# Energy Efficiency

## in the Wastewater Treatment Process

Anett Baum, DWA

IWAMA 3rd International Capacity Development Workshop

Szczecin, 07.06.2017

# Contents

## 3 Main Parts

1. DWA and Energy
2. DWA-A 216
3. Research Project
   “Energy efficient Watermanagement”
   ERWAS

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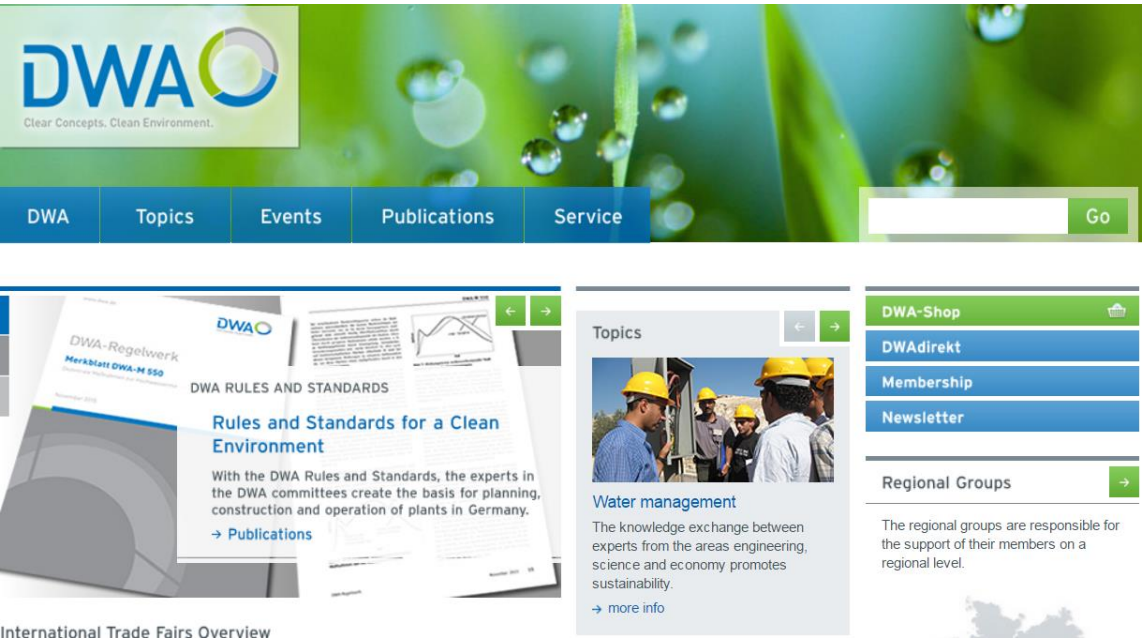
# Part 1

## 3 Main Parts

1. **DWA and Energy**
2. A 216
3. Research Project "Energy efficient Watermanagement" ERWAS

# Who is DWA ?




International Trade Fairs Overview

**DWA**

- non-governmental
- non-profit organisation
- represents the specialists, active in the fields of water management, wastewater and waste

**DWA´s acitivities**

- politically and financially independent

**It deals with**

- technical-scientific topics and
- economic and legal issues of environmental protection

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Research and Innovation

Coordination of themes concerning
Energy and research

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DWA
Klare Konzepte. Saubere Umwelt.

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# Research and Innovation: DWA´s Tasks


- Networking, information and communication
- DWA Information System Energy
- Annual DWA event „DWA Energy Days“
- Networking and transfer of knowledge
- Initiation of and assistance for research projects
- Political consultation

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# Wastewater Management and Energy


Digester sewage treatment plant Hamburg, picture: fotolia

- What is the trend of energy utilisation in wastewater management in Germany?
- What triggers German municipalities to utilize/save energy in wastewater treatment
- What is the role of DWA in this area?

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# High-tech strategy of the Federal Government, Germany

If we had two earths ….

…We only have one earth. Let´s save it,

let´s shape it!

Bild- und Textquelle: http://www.hightech-strategie.de/

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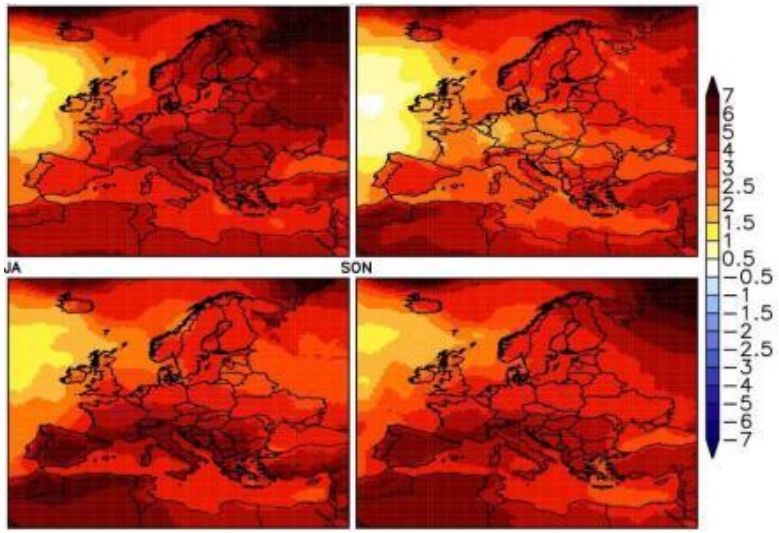
# Significance




- Increasing energy costs
- Decreasing fossile energy resources
- Decreasing of non renewable ressources
- Climate change:
  Water is the key for adapation;
  Energy is the key for climate mitigation

Wastewater holds ressources that can help us to find solutions for some of the worlds most pressing problems

# Municipal Wastewater treatment in Germany

Water sector must play an active role to protect climate, environment and resources by

- Energy savings
- Increase of energy efficiency
- Development of renewable resources

- 10.000 municipal WWTP
- > 97 % treated in WWTP
- 515.000 km public sewer
- 9.443 Mio m³ wastewater discharge
- Total design capacity: 155 Mio. pe
- 7000 wwtp < 10.000 (pe)
- 14 plants (100.000 – 2 Mio. pe) represent 83% of the total design capacity for municipal wastewater

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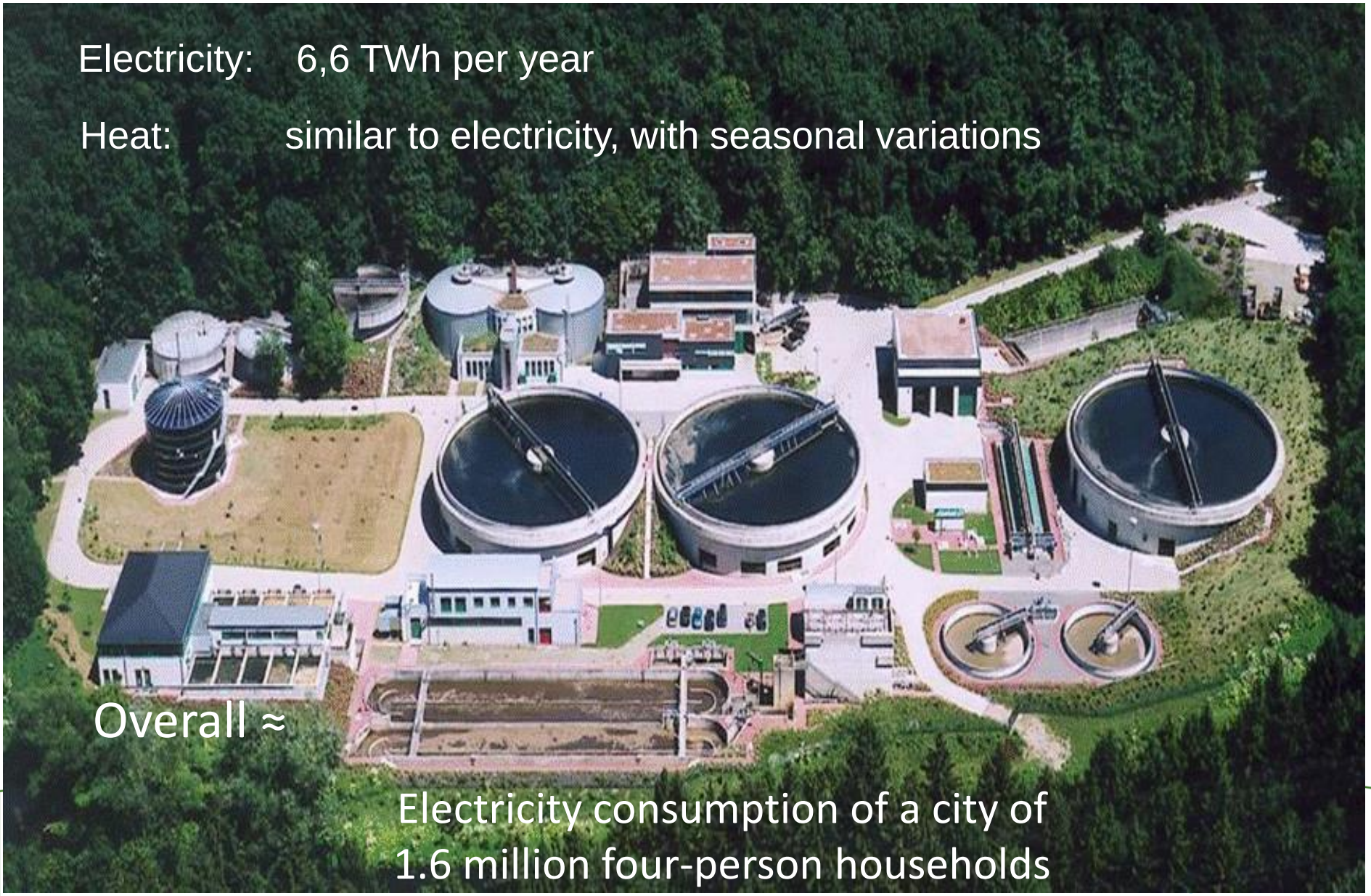
Electricity: 6,6 TWh per year
Heat: similar to electricity, with seasonal variations
Overall ≈
Electricity consumption of a city of
1.6 million four-person households

# Energy Potentials of the German Water Sector


- **Potentials for energy optimisation have not fully been realised yet.**
  - 1,4 TWh/a electricity production on WWTP
    is only 1/3 of the possible potential.
- **WWTP can triple their electricity production**
  - 3 TWh per year

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# Part 2

## 3 Main Parts

1. DWA and Energy
2. **DWA-A 216**
3. Research Project “Energy efficient Watermanagement” ERWAS

# How Operators benefit from Standardisation Activities

–

the case of DWA standard

*Energy check and energetical analysis*
DWA-A 216

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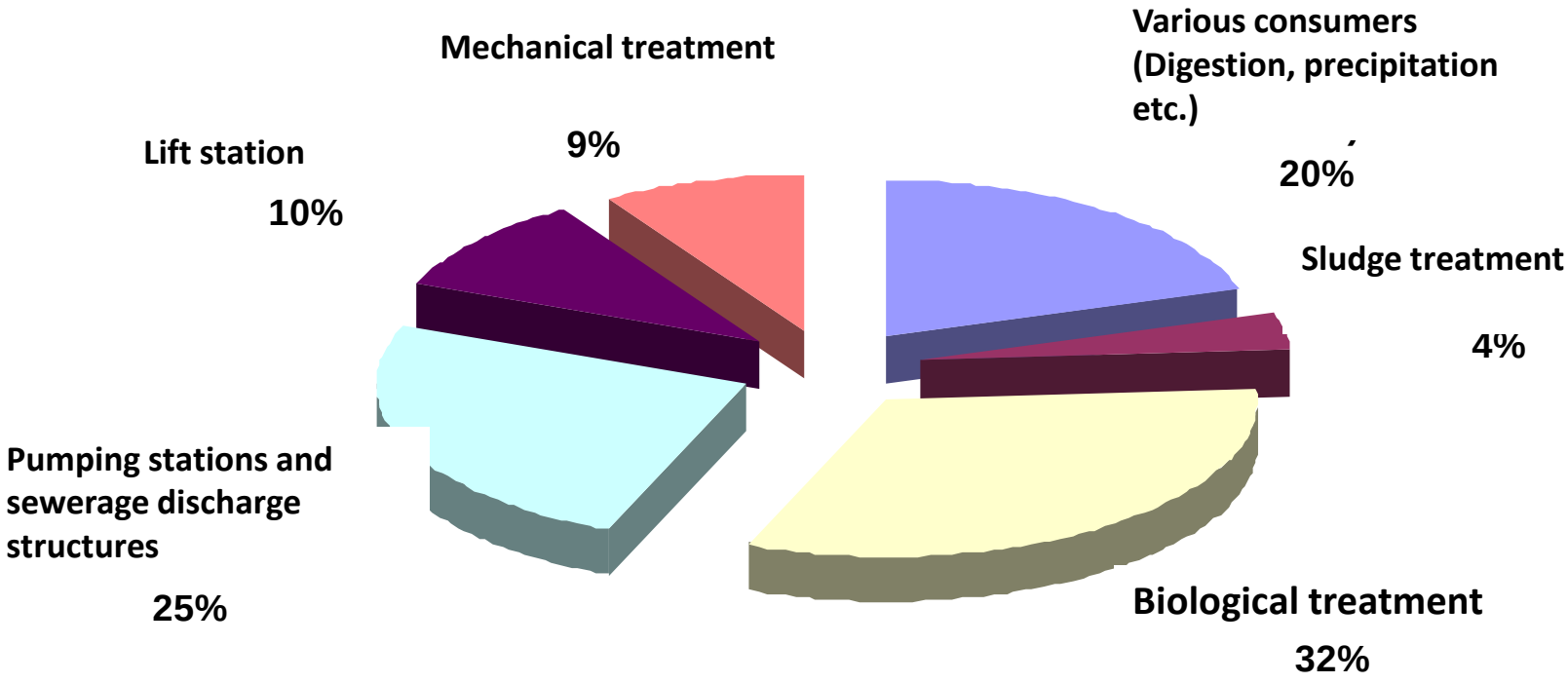
# Average energy use of a WWTP



# Energy check and energy analysis


- 2 Steps

1) Energy check

2) Energy analysis

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# Energy Check

- Rough estimation of the energy consumption
- Usage of easy to determine performance indicators
- Evaluation of those performance indicators over a certain time span
- Recognition of gaps and failures
- Need for action has to be formulated

# EC Performance Indicators for an energy check

| | | | |
|---|---|---|---|
| • Specific total power consumption | | $e_{ges}$ | [kWh/(E · a) ] |
| • Specific power consumption aeration | $e_B$ | | [kWh/(E · a) ] |
| • Specific production of digester gas | $e_{FG,1}$ | | [$l_N$/(E · d) ] |
| | | $e_{FG,2}$ | [$l_N$/kg oTR ] |
| • Degree of digester gas conversion in electricity | | $N_{FG}$ | [% ] |
| • Self supply with electricity | $V_E$ | | [% ] |
| • Specific externer thermal (heat) requisition | | $e_{ext}$ | [$kWh_{therm}$/(EW · a)] |
| • Specific power consumption pumps | $e_{PW,1}$ | | [kWh/($m^3$ · m)] |

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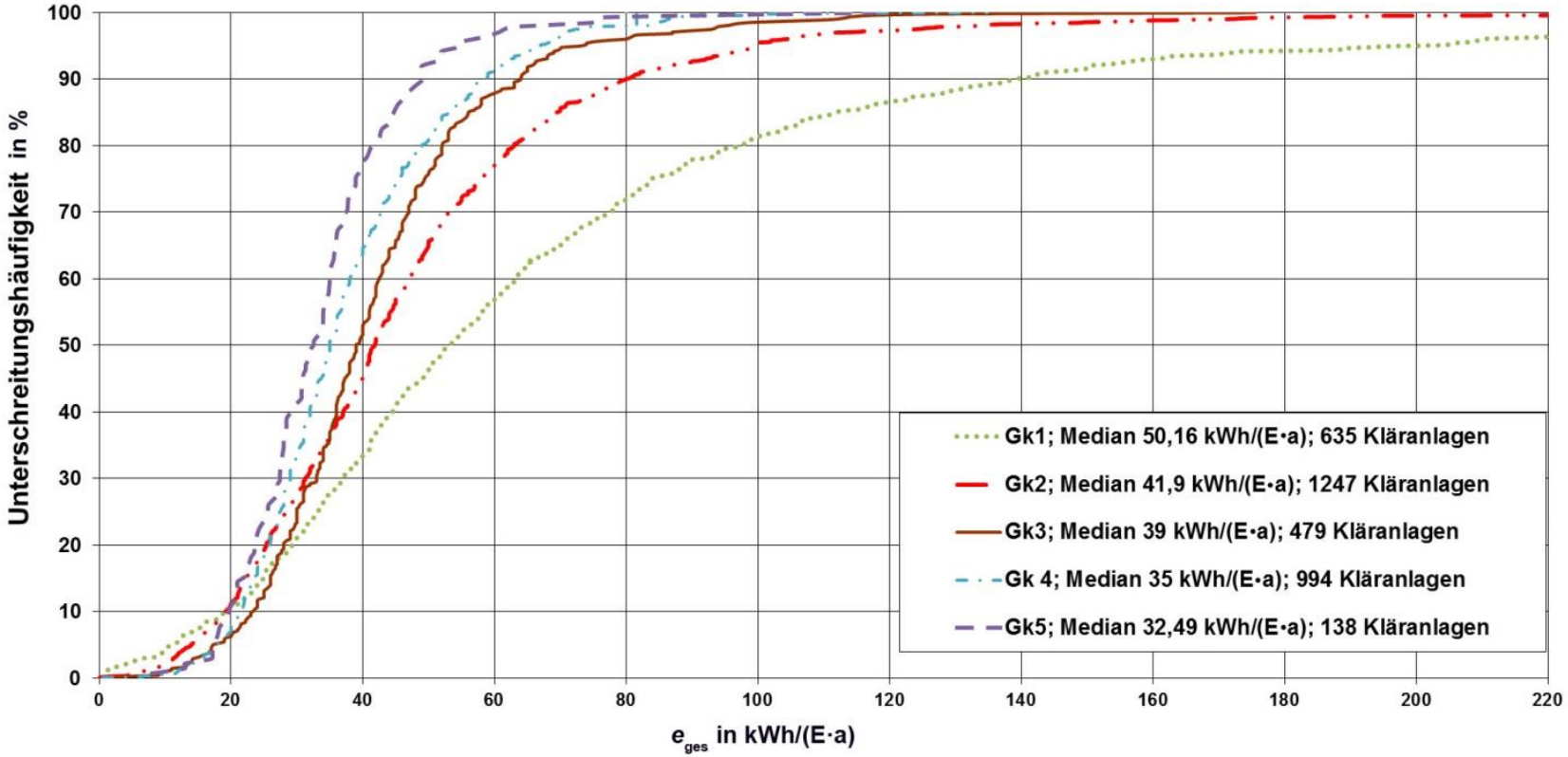
# Further Steps

- Implementation of the EC performance indicators in the recurring control processing of the WWTP
- thus an continuing assessment of the power consumption becomes possible
- data lead to an increasing data quantity and help to improve statistically analyses in the future (e.g. DWA-enquiries)

# Energy check




Specific total power consumption $e_{ges}$ (kWh/(pe·a)) of WWTP by size categories

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# Step 2: Energy Analysis (EA)


- Objective of an EA is to improve the energy efficiency of the WWTP
- Compared to the Energy check (EC) the EA goes more into detail and considers the construction works, the process as such, the techniques in place and the equipment (machines)

# EA includes the following steps

1. Fact finding of the actual power consumption
2. Balance ( Sum up) of the different actual power consumption machines / equipments
3. Determination of ideal (calculated theoretical ) values in respect to the equipment used
4. Assessment of the status quo and identification of measures for improvement
5. Calculation of power savings taking into account economic aspects,
6. Establishing prioritized work packages.

# Evaluation of success

## Contiunous improvement process


- EC and EA are ongoing processes
- The evaluation of success is part of the process.
- Success has to be considered under comprehensible economic calculations. (Multicriterial assessment)

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# Part 3

## 3 Main Parts

1. DWA and Energy
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3. Research Project “Energy efficient Watermanagement” **ERWAS**

# Other research projects

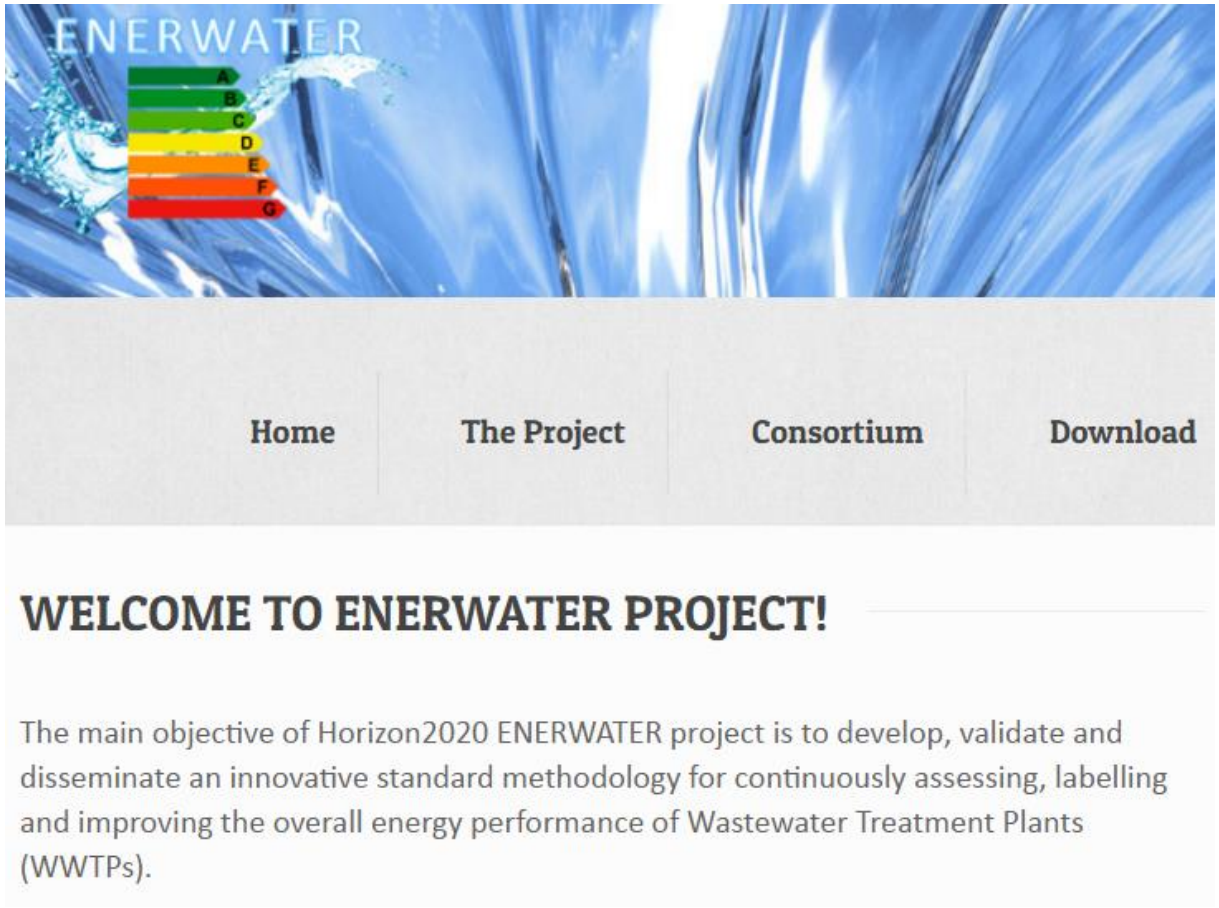
- UIP
- Powerstep
- ENERWATER
- IWAMA

## Successful Applicants „Environmental Innovation Programme“

1. Stadtwerke Schlitz,
   **Energetical Optimisation of the WWTP Schlitz-Hutzdorf**
2. Stadtentwässerung Lingen,
   **Plus-energy-WWTP with phosphorus recovery**
3. Abwasserverband Braunschweig,
   **Energy generation with Organic-Rankine-Cycle (ORC)-Process in WWTP Steinhof**
4. Wasser- und Abwasserzweckverband Jena,
   **The energy self-sufficient WWTP**
5. Stadtwerke Schwalmstadt,
   **Increase of ressources and energy efficiency of a WWTP Treysa**
6. Buchmann GmbH, Annweiler-Sarnstall,
   **Addition of an anaerobic step at WWTP of Buchmann GmbH**
7. Umweltbetriebe der Stadt Kleve,
   **Use of sewage sludge with hydrothermal carbonisation and conversion into electricity**
8. Verbandsgemeinde Weilerbach,
   **Energy self sufficient group WWTP Weilerbach**
9. Trinkwasser- und Abwasserzweckverband Oderaue ,
   **Energy autarkical WWTP with de-ammonification**
10. Erftverband, Bergheim,
    **Energetical Optimisation of the municipal membran WWTP of the example of the group WWTP Nordkanal**

# Research projects

# Research projects

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# Research Projects


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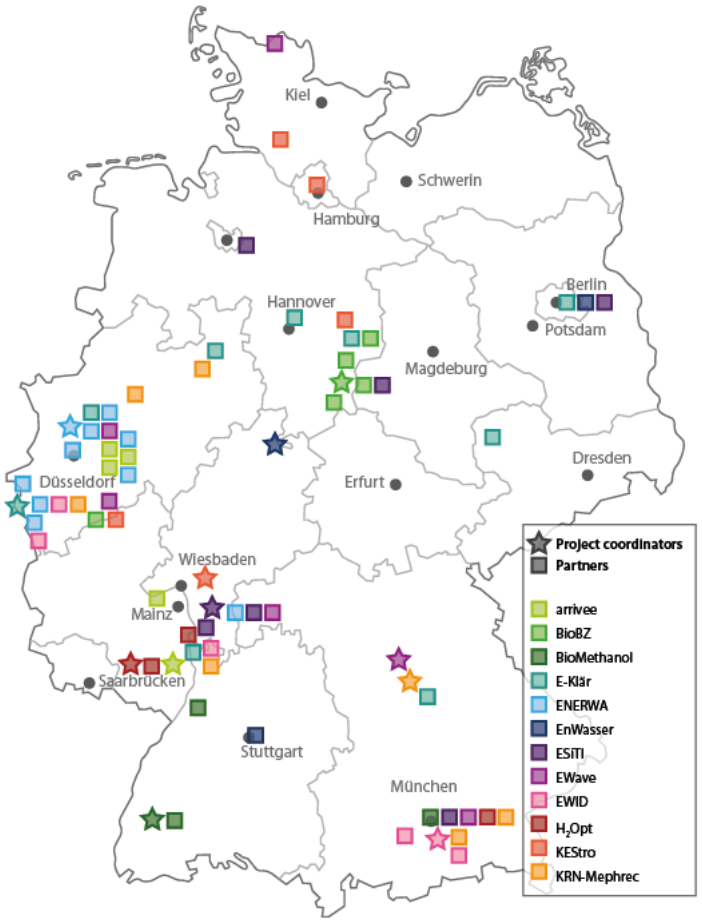


Fig. 3: BMBF funding measure ERWAS – Location of participating institutions

## Water meets Energy

ERWAS will provide solutions and technologies for managing the nexus between water, resources and energy

## Basic Data

- 12 joint research projects
- 20 research sites
- 27 mio. euro funding
- 81 project partners
- Duration: 3 years
- Start of the research projects, april 2014

## Research Foci

- New ways of using the energy potential of wastewater and drinking water
- Link the water and energy sector.

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NaWaM Nachhaltiges Wassermanagement ERWAS

Zukunftsfähige Technologien und Konzepte für eine energieeffiziente und ressourcenschonende Wasserwirtschaft

# Increase of energy efficiency – energy generation in the field of waste water treatment (7 joint research projects)

- Technology modules for an energetic optimisation
- Integration into regional material flows and recycling processes
- Elimination of micropollutants
- Development of bio fuel cells
- Linkage with energy networks
- Use of load management potentials

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# Energetic optimisation of water supply systems (5 joint research projects)

- Energy efficient management and planning
- Energy recovery
- Linkage with energy networks
- Use of load management potentials

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NaWaM Nachhaltiges Wassermanagement ERWAS

Zukunftsfähige Technologien und Konzepte für eine energieeffiziente und ressourcenschonende Wasserwirtschaft

1. arrivee
2. BioBZ
3. BioMethanol
4. E-Klär
5. ENERWA
6. EnWasser
7. ESiTI
8. EWave
9. EWID
10. $H_2$Opt
11. KEStro
12. KRN-Mephrec

1. **Wastewater treatment plants as control components in energy grid**
2. **Microorganisms produce energy**
3. **Methanol synthesised from wastewater**
4. **The "Future wastewater treatment plant" reconsidered**
5. Energy-efficient water supply systems
6. Energy use to protect the environment
7. **The wastewater treatment plant as energy service provider**
8. Optimising operational plans, saving energy
9. Depressurising generates energy
10. Software improves water supply´s efficiency
11. **Wastewater treatment plants as energy buffer for power grids**
12. **Transforming sewage sludge to energy and phosphoric fertiliser**

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NaWaM ERWAS

**BMBF Funding Measure**

Future oriented technologies and concepts for an energy-efficient and resource-saving water management „ERWAS“

# Results - Summary


Future-oriented knowledge that must be disseminated, tested, transferred and developed

Water treatment and energy must be connected

1. Microbial fuel cells work and provide potentials
2. Water management facilities provide flexibility components for the electricity market
3. Socioeconomic framework conditions are crucial for system integration an optimisation
4. Mathematical optimisation algorithms and ‚easy to use‘ optimisation processes save energy

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# ARRIVEE

## Wastewater treatment plants as control components in the energy grid.

Digester sewage treatment plant Hamburg, picture: fotolia

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**Arrivee - Outlook**

1. WWTPs in Germany are capable to provide the needed technical requirements and potentials to interact on the energy sector and contribute to the German energy transition
2. Economic incentives and further legal certainty are strongly needed
3. Individual solutions are - under suitable conditions - reasonable and feasible implementations
4. The demonstrated potentials and findings are suitable for plant internal utilisation like internal (electric) load management.
5. The implementation of Power-to-Gas-concepts will increase the impact of WWTPs as a municipal participant for system services significantly and will show that these plants are capable to operate not only as a consumer, but as a producer of energy on a stable operation of energy grids.
6. Synergies can be created on the plant for the different material flows like:
   the use of oxygen for aeration, hydrogen as a long-term storage option.
7. Dissemination of the gained knowledge and successful practical implementations for this new task of the water management sector is mandatory to move ahead in development

# E-KLÄR

## The "Future wastewater treatment plant" reconsidered

Sewage treatment plant, picture: fotolia

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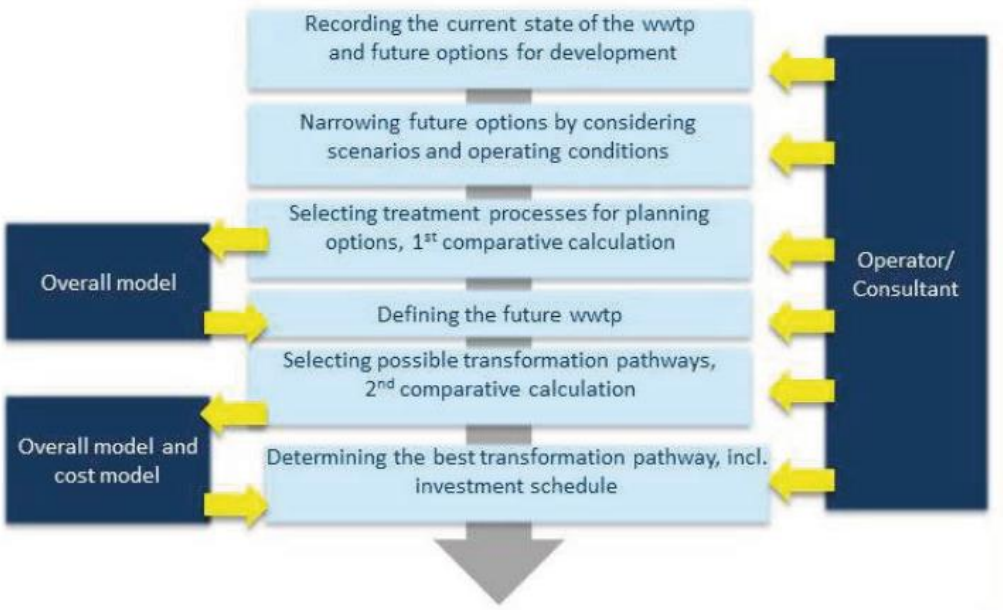


*Fig. 3: Operating procedure describing the interactions between model use, results evaluation and the transformation process*

E-Klär

1. The developed methodical and planning tools enable the identification of the optimal transformation pathway
2. They alow the integration of innovative technologies into wastewater treatment schemes for an optimal use of the energy and resources contained in wastewater
3. The strategic infrastructure planning is conceived as a continuous controlling-process, where selection and evaluation of pathways can be regularly reviewed to take the development of local framework conditions into account.

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# ESITI

## The wastewater treatment plant as energy service provider

Digester of the sewage treatment plant Darmstadt south, picture: TU Darmstadt, Institute IWAR

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ESiTI - Outlook

1. The requirements of the energy sector for flexible energy producers resp. consumers include flexible load management at WWTPs by combining different facilities.
2. The former approach of improving the efficiency of individual units by energetic optimization is not sufficient any more, and has to be supplemented by the holistic approach on flexibilisation potentials.
3. Besides considering technical parameters on diurnal variations of electricity and heat consumption, it is also necessary to look at environmental impacts and socio-scientific aspects
4. The manual, elaborated within the frame of ESiTI, addresses operators of WWTP and brings all results together presenting possibilities and limits of flexible management and operation.

# KRN-MEPHREC

## Transforming sewage sludge to energy and phosphoric fertiliser



Pyrolysis plant in Burgau, picture: Ralf Schultheiß

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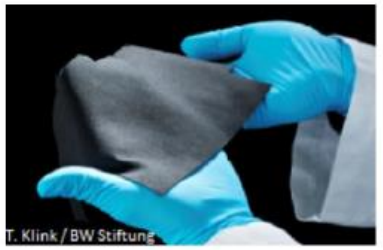
**KRN-Mephrec - Outlook**

1. The **metallurgical conversion** of sewage sludge into metal and phosphorus slag is a particularly promising process, which is workable, sustainable and at the same time financially viable.
2. Recovery of the products is particularly high (over 80 % of the total phosphorus).
3. Method is particularly efficient and compact because of its one-stage operation.
4. The synthesis gas can be reused, for example in combined heat and power units
5. phosphorus-rich slag is further processed mechanically into a fertilizer with medium and sustained fertilizer effect. It is very low-polluting and has good prospects to prove itself in agriculture due to the low cost supply. The tapped metallic alloy goes to the scrap metal trade.
6. If the first test results have been confirmed and the technically required individual components for a large plant have been clarified within the framework of the pilot project, following thorough economic feasibility studies a large-scale plant may be established, which can be process up to more than 70,000 Mg of sewage sludge per year.

# Cross cutting issues

## QT Bio-fuel cells




## QT Energy storage and energy grids

## QT Sewage sludge

## QT Modeling and simulation

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# BIO-ELECTROCHEMICAL FUEL CELL

Power generation during wastewater treatment

Bacterial colony on agar plate, picture: fotolia

## Results

Bacteria can clean wastewater and simultaneously produce energy

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# ENERGY STORAGE AND ENERGY GRIDS

Water management facilities provide flexibility components for the energy market


**Results**

Water management facilities provide flexibility components and can take part in the electricity market

# MODELING AND SIMULATION

## Energetic optimisation of piping systems in drinking water supply


**Results**

Energetic optimisation of piping systems in drinking water supply can save energy

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## ERWAS Website

- Information [www.bmbf.nawam-erwas.de/en](www.bmbf.nawam-erwas.de/en)
- Events and latest news
- ERWAS meta-search engine

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