A NEW report — “Food Waste Codigestion at Wastewater Resource Recovery Facilities: Business Case Analysis” — represents the last logical link in a series of topics covered in the Water Environment and Reuse Foundation (now the Water Research Foundation (WRF)) program of research exploring the technology and economics of implementing codigestion. Other research in the series examined strategies to address operational and regulatory risks (Van Horne et al. 2017, Appleton et al. 2017).

These studies were motivated by the unrealized potential for codigestion in the wastewater sector. Though codigestion can provide financial benefits to WRRFs, as well as a broad range of environmental and community benefits, fewer than 1 in 10 of the 14,000 wastewater treatment plants use anaerobic digestion (AD) to process wastewater solids, and fewer than 1 in 10 of those digest food waste. The literature has identified various financial, operational, regulatory, stakeholder/political, and organizational risks and impediments to adoption of codigestion and energy generation projects, which are outside core wastewater treatment services.

The new report’s primary focus is on strategies WRRFs can develop to create value, and to manage the associated financial risks. These risks may include issues of inadequate, and/or uncertain, financial benefit streams (e.g., due to lack of reliability in quantity, quality and/or price of feedstock supply; or lack of reliability in quantity produced and/or sales price of WRRF end-products); and uncertainty about access to capital, and related challenges in getting approval of investment projects, financing, and rate increases. The report is concerned with other sets of impediments and risks (studied in prior reports in the WRF series) to the extent
that they affect the economics or access to capital.

Our initial hypothesis was that we could identify alternative business models for codigestion at wastewater treatment plants from which utilities could select to suit their context. However, we quickly concluded there is no straightforward menu of options. Rather each utility needs to tailor its business strategy to its mission, resources, and scale, as well as its external market and policy environments.

The report offers general principles and case study examples of how to create value and manage risks in a food waste codigestion program, plus a framework for utility self-assessment to analyze the opportunities and the business case for codigestion. Six major case studies, plus 25 thumbnail sketches, are reported, which together represent the full range of WRRFs based on WRRF characteristics (size, region), policy and market environments, and strategic choices in food waste feedstocks, energy uses, biosolids uses, contracting and financing options. The report also provides examples of WRRFs that decided against adopting codigestion, or that have suspended or cutback programs in place. To inform our analysis, structured interviews were conducted with more than 65 organizations, including wastewater utilities, and representatives from the solid waste, energy, technology, project development, and government sectors.

**WRRF CODIGESTION EXPERIENCES**

The report summarizes key takeaways from our study of over 30 WRRFs. Table 1 summarizes findings for the six major case studies in the report.

**Financial Drivers**: Most frequently mentioned by WRRFs were rising energy costs, and financial support programs to promote greenhouse gas mitigation, renewable energy, and food scrap diversion. Some also cited their opportunity to add investments to support codigestion as part of large facility upgrade investment projects, which allowed them to scale planned AD, energy, and/or biosolids management investments to accommodate codigestion.

For example, the City of Dubuque, Iowa, capitalized on an opportunity to include investment in AD and energy generation as part of a very large-scale investment project to upgrade the outdated and inefficient wastewater plant. Incorporating resource recovery and transforming the plant into a Water and Resource Recovery Center addressed the City’s sustainability goals.

**Operational Drivers**: These included underutilized AD or energy infrastructure, more stringent requirements for biosolids management, and the need to divert growing quantities of pretreatment program wastes to AD in order to preserve wastewater treat-

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>VVWRA</th>
<th>City of Stevens Point (WI) WTP</th>
<th>City of Dubuque (IA) WRRC</th>
<th>DTMA WEF</th>
<th>CMSA</th>
<th>LACSD JWPCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW Treatment (MGD) avg daily dry weather flow</td>
<td>11.3</td>
<td>2.8</td>
<td>7</td>
<td>4</td>
<td>7.5</td>
<td>280</td>
</tr>
<tr>
<td>Tipping fee rates: FOG ($/gal)</td>
<td>0.04</td>
<td>Dropped FOG for more valuable feedstocks</td>
<td>0.06</td>
<td>1.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food processing residuals ($/gal)</td>
<td>0.04</td>
<td>0.00606, from service area, 0.0398, from outside service area</td>
<td>0.03-0.06</td>
<td>0.0378</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Food scraps slurry ($/gal)</td>
<td>0.04</td>
<td>NA</td>
<td>NA</td>
<td>0.0378</td>
<td>0.0938</td>
<td></td>
</tr>
<tr>
<td>Total tipping fee revenues for food waste ($)</td>
<td>249,693</td>
<td>110,000/yr on average</td>
<td>189,644 (FY 2019)</td>
<td>FOG: 387,400 (2018)</td>
<td>150,000 (2017-2018)</td>
<td>1.5 million (FY2019-20)</td>
</tr>
<tr>
<td>Feedstock contracting</td>
<td>No contracts</td>
<td>Long-term agreement with brewery</td>
<td>No contracts</td>
<td>G2E; MOU for food scrap slurry with Divert</td>
<td>Longterm MOU for food scrap slurry with Marin Sanitary Services</td>
<td>Current 1-yr contracts for food scrap slurrys (multiple private haulers; county facility)</td>
</tr>
<tr>
<td>Onsite feedstock pretreatment equipment</td>
<td>No equipment</td>
<td>Bar screen, rock trap, grit sump pump, chopper pump</td>
<td>No equipment</td>
<td>Aerobic FOG conditioning, rock trap, grinder, chopper pump</td>
<td>Rock trap grinder, paddle finisher</td>
<td>Pending: grit and plastics removal</td>
</tr>
<tr>
<td>Food waste as share of total AD feedstock³</td>
<td>10% of volume, 20% of TSS</td>
<td>34.1% of volume, 39.7% of TVS</td>
<td>22% of volume, 44% of TSS</td>
<td>12% of volume, 33% of TVS</td>
<td>20% of volume</td>
<td>9% of volume, 30% of TSS (in 1 codigesting AD out of 24 total for demo project)</td>
</tr>
</tbody>
</table>
Table 1. Data from 6 major case studies (cont’d.)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>VVWRA¹</th>
<th>City of Stevens Point (WI) WTP</th>
<th>City of Dubuque (IA) WRRC</th>
<th>DTMA WTF⁸</th>
<th>CMSA³</th>
<th>LACSD JWPCP⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas production (% increase; Total scfd with codigestion)</td>
<td>120; 685,000 (2016)</td>
<td>100; 100,000</td>
<td>33-78; 300,000-400,000</td>
<td>78; 267,000</td>
<td>80; 280,000 (2018)</td>
<td>33 in codigesting AD, 1.4 overall; 7,300,000 (demo project)</td>
</tr>
<tr>
<td>Biogas uses (beyond boilers)¹²</td>
<td>1) CHP; 2) Microgrid/battery storage, RNG production (pending)</td>
<td>1)CHP; 2) Biosolids thermal dryer (pending)</td>
<td>1) CHP; 2) RNG to pipeline injection</td>
<td>1) Biosolids thermal dryer; 2) CHP engine; 3) Addtl. CHP (pending)</td>
<td>1) CHP; 2) New CHP for electricity (pending)</td>
<td>1) CHP; 2) CNG for fueling station sales (pending); More CHP or RNG pipeline injection (pending)</td>
</tr>
<tr>
<td>WRRF energy sales tariffs¹⁶</td>
<td>1) No energy sales; 2) Net metering sales (pending)</td>
<td>Wisconsin Public Service Renewable Energy Tariff: $0.10/kWh (peak) $0.05/kWh (offpeak)</td>
<td>5% of gross RNG and RIN sales revenue</td>
<td>No energy sales</td>
<td>Electricity sales to Marin Clean Energy at $0.105/kWh</td>
<td>Spot market sales to CA ISO Grid</td>
</tr>
<tr>
<td>P3 structure⁷</td>
<td>1) PPA and lease with Anaergia; 2) Negotiating a DBFOM with Anaergia for RNG pipeline injection</td>
<td>P3: Brewery &amp; WRRF share costs of dedicated pipeline &amp; HSOW receiving station</td>
<td>DBFOM with BioResources Development for RNG pipeline injection</td>
<td>Future performance-based contract for expanded codigestion under Pennsylvania’s GESA</td>
<td>PPA with Marin Clean Energy (10-year contract)</td>
<td>NA</td>
</tr>
<tr>
<td>Biosolids: Change with codigestion</td>
<td>No change</td>
<td>12% increase</td>
<td>Minimal change</td>
<td>15% increase</td>
<td>Minimal change</td>
<td>No detectable change (demo project)</td>
</tr>
<tr>
<td>Financing and Grants⁴</td>
<td>Private sector P3 funding, CA grants</td>
<td>Wisconsin Focus on Energy grants, Build America Bonds; 2) WI Clean Water Fund bonds</td>
<td>State Revolving Fund loans</td>
<td>1) Municipal bonds; 2) Municipal bonds, Pennsylvania Green Energy Grant</td>
<td>Utility Capital Investment Accounts</td>
<td>Internal funds, CA grants</td>
</tr>
</tbody>
</table>

Key: CHP: Combined heat and power; DBFOM: Design-build-finance-operate-maintain; FOG: Fats, oil, grease; GESA: Pennsylvania’s Guaranteed Energy Savings Act; HSOW: High strength organic waste; MOU: Memo of Understanding; NA: Not Applicable; PPA: Power purchase agreement; RNG: Renewable natural gas; SCFD: standard cu. ft./day

¹VVWRA: Victor Valley Water Reclamation Authority, Victorville, CA; ¹²DTMA: Derry Township Municipal Authority Waste Treatment Facility, Hershey, PA; ³CMSA: Central Marin Sanitation Agency, San Rafael, CA; ⁴LACSD: Los Angeles County (CA) Sanitation Districts Joint Water Pollution Control Plant; ⁵G2E: Grind to Energy; ⁶TSS: total suspended solids. TVS: total volatile solids; ¹⁷¹, 2) and 3) refer to separate codigestion projects; ¹⁷¹ and 2) refer to separate codigestion projects.

ment capacity and the economic development potential to attract new “wet” businesses to the area. For example, Stevens Point, Wisconsin, considered codigestion to be essential to process the dramatic increase in brewery pretreatment wastewaters that resulted from the escalating expansion of its local brewery.

**Environmental and Community Drivers:** Examples include: providing a service to FOG (fats, oils, grease), food processing and food scrap waste generators (particularly ones from their service area) that are facing more stringent regulatory requirements; supporting economic development; and contributing to community goals for sustainability, renewable energy, greenhouse gas (GHG) reduction, and food scrap diversion. The Los Angeles County Sanitation Districts (LACSD) is a joint solid waste-wastewater agency. Its codigestion initiative is motivated in part to serve the needs of its solid waste stakeholders, now required to comply with a statewide food scrap recycling mandate. LACSD created its own food scrap slurrying facility at its Puente Hills Material Recovery Facility, so that small to medium-sized hauling companies could have an affordable processing option that would allow them to remain competitive (see “Sanitation Districts Gears Up For Food Waste Codigestion” in this issue).

**Decision Criteria For Investments:** Many codigestion projects were required to meet return on investment (ROI) or payback period tests, though the thresholds for approval varied widely. For non-core mission projects, LACSD uses 5 to 10 years as a maximum payback target, whereas Stevens Point requires a robust ROI on a 20-year cash flow analysis. WRRFs also placed different requirements on these projects in non-core business lines, including maintaining or improving water quality, no detrimental impact on facility operations, and no impact on water rates.

**Project Scope And Costs:** Successful codigestion programs are typically implemented over time in a series of projects or phases. The scale of investment for the initial project varies tremendously across WRRFs, depending upon the facilities currently available, the type and quality of incoming feedstock supply, and the stage of commitment to codigestion. For example, the Victor Valley WRA (VVWRA) spent $10,000 to convert an existing tank to a FOG receiving station, whereas Central Marin Sanitation Agency in San Rafael, CA, spent $2 million on a new organisms receiving station, which includes a 300,000-gallon tank, mixing pumps, rock trap grinder, paddle finisher and odor control system.
Biogas and Biosolids Production: Biogas production increased substantially from the addition of codigestion substrates, with rates of increase depending upon share of high strength organic wastes (HSOW) in digester feedstocks, and share of total digesters involved in codigestion. Plant managers for four out of the six major case studies reported biosolids did not increase with codigestion.

CODIGESTION NO-GOES
Among WRRFs that evaluated codigestion, the primary reason offered for not going forward is the lack of sufficient economic returns. Contributing factors cited include uncertain or low feedstock supply and revenues, low energy prices (and, as a result, low energy savings), scale too small to attain economies of scale, and lack of incentive programs to provide financial support. Nonfinancial reasons offered for no-go decisions include NIMBY (not in my backyard) concerns and changes in political leadership, with resulting changes in priorities.

Plants have suspended codigestion due to changes in feedstock or energy markets that reduced revenues or savings, problems with feedstock quality or availability, and unanticipated requirements to invest in additional equipment. Plants have cutback codigestion due to the loss of a major supplier(s) (and no program to develop feedstock supplies). Others cite the loss of capacity to recycle biogas or biosolids, and the lack of capacity to make needed investments for additional capacity, at least in the short run. DTMA stopped accepting food scrap slurries after losing part of its capacity to manage biosolids when its thermal dryers to create Class A EQ biosolids management costs by supporting thermal dryers to create Class A EQ biosolids. Also cited were financial incentive programs providing grants or green payments.

Source separated food waste collected by Marin Sanitary Service is preprocessed on a sorting line and in a vertical grinder (1), then hauled to the Central Marin Sanitation Agency’s WRRF (2) where it is unloaded into a receiving tank (3). Anaerobic digesters at CMSA (4).

Cost Savings and Revenues: The sources of financial gain most frequently cited by WRRFs included: tip fee revenues (which can contribute revenue streams to support major AD upgrades, as well as receiving station investments), energy cost savings and/or revenue, savings in wastewater aeration costs by diverting liquid wastes from the headworks to the digester, and savings in biosolids management costs by supporting thermal dryers to create Class A EQ biosolids. Also cited were financial incentive programs providing grants or green payments.
mal dryer was taken out by a flood, but continues to accept FOG and food processing residuals. The dryer’s replacement is in the capital budget schedule for approximately 5 years in the future.

**SUCCESSFUL BUSINESS STRATEGIES — ESSENTIAL ELEMENTS**

The business challenge WRRFs face is to create a balanced system across all the elements required to recycle food waste, recover products and create value. These elements include coordinating plant AD capacity, feedstock supplies and feedstock receiving station capacity — with plant capacity to recycle the biogas and biosolids into valuable products. For each WRRF, the specifics of a successful business strategy for codigestion vary depending upon the policy and market environment in the region, as well as utility long-term strategic goals, organizational culture, and resources.

To create a successful codigestion program, a utility needs to have certain elements in place:

- **Codigestion champion** in the utility or municipal government.
- **Enough site space for vehicles to deliver feedstocks and for other equipment needs**
- **Business mindset to resource recovery**
- **Visionary utility board or municipal decision-makers who will support projects beyond the core wastewater mission that make economic sense to ratepayers**
- **Location with access to a sufficient supply of feedstock at a good price**

Key elements of a successful business strategy include the following:

- The business strategy ensures codigestion operations will not compromise plant compliance with its environmental permits, and the WRRF’s responsibilities for public health and environmental quality, which are central to its mission.
- The business strategy employs a life cycle perspective, taking into account revenues and costs from the time of initial investments through repair and replacement investments.
How To Resolve Codigestion Impediments And Risks

Q The lack or high uncertainty of economic returns has stymied codigestion project development. How does my utility respond to these concerns, which include access to capital?

A Explore all business options to generate cost savings and/or revenues, including tip fees, energy cost savings, and sale of energy and/or RNG and nutrients. Also explore possible grants, green payments, below-market Clean Water State Revolving Fund loans, the use of internal capital reserve funds and access to private funds through Public/Private Partnerships (P3).

Q What are options to address variable and uncertain quantity, quality and price (tip fees) of feedstock supplies?

A Conduct a market assessment of potential feedstock supplies, and implement a program for market development and supplier retention. Leverage regulations for more stringent requirements for FOG, liquid industrial wastes, and food scraps to attract more suppliers, and consider partnering with haulers or generators of food scraps in order to reduce contamination and ensure a reliable supply. Consider private market sources of slurries, or installing onsite depackaging and slurring capacity to create your own. Explore collaborations with solid waste agencies as a processor for collected organics and encourage them to enforce recycling mandates where they exist. Establish long-term contracts where possible. Finally, diversify food scrap sources to avoid reliance on a single anchor supplier.

Q What impact does accepting food scraps have on our biosolids management program?

A To manage the impact on quality and quantity of biosolids produced, optimize feedstock types and solids processing. Not all cases of codigestion result in additional biosolids. It will depend upon the relative share of high strength organic waste feedstock. With regard to quality, evaluate opportunities for producing new products from nutrients to address potential increases in nutrient loading.

Q Codigestion is a cultural shift for my wastewater agency, which tends to be risk-averse. What are approaches when introducing them to codigestion?

A For framing, develop a “Utility of the Future” perspective, shifting from a focus on disposing waste to managing critical resources—water, energy, and nutrients; focus on local benefits that will accrue, including jobs, greenhouse gas emissions mitigation, economic development, and community sustainability. Tap into available codigestion “best practice” resources. Conduct feasibility studies, and implement codigestion projects in stages, with pilot and demonstration projects providing an opportunity for stakeholders to provide feedback to improve processes and create buy-in. And involve employees in implementing codigestion and improving the process.

Note: Q&A is excerpted from Table 11-2, Chapter 11 in Full Report.

CONCLUSION

Codigestion at WRRFs can be successful where there is a fit with the organization’s culture, support from the utility decision-makers for projects outside of the core mission area, and market and policy opportunities to create economic value. It is important to recognize that codigestion does not fit in all circumstances. In some contexts, the business case analysis will indicate that the best option, under the current understanding of life cycle potential, is to not move forward at this time. It may also provide insights for a path toward a future successful codigestion program.

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LITERATURE CITED
