Water-Energy Nexus

Speakers:
• George Hawkins, Moonshot, LLC

• Alice G. Dasek, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy

Moderator:
• Travis Loop, Director of Communications Water Environment Federation
Producer and Host of *Words on Water* Podcast
Introduction

- Released in March 2018
- Explores how ESPC can help facilities achieve priorities for the wastewater market
- One of a series of guides for markets underserved by ESPC
Overview

▪ What is Energy Savings Performance Contracting (ESPC)?
▪ Why ESPC?
▪ A Look at the ESPC Market
▪ ESPC Wastewater Case Studies
▪ DOE Resources for the Wastewater Sector
What is ESPC?
ESPC is

A contracting and financing method that provides upfront financing for energy efficiency projects and repaid by the savings on utility bills resulting from the upgrades.
How Does it Work in Practice?
ESPC Relationships

1. Financing for Construction
2. Utility Incentives
3. Energy Services Agreement
4. Payments for Guarantee
5. Reduced Utility Payment
6. Payments from Savings

Financier, Bonds, or Muni Lease → ESCO

School

Utility
Financing Options

Agency/Owner

Performance Contract

ESCO guarantee:
Projected savings =>
Payment

Funding Arrangement

Financier
The Performance Guarantee

- Unique feature of ESPC

The ESCO:
- Assumes financial, operating, and performance risk
- Guarantees project savings
- Measures and verifies savings
- Provides reimbursement if guaranteed savings not met and/or fixes the problem at no additional cost
Why ESPC?
General ESPC Benefits

- No upfront costs needed
- ESCO accountable for project design, construction, and post-installation monitoring
- ESCO serves as single point of contact for project
- ESCO takes on project risks
- Guaranteed cost and energy savings
- Savings measured and verified as “real”
Opportunities for Wastewater Facilities

- Achieve Wastewater Sector Mission
- Upgrade Infrastructure
- Manage Energy Costs
Achieve Wastewater Sector Mission

Issue

- Increasingly stringent regulatory requirements
- Demand on facilities expected to grow 23% by 2032\(^1\)
- Need for reliable service for customers through outages

Opportunity

- ESPC project upgrades can help plants meet NPDES discharge permit requirements
- Streamlined operations help meet the demand for clean water at reasonable user rates
- Generating energy onsite can support operations resiliency

\(^1\)https://www.infrastructurereportcard.org/the-impact/explore-infographics/americas-infrastructure-grade/
Upgrade Infrastructure

Issue

- WRRFs built to meet supply, not efficiency
- Aging equipment costs more to operate & maintain
- Infrastructure rated a D+ and capital investment needs estimated at $271B\(^1\) ($2.4B over next 20 years in MN\(^2\))

Opportunity

- Comprehensive nature of ESPC projects allows upgrades that improve overall project operations
- Upgrades can ensure operational stability
- ESPC projects can provide upfront investment not readily available

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1. [https://www.infrastructurereportcard.org/cat-item/wastewater/](https://www.infrastructurereportcard.org/cat-item/wastewater/)
2. [https://www.infrastructurereportcard.org/state-item/minnesota/](https://www.infrastructurereportcard.org/state-item/minnesota/)
Manage Energy Costs

Issue
- 2000-2010 energy costs rose by ~80%\(^3\) and are estimated to continue rising through 2040\(^4\)
- Energy often second highest operating cost in WRRF
- WRRFs represent 30-40% of energy use in community

Opportunity
- Individual ESPC projects have demonstrated up to 50% energy savings
- ESPC project can reduce utility bills
- Equipment improvements can also reduce other operating & maintenance costs


A Look at the ESPC Market
A Perfect Storm for ESPC

- Tight budgets for energy efficiency retrofits
- Good energy savings track record
  - ESPC projects active in 2012 saved 34 million TWh and 224 million MMBtu or approximately 1% of total US commercial building energy consumption\(^6\)
  - A typical ESPC project in the MUSH market saves approximately 13% to 31% annually compared to its baseline consumption\(^7\)
- High market growth potential for ESPC
  - Anticipated 2017 revenues of $7.6 billion, representing an average annual growth of 13% over the period 2015-2017\(^8\)
  - Estimated ESPC project investment opportunity in MUSH market: \(~$51.8\text{-}$86.8 billion\(^9\)
The Potential for ESPC in WRRFs

<table>
<thead>
<tr>
<th>Market</th>
<th>2008 (n=29)</th>
<th>2011 (n=35)</th>
<th>2014 (n=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Govt.</td>
<td>15.4%</td>
<td>21.4%</td>
<td>20.7%</td>
</tr>
<tr>
<td>State/Local Govt.</td>
<td>23.0%</td>
<td>24.0%</td>
<td>25.4%</td>
</tr>
<tr>
<td>K-12 Schools</td>
<td>22.4%</td>
<td>19.4%</td>
<td>23.5%</td>
</tr>
<tr>
<td>Univ./College</td>
<td>16.2%</td>
<td>13.7%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Healthcare</td>
<td>6.3%</td>
<td>5.9%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Housing/Other</td>
<td>9.4%</td>
<td>7.5%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>7.3%</td>
<td>8.1%</td>
<td>7.9%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>


- State/local governments incur approximately 95% of the capital investments annually to maintain & improve the infrastructure
- ESPC can provide upfront project financing in the face of limited budgets
- Upgrades in WRRFs can achieve up to 50% energy savings

Note Regarding ESPC Legislation

- Most states have legislation enabling ESPC
- Individual states might have language addressing ESPC specifically for school districts
- Legislation may set requirements for procurement, allowable energy conservation measures, financing terms, structure of the guarantee, M&V, and budget streams
- Good practice to consult your General Counsel, the State Energy Office, and/or project facilitator
What’s Holding Back the ESPC Market

Frequent barriers to broad use of ESPC expressed by MUSH market:

- Complicated and time-consuming procurement process
- Hard-to-access data on existing projects
- Inadequate data to make business case for ESPC
- Insufficient knowledge about mechanism details
- Inexperience in using ESPC in certain market sectors

ESPC Case Studies for Wastewater Facilities
City of Riverbank, CA

- Small city – population 23,000
- Focus on infrastructure stability and product quality
- $3.9 million in energy improvements
  - Upgraded to fine-bubble aeration system
  - Variable Frequency Drives (VFDs)
  - Filters, valves, gauges, control panels
- $200,000 annual savings
Hutchinson Wastewater Facility, MN

- Small city – population 14,000
- Capacity 3.5 MGD/day
- Focus on infrastructure stability
- $375,000 in energy improvements
  - Variable Frequency Drives (VFDs)
  - Lighting
  - Reduced maintenance needs
- Post-project motors can run at 30-35% capacity
- $60,000 annual savings (almost twice the guarantee)
Back River Wastewater Treatment Plant
City of Baltimore, MD

- Service population 1.3 million
- Uses anaerobic digesters
- Goal to use all of methane gas
- $14 million in energy improvements
  - New Combined Heat & Power (CHP) Plant
  - Replaced boilers and chillers equipped to run on methane gas
  - Replaced lighting
  - Replaced electric motors
- Payback period of 15 years
- Methane supply projected to generate 2.4MW of electricity, providing 20% of plant’s needs; CHP plant can expand as needed

Photo source: Golden, Onion Dome Digesters by Kristian Bjornard is licensed under CC BY 2.0
DOE Resources for Wastewater Facilities
ESPC Accelerator Toolkit

https://betterbuildingssolutioncenter.energy.gov/energy-savings-performance-contracting-espc-toolkit

- The ESPC project process
  - Model contract documents, ESPC project database, financing decision tree, online guide to implementing ESPC, best practices for selecting energy service company

- The ESPC institutional infrastructure
  - Resources for developing ESPC project champions and for building support network for ESPC across jurisdiction, fact sheet on economic impact analysis tools, ESPC vs. Design-Bid-Build, guide for establishing ESPC technical assistance program

- Application of ESPC to new markets
  - Guide to ESPC in the wastewater sector
DOE Resources for Wastewater

- Better Plants
- Superior Energy Performance (SEP) Program
- ISO 50 001 Ready
- Industrial Assessment Centers (IACs)
- CHP Deployment Program
- CHP Technical Assistance Partnerships (CHP TAPs)
- CHP for Resiliency Accelerator
- Sustainable Wastewater Infrastructure of the Future (SWIFt) Accelerator
SWIFt Goals & Structure

**Goals**
- Document model plans for transitioning to a sustainable infrastructure that will help drive more solutions in the industry
- Develop assessment and decision tools for selecting best-practice approaches and tools on the pathway toward a sustainable infrastructure

**Structure**
- **Phase 1**: Energy Data Management
- **Phase 2**: Measure Planning & Implementation
- **Phase 3**: Project Financing
- **Phase 4**: Plan Drafting

https://betterbuildingssolutioncenter.energy.gov/accelerators/wastewater-infrastructure
- Published 2017
- Explains the energy data management process, provides step-by-step approach, and provides data tool comparison matrix

Assessments & Low- and No-Cost Measures

Low- and No-Cost Measures List

Installation
- Install timers on light switches and occupancy sensors in little-used areas and adjust for scheduled operations as needed.
- Install programmable thermostats and use night set-back/strip settings.
- Turn off unnecessary lighting and install occupancy sensors.
- Identify and use energy-efficient belts compatible with your facility’s equipment.
- Change aerator blower intake filters regularly to minimize air intake resistance. 1
- Use automatic controls when advisable to optimize equipment, process monitoring, and operations.

Assessment
- Review and assess ventilation requirements to optimize efficiency, reduce space conditioning during non-working hours, and manage space conditioning energy use during non-occupancy times.
- Assess the potential to remove organic prior to entering the secondary treatment systems. Assess the capability for high-strength organic discharges to feed directly to an aerated digestor.
- Review operational data to identify any pumps or blowers that are being throttled and assess them to determine if they can be adjusted to operate more efficiently.
- Assess air and water piping systems in need of insulation (exposed piping).
- Identify equipment speeds and rehouse blowers where needed.
- Contact your energy utility account manager to evaluate rate schedules and determine the most efficient rate for your facility.

Operation
- Test, calibrate, and maintain dissolved oxygen level sensors in aeration tanks. 2
- Shift to smaller HP pumps/blowers during night/low flow periods or seasonal low flow periods, if applicable. 3
- Reduce blower pressure to the minimum required through proper maintenance of aerator diffuser and distribution system to minimize head loss. Control the set point in the aeration blower control strategy. Also, identify, test, and repair aeration system air leak mainaks - impulse gauges, repair corrosion, underground maintenance, and lower aerator tank levels to reduce air header static pressure, if applicable. (May need sensing O2 level).
- Turn off equipment when not in use (e.g., turn off aerobic digestor blowers, periodically or operate intermittently).
- Adjust system operations when there is a change in wastewater load.
- Raise wet well levels to reduce static head in the pump system. Coordinate all control points (low-level alarm, pump start/stop, high-level alarm) to adjust the wet well level upward. Consider hydraulic profile of the facility when doing so.
- Eliminate leaks in insect and compressed air lines/valves.
- Operate select aeration tanks as needed while also establishing operating protocols to enable the plant to bring tanks back on line efficiently.
- Routinely clean UV lamp sleeves to enhance transfer efficiency and decrease the number of UV lamps where possible while still meeting disinfection needs.
- Idle aeration basins/lines, if not needed (periodic maintenance may still be required).
- Reschedule plant operations or reduce load to avoid on-peak hours (e.g., operate de-watering equipment during off-peak, load digestors during off-peak, repair equipment, and shift recycling of supernatant to off-peak).

1 Use static pressure to check if filters need replacement.
2 Replacing existing tanks. Otherwise, backwash can be much shorter.
3 Must have more than one/periodically (significantly frequent) nightly low-flow periods.

Photo courtesy of Dennis Clough, Energy Systems Group
Measure Planning

23 measures across 4 categories

Technologies
- Blower Technologies + Optimization
- Ammonia-based Aeration Control (ABAC)
- Blower Optimization (w/ Technologies)
- Chemically-Enhanced Primary Treatment (CEPT)
- Dissolved Oxygen (DO) Control (w/ Technologies)
- Modifying System Operations Seasonally
- Pumping System Optimization (w/ Technologies)
- Pure Oxygen (Pure Ox) Systems
- Solar Photovoltaic (PV)
- Ultraviolet (UV) Disinfection Systems
- Emerging Diffuser Technologies
- Membrane Bioreactors (MBR)
- Pumping System Technologies + Optimization
- Dissolved Oxygen (DO) Control
- Emerging Diffuser Technologies
- Membrane Bioreactors (MBR)
- Pumping System Technologies + Optimization
- Pure Oxygen (Pure Ox) Systems
- Solar Photovoltaic (PV)
- Ultraviolet (UV) Disinfection Systems

Process Improvements
- Blower Optimization (w/ Technologies)
- Chemically-Enhanced Primary Treatment (CEPT)
- Dissolved Oxygen (DO) Control (w/ Technologies)
- Modifying System Operations Seasonally
- Pumping System Optimization (w/ Technologies)
- Energy Assessment
- Energy Conservation Programs
- Energy Management Systems
- Infiltration/Inflow (I/I) Studies
- Rate Structure Management
- Real-time Monitoring & Control
- Anaerobic Digestion
- Biosolids Energy Recovery
- Combined Heat & Power (CHP)
- Heat Recovery
- Inline Hydropower
- Onsite Water Reuse

Management Approaches

Resource Recovery

U.S. DEPARTMENT OF ENERGY
### Measure Planning Workbooks

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Preparation</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the potential environmental impact?</td>
<td>Score notes</td>
<td>Score notes</td>
</tr>
<tr>
<td>A reduction in monthly average concentration for one permitted parameter (e.g., BOD)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>A reduction in monthly average concentration for two permitted parameters (e.g., BOD, TSS)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Blower technology optimization with more operational benefits equals higher score, benefit depends on variability in influent water quality and existing control strategies at the treatment plant</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>What is the turn-down capacity for the blower system? (Excluding jackknife blowers)?</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Overall blower system turn-down 1.1 to 2.1 (60% to 80%)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Overall blower system turn-down 2.1 to 4.1 (35% to 50%)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Overall blower system turn-down 4.1 to 8.1 (13.9% to 25%)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Higher turn-down capacity equals higher score (e.g., 4.1 turn-down is a reduction from 100% to 25%)</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

### Ongoing Operations

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Scoring notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What level of effort is needed to operate and maintain blower technologies and their control systems?</td>
<td>Score notes</td>
</tr>
<tr>
<td>Requires operator to make frequent manual adjustments; high repair costs; professional maintenance needed; complex system requiring expert contractor support</td>
<td>1</td>
</tr>
<tr>
<td>Requires operator to make manual adjustments occasionally; several regular maintenance items to maintain operation (e.g., bearings, seals, electronic components)</td>
<td>2</td>
</tr>
<tr>
<td>Simplified automated operation; minimal maintenance requirements that can be performed by plant personnel; mean time between overhauls typically 6 to 10 years</td>
<td>3</td>
</tr>
</tbody>
</table>

### Potential Benefits

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Scoring notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What facility-wide energy savings are expected?</td>
<td>Score notes</td>
</tr>
<tr>
<td>&lt;10%</td>
<td>1</td>
</tr>
<tr>
<td>10% - 20%</td>
<td>2</td>
</tr>
<tr>
<td>20% - 30%</td>
<td>3</td>
</tr>
<tr>
<td>&gt;30%</td>
<td>4</td>
</tr>
<tr>
<td>What will be the payback period?</td>
<td>Score notes</td>
</tr>
<tr>
<td>&gt;10 years</td>
<td>1</td>
</tr>
<tr>
<td>7 - 10 years</td>
<td>2</td>
</tr>
<tr>
<td>3 - 7 years</td>
<td>3</td>
</tr>
<tr>
<td>&lt;3 years</td>
<td>4</td>
</tr>
</tbody>
</table>

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## Project Financing Comparison Matrix

### SWIFT: Project Financing Comparison Matrix

<table>
<thead>
<tr>
<th>Financing Source</th>
<th>Funding Details</th>
<th>Eligible Activities</th>
<th>Application Requirements</th>
<th>DED support available?</th>
<th>Contact with other funding sources?</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. EDA Water Infrastructure Finance and Innovation Act (WIFIA) Program</td>
<td>Loan Term: 10 years; interest rate: 2.5% for large communities and 3.5% for small communities (as of publication).</td>
<td>Development phase and O&amp;M; Construction; O&amp;M; Environmental, community and race relations activities; Acquisition of real property or interests in real property; Environmental remediation; and acquisition of equipment.</td>
<td>If innovative projects have not been funded, please contact WIFIA for further information.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>U.S. DOD Community Development Block Grant (CDBG) Program</td>
<td>Grant Size: up to 10% of eligible project costs</td>
<td>Administration must one of the national priorities for the program. (1) Beneficiaries and eligible community participation in the project. (2) Project size. (3) Type of community and area of opportunity.</td>
<td>Growth and Development of Urban and Rural Areas Community Development and Infrastructure.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>USDA Rural Development Energy &amp; Water Infrastructure Loan &amp; Grant Program</td>
<td>Grant Size: up to 75% or 85% of eligible project costs</td>
<td>Energy activities include, but are not limited to, acquisition, construction or rehabilitation of drinking water systems, treatment and disposal of wastewater systems, energy waste reduction measures, and increased energy efficiency projects.</td>
<td>Financial assistance for a public purpose project which may be financially attractive.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clean Water State Revolving Fund (CWSRF)</td>
<td>Loan Term: 30 years or the useful life of the project, whichever is longer</td>
<td>Municipalities, tribes, or intergovernmental, interstate, interterritorial, and state-agency, non-profit organizations and National Disaster Programs</td>
<td>The project must be on the State's priority list or be eligible for assistance under federal, state, and other funding sources.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Notes:**
- DED: Direct Energy Efficiency
- SWIFT: Statewide Information Technology for Water Infrastructure
- CWSRF: Clean Water State Revolving Fund
- WIFIA: Water Infrastructure Finance and Innovation Act
- CDBG: Community Development Block Grant
- USDA: United States Department of Agriculture
- USDA Rural Development: United States Department of Agriculture, Rural Development
- CWSRF: Clean Water State Revolving Fund
- CWSRF: Clean Water State Revolving Fund
- Project Financing Comparison Matrix

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**Additional Information:**
- Project Financing Comparison Matrix
- Funding Details
- Eligible Activities
- Application Requirements
- DED support available?
- Contact with other funding sources?
Other Project Financing Resources

- **DOC's Better Buildings Financing Navigator**
  - [https://betterbuildingsinitiative.energy.gov/financing-navigator](https://betterbuildingsinitiative.energy.gov/financing-navigator)
  - Online tool helps public and private sector organizations identify the most appropriate financing solutions for their energy efficiency and renewable energy projects.

- **EPA's Water Finance Clearinghouse**
  - [https://www.epa.gov/watertreatmentcenter/water-finance-clearinghouse](https://www.epa.gov/watertreatmentcenter/water-finance-clearinghouse)
  - Online portal designed to help communities locate potential funding sources. The portal consists of a searchable database of funding sources from federal, state, utility, nonprofit, and other public and private organizations. The portal enables users to apply several filter categories and search criteria to find the most relevant opportunities.

- **Database of State Incentives for Renewables & Efficiency (DSIRE)**
  - [http://www.dsireusa.org/](http://www.dsireusa.org/)
  - A searchable database of information on incentives and policies that support renewable energy and energy efficiency in the United States. Wastewater facilities can use this tool to identify financial incentives such as tax credits, rebates, bonds, loan guarantees, loans, and grants.
Thank You!

Questions?

For additional information, contact

Alice Dasek
alice.dasek@ee.doe.gov