INNovative Energy Recovery Strategies in the urban water cycle – INNERS

Energy Balances at a City Scale – Overview/Data

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Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
INTERREG IVB

Participating partners

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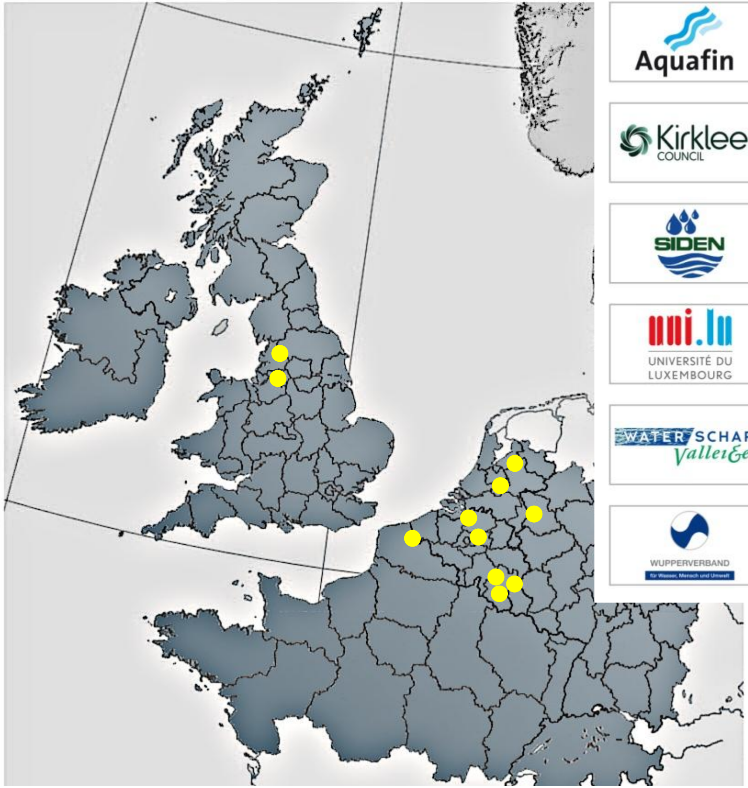
- 11 project partners …
  from 6 countries in NWE

- … with one common goal:
  Creating a more sustainable urban water cycle by collecting, reuse and saving of energy.



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Project Objectives

- Understand and quantify the energy balance of the urban water cycle (UWC)
- Attainment of an energy neutral or producing UWC

Outline of Presentation

- Introduction
- General overview about INNERS
- Selected Data Collection Activities – issues
- Future Work

INNERS activities

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- To collect data and to perform modeling studies to understand the “urban water cycle” in terms of energy.
- Demonstration projects: thermal energy recovery
- Demonstrations projects: operational and chemical energy optimization

- To inform technical specialists and policy makers – via new knowledge and demonstration at full scale.
- To identify legal and organizational barriers for implementation of energy recovery in the urban water cycle.

Work packages and actions

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Actions	Energy Balance of the UWC	Thermal energy recovery	Chemical and operat. energy	Enabling implementation
	Inventory of data, models for UBC	Compilation of relevant energy data	Benchmark study: operational energy	Disseminate INNERS results to decision makers
	Identify lack of data for UWC	Feasibility studies on thermal energy	Feasibility studies for improvement of energy balance	Disseminate technical knowledge to future specialists
	Energy balance assessment tool (EBAT)	Implementation of thermal energy systems	Demonstration project on energy neutral WWTP	Study the legal and organisational barriers for implementation
	Collecting data for EBAT		Demonstration project on new sanitation concept	
	Development modules for EBAT (EOS / CO_2 footprint)		Pilot: energy online system (EOS)	

Energy in the Urban Water Cycle

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Drinking water supply

- transport, treatment, distribution
  ~0.5 kWh/m³

Wastewater

- treatment
- 0.9 - 10 kWh/m³

chemical and operational energy

Wastewater

- collection
- 0-16 kWh/m³

operational energy

Domestic water use

- cooking, washing, cleaning
- **> 50** kWh/m³

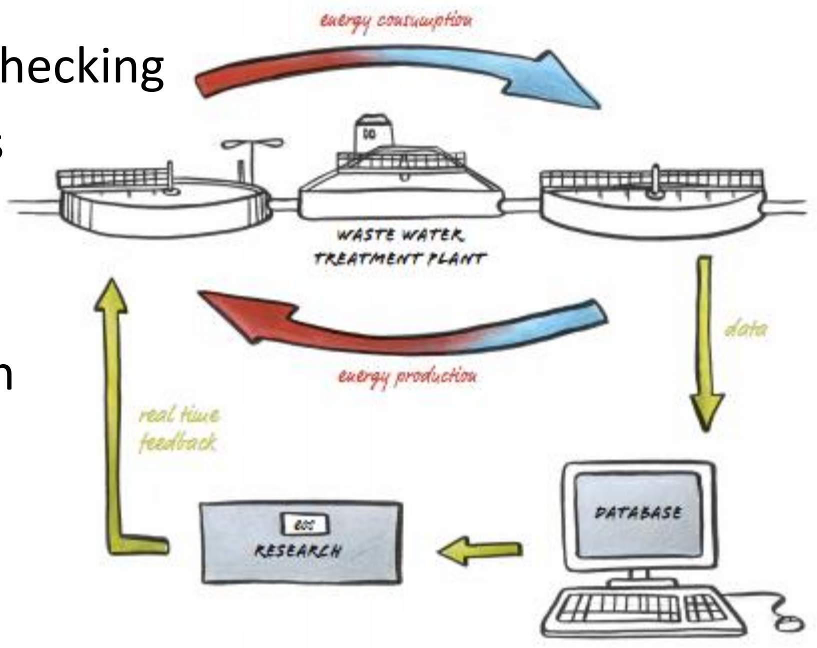
thermal energy

(data by Olsson, 2011)

Energy online system

System Concept

- Benchmarking – cross border activity
- On-line data acquisition and quality checking
- User selected Performance Indicators
- Decision Support System
- Infrastructure and data security
- End user designed interface for action



Energy online system

must have

if budget allows purchase

WWTP Heiderscheidergrund	rated power [kW]	year of construction [a]	voltage [V]	nominal current [A]	hours of operation online	energy usage: rated power x hours of operation [kWh/a]	Percentage of total
Lifting pumps						**127260**	**27.2%**
Pump 1	15	2009	400	30.00	2,405	36075	
Pump 2	15	2009	400	30.00	2,955	44325	
Pump 3	15	2009	400	30.00	3,124	46860	
Sand trap						**27097**	**5.8%**
Trap 1	3.10	2009	400	6.80	4241	13147	
Trap 2	3.10	2009	400	6.80	4500	13950	
Biology						**154106**	**33.0%**
Blower 1	18.50	2009	400	33.10	2169	40127	
Blower 2	18.50	2009	400	33.10	1984	36704	
Blower 3	18.50	2009	400	33.10	1980	36630	
Stirrer 1.1	2.30	2009	400	5.50	8754	20134	
Stirrer 1.2	2.30	2009	400	5.50	8756	20139	
Stirrer 2.1	2.30	2009	400	5.50	81	186	
Stirrer 2.2	2.30	2009	400	5.50	81	186	
Return sludge pump						**12056**	**2.6%**
Pump 1	4.70	2009	400	10.00	25	118	
Pump 2	4.70	2009	400	10.00	2540	11938	
Pump 3	4.70	2009	400	10.00	1590	7473	
Stirrers	2.50	2009	400	7.00	5087	12718	
Ionisation						**29563**	**6.3%**
Blower Dehydration	5.50	2009	400	11.30	5375	29563	
Sludge dehydration						**10604**	**2.3%**
Centrifuge	22.00	2009	400	39.00	482	10604	
Filtration						**22500**	**4.8%**
Sand filtration	7.50	2009	400	16.50	3000	22500	
UV						**83835**	**18.0%**
UV lamp 1	11.50	2009	400	22.00	475	5463	
UV lamp 2	11.50	2009	400	22.00	475	5463	
UV lamp 3	11.50	2009	400	22.00	3170	36455	
UV lamp 4	11.50	2009	400	22.00	3170	36455	
Operational building						**0**	**0.0%**
Operational building						0	
Workshop						0	
rated consumption						467020	**100.0%**
Energy bill						433,469	**92.8%**

Installed energy meters

- 1st level data quality checks
  - Check if data values are in a predefined range
- 2nd level data quality checks
  - More extensive statistical checks
    - Single dimensional (e.g. constancy of time series)
    - Multi dim. (e.g. relation between parameters C/N/P)
  - Energy related failures (e.g. total energy consumption of plant is zero)
- Generally, data will be flagged, never deleted to keep information
- Level of flags can tell about reliability/quality of data points

Bench Marking Tools for EOS

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Aims of EOS Benchmarking

Trans-European Benchmarking studies regarding energy efficiency of WWTPs

Capability to have end user friendly decision support

Target Value
- Defined by literature
- Most of the plants can reach it without much effort

Best Practice Value
- Defined by literature
- State of the art technique
- Only 5-10% of the plants can reach it

Benchmark Value
- Classical benchmark tool
- Created by EOS from participating plant data

Personal Target Value
- Defined by user

Data

↓

Performance Indicators

↓

Decision support

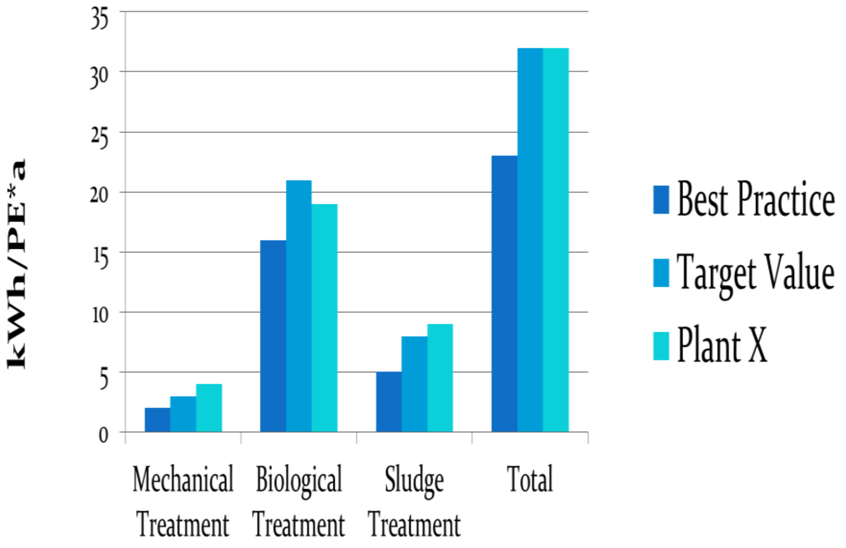
↓

Information - Action

Key Performance Indicators in EOS

Energy related KPIs	Plant Location	Unit
Overall specific energy consumption	Global	kWh/PE*a
Specific energy consumption based on eliminated COD	Global	kWh/kg_{COD}
Electrical Self-coverage	Global	%
Specific energy consumption of the biology	Biology	kWh/PE*a
Specific energy consumption of the stirrer	Different locations	W/m^3
Specific energy consumption of the blower	Different locations	kWh/m^3*bar
Process related KPIs	**Plant Location**	**Unit**
COD elimination rate	Global	%
N elimination rate	Global	%
Specific biogas production	Digester	l/PE*d
Hydraulic retention time digester	Digester	d
Sludge age	Biology	d
Recirculation ratio	Biology	%

Examples of KPI tested in EOS



Energy online system - delivery

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- Online collection of energy use data
- Performance indicators for energy use in wastewater treatment plants
- Multi-criteria expert system for a real-time optimisation of energy consumption at WWTPs
- End user friendly interface
- Installation and testing of tool at two WWTPs in Germany and Luxemburg
- Rolling out system to other WwTP
- Flexible - cross plant/border comparison

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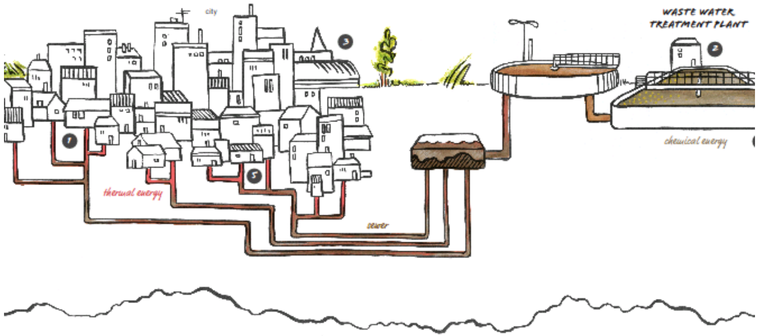
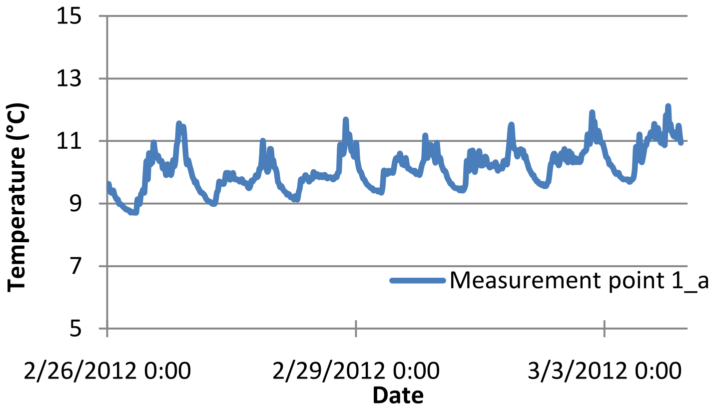
Thermal energy recovery from sewers





- Thermal energy lost from properties
- Data collection in combined sewers
- Harsh environment/intrinsically safe/data logger based data collection
- Expensive
- Data needed for heat transfer model - link with large 1D sewer network model

Sewer and Ground Temperature Measurements

Six combined sewer locations

Air temperature 1m below manhole

Sewage temperature – invert of pipe

Flow depth and velocity – 5 minutes

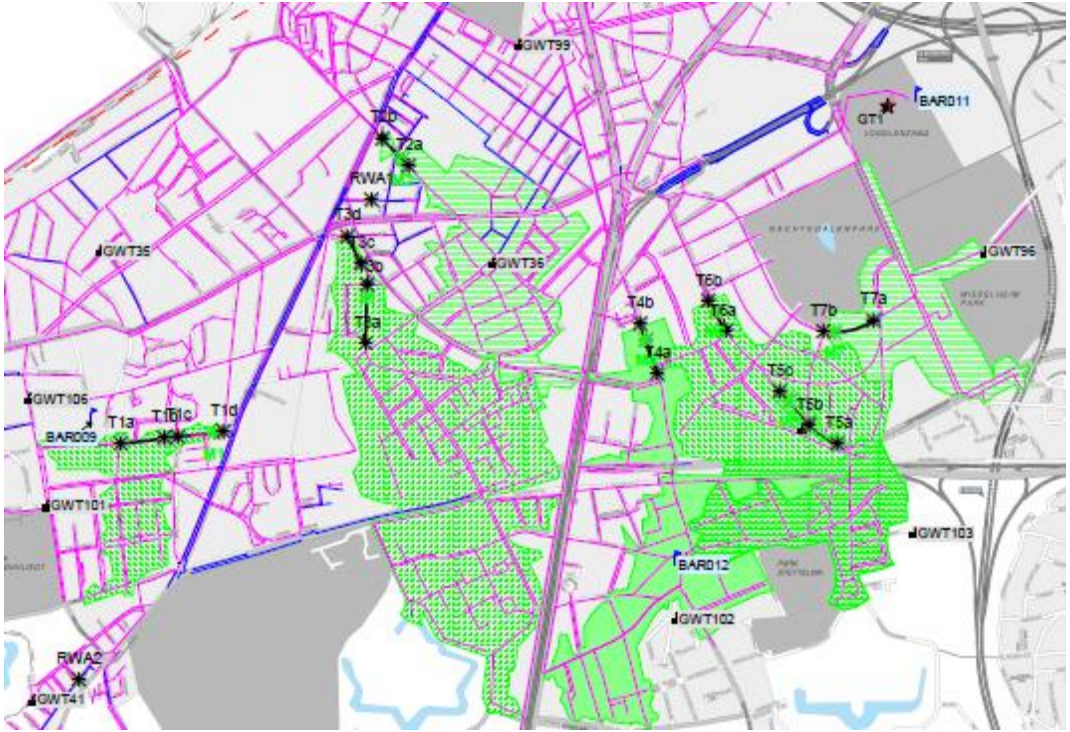
Groundwater level

1.5m to 3.7m below GL

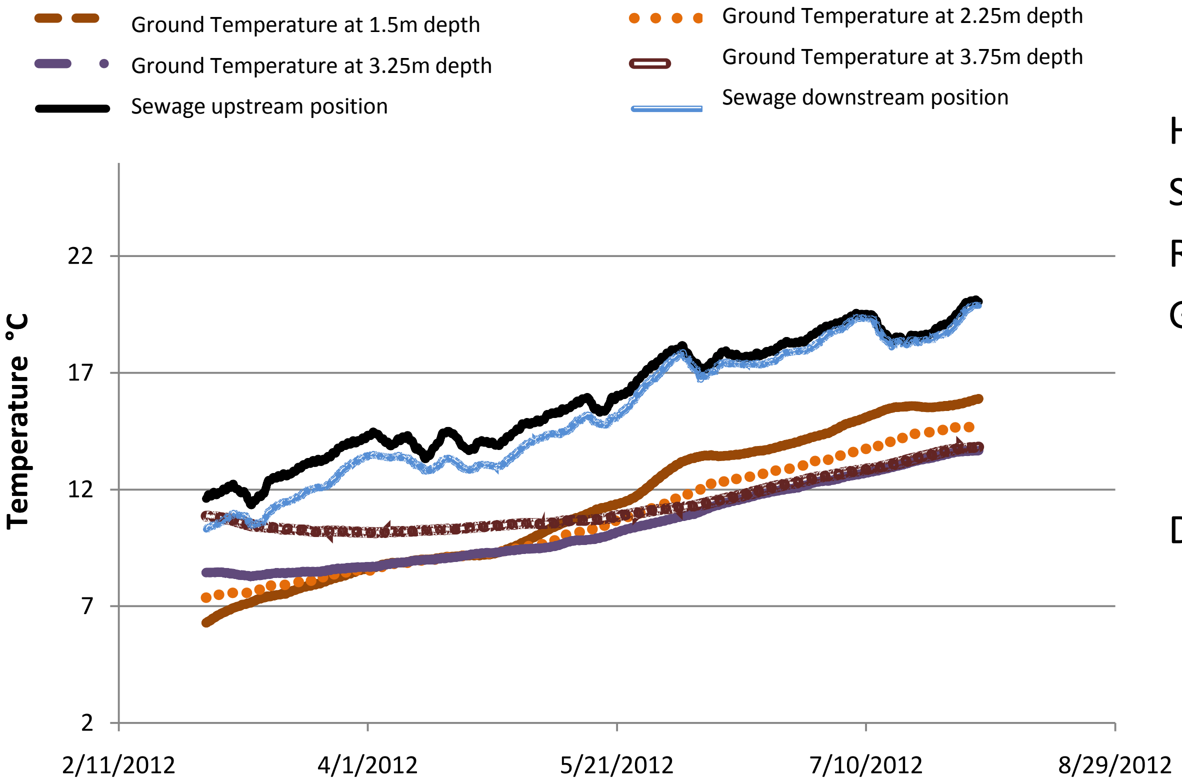
saturated/partially saturated – time varying

Sampling rate – every 20 minutes

Pipe Material – masonry/concrete

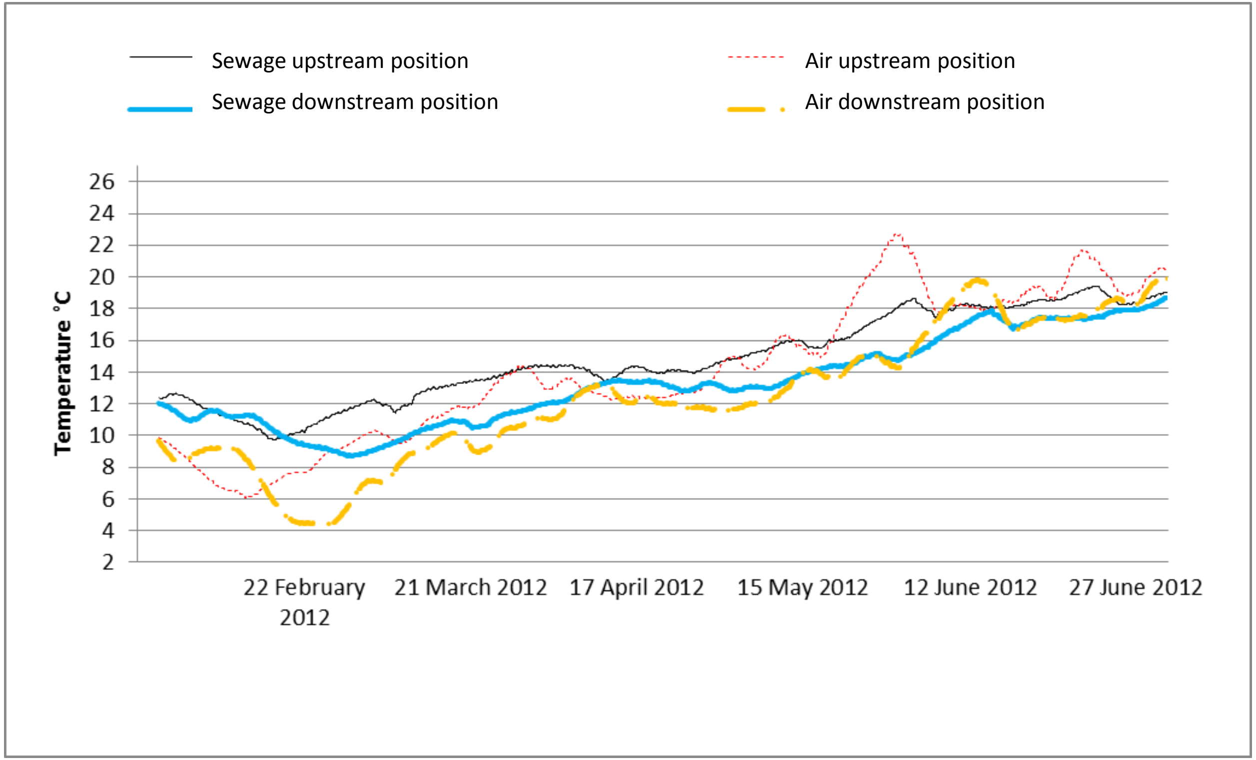


Sewer and Ground Temperature Measurements



- Heat transfer to soil along pipe
- Seasonal variation
- Rainfall effects - minor
- Ground temperatures vary with depth and close to ground level - air temperatures
- Data used to calibrate heat transfer model for pipe material and local soil conditions

Sewer and Ground Temperature Measurements



Air temperatures poorly correlated with sewage temperatures

Data issues

Requirement to replace batteries and download data

Timing between data loggers

Unforeseen events

Conclusions

Modelling/Assessment – different scales

Whole urban water cycle scale – operational energy, heat and water fluxes at water supply, residential use, transport and treatment levels in urban water cycle (valuation tools)

Identify key opportunities for energy recovery, or reduction

Sub city scale assessment – tools for feasibility studies at an intervention scale, e.g. WwTP (performance/cost)

Data collections efforts – to support various scales of modelling tools

Residential scale – sewage separation, ground source heat/stormwater combination –

- data security, access for maintenance, low frequency, communication good

Sewer Network – flow velocity, depth , soil, air and sewage temperatures, high and low frequency, poor access and communication

WwTP – energy and chemical use, flows, medium frequency, good power and communication, on-line data collection possible, data sets relatively small, variable in quality

Demonstration

Demonstration projects to show technical feasibility and practical implementation