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Can water resource recovery facilities participate in the stabilization of the energy system?

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Introduction: Grid frequency f is an essential parameter in energy systems and must be as close as possible to its nominal value (f_{nom}). However, over recent decades, and because of the transition towards larger share of renewable energies, power systems have been gradually changing. Energy systems relying on diverse energy sources suffer from frequent deviations from f_{nom} . To compensate this, consumers can participate in the energy market by selling capacity (i.e., compromising themselves to increase power demand above their needs) or reducing demand, thereby compensating for the deviations caused by renewable energies during their (de-)activation. In this study we assess the feasibility of using WRRFs to compensate for these deviations by optimizing aeration regimes.

Methods and data: the plant model describes the Kolding WRRF, which is modelled as two alternating aeration tanks for nitrogen removal, following the bio-denitro process. Aeration is responsible for at least 60% of the power consumption of the WRRF. The NDHA model is used to describe carbon and nitrogen removal. The model accounts with ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB). AOB model describes both the nitrifier, nitrification and the denitrifier denitrification pathways for N_2O generation. Heterotrophic denitrification is described as a four steps process. Considering that a WRRF is participating in the grid frequency control, when $f \neq f_{nom}$ during a certain amount of time, such WRRF is committed to modify its energy consumption. The aerators of the WRRF would be switched ON/OFF depending on the grid frequency:

- $f < f_{nom} \rightarrow$ Turn OFF both aerators \rightarrow reduce consumption
- $f > f_{nom} \rightarrow$ Turn ON both aerators \rightarrow increase consumption

Once that both aerators are simultaneously connected or disconnected, inflow is divided into the reactors. When either the frequency has been restored or the maximum duration has been exceeded, the frequency control by the WRRF is not required anymore and the WRRF recovers traditional rule-based control.

Results: results (fig.1) suggest that WRRFs can participate in the energy system for frequency compensation in most assessed scenarios. When short term control actions are required (approx. <40 min), the WRRF shows better nitrogen removal during the night and early morning. However, long interventions should be avoided during the highly loaded

periods, such as midday, when the WRRF is affected by the wastewater discharged to the sewers in the morning. It is also during this period when N_2O emissions reach their highest values (data not shown), compromising the carbon footprint of the WRRF. Carbon removal is improved when the energy demand is increased, while it is poorer when the aerators are switched off and nitrate is completely removed.

Figure 1. Left: increase on energy demand and impact on nitrogen removal when the WRRF sells capacity at different intervals of control switch (x-axis) and times of the day (y-axis). **Right:** decrease on energy demand and impact on nitrogen removal when the WRRF reduces energy demand.

