DTU Compute
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# Demand Response Opportunities in Wastewater Treatment

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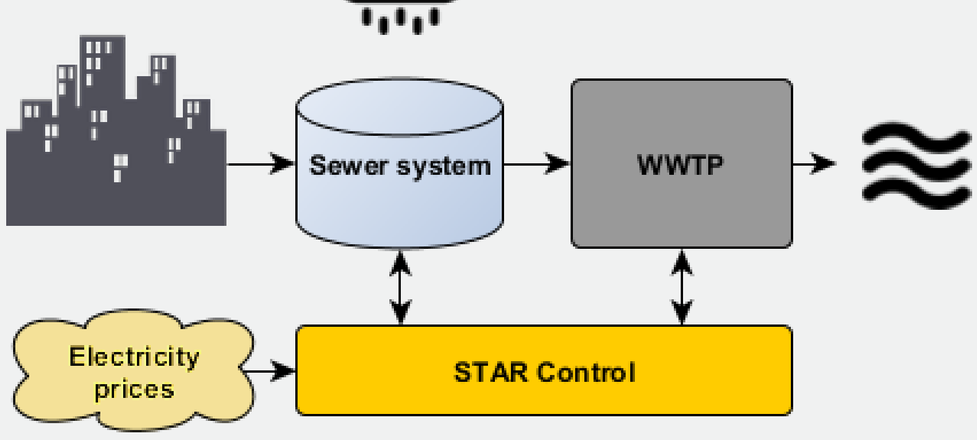
**Denmark's political ambitions of a fossil fuel free energy system by 2050 calls for more renewable energy sources such as wind and solar. These green energy resources generate a fluctuating power. So the transition to a green energy system requires a *Smart Grid* with flexible consumers that balance the fluctuating power production. The energy-heavy processes for wastewater transport and treatment could potentially provide a flexible operation with storage capabilities and be a valuable asset to a Smart Grid.**

## Wastewater objectives

The primary aim of a Wastewater Treatment Plant (**WWTP**) is to treat the incoming wastewater to a sufficient water quality safe for the environment. The secondary aim is to treat the wastewater using as little energy as possible or even produce energy from by-products. In the future wastewater will be considered an energy resource, that contains valuable nutrients convertible to green biogas and in turn electricity and heat.

Wastewater is transported to the WWTP through the sewer system that must minimize overflow risk, especially in rain weather. In dry weather the overflow risk is low and we can exploit the buffer storage capacity to delay or defer treatment; and consequently control the power consumption of the plant and the pumps. Offering this flexibility to the power system is often referred to as Demand Response.

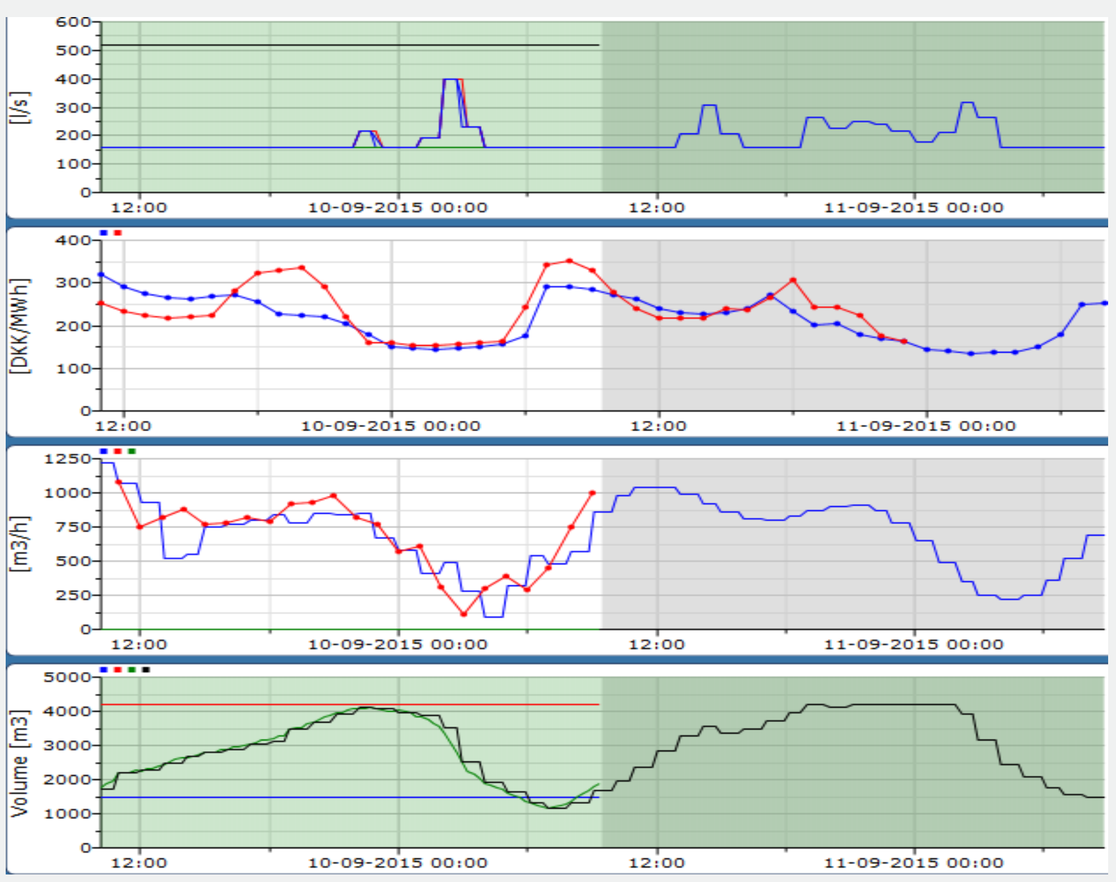
In a Smart Grid consuming or producing energy at the right time is key to **lower plant electricity costs in a sustainable way** and **actively help to balance the renewable energy system**.




Wastewater and rain is transported through the sewer system to the WWTP that treats the water before returning to the recipient. The process control system monitors both sewer system and WWTP and adjusts operation according to electricity prices.

## Demand response opportunities

- Treatment, and hereby power consumption, can be delayed or deferred by storing the incoming wastewater in tanks and in the sewer system.
- Power management of the aeration process. At least 50% of the total electricity consumption of a WWTP is spent on aeration, i.e. having rotors periodically blow air into the wastewater to start the nitrogen removal treatment process. When the aeration pattern changes, the effluent water quality also changes. The water quality is the most important plant output and is frequently measured by local authorities and economically penalized through regulatory requirements.
- Power management of the sewer system pumps.
- Sludge outtake for on-site biogas production and on-demand gas turbine-produced electricity and heat.




Signals and their forecast from realtime Smart Grid operation in Kolding. From the top: controllable flow with constraints, electricity prices, inlet flow to controllable volume, measured and modelled volume with constraints.

## Case study: Kolding WWTP in Denmark

We upgraded the STAR control system to operate the sewer system and the WWTP by taking electricity prices into account. The solution is based on Model Predictive Control (MPC) that integrates dynamic models and forecasts of the plant operation using data from existing online plant sensors. The DSO, EnergiDanmark, provides online forecasts of the hourly day-ahead Elspot prices from NordPool. The prototype system is currently being tested at a 70.000 PE plant in Kolding, Denmark. In the current market this plant will save up to 200.000 DKK/year in electricity costs. The solution is expected to be part of Krüger's advanced process control software *STAR control*® already used at plants worldwide.

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