the elaboration and identification of promising WWTP based energy supply concepts.

However, one has to keep in mind, the presented approach intend to highlight those energy supply options worth of being further investigated. It does not replace (subsequent) detailed planning.

LITERATURE

ecoinvent (s. a.): ecoinvent data v3.4, ecoinvent reports No. 1-26. www.ecoinvent.org : Swiss Center for Life Cycle Inventories.

Lindtner, S. (2008): Leitfaden fuer die Erstellung eines Energiekonzeptes kommunaler Klaeranlagen (Guideline for the development of an energy concept for municipal wastewater treatment plants). Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management (BMLFUW), Vienna.

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