A GUIDE TO NET-ZERO ENERGY SOLUTIONS FOR WATER RESOURCE RECOVERY FACILITIES

EXECUTIVE SUMMARY

Energy is often the second-highest operating cost at water resource recovery facilities (WRRF) behind labor costs. Additionally, fossil fuels are the basis of most purchased energy, which contributes to carbon footprints and public health risks due to air pollution by the wastewater sector. In recent years, the Water Environment Research Foundation (WERF) advanced knowledge and implementation of energy efficient best practices in the industry and is embarking on research to move WRRFs closer to achieving energy neutrality. Energy neutrality for the domestic wastewater industry is within reach, and this project contributes greatly to the industry's understanding of the complexities, opportunities and challenges that face WRRFs as they strive for energy neutrality.

The overall goal of this project is to help WRRFs quickly assess their energy management performance and move toward "net-zero" energy use through current best practices and proven technologies in the areas of energy efficiency, demand reduction, and onsite renewable energy production. This study investigates the energy neutrality potential of WRRFs through detailed modeling of the energy flows around and between individual unit processes. It is to be read in conjunction with these additional WERF reports:

- *Triple-Bottom Line Evaluation of Biosolids Management Options* (ENER1C12a).
- *Demonstrated Energy Neutrality Leadership: A Study of Five Champions of Change* (ENER1C12b).
- *Utilities of the Future Energy Findings* (ENER6C13).

The core outputs of the study are energy balances (see examples attached) generated for typical and best practice facility configurations commonly used for domestic wastewater treatment in the developed urban world. The research team identified 25 wastewater treatment process flow schemes (configurations) that are representative of most WRRFs in North America. In addition, the project team identified eight modifications to specific unit processes that could be applied to certain WRRF configurations.

As a result of this analysis and the generation of the Sankey energy diagrams associated with the typical and best practice configurations, researchers made key observations and drew some universal conclusions. Most notably, the contribution of best practices to energy neutrality was greater than expected; however, best practices alone will not achieve energy neutrality at any of the WRRF configurations modeled. Other findings include:

- The full combination of best practices resulted in approximately 40% lower energy consumption than "typical" performance.
- Improving primary treatment and solids capture in thickening and dewatering processes had the most significant total positive impact of all the best practices modeled.
- Significant savings in aeration blower electricity usage was achieved by reducing fouling in fine bubble diffusers through improved operation and maintenance procedures. This best practice is often overlooked.

- Anaerobic digestion with combined heat and power (CHP) was the most advantageous approach to energy recovery, reducing energy requirements by up to 35% at WRRFs that have anaerobic digestion.
- Dewatered biosolids (cake) retained a significant portion of the influent chemical energy, ~30% post digestion and ~50% for lime stabilization

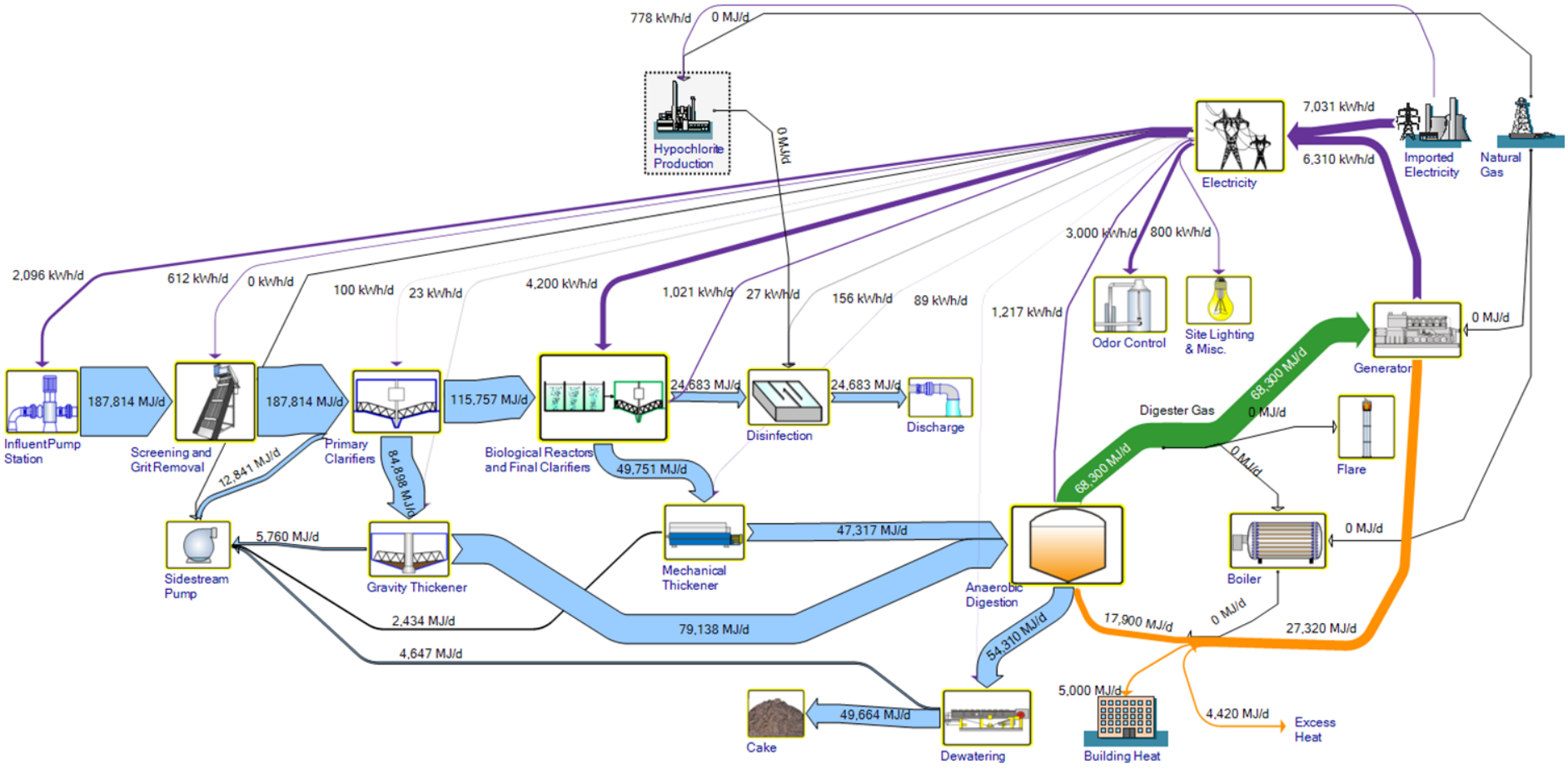
The research team identified 18 "pioneering" processes that made use of current and emerging technologies and process configurations to minimize energy use and/or maximize energy recovery. The team also generated energy flow diagrams for the pioneering processes and compared them to best practice configurations. Researchers used combinations of best practice and the most promising pioneering solutions to develop 10 hypothetical "model high-performance facilities" that approach or exceed energy neutrality. As a result of this analysis, researchers made key observations and conclusions:

- Conventional secondary treatment and nitrification facilities can be net-energy positive.
- BNR and ENR facilities can only achieve as high as 50-60% energy neutrality.
- Co-digestion of high-strength waste (HSW) in anaerobic digesters was a valuable approach to achieve energy neutrality.

Several recommendations emerged as a result of the analyses performed during this study. These recommendations are presented in two groupings. The first set of recommendations is a guide for water resource recovery facilities embarking on energy management programs or advancing their position on the road to energy neutrality. Additional recommendations inform the future direction of research under taken by WERF and other organizations to advance understanding and technology options for the wastewater industry. The recommendations for further research focus on:

- Enhance and optimize carbon management.
- Advance low energy alternatives to typical nitrification/denitrification processes for nitrogen control.
- Explore and expand the potential for heat recovery.
- Develop technologies to extract more energy from biosolids.

Energy Balance of Activated Sludge Plant for Secondary Treatment - Typical



Energy Balance of Activated Sludge Plant for Secondary Treatment – Best Practices