This presentation premiered at WaterSmart Innovations

watersmartinnovations.com

Harnessing the Energy Embedded in Water

Image: http://ian.umces.edu

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WESTERN RESOURCE ADVOCATES

Water Smart Innovations, 2014

The Embedded Energy In Water

- Energy inputs: pumping, heating and treating
- 13% of total energy use in the U.S.[1]
- 30 – 60% of U.S. municipal energy costs
- Convert those energy inputs into energy outputs?

1. Sanders, K. T., Weber, M.E. 2012. Evaluating the energy consumed for water use in the United States. Environ. Res. Lett. 7 034034

The Water-Energy Nexus:
Energy Opportunities in the Water Sector

1. Energy forms and “locations”
2. Energy Generation & Energy Efficiency
   a) Conveyance and Distribution
   b) Water Use
   c) Wastewater Treatment
3. Net Zero Energy Case studies
4. Big Picture Ideas

Harnessing the Embedded Energy In Water

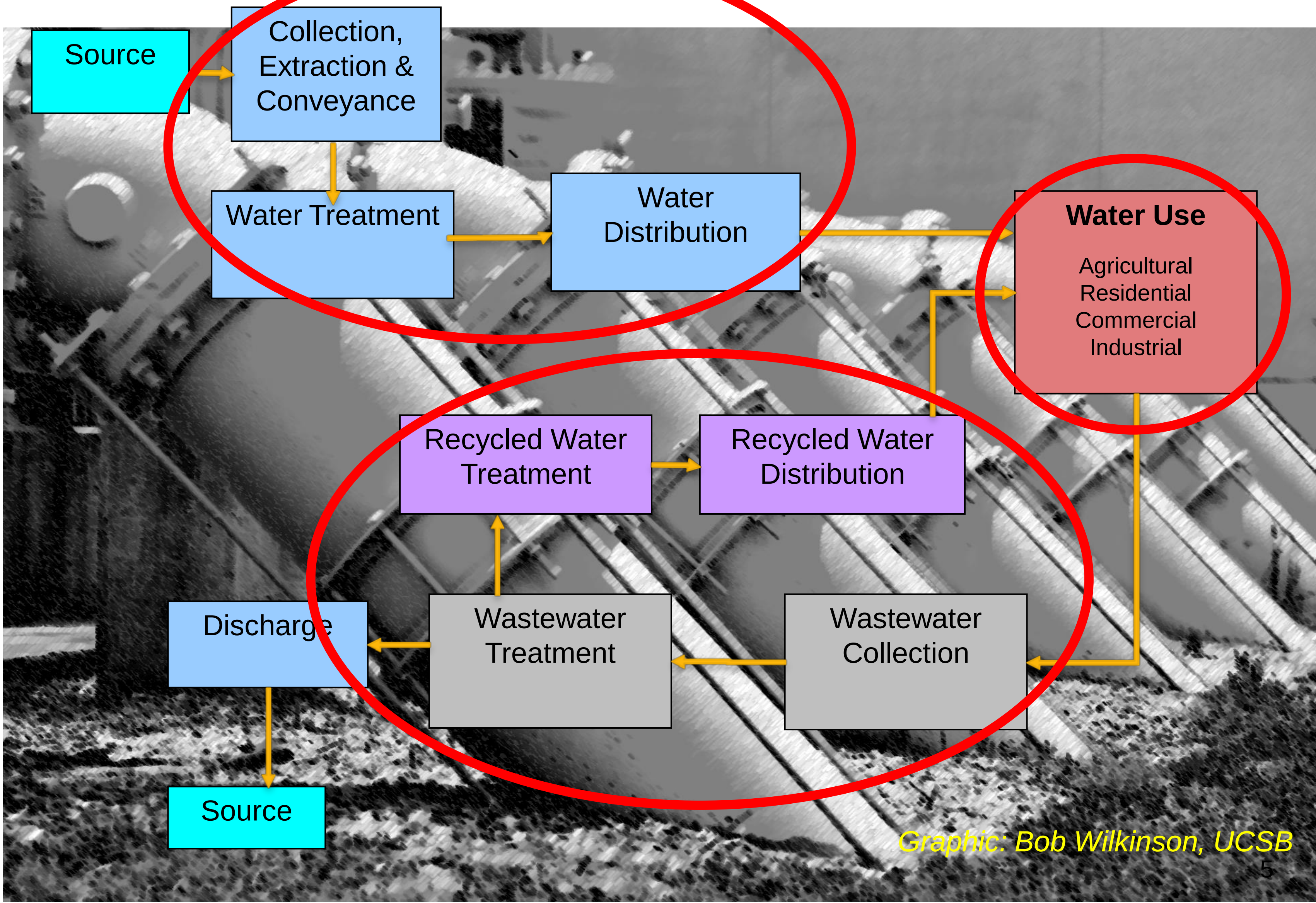
Forms of Energy:

- **Mechanical Energy** (hydraulic energy) - kinetic and potential energy, also pressure and friction
- **Thermal Energy** – heat differentials
- **Chemical Energy** – Energy stored within the bonds between molecules (here: organic chemicals)

New paradigm of thinking:
It's not just water resources management.

Water carries with it valuable energy and nutrients that can be harnessed.

Embedded Energy in the Water Supply Cycle



Water Conveyance & Distribution

Hydraulic Energy:

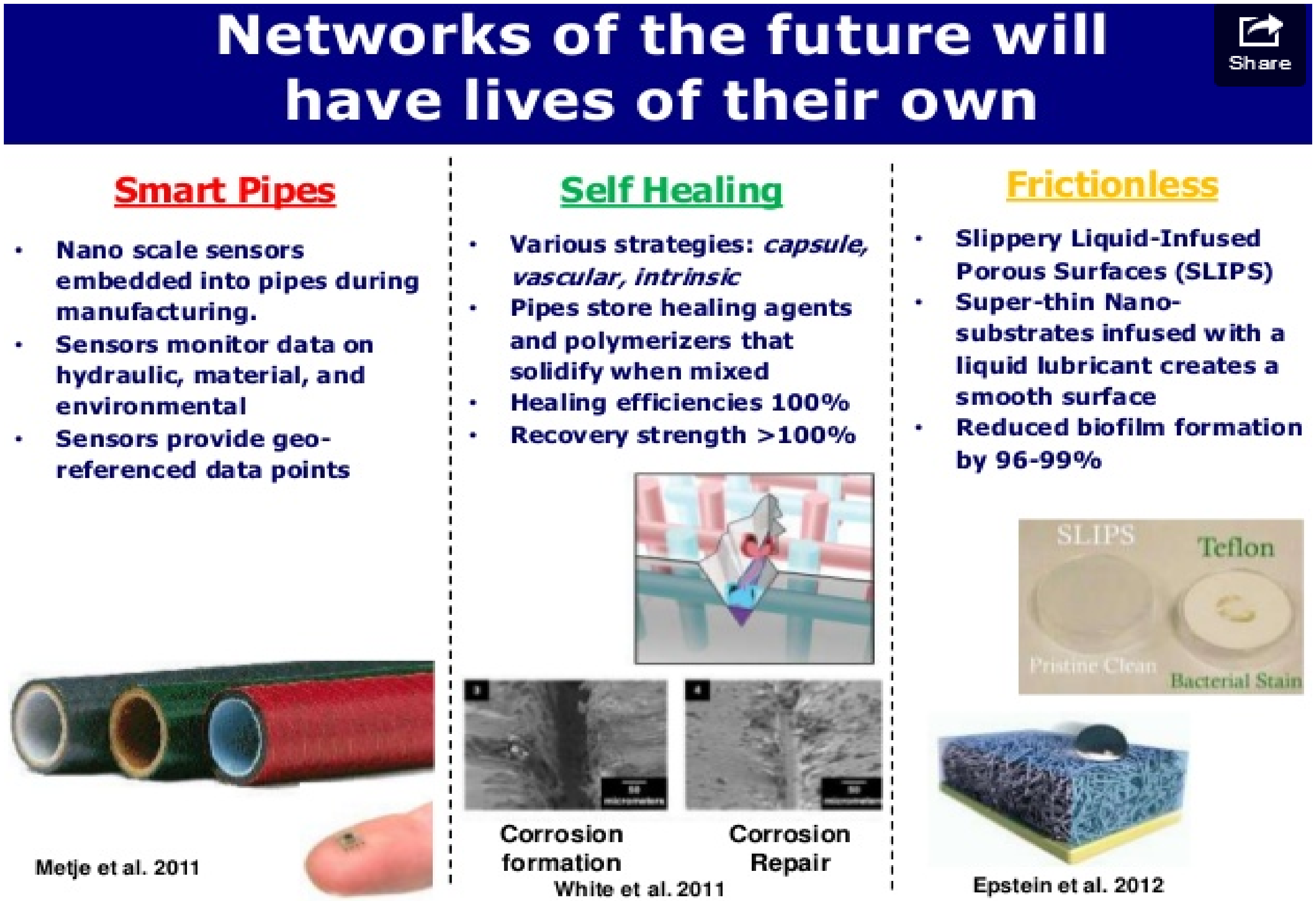
- Install low head hydro inside conduits (pipes, ditches)
- Replace Pressure reducing valves (PRVs) with hydropower turbines
  - Logan, Utah
  - Las Vegas, NV

Opportunities:

- FERC small hydro exemptions
- American Society of Civil Engineers: more than $1 trillion in drinking water systems repairs; $300 billion in WWT systems needed. **Can we make those investments pay off?**

Francis turbines provide energy recovery for the City of Las Vegas.

Water Conveyance & Distribution



by Dr. Kala Vairavamoorthy

Water Use

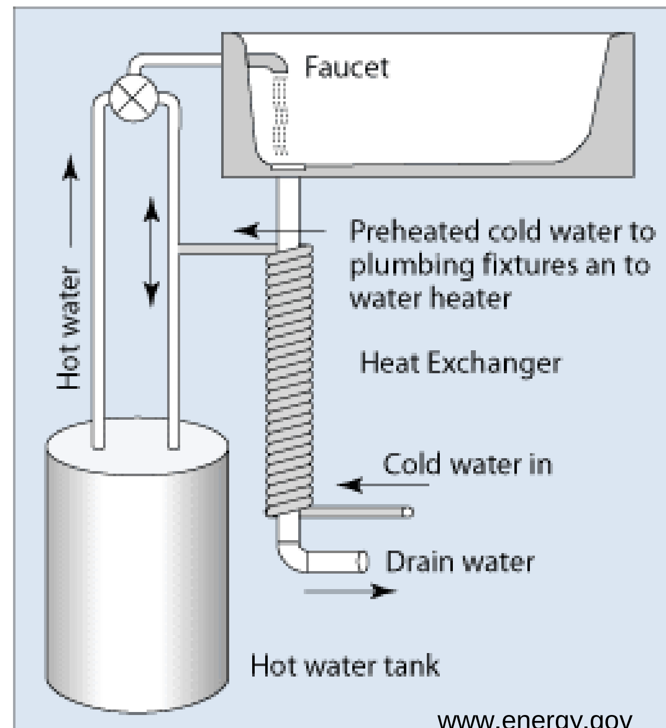
- Heating water is the MOST energy intensive stage of the water use cycle
  - Desalination ~5,000 kWh/AF
  - Heating water ~ at least **50,000** kWh/AF
- Heating water typically accounts for 20% of home energy use

Norfolk County Plumbing.com

Water Use

- Drain Water Heat Recovery
  - Recovers heat from the hot water in showers/bathtubs, sinks, dishwashers, and clothes washers

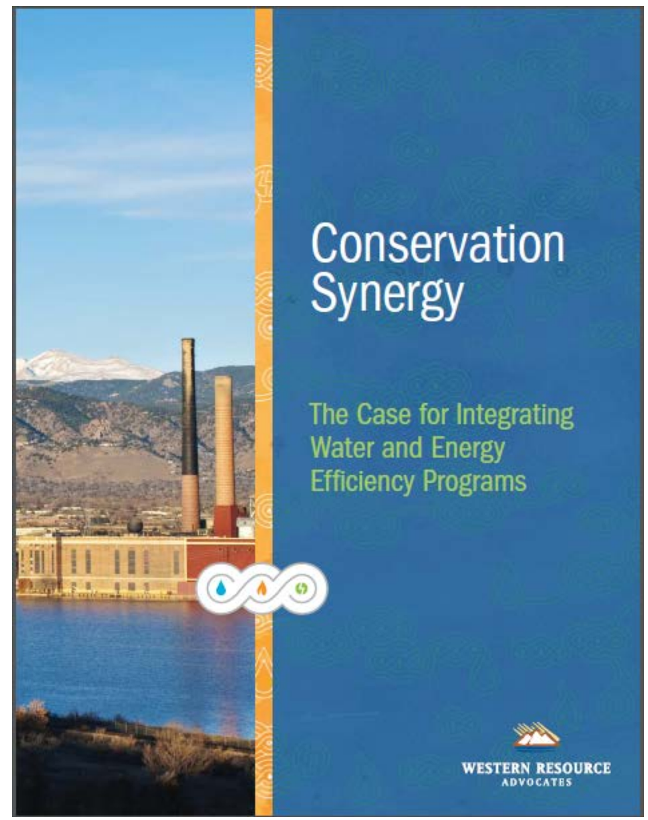
- And we can also harness some of this heat energy further down the line….



Water Use

And, we can exploit this embedded energy though “Conservation Synergy”

Integrating water efficiency with energy efficiency initiatives through utility collaboration or 3rd parties programs



Wastewater Treatment -Resource Water!

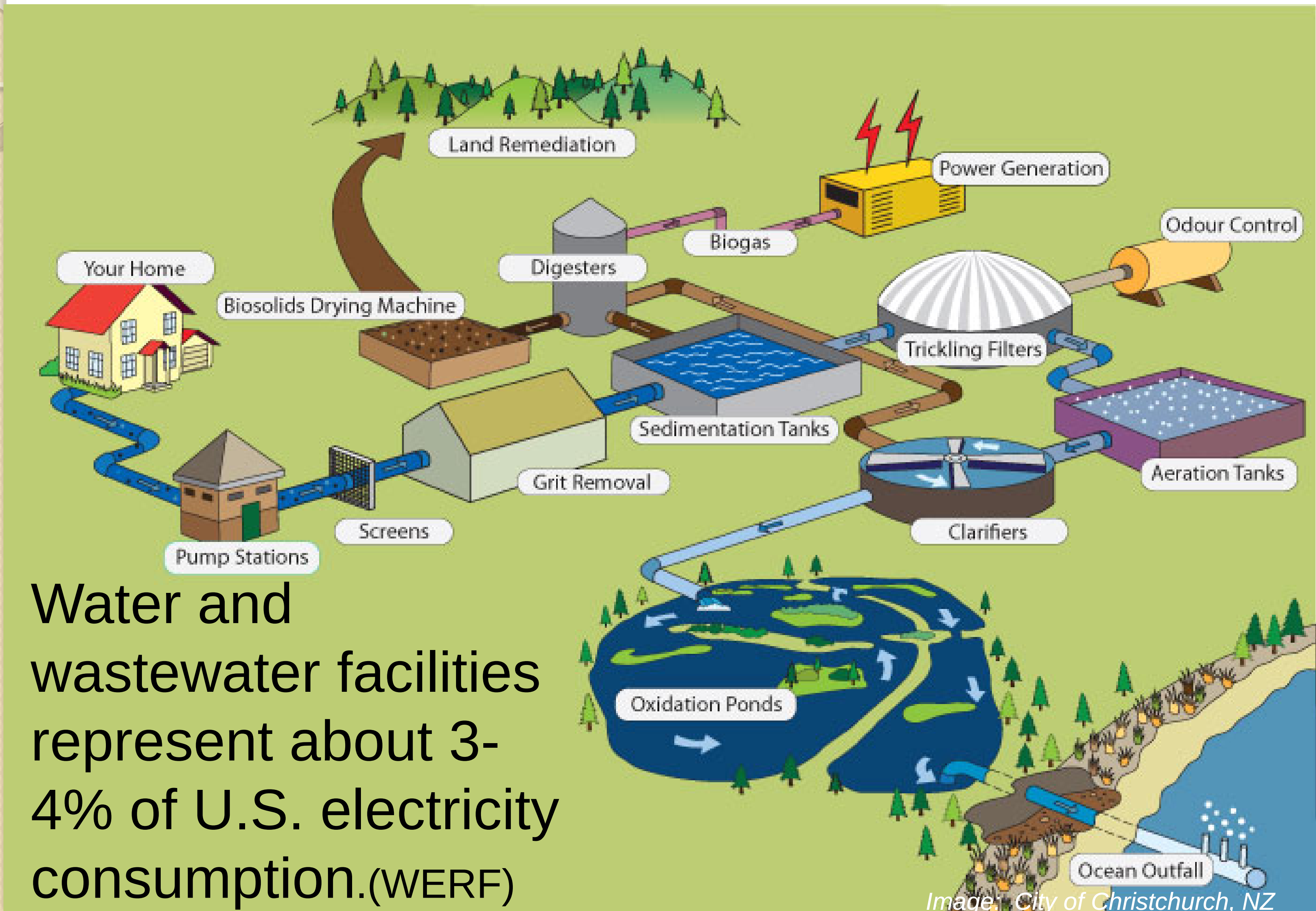


Image: City of Christchurch, NZ

Water and wastewater facilities represent about 3-4% of U.S. electricity consumption.(WERF)

Wastewater Chemical Energy:
The typical energy content of wastewater is 21 GJ/MG (range 11-46 GJ/MG).

Energy Demand for Wastewater Treatment, by Plant Size, for On-Site Metered Electric Energy and Source Energy

Plant Capacity	Plants Operating at 80% Influent Capacity	
Average Daily Flow	Primary (Source) Energy	Secondary (Site) Electrical Energy
1 MGD	19.6 GJ/MG	1,629 kWh/MG
5 MGD	15.2 GJ/MG	1,264 kWh/MG
10 MGD	13.3 GJ/MG	1,107 kWh/MG
20 MGD	11.4 GJ/MG	950 kWh/MG
50 MGD	8.9 GJ/MG	742 kWh/MG
100 MGD	7.0 GJ/MG	585 kWh/MG

U.S. EPA Energy Star®; WERF, 2011.

1,100 kWh = ~4 GJ but does not account for losses

This is 1.3x more energy than avg. primary source energy, and 4.3x higher than avg. electrical demand.

Net-Zero Energy WWTPs

Add in hydraulic and thermal heat capture and in the *largest* plants you will find that **wastewater has 10x the amount of energy embedded in water as is need on site. (WERF)**

- It's technically achievable by smaller ones too

Thinking ahead – As population grows, how will local WWT grow? What opportunities exist?

Case Study - Gloversville-Johnstown Joint WWT Facility, NY

- 25,000 residents
- 14 million gallons treated daily

(~63 million litres daily)

Photo: O'Shaughnessy & Bassette

Case Study - Gloversville-Johnstown Joint WWT Facility, NY

Figure 1: Electrical Consumption and Production, 1994-2011

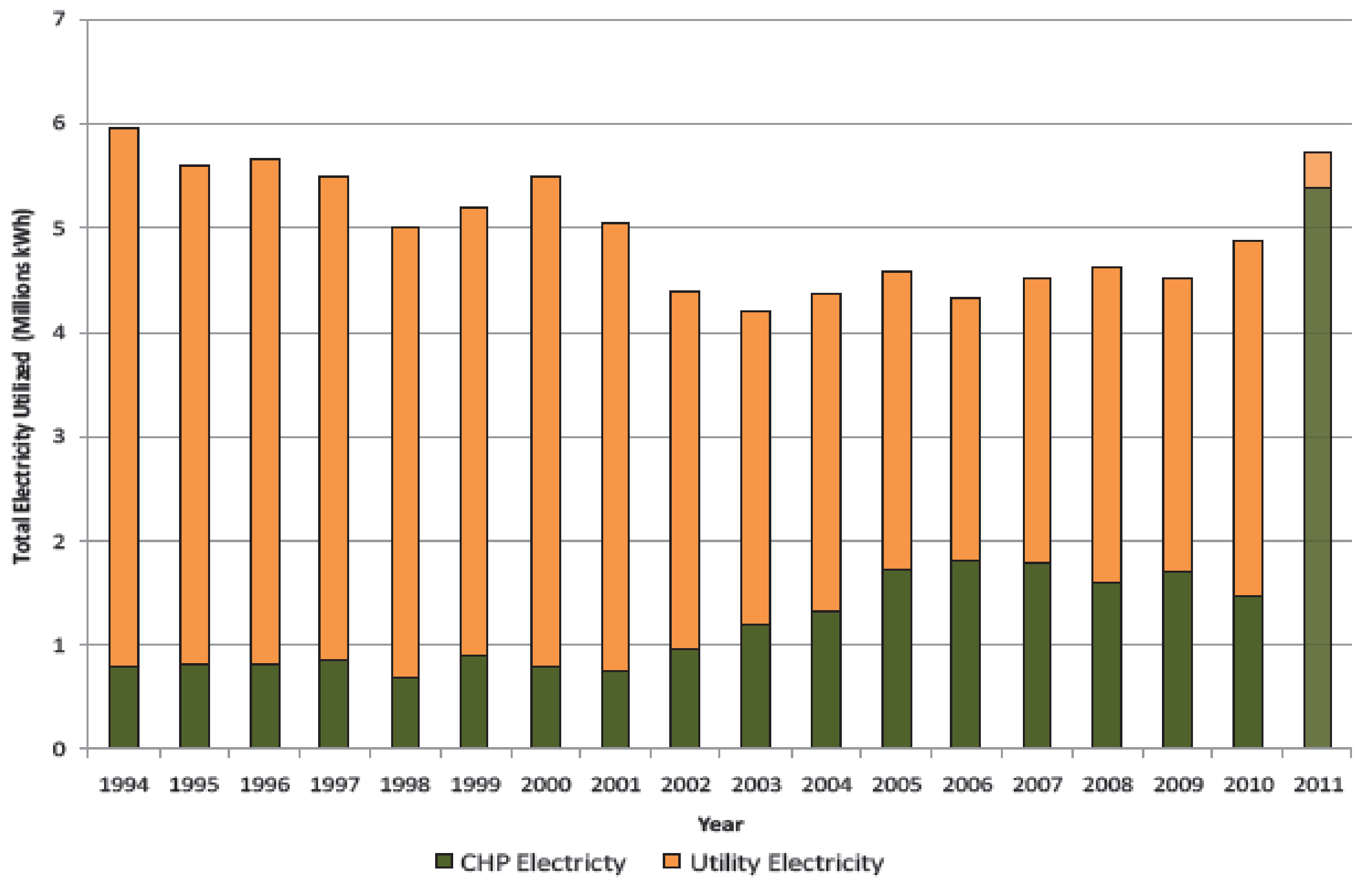


Figure from *Gloversville-Johnstown Joint Wastewater Treatment Facility Co-digestion Leads to a Sustainable Future*, Ostapczuk, et al., 2011

Case Study - Gloversville-Johnstown Joint WWT Facility, NY

Currently Approaching Net Zero:

- Efficiency: operational and capital improvements, aeration efficiency
- Generation: increased and optimized biogas production and capture
- 91% of electricity demands are met
- Greenhouse gas emissions reduction of 3,550 tons of carbon dioxide per year.
- Currently, the facility is unable to sell their excess electrical energy back to the grid.

Case Study-East Bay Municipal Utility District, CA

- 650,000 customers
- 63 million gallons treated daily

(~286 million litres daily)

Case Study-East Bay Municipal Utility District, CA

Currently a Net Energy Producer: 1st in US

- Efficiency: Use 82% less energy than other, similar facilities in California
- Generation from Hydropower, Biogas & Solar power
- $3 million saved each year
- Energy purchases from the grid are still necessary due to temporal differences in demand and production levels.

Case Study-East Bay Municipal Utility District, CA

- Biogas also produced from anaerobic digestion of food scraps
- Food scraps produce 3x as much methane as municipal wastewater solids
- Food waste is digested separately from other wastes
- Left over material can be composted and used as fertilizer

Anaerobic Digestion in WWT:

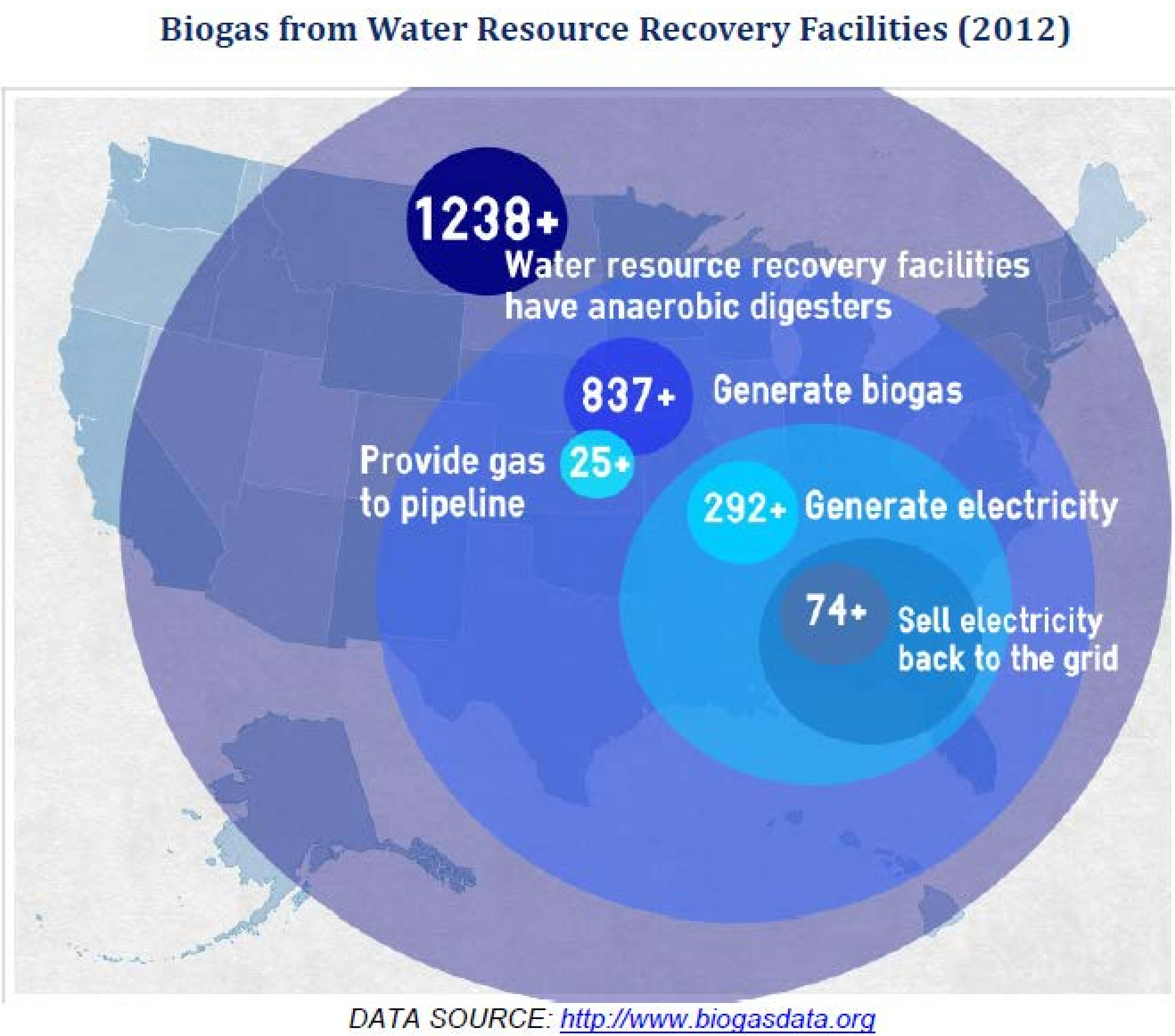


Image: Water Energy Foundation (2013)

Opportunities

- ~ 900 WWT “could” generate electricity from their biogas
- Many facilities are older and due for upgrades
- Rising cost of energy makes net-zero more attractive and financially sound
- Water Environment Research Foundation documenting the process of converting 23 WWT facilities to net zero energy facilities

Challenges

- Net-metering: policies state to state vary (in the west it’s largely allowed) but it may not always be easy.
- Payback times are longer which can be a barrier, often utilities are prefer short payback periods (e.g. 2 years)
- Capital and financing are not well known, understood, and/or available
- Facility size – technically, smaller utilities can do it, but they tend to lack capital, expertise and staff to pull it together

Big Picture Ideas

New paradigm of thinking:

It's not <u>just</u> water resources management.

- Small hydro & Smart pipes
- Thermal heat capture in home and throughout system
- Chemical, thermal and hydro energy capture at WWT
- Municipal waste capture (food, FOG)

As water systems age and population grows, think about the system as a whole and how can we do more with these embedded resources.

Thank you!

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