Municipal Wastewater Treatment Systems and their Future Role in Efficient and Sustainable Energy Systems

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INTRODUCTION

“To combat climate change it is necessary to establish efficient and sustainable energy systems within the energy transition.”
INTRODUCTION

CONTROLLED UNIT / ENERGY SERVICE PROVIDER

ENERGY SERVICES OF WASTEWATER TREATMENT PLANTS...
- Constant electric or thermal energy supply
- Frequency reserve

POTENTIAL DEPENDS ON...
- The energy intensive units,
- The amount of bioenergy potentials → digester gas and sewage sludge
- The storage possibilities
- The flexible useable units.

Reference (7)
**Methodology**

- Energy demand = ?
- Amount of bioenergy potentials = ?

**Mass and Energy Balances of Waste Water Treatment Plants**

- Depend on...
  - Plant size
  - Treatment technology
  - Sewage composition
**METHODOLOGY**

**STEP 1: Non-time-resolved mass and energy balances**

Modular structure for considering different plant configurations

- Excel-based data collection
- Calculation of all treatment processes up to the dewatering unit
- Focus on aerobic and anaerobic treatment plants
- Standardized formulary
METHODOLOGY

- Integration of bioenergy potentials = ?

DECENTRALISED ENERGY PRODUCTION ON-SITE

- Analysing the potential for supplying electric and thermal energy by digester gas and sewage sludge utilisation
- Role as energy service providers in medium- and low-voltage grids
**Methodology**

**STEP 2: Designing energy networks**

Expansion of the non-time resolved modular tool

- Digester gas utilisation by CHP-units, micro gas turbines or gas boilers
- Sewage sludge utilisation by combustion or gasification
- No state-of-the-art technology

Assumptions:
- 8,000 operating hours
- Compatibility
- Optimal output quality

Cooperation partner:

![Sülzle Kopf Logo](image-url)
**METHODODOLOGY**

- **Optievlex**

  1. Step 1: Non-time-resolved mass and energy balances
  2. Step 2: Identification of optimal energy networks
  3. Step 3: Daily dry weather load- and production profiles
  4. Step 4: Maximum flexibility range

**TIME-RESOLVED LOAD AND PRODUCTION PROFILES**

- Identifying real interaction possibilities with medium- and low voltage grids
**METHODODOLOGY**

**STEP 3: Daily dry weather load- and production profiles**

Expansion of the EXCEL-Tool by a time-resolved inflow model via MATLAB

- Dry weather inflow model of the “Hochschulgruppe Simulation”
- Transferred to a MATLAB script

Dry weather inflow \([m^3/h]\)  
(100,000 PE)

- Inflow quantity \([m^3/h]\)
- Time \([h]\)

Sewage Composition \([g/m^3]\)  
(100,000 PE)

- Concentration \([g/m^3]\)
- Time \([h]\)
**Methodology**

- **Flexible useable units = ?**
- **Flexibility potential = ?**

**Maximum Flexibility Range**

- Identifying the maximum flexibility potentials of a waste water treatment plant by constant purification performance
**METHODODOLOGY**

**STEP 4: Maximum flexibility range**

Five decisive factors concerning the flexibility potential

- High electric and thermal energy self-sufficiency
- Minimal available power
  - Low-voltage grids: > 5 kW
  - Medium-voltage grids: > 50 kW
- Deactivation time and responds speed of the units
  - Respond speed: max. 5 minutes
  - Deactivation time: min 15 minutes
- Full-load hours of the units
- Availability of storage possibilities for digester gas and sewage sludge

→ Pump station, blower sand trap, blower aeration tank, recirculation pump, return sludge pump, CHP-units
**Methodology**

Standalone application **OPTIEVLEX**

“**Optimierte Energieverbunde kommunaler Abwasserbehandlungsanlagen als Flexibilitätsbausteine in den kommunalen Netzen der Zukunft**”
**METHODOLOGY**

**Standalone application OPTIEVLEX**

Enables to...

- Time-resolved and Non-time-resolved simulations
- Calculation of the mass and energy balances of user-defined waste water treatment system configurations
- Determination of the energy self-sufficiency
- Estimation of load and production profiles
- Derivation of maximum flexibility ranges

6. Get results
RESULTS

• Energy self-sufficiency is important parameter concerning the flexibility potential

• Mass and energy balances of different plant configurations:
  - Configuration 1: Anaerobic WWTP + Digester gas CHP-unit
  - Configuration 2: Anaerobic WWTP + Digester gas CHP-unit + LT-Belt-dryer
  - Configuration 3: Anaerobic WWTP + Digester gas CHP-unit + LT-Belt-dryer + Gasification + Syngas CHP-unit
RESULTS AFTER STEP 2 - ELECTRIC ENERGY SELF-SUFFICIENCY

Output of a static simulation with OPTIEVLEX

- Average system units and different plant capacities
- Austrian effluent limit values

Configuration 1: Anaerobic WWTP + Digester gas CHP-unit
Configuration 2: Anaerobic WWTP + Digester gas CHP-unit + LT-Belt-dryer
Configuration 3: Anaerobic WWTP + Digester gas CHP-unit + LT-Belt-dryer + Gasification + Syngas CHP-unit
OUTLOOK FOR STEP 3

STEP 3: Daily dry weather load- and production profiles

• Generating a data pool by performing static simulations via OPTIEVLEX
  ▫ Several waste water treatment system configurations
    • Aerobic treatment plants with gasification and combustion units
    • Combustion with/without ORC-Process
    • Gasification with a Syngas utilisation in a CHP-Unit or heating boiler
  ▫ Different plant capacities

• Simulation of daily load- and production profiles
OUTLOOK FOR STEP 4

STEP 4: Maximum flexibility range

Five decisive factors concerning the flexibility potential

- High electric and thermal energy self-sufficiency
- Minimal available power
- Deactivation time and responds speed of the units
- Full-load hours of the units
- Availability of storage possibilities for digester gas and sewage sludge

Daily load profile [kW] (100.000 PE)

Maximum flexibility range [kW] (100.000 PE)

Positive flexibility = Load reduction + Production increase

Negative flexibility = Load increase + Production reduction
OUTLOOK FOR OPTIEVLEXPLUS

- Actual flexibility potential = ?
- Energy services = ?

YEARLY LOAD— AND PRODUCTION PROFILES BASED ON TYPICAL METEOROLOGICAL DAY

- Identifying the actual flexibility potentials of a waste water treatment plant by constant purification performance
- Stabilization potential within the electric energy grid
THANK YOU FOR YOUR ATTENTION!
REFERENCES

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