Heat Recovery from Wastewater

-Swedish case-study

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BACKGROUND

Why recover heat from wastewater?

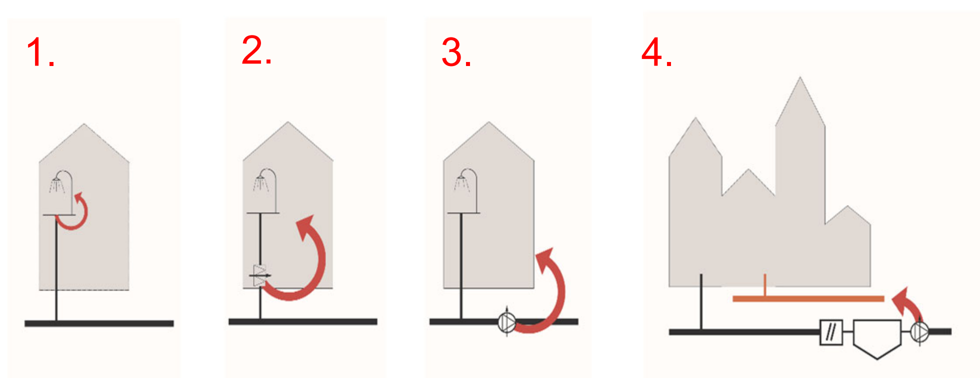
10% - urban water cycle

National energy usage

90% - heating tap water

Energy use for urban water cycle (Olsson, 2012)

Where can we recover heat from ?



Olsson, G. (2012). *Water and Energy – Threats and Opportunities*. IWA Publishing, London, UK.

BACKGROUND - HÅVA

HÅLLBARHETSANALYS AV VÄRMEÅTERVINNING UR AVLOPPSVATTEN

HÅVA – Hållbarhetsanalys för värmeåtervinning ur avloppsvatten

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FORMAS

4 years - 6 MSEK

Key partners:

Lund University

RISE Research Institutes of Sweden

VA SYD

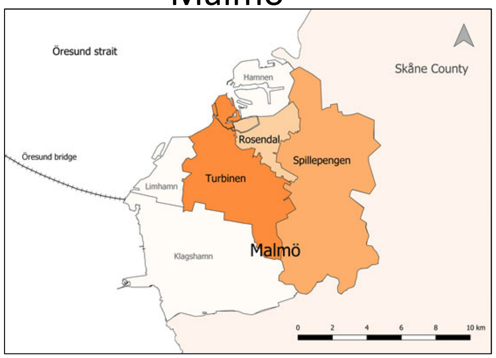
KÄPPALA För renare sjöar och skärgård

Tekniska verken

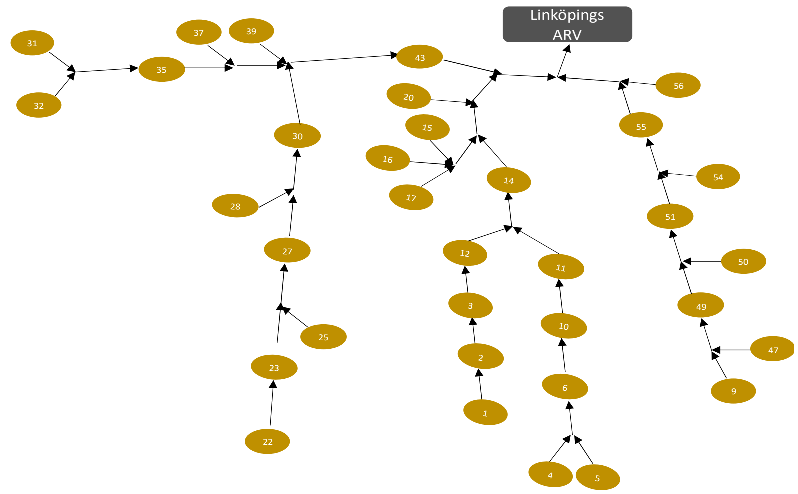
sweden water research

BACKGROUND - HÅVA

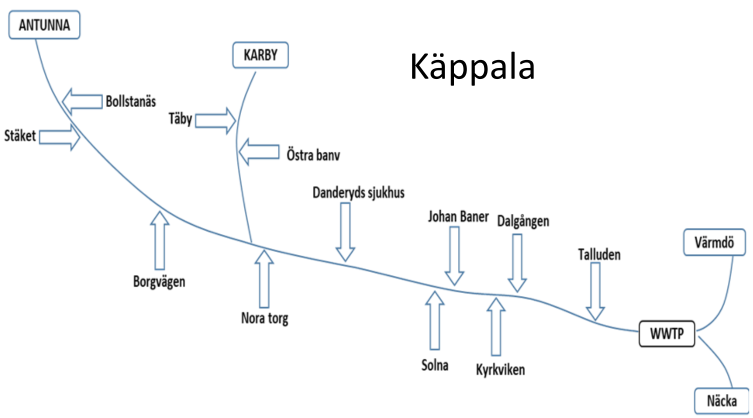
Malmö



Linköping



Käppala

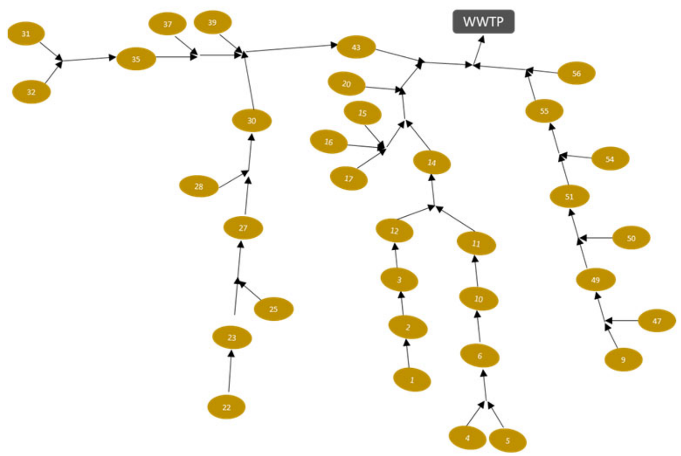


BACKGROUND - HÅVA

- Wastewater generation
- Heat transfer in the sewer system
- Heat exchangers
- WWTP

LINKÖPING - OVERVIEW

Name	Average flow rate (m^3/d)
Domestic (modelled)	25840
Industrial (modelled)	12000
Infiltration	10%
WWTP (data)	42600

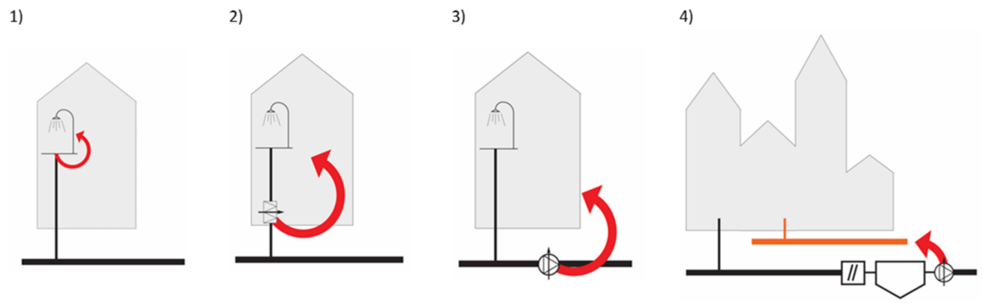


- Seperate sewer system
- 34 sections (3 industrial sections)
- Calibrated WWTP model

- Stochastic wastewater generation model
- Combination of detailed sewer model and conceptual model for different sections
- Calibrated WWTP model

- Simulation period: Jan 2020 and April 2020
- **Uncertainty analysis – several parameters varied by 25%.**

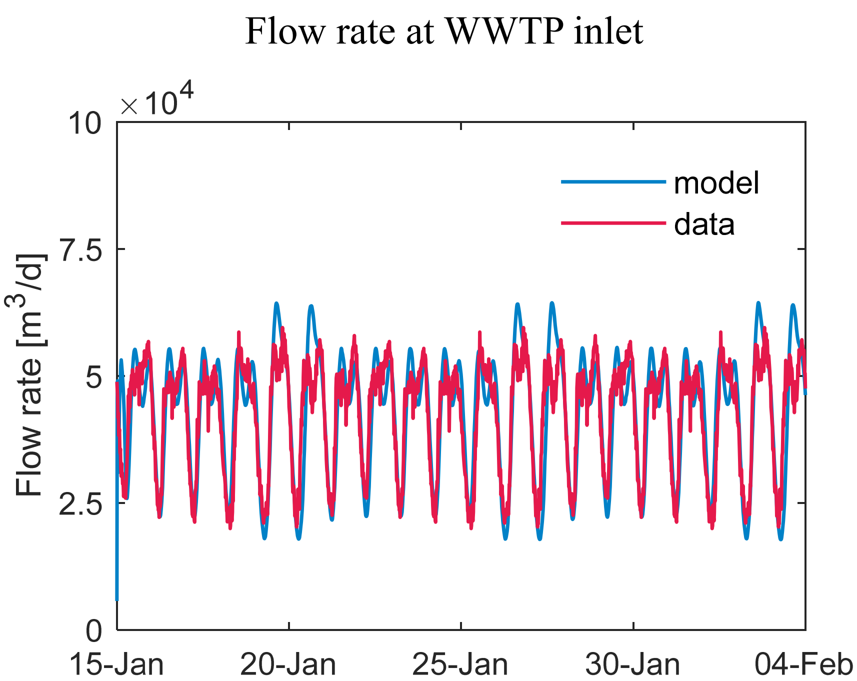
LINKÖPING - SCENARIOS

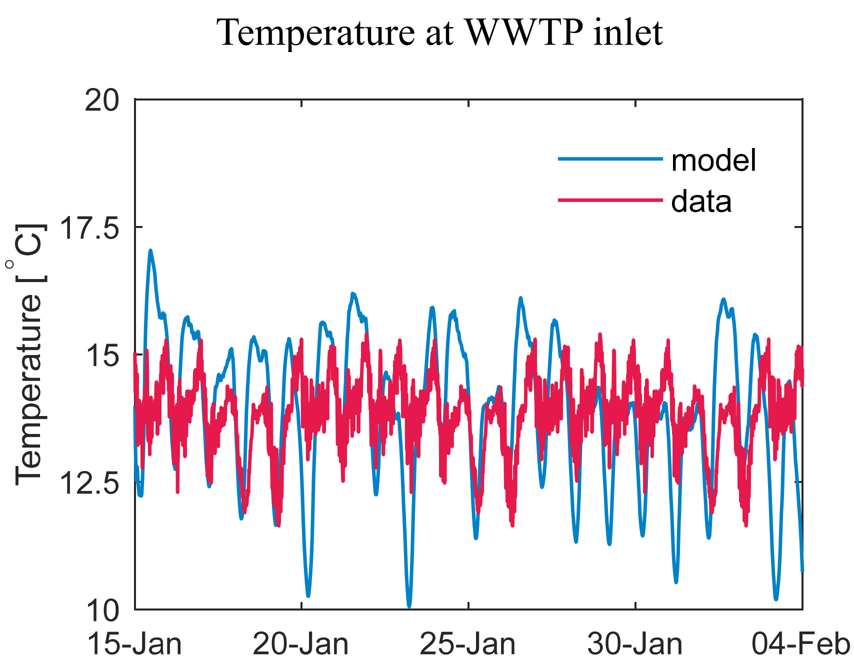


	16 %	42 %	77 %	100%
Pos. 1	P1.I16	P1.I42	P1.I77	
Pos. 2	P2.I16	P2.I42	P2.I77	
Pos. 3	P3.I16	P3.I42	P3.I77	
Pos. 4				WWTP

+ Default (No heat recovery) = 11 Scenarios

LINKÖPING - RESULTS

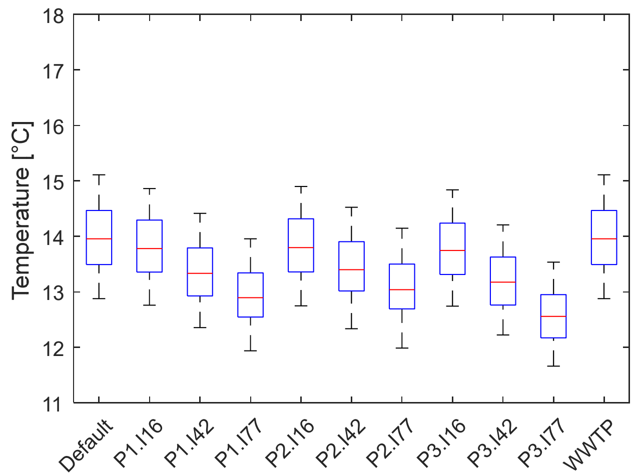




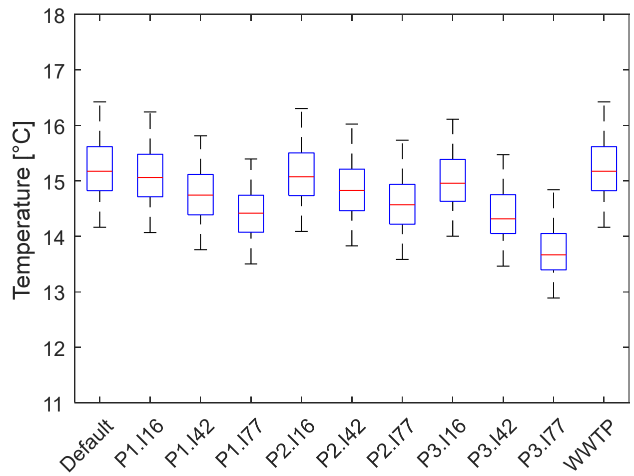
LINKÖPING - RESULTS

Mean WWTP inlet temperature

Jan 2020



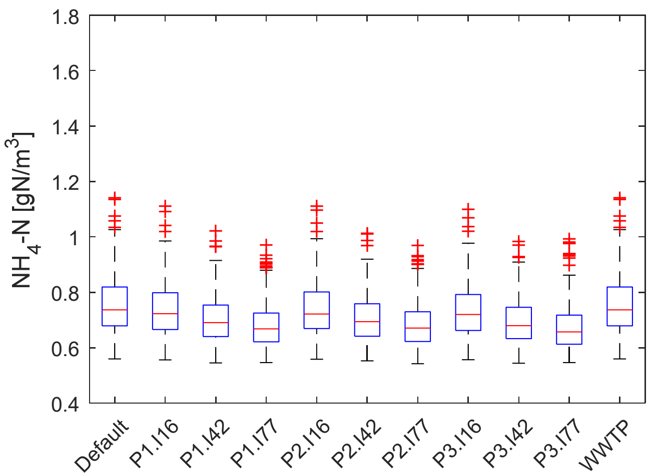
April 2020



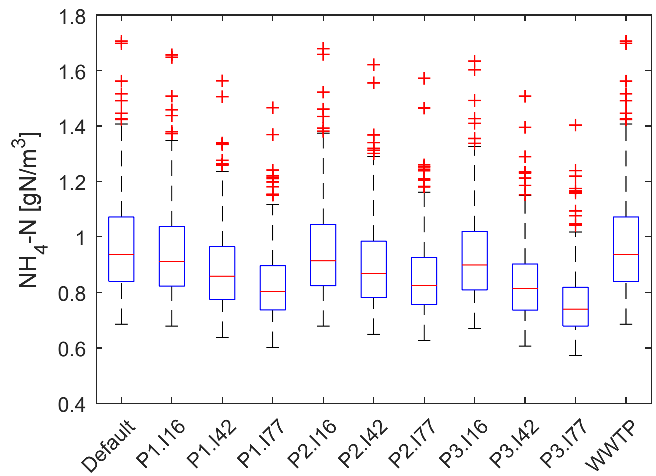
LINKÖPING - RESULTS

WWTP effluent NH_4-N conc.

Jan 2020



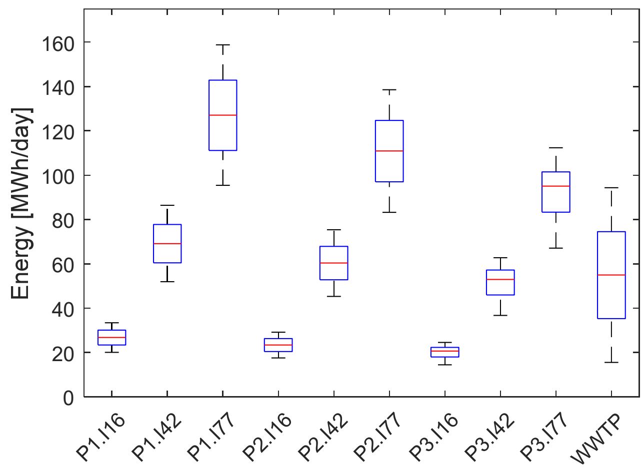
April 2020



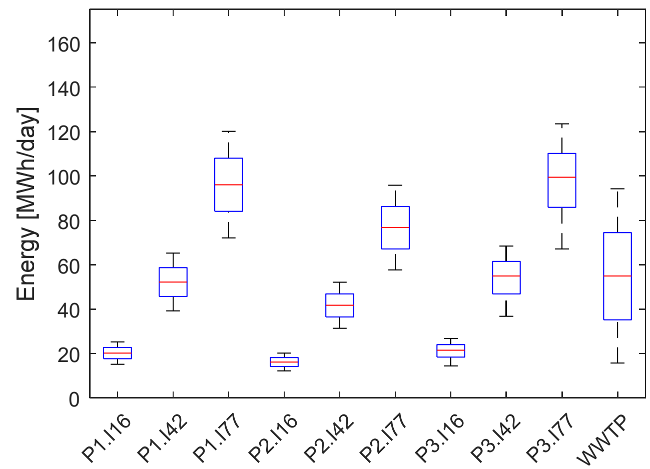
LINKÖPING - RESULTS

Energy recovery for all scenarios

Jan 2020



April 2020



CONCLUSIONS

- In general, upstream heat recovery (for the considered scenarios) does not lead to effluent limit violations at the WWTP.

- The more upstream we recover heat, the lesser is the impact on WWTP inlet temperature and performance - Recovery at showers, households better than at sewer pipes, but...

- It is possible to conduct a practical and realistic scenario analysis for several wastewater heat recovery possibilities with modelling tools.

- While even high heat recovery scenarios did not lead to nitrification problems at the WWTP, it can impact (and reduce) the overall lifespan of the current WWTP design.

PUBLICATIONS

Technical Reports

- Arnell M., Saagi R., Wärff C., Ahlström M. och Jeppsson U. (2021). *Värmeåtervinning ur avloppsvatten. Energiåtervinning och påverkan på avloppssystemet*. SVU-rapport 2021-26. Stockholm, Svenskt Vatten.
- Saagi, R., & Arnell, M. (2021). *Upstream heat recovery impacts on Käppala WWTP performance – Model-based analysis combining sewer tunnel and WWTP* (Technical Report No. LUTEDX/(TEIE-7282)/1-16/(2021)). Division of Industrial Electrical Engineering and Automation, Lund University, Sweden.
- Arnell, M., Saagi, R. (2020), *Modelling of Heat Recovery Equipment*. Technical report, Division of Industrial Electrical Engineering and Automation, Lund University, LUTEDX/(TEIE-7280)/1-8/(2020).
- Wärff, C. (2020), *Household wastewater generation model*. Technical report, Division of Industrial Electrical Engineering and Automation, Lund University, LUTEDX/(TEIE-7279)/1-29/(2020).
- Arnell, M., Lundin, E., & Jeppsson, U. (2017). *Sustainability analysis for wastewater heat recovery—Literature review*. Technical Report, Division of Industrial Electrical Engineering and Automation, Lund University, LUTEDX/(TEIE-7267)/1-41/(2017).

Journal publications

- Saagi, R., Arnell, M., Wärff, C., Ahlström, M., & Jeppsson, U. (2022). City-wide model-based analysis of heat recovery from wastewater using an uncertainty-based approach. *Science of The Total Environment*, *820*, 153273.
- Saagi, R., Arnell, M., Reyes, D., Wärff, C., Ahlström, M., & Jeppsson, U. (2021). Modelling temperature dynamics in sewer systems – comparing mechanistic and conceptual modelling approaches. *Water Science and Technology*, *84*(9), 2335–2352.
- Arnell, M., Ahlström, M., Wärff, C., Saagi, R., & Jeppsson, U. (2021). Plant-wide modelling and analysis of WWTP temperature dynamics for sustainable heat recovery from wastewater. *Water Science and Technology*, *84*(4), 1023–1036.
- Wärff, C., Arnell, M., Sehlén, R., & Jeppsson, U. (2020). Modelling heat recovery potential from household wastewater. *Water Science and Technology*, *81*(8), 1597–1605.

Code

- https://github.com/wwtmodels

THANK YOU

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