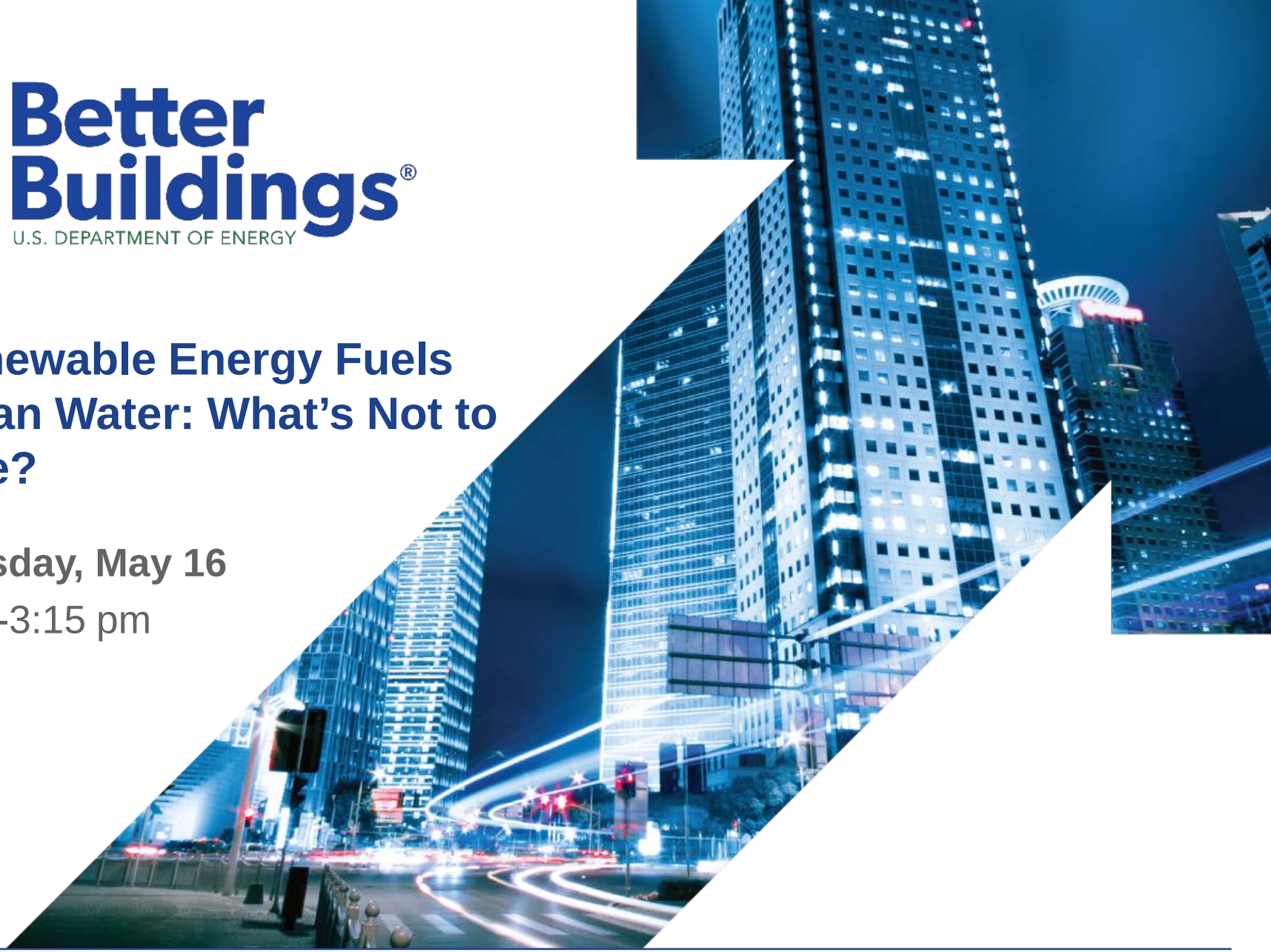
Better Buildings®
U.S. DEPARTMENT OF ENERGY

Renewable Energy Fuels Clean Water: What's Not to Like?

Tuesday, May 16

2:00-3:15 pm



U.S. DEPARTMENT OF ENERGY

Panelists

- Andy Terrey, City of Phoenix, Water Services Department
- Bruce Bartel, NEW Water (Green Bay Metropolitan Sewerage District)
- Jim Newton, Kent County Department of Public Works
- Bruce Lung, U.S. Department of Energy (Moderator)

Andy Terrey

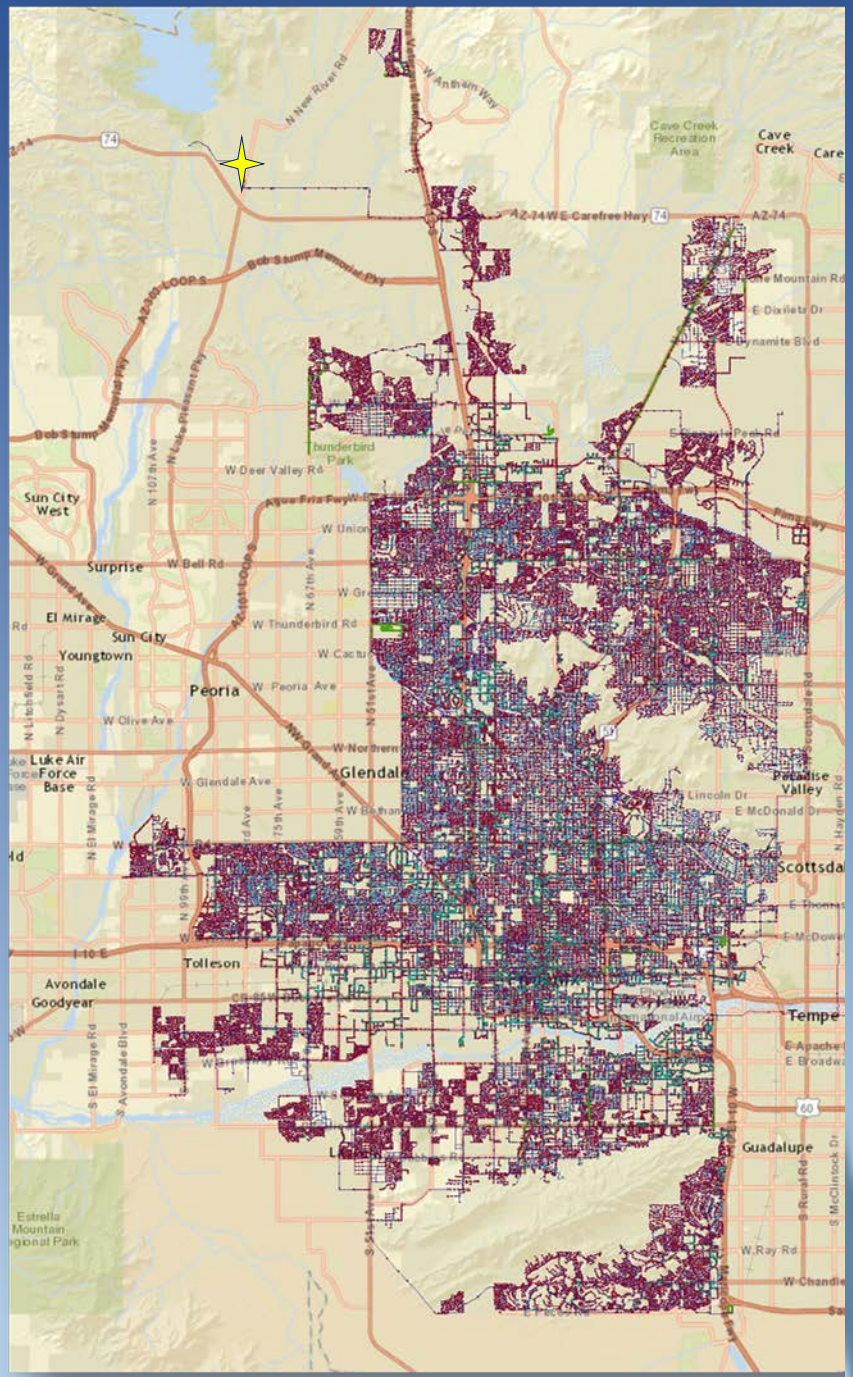
City of Phoenix, Water Services Department

U.S. DEPARTMENT OF ENERGY

City of Phoenix
Lake Pleasant Solar Generation Facility

2017 Better Buildings Summit
Washington, DC
May 15-17, 2017

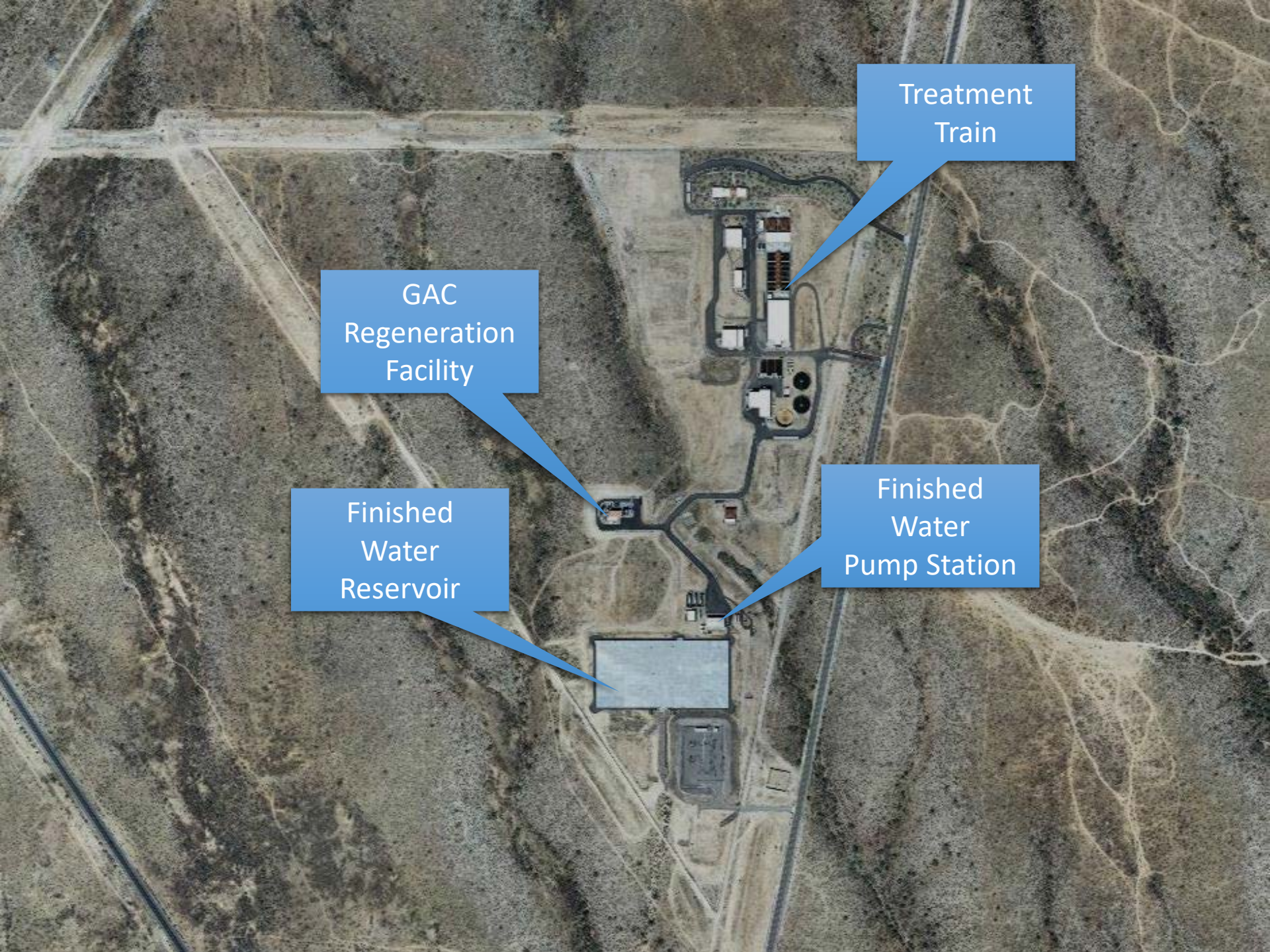
Andy Terrey
City of Phoenix
Water Services Department

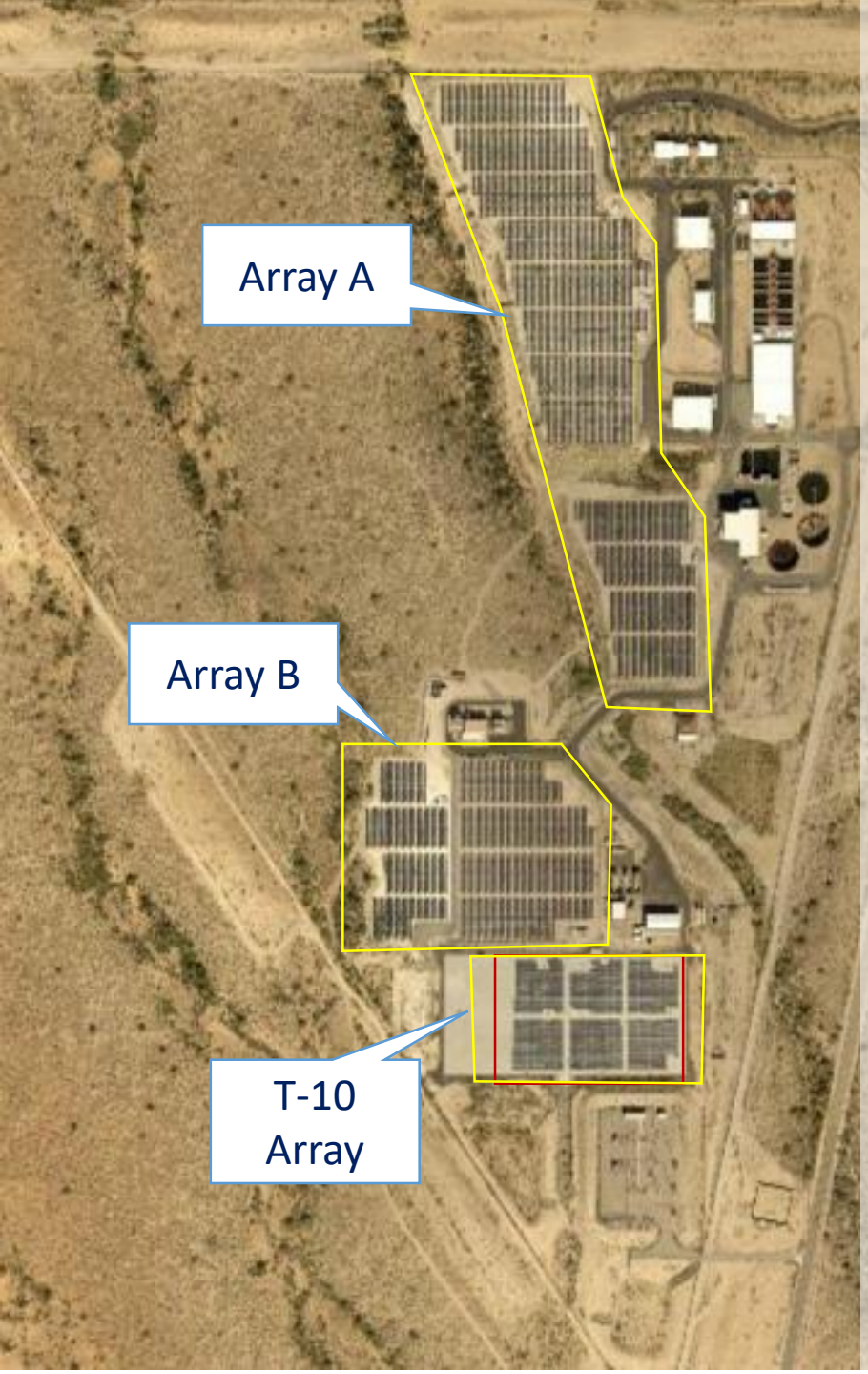


Fast Facts

- 1.5 Million Water Customers
- 8 Water Treatment Plants
- 7,000 Miles of Water Lines
- 74 Pressure Zones
- 2.5 Million Wastewater Customers
- 3 Wastewater Treatment Facilities
- 5,000 Miles of Sewer Lines
- Energy
  - 254M kWh per Year
  - $22M Energy Budget

Raw Water
Pump Station
Water
Treatment Plant


Treatment Train
GAC Regeneration Facility
Finished Water Reservoir
Finished Water Pump Station



Solar Generation Facility

- 30 Acres
- 22,936 Solar Panels
- Power Generation
  - Tracking 6,500 kWp
  - Roof System 1,000 kWp
  - Total 7,500 kWp
- ~ 15M kWh per Year
- CO2 Offset of 9,000 Tons per Year
- $4.2M in Cost Savings over 20-Year Life of System

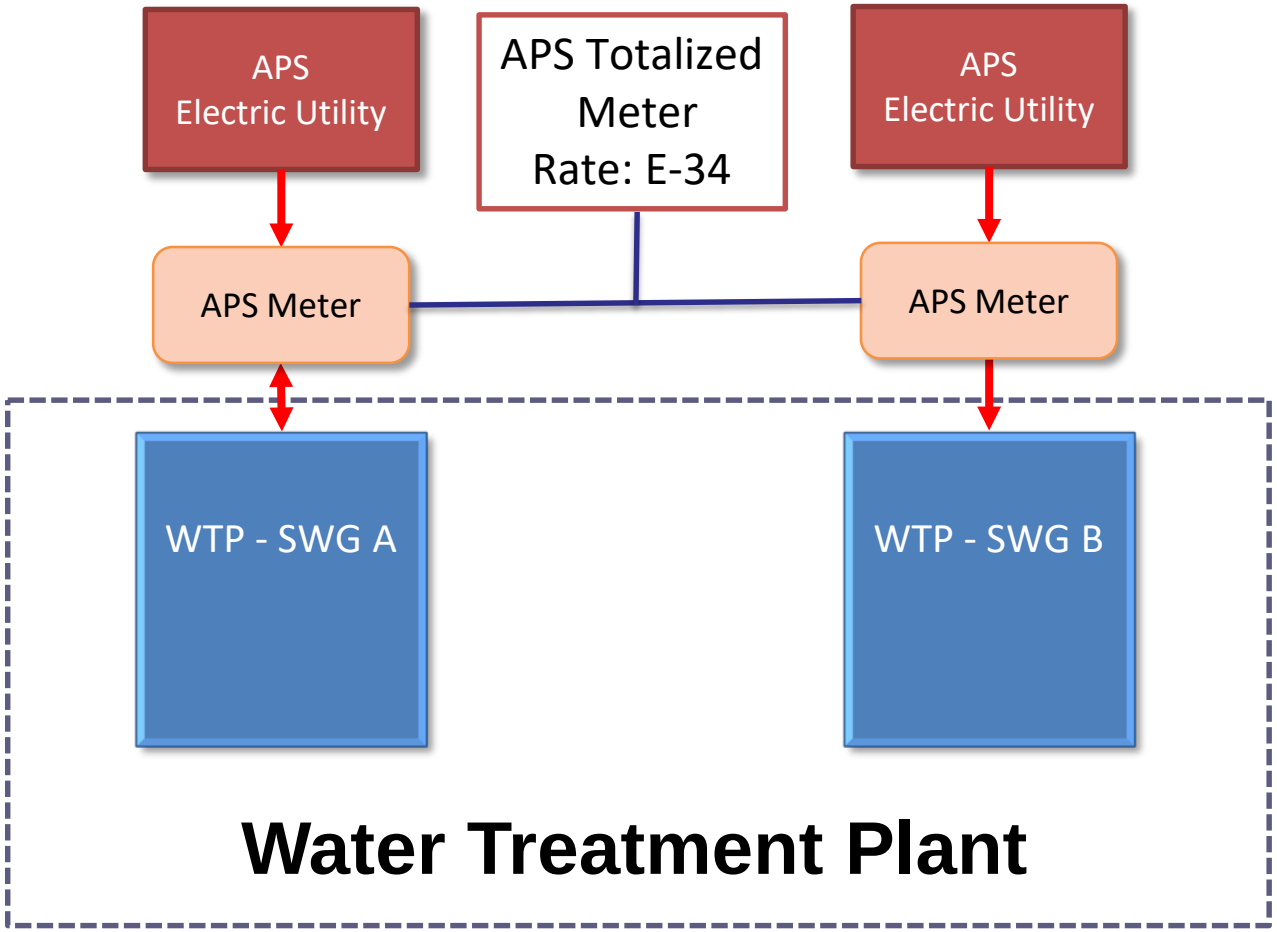
United Rentals
1-800-UR RENTS
PREMIER

SUNPOWER

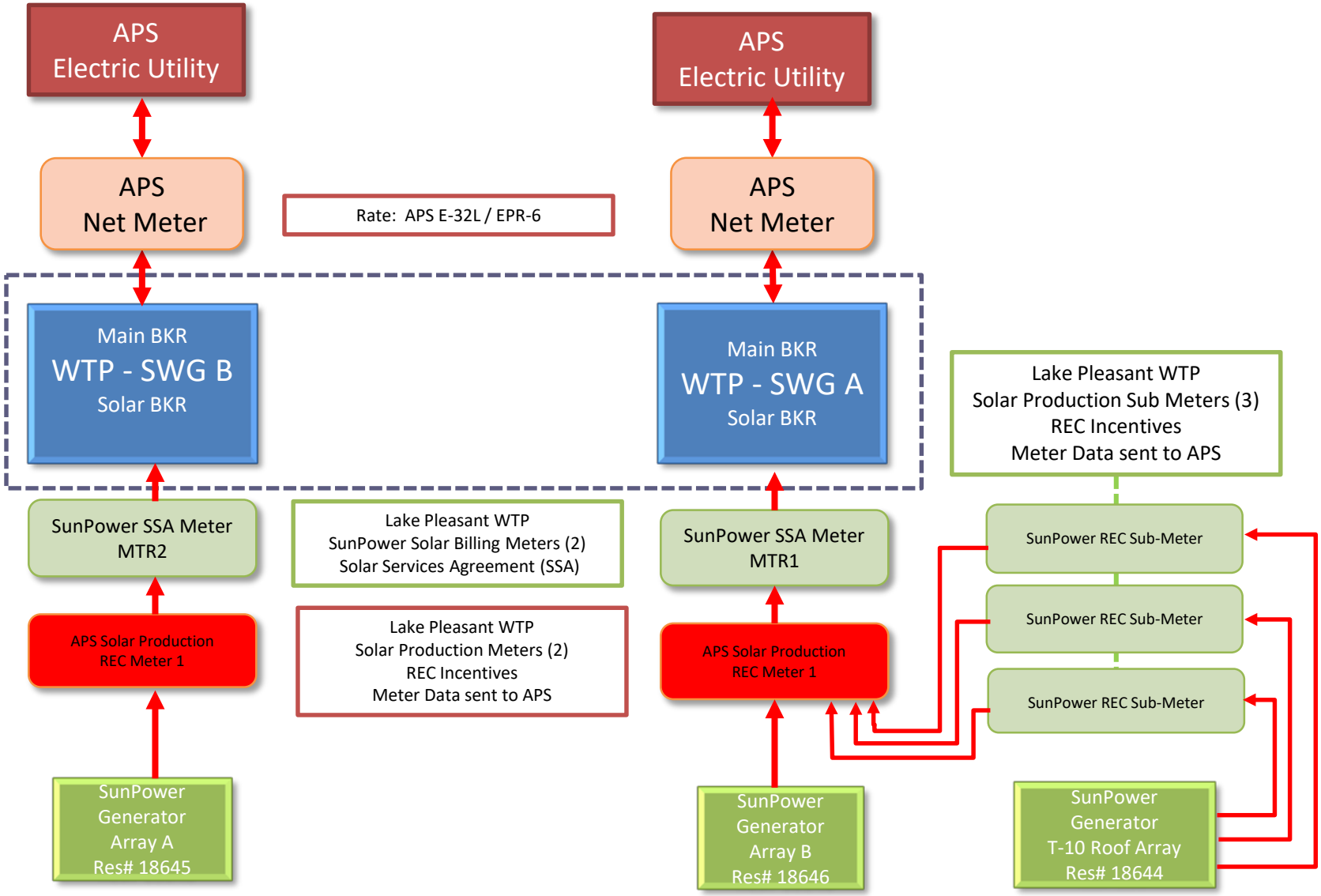
The Deal

- 20 year Agreement
- Phoenix leases land for $10.00 per year
- Solar provider constructs and maintains facility at its own expense
- Energy sold at $0.0674/kWh with a 1% annual escalation factor
- Phoenix purchases all of the kWh produced by the facility
- Solar provider gets the Renewable Energy Credits

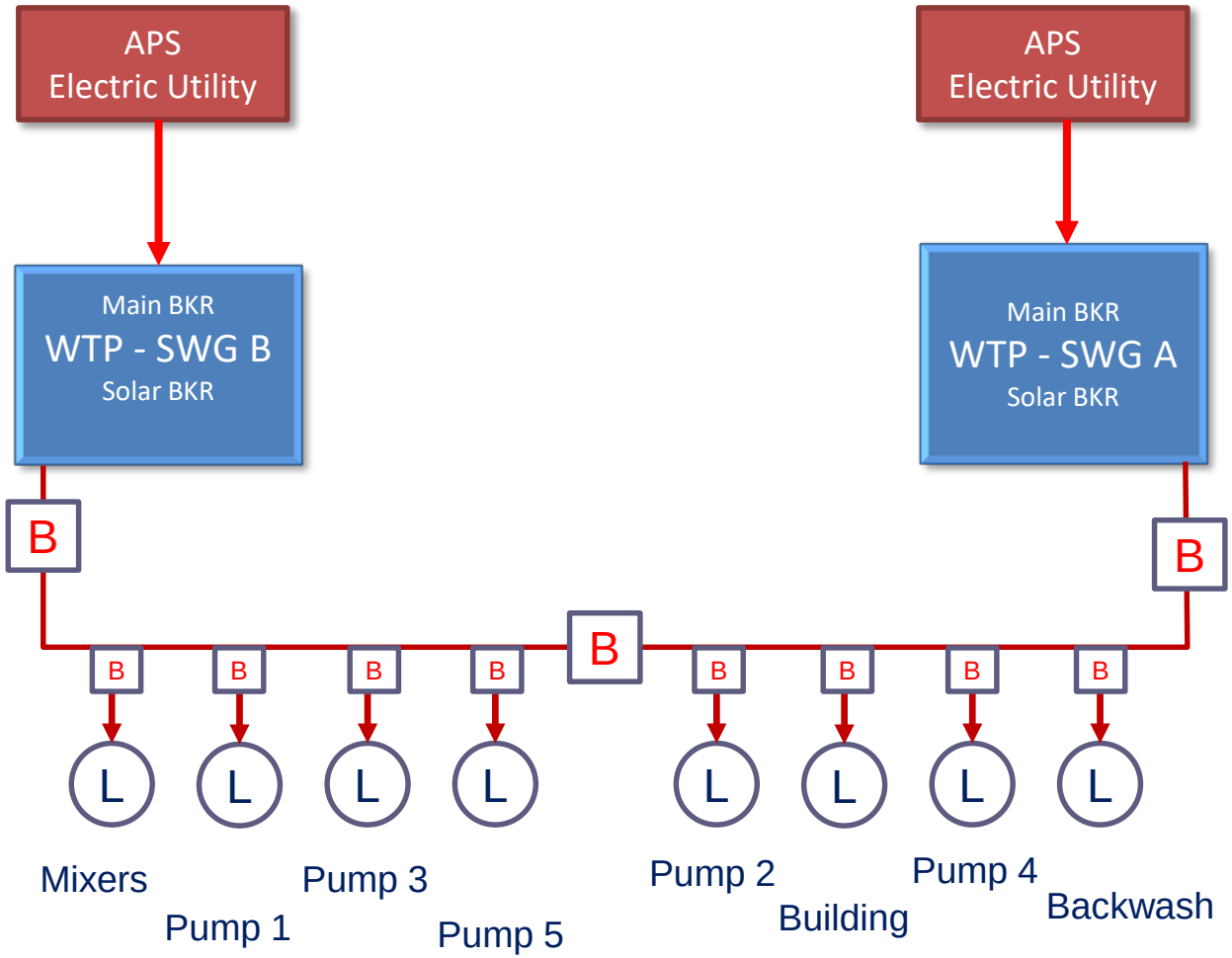
Metering Arrangement Before Solar



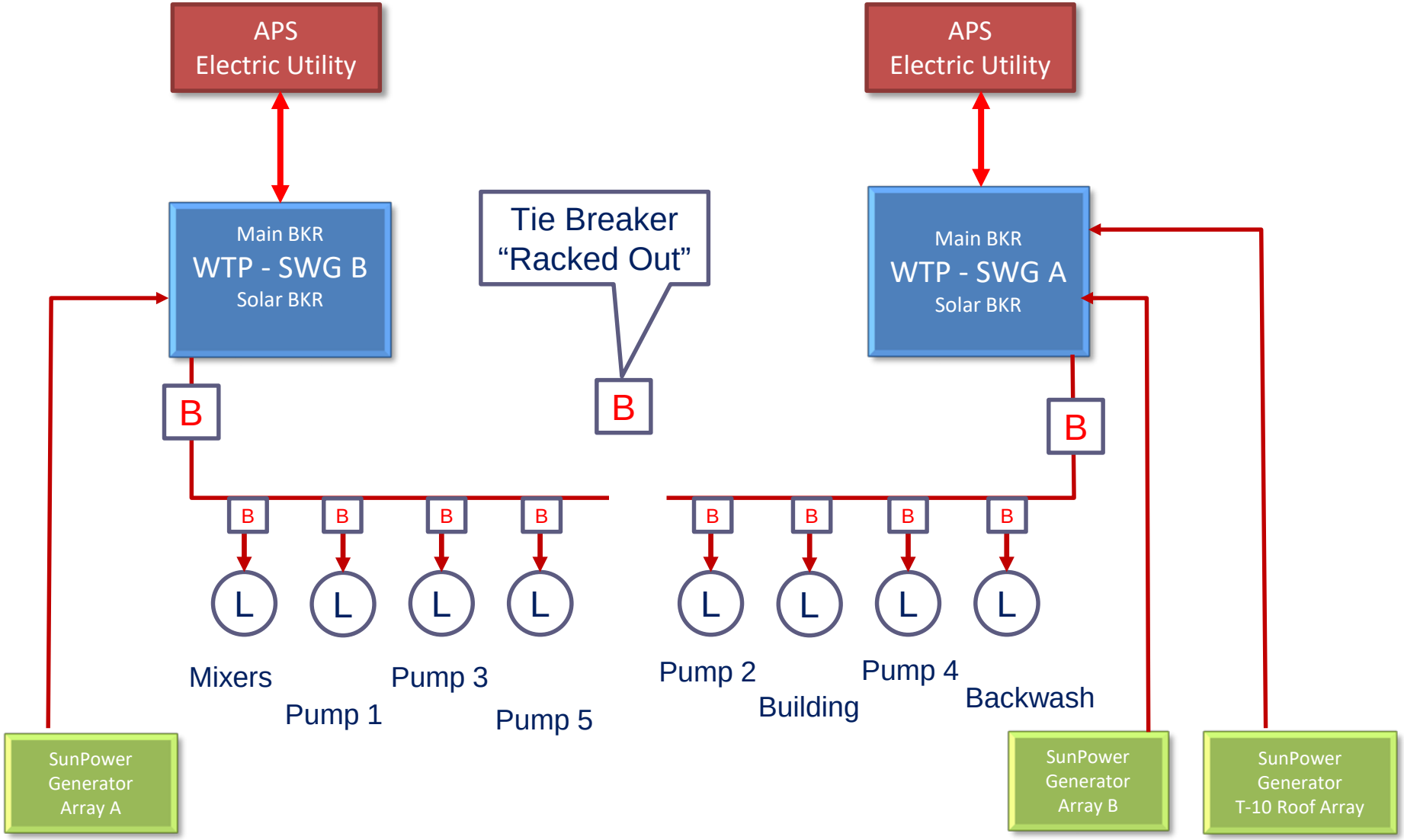
Metering Arrangement After Solar

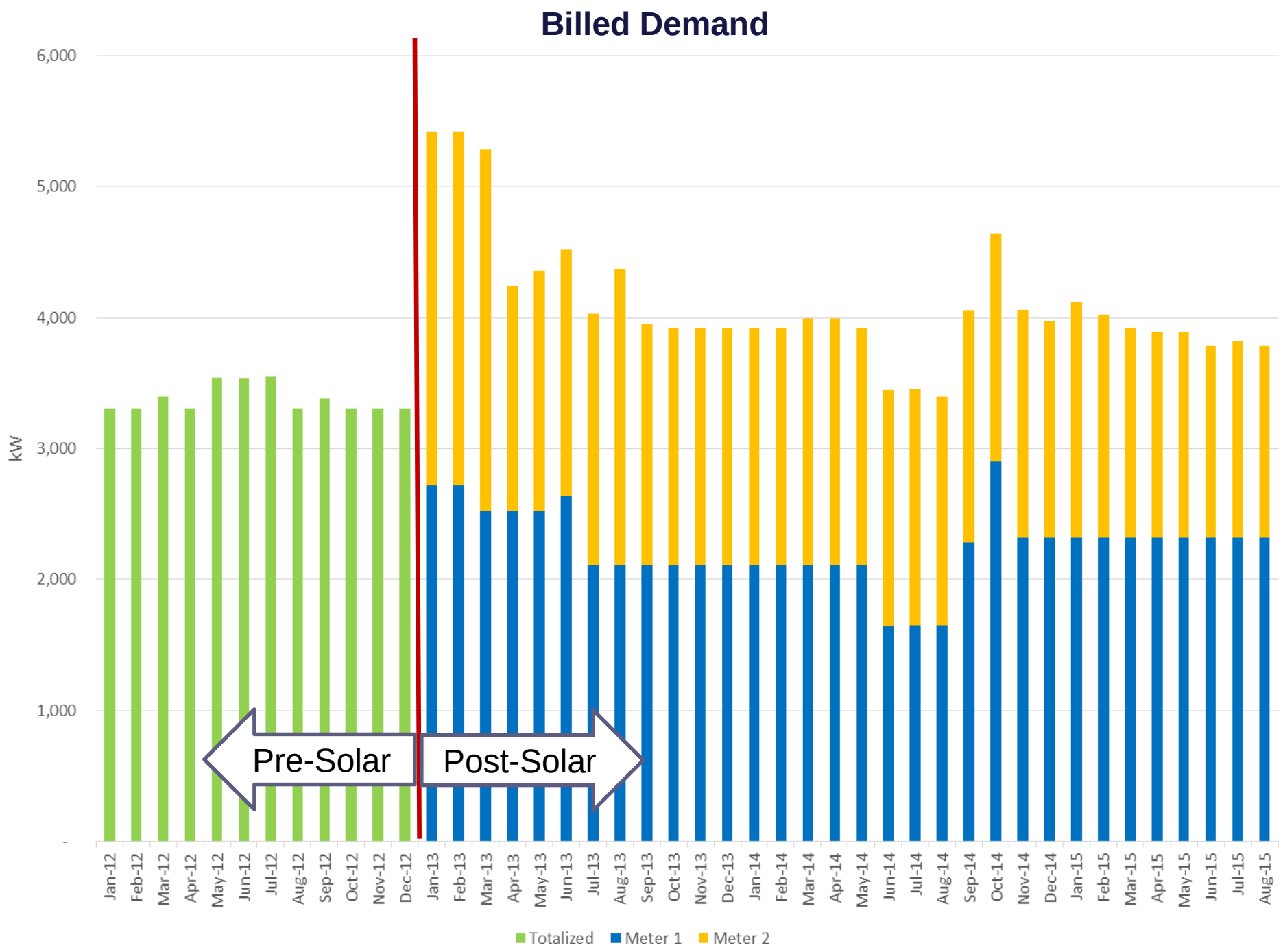


Power Distribution Before Solar



Power Distribution Before Solar




Billed Demand
kW
6,000
5,000
4,000
3,000
2,000
1,000
-
Pre-Solar
Post-Solar
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
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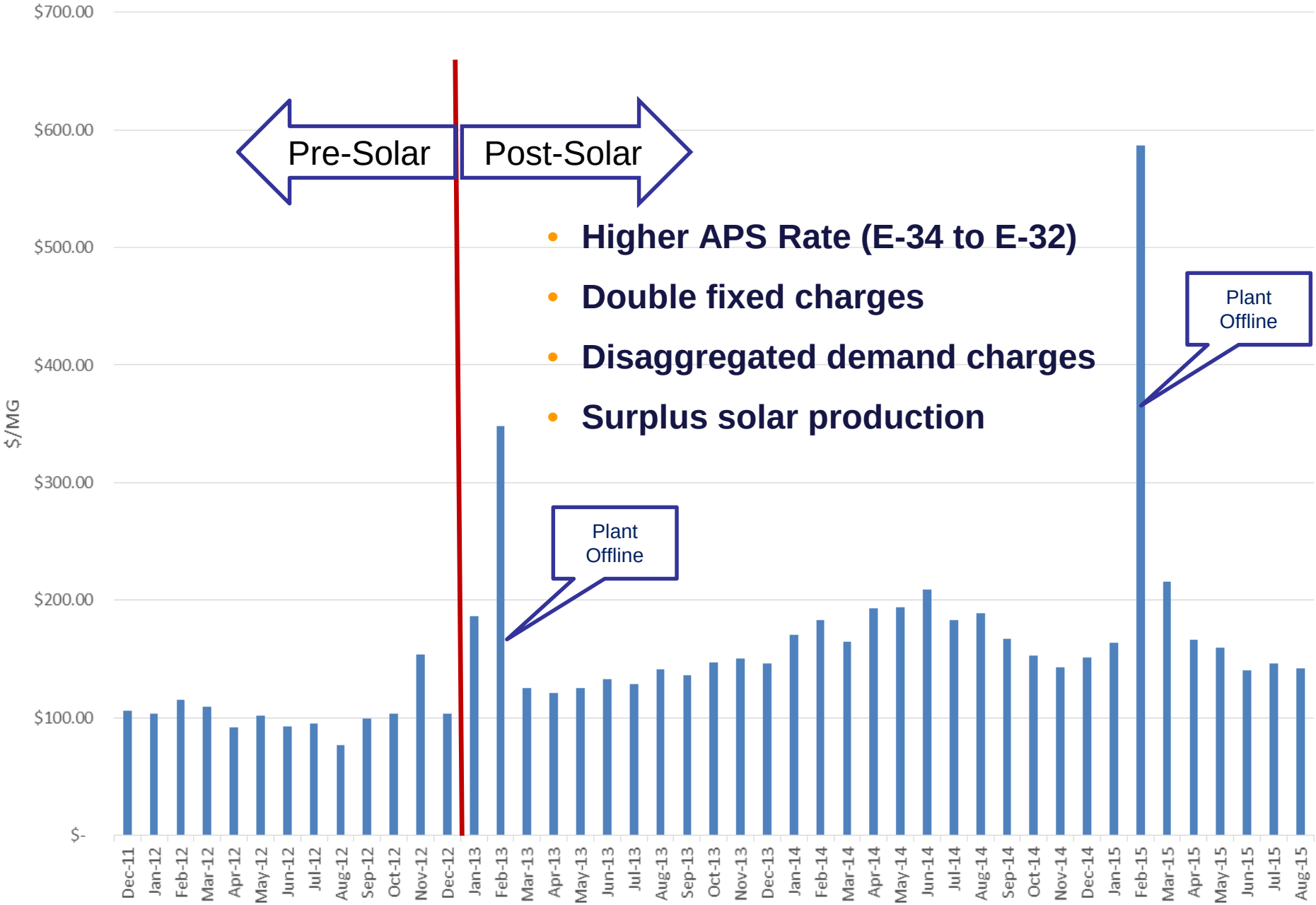
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Totalized
Meter 1
Meter 2

Lake Pleasant WTP Electric Cost Per-Unit Production

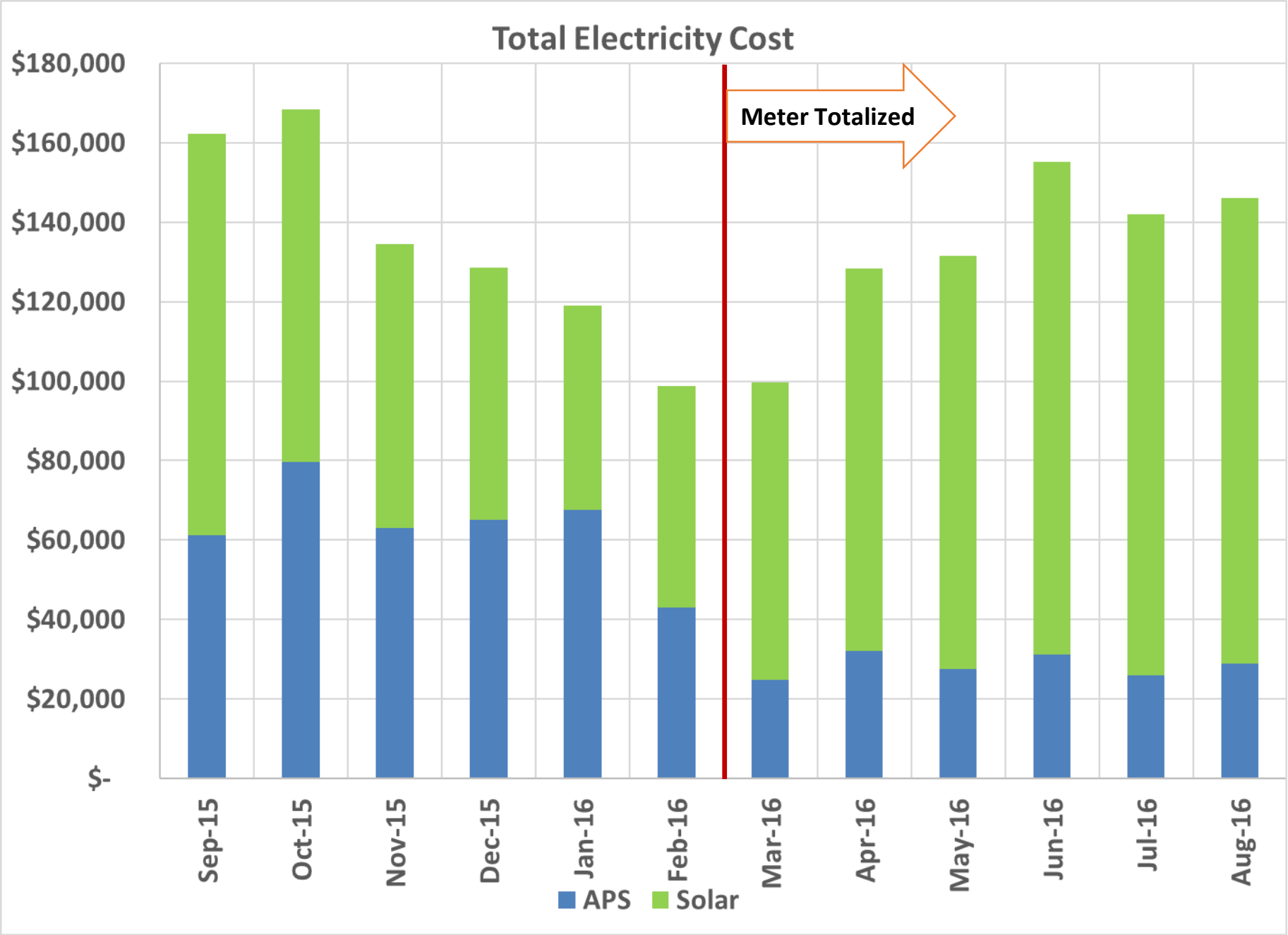


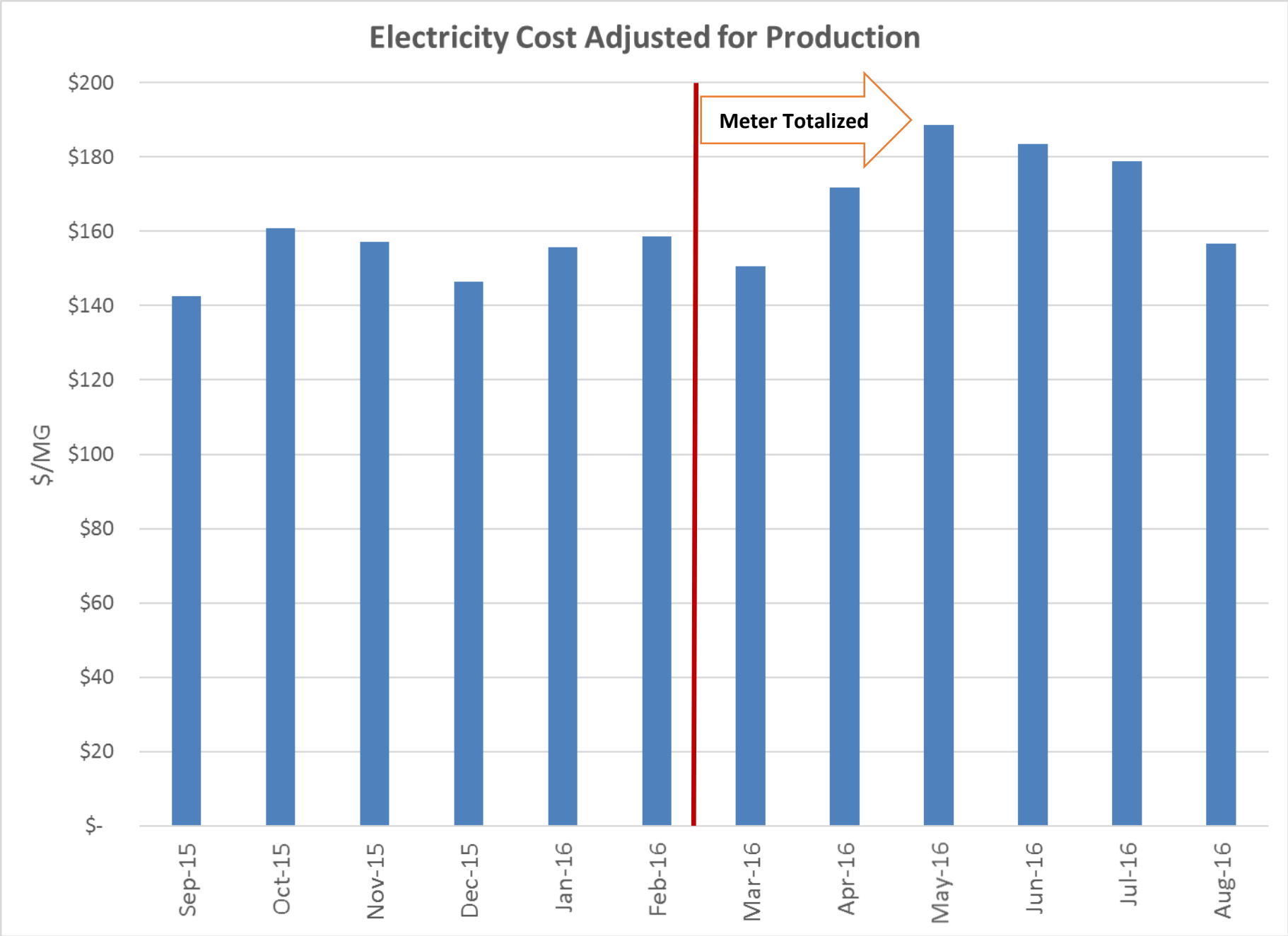
- **Higher APS Rate (E-34 to E-32)**
- **Double fixed charges**
- **Disaggregated demand charges**
- **Surplus solar production**

Surplus Energy Credits

	Account 59467284			Account 900647284		
Month	kWh Metered	kWh Credited	Net kWh	kWh Metered	kWh Credited	Net kWh
Jan-14	716,000	142,000	574,000	39,000	274,000	(235,000)
Feb-14	618,000	180,000	438,000	45,000	326,000	(281,000)
Mar-14	14,000	595,000	(581,000)	620,000	196,000	424,000
Apr-14	16,000	661,000	(645,000)	621,000	201,000	420,000
May-14	517,000	426,000	91,000	232,000	553,000	(321,000)
Jun-14	523,000	439,000	84,000	12,000	586,000	(574,000)
Jul-14	547,000	324,000	223,000	4,000	1,808	2,192
Aug-14	338,000	452,000	(114,000)	250,000	1,750	248,250
Sep-14	9,000	529,000	(520,000)	675,000	1,770	673,230
Oct-14	23,000	469,000	(446,000)	666,000	1,740	664,260
Nov-14	47,000	406,000	(359,000)	809,000	1,740	807,260
Dec-14	48,000	224,000	(176,000)	770,000	1,650	768,350
Total	3,416,000	4,847,000	(1,431,000)	4,743,000	2,146,458	2,596,542

Surplus Credits	**1,431,000**	**0**
Puchased from SunPower @ $0.0681 / kWh	**$ 97,414**	
Sold to APS @ $0.02895 / kWh	**$ 41,427**	
Operating LOSS	**$ 55,986**	


Total Electricity Cost
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$-
Meter Totalized
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16
APS
Solar


Electricity Cost Adjusted for Production
$/MG
$200
$180
$160
$140
$120
$100
$80
$60
$40
$20
$-
Meter Totalized
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Mar-16
Apr-16
May-16
Jun-16
Jul-16
Aug-16

We're Currently Upside Down

But the future is bright…

- **We are continuing to offset our carbon footprint**
- **We are locked into a low rate of escalation in solar cost**
- **Water production (energy use) will eventually increase so all solar credits are used**

It's Not Easy Being Green

Lessons Learned

1. ***Never every*** have a solar generation system sized larger than what your facility needs on a monthly basis.
2. ***Understand*** how solar may impact how loads can be distributed within your facility.
3. ***Understand*** how solar may impact you electric bill
   1. May shift account(s) into a less attractive tariff
   2. May loose benefit of totalized metering
   3. Demand charges may not go down, but may in fact go up
4. ***Be prepared*** to spend time reviewing both solar and grid electric billing to ensure it is being done correctly.
5. **Get expert advice** from a third party before entering in a solar agreement.

Kermit the Frog is a trademark of The Muppets Studio, LLC

Bruce Bartel

NEW Water (Green Bay Metropolitan Sewerage District)

U.S. DEPARTMENT OF ENERGY

US DOE Better Plants Summit

Resource Recovery Electrical Energy (R2E2)

May 16, 2017

Bruce Bartel – NEW Water
Treatment Manager

R2E2 PROJECT

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

Who or What is NEW Water?

- Brand of Green Bay Metropolitan Sewerage District
- Wastewater treatment services for 18 municipalities
- Two treatment facilities serving NE Wisconsin 24/7/365

NEW Water

The brand of the Green Bay Metropolitan Sewerage District

Protecting our most valuable resource, water

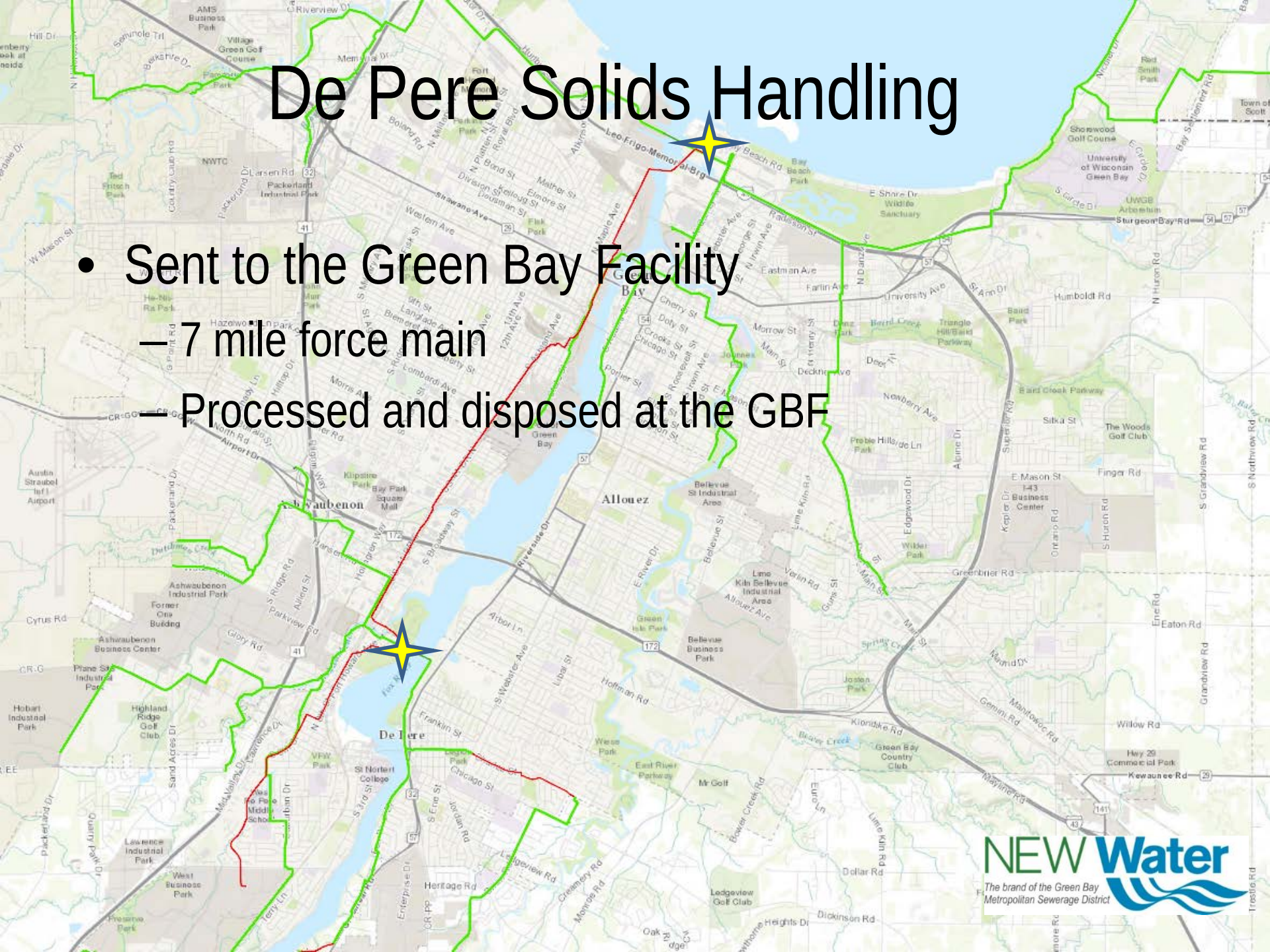
Lake Superior
Apostle Is
Lake Superior
Superior
MICHIGAN
St. Croix
Rhinelander
WISCONSIN
Lake Michigan
Eau Claire
Wausau
Green Bay
Stevens Point
Appleton
Lake Winnebago
MINNESOTA
Black
La Crosse
Oshkosh
Manitowoc
Mississippi
Fond du Lac
Sheboygan
Wisconsin Dells
Menomonee Falls
Wisconsin
MADISON
Waukesha
Milwaukee
West Allis
IOWA
Janesville
Racine
MICHIGAN
Beloit
Kenosha
ILLINOIS

Green Bay Facility
32 mgd

De Pere Facility
8 mgd

De Pere Solids Handling

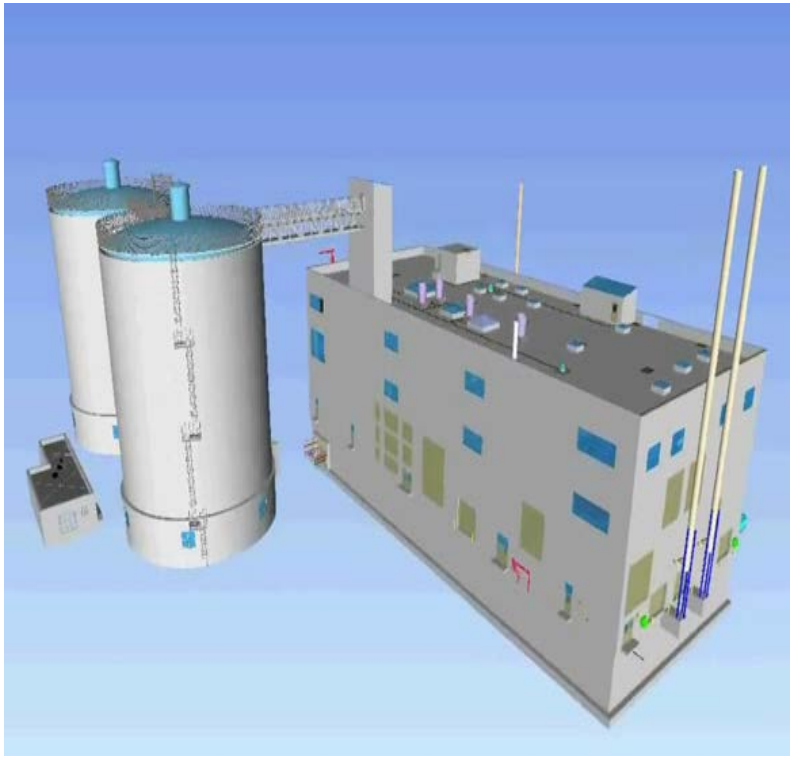
- Sent to the Green Bay Facility
  - 7 mile force main
  - Processed and disposed at the GBF



R2E2
Resource Recovery Electrical Energy Project

Most cost-effective solution to replace solids handling at the Green Bay Facility

Tools to <u>treat wastewater as a resource</u>



R2E2 PROJECT

NEW Water
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Background Information

Three main drivers:

- Aging infrastructure
- Environmental regulations
- Increased capacity needs

R2E2 PROJECT

NEW Water
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NEW Water
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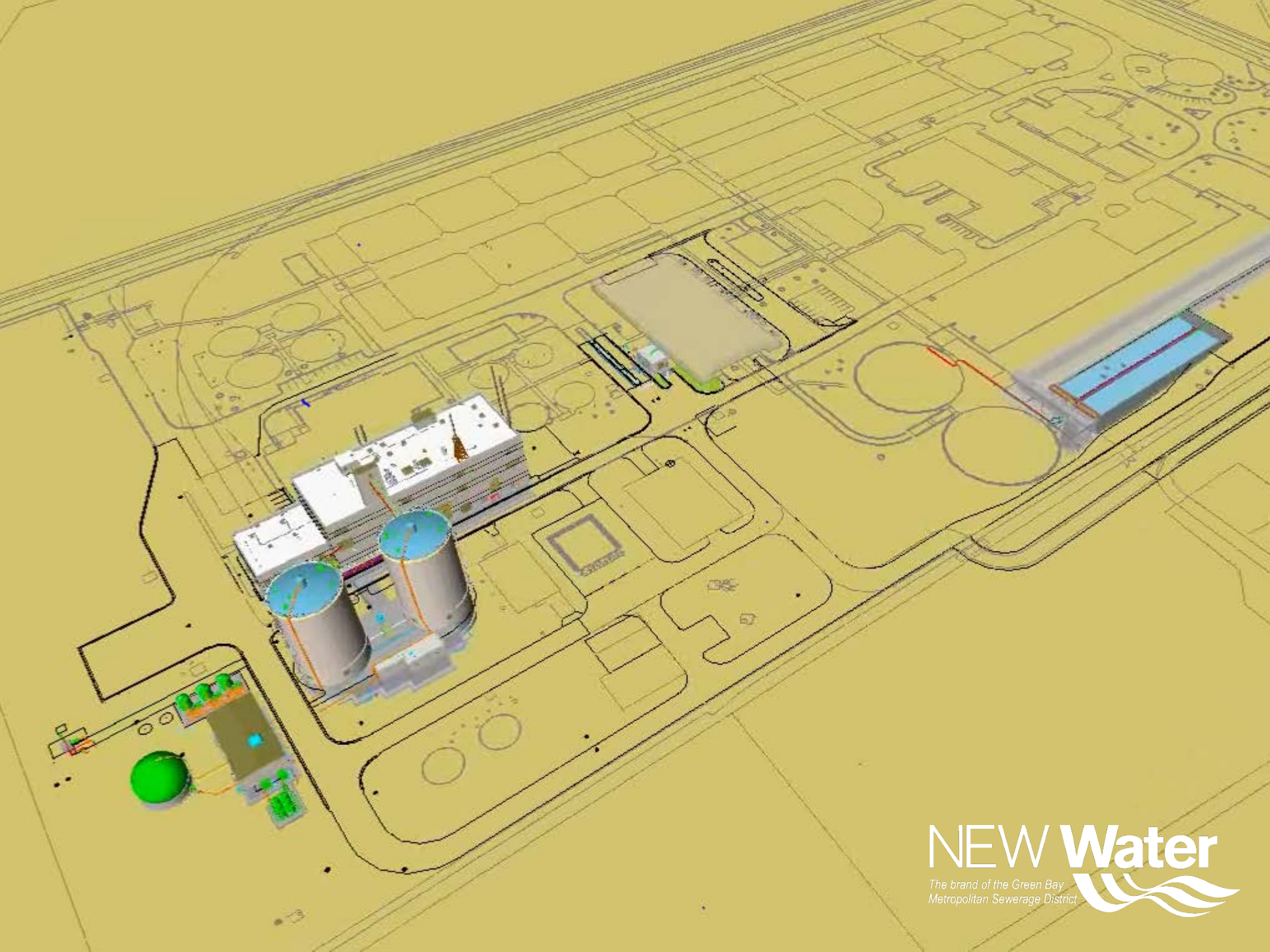
Metropolitan Sewerage District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Metropolitan Sewerage District

Green Bay Facility Solids Handling Upgrade - R2E2

R2E2

- R2E2: Solids & Digestion Facilities
  - Includes:
    - Anaerobic Digestion
    - New Solids Building
    - Centrifuge Dewatering
    - Dryer
    - Biogas Storage
    - Electrical Energy Generation
    - Nutrient Recovery
    - Ash Dewatering and Storage
    - Installation of Fluid Bed Incinerator Equipment

R2E2 PROJECT

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

R2E2

- R2E2: Solids & Digestion Facilities
  - Energy Recovery:
    - Biogas to run two – 2.2 MGW I.C. Engines
    - Heat from the I.C. engines to heat the anaerobic digesters
    - Heat recovery from the fluid bed incinerator to run dryer
    - Autogenous incinerator operation
    - Nutrient harvesting to produce fertilizer product

R2E2 PROJECT

NEW Water
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KR 806-5G
McQuay

BLDG
6
C.D. SMITH
C.D. SMITH
C.D. SMITH
12/22/2016 09:25 AM

CAT

R2E2 Timeline

- Planning Stage (2008-2011) **Complete**
- Design Stage (2012-2015) **Complete**
- Equipment Procurement (2013-2014) **Complete**
- Construction Project #1 (2014) **Complete**
- Construction Project #2 (2015-2018) **Underway**
- Implementation (2018)
- Construction Project #3 (2019)

R2E2 PROJECT

NEW Water
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R2E2 Costs

Project Phase	Approximate Costs
Engineering Services	$25,000,000
Fluidized Bed Incinerator Equipment	$21,200,000
Construction Project #1	$6,300,000
Construction Project #2	$114,000,000
Construction Project #3	$2,500,000
Total	$169,000,000

R2E2 PROJECT

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

R2E2 Benefits

- Addresses the original project drivers:
  - Aging infrastructure
  - Environmental regulations
  - Increased capacity needs
- Lowest cost plan over a 20-year planning period
- Generate about 50% of NEW Water's energy needs

R2E2 PROJECT

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

R2E2 Benefits

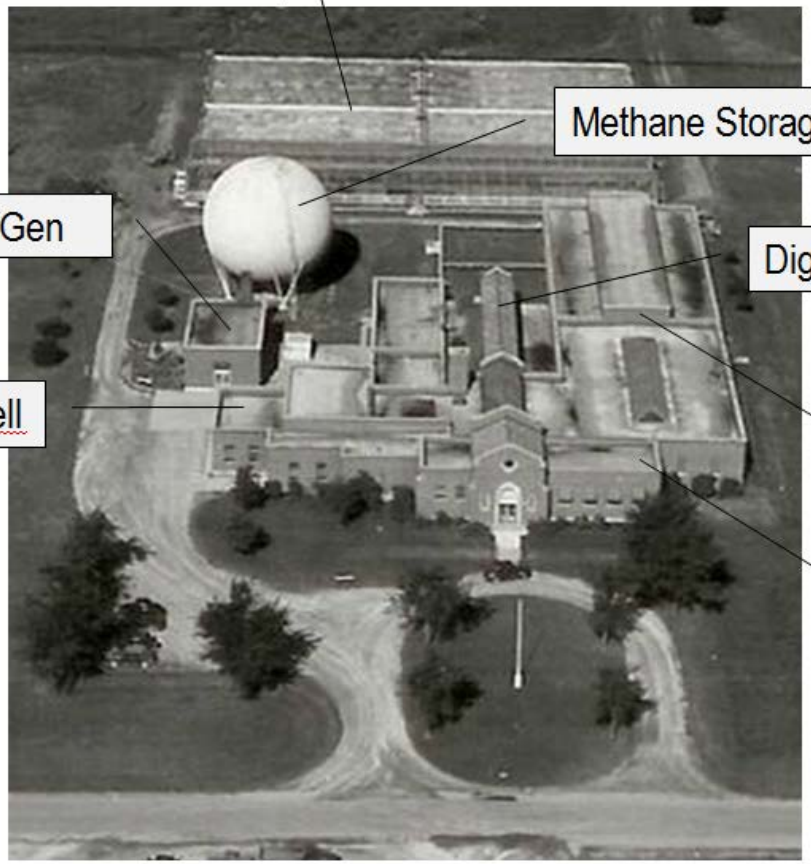
- Accept different wastes (i.e. dairy, sugar, and food processing) that can boost energy production
- Use approx. 90% less natural gas than current system
- Struvite is a slow release fertilizer; $400,000/year revenue

R2E2 PROJECT

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

Back to the Future:
Resource Recovery and Electrical Energy (R2E2)

1935: GBMSD Plant



NEW Water
The brand of the Green Bay Metropolitan Sewerage District

Thank You!

Questions / Comments?

Contact Information:
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(920) 438-1006

For more information please visit:

www.newwater.us

Stay connected with us:

Jim Newton

Kent County Department of Public Works

U.S. DEPARTMENT OF ENERGY

Renewable Energy at Resource Recovery Facilities

Jim Newton, P.E., BCEE, ENV SP
Kent County Public Works
Milford, DE

Understand Where You're At

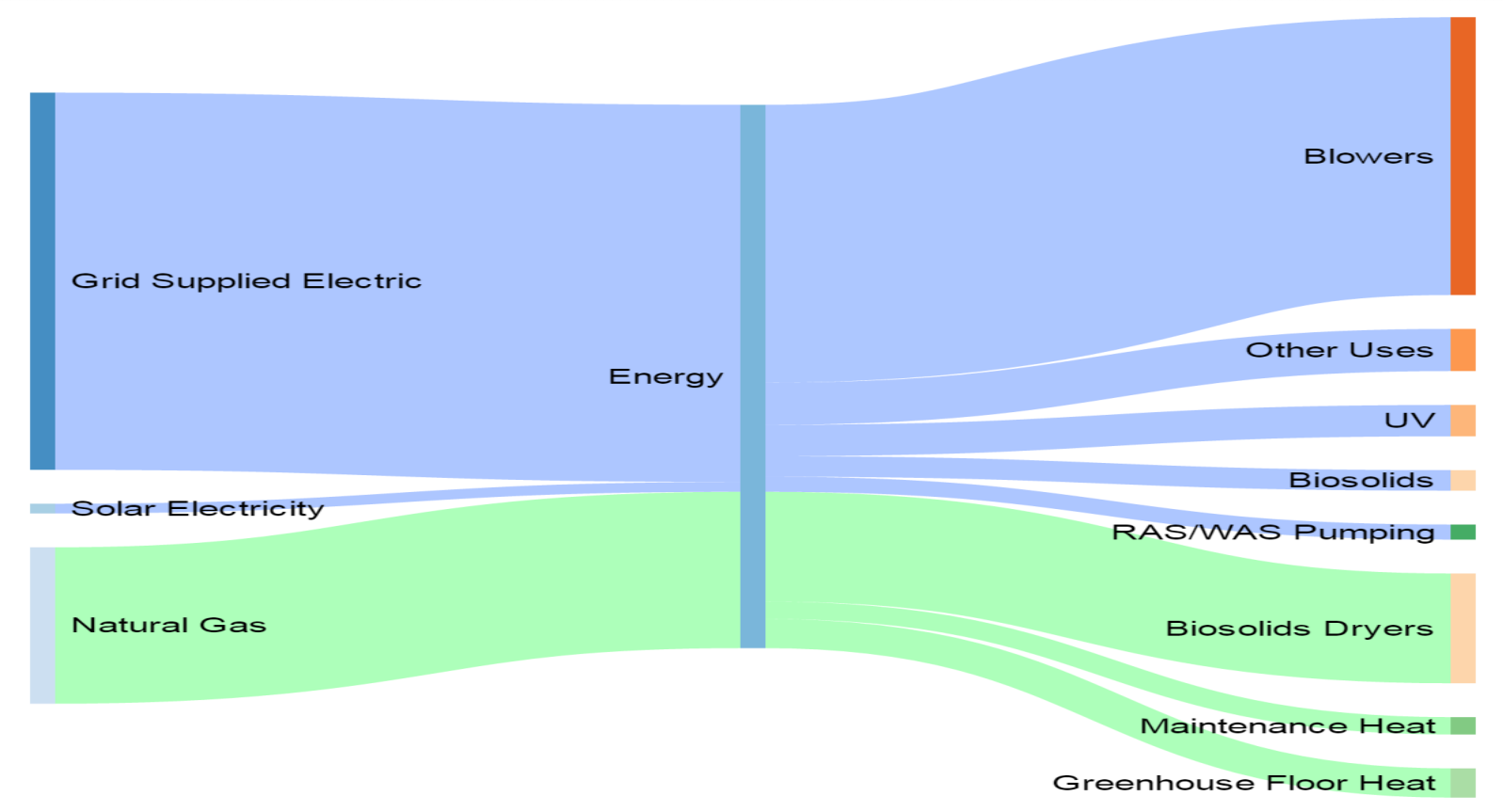
- Determine Significant Energy Sources
  - Electricity (grid supplied, onsite generated)
  - Natural Gas
  - Diesel
- Determine Energy Uses
  - Pumping
  - Aeration
  - Drying
- Determine Baseline Energy Consumption
  - Total energy in from all sources
  - Add in onsite renewables
  - Estimate all consumption

- Determine Basic Design and Operating Criteria
- Take advantage of DOE programs
  - Industrial Assessments
- Develop an Energy Management System
  - ISO 50001
  - Superior Energy Performance (SEP)

Begin by Making A Plan

- Look at establishing an ISO 50001 Energy Management System (EnMS)
- Look at incorporating DOE's Superior Energy Performance (SEP) program
- Submeter where necessary

Kent County Energy Balance



Renewable Energy Options

- Solar
- Hydro
- Geothermal
- Wind
- Biomass

Solar Options

- Photovoltaic
- Solar Biosolids Drying
- Passive Design

21 8:26 AM

Hydro Options

- Head
- Flow
- P (kW) = 10 * n * Q * H

N = Efficiency

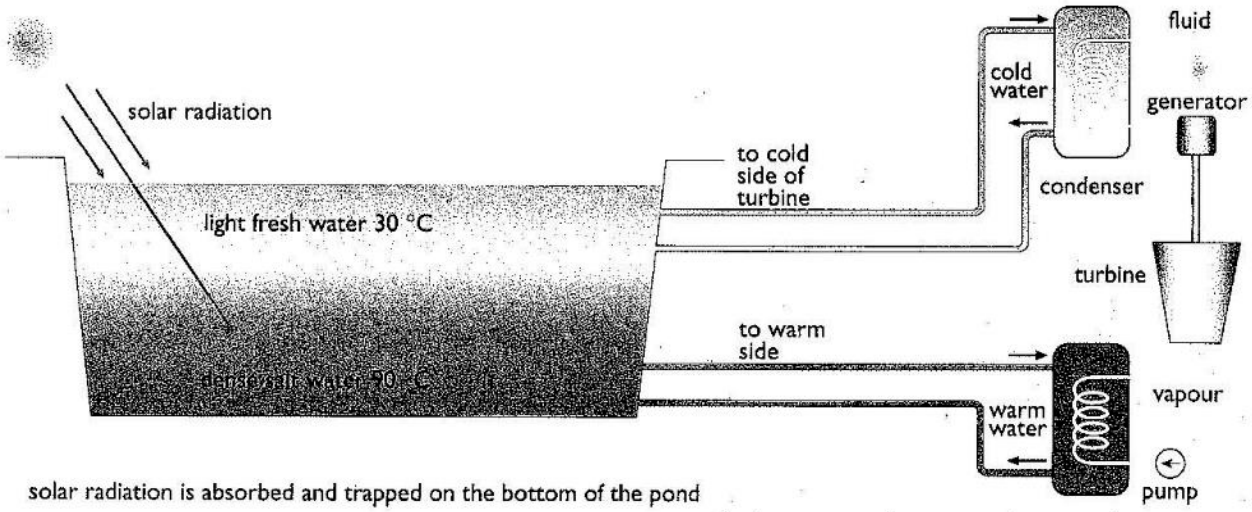
Q = Flow

H - Head

Geothermal Options

- HVAC

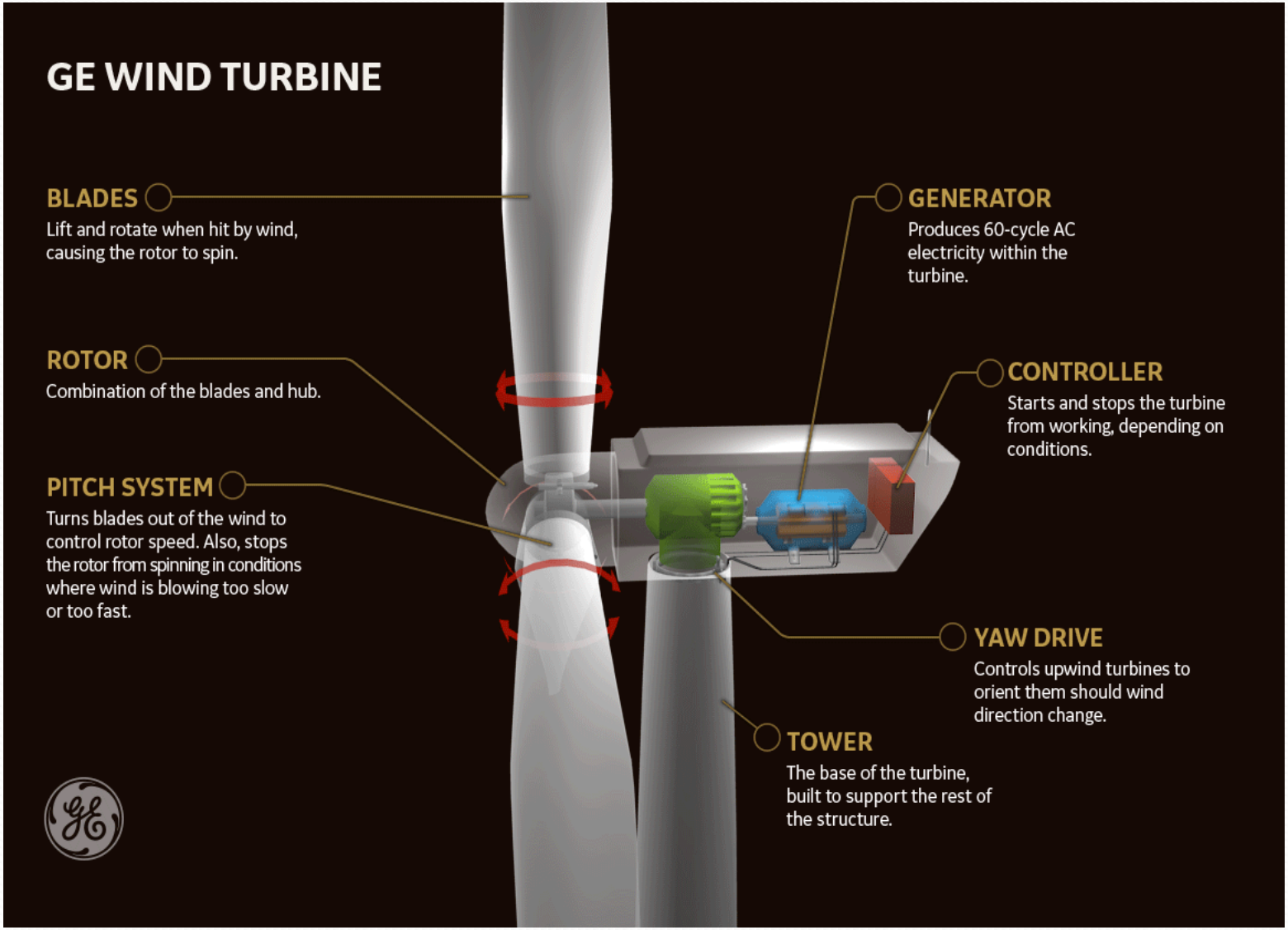
- Thermal energy in water

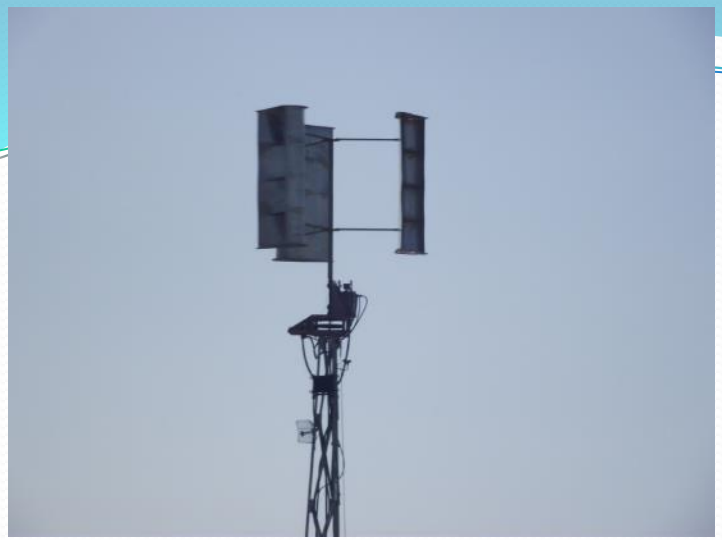


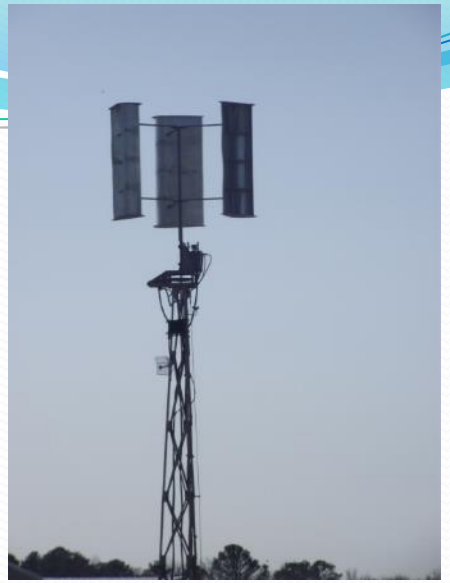
solar radiation is absorbed and trapped on the bottom of the pond

Wind Options

- Horizontal Turbines
- Vertical Turbines
- Other systems

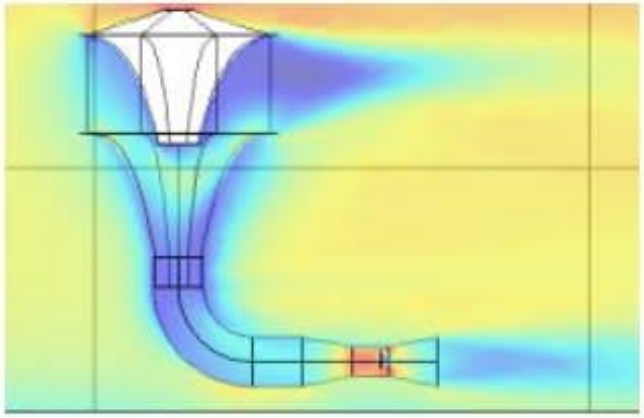

GE WIND TURBINE
BLADES
Lift and rotate when hit by wind, causing the rotor to spin.
ROTOR
Combination of the blades and hub.
PITCH SYSTEM
Turns blades out of the wind to control rotor speed. Also, stops the rotor from spinning in conditions where wind is blowing too slow or too fast.
GENERATOR
Produces 60-cycle AC electricity within the turbine.
CONTROLLER
Starts and stops the turbine from working, depending on conditions.
YAW DRIVE
Controls upwind turbines to orient them should wind direction change.
TOWER
The base of the turbine, built to support the rest of the structure.



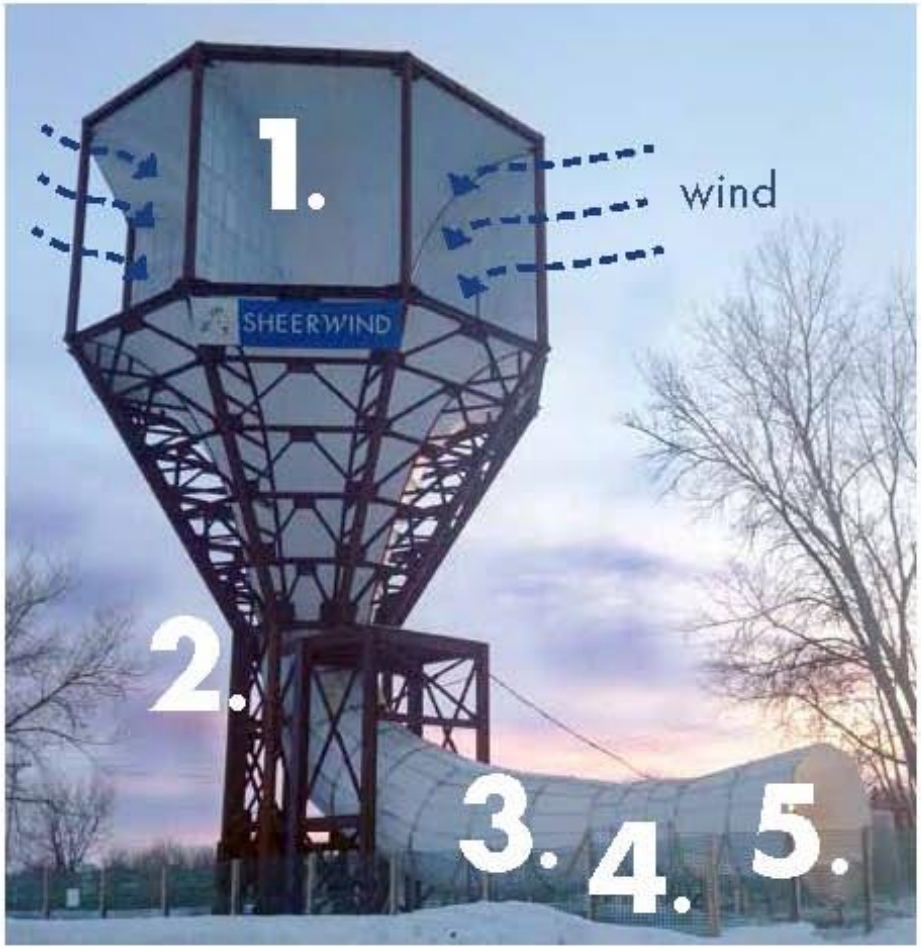


How INVELOX works

1. 360° intake collects wind
2. Wind is funneled to concentrate
3. Venturi is used to increase wind speed
4. Turbine generators are placed at optimum wind speed and convert wind power to electrical energy
5. Diffuser slows wind before returning to environment



For more information visit SHEERWIND.com



High resistance,
starts producing
at 7.5 mph (12 km/h)
wind speed
Low resistance,
starts producing
at 2 mph (3 km/h)
wind speed
Traditional
Gearbox
Turbine
Up to 200 ft
6 ft across
170 lbs (77 kg)
Honeywell
Gearless
Wind Turbine

Wind power formula

Power = k* Cp* 1/2 *ρ* A*V^3

Where

P = Power output, kilowatts

Cp = Maximum power coefficient, ranging from 0.25 to 0.45,dimension less (theoretical maximum = 0.59)

ρ = Air density, lb/ft^3

A = Rotor swept area, ft^2 or π D^2/4 (D is the rotor diameter in ft, π = 3.1416)

V = Wind speed, mph

k = 0.000133 A constant to yield power in kilowatts.

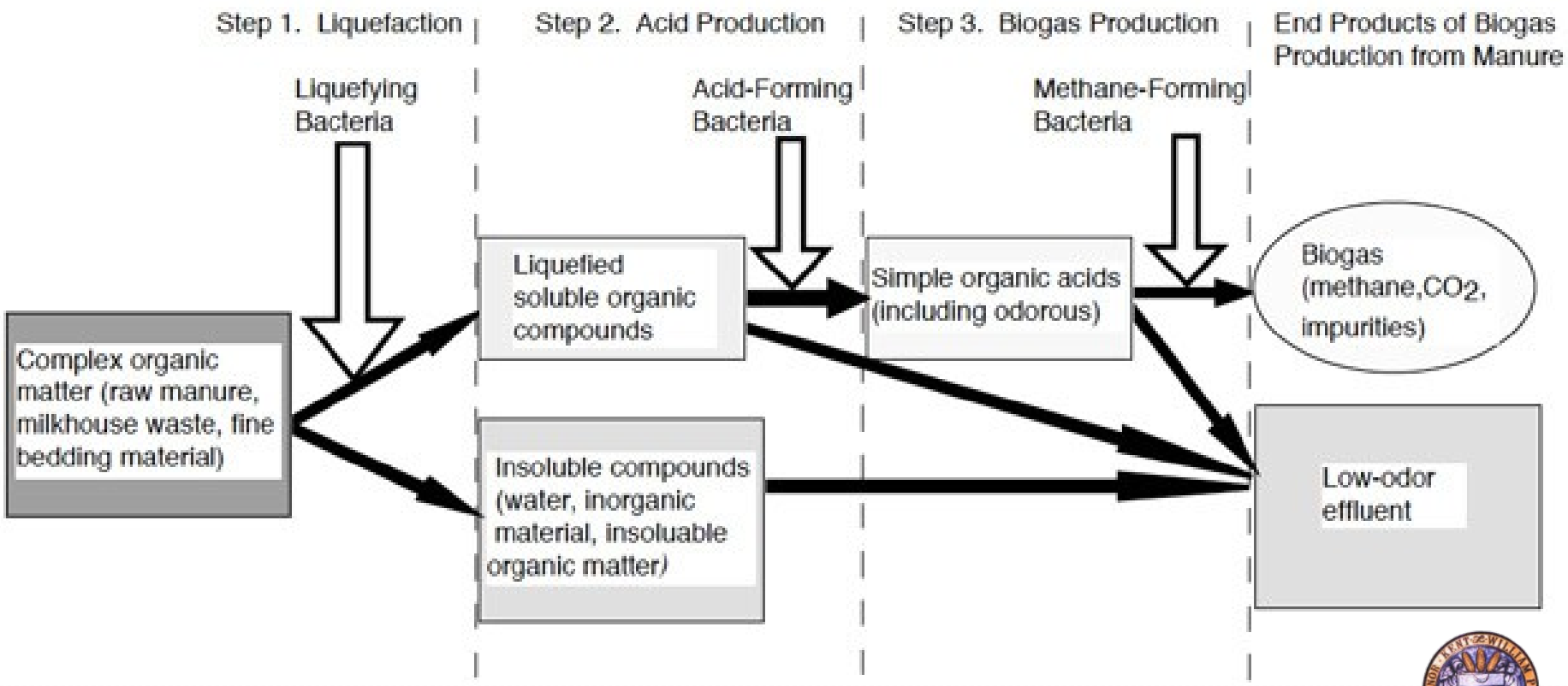
(Multiplying the above kilowatt answer by1.340 converts it to horsepower. [i.e., 1 kW = 1.340 horsepower]).

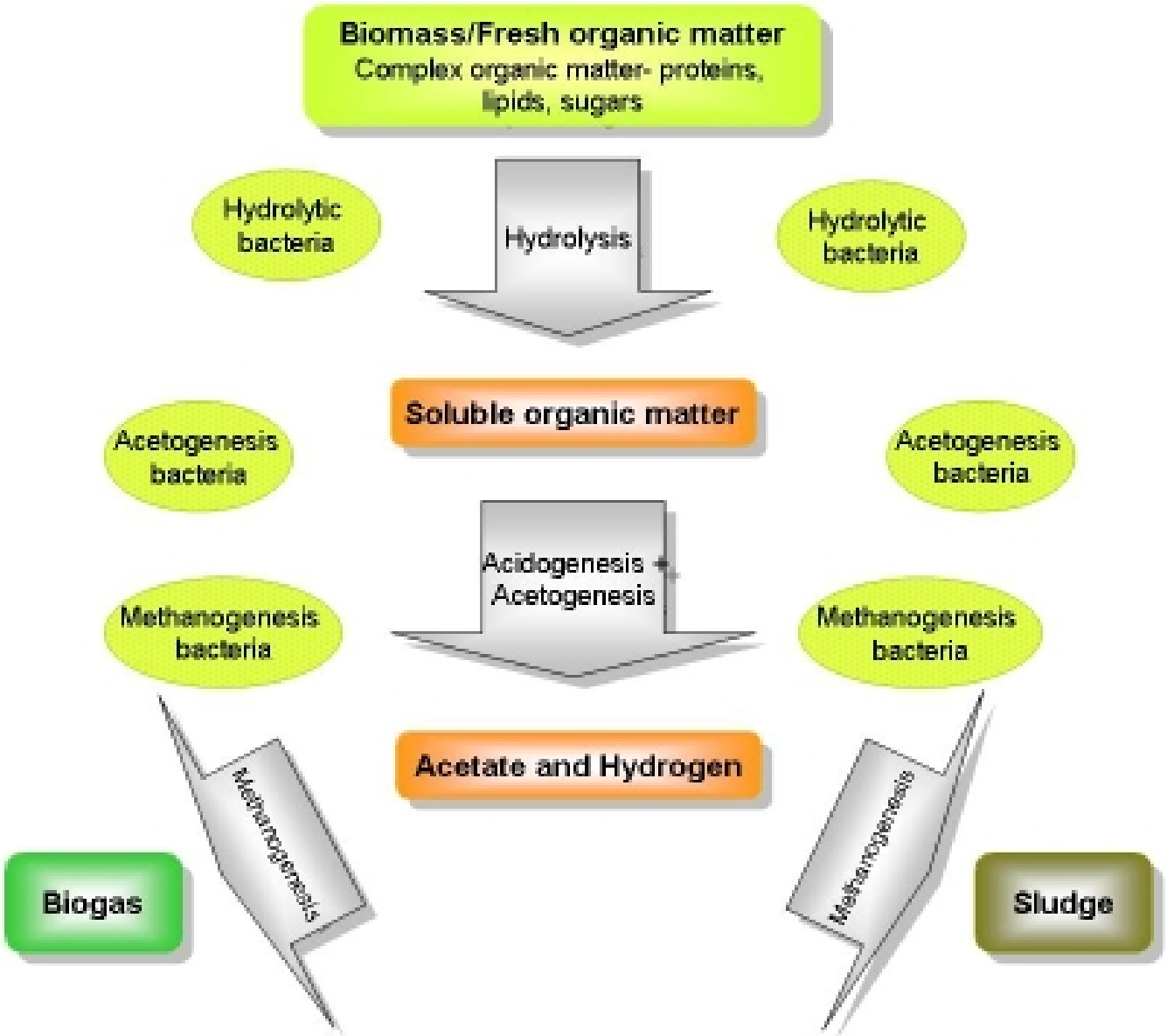
Biomass Options

- Anaerobic Digestion
- Composting
- Landfill Gas

Biosolids Digestion

- Anaerobic digestion considerations
  - Control temperatures
  - Generate digester gas
  - Add other fuel materials
    - FOG
    - Food waste
    - Yard waste


Step 1. Liquefaction
Step 2. Acid Production
Step 3. Biogas Production
End Products of Biogas Production from Manure
Liquefying Bacteria
Acid-Forming Bacteria
Methane-Forming Bacteria
Complex organic matter (raw manure, milkhouse waste, fine bedding material)
Liquefied soluble organic compounds
Insoluble compounds (water, inorganic material, insoluable organic matter)
Simple organic acids (including odorous)
Biogas (methane, CO_2, impurities)
Low-odor effluent


Biomass/Fresh organic matter
Complex organic matter- proteins, lipids, sugars
Hydrolytic bacteria
Hydrolysis
Hydrolytic bacteria
Soluble organic matter
Acetogenesis bacteria
Acetogenesis bacteria
Acidogenesis + Acetogenesis
Methanogenesis bacteria
Methanogenesis bacteria
Acetate and Hydrogen
Methanogenesis
Methanogenesis
Biogas
Sludge

- About 1 ft^3 of digester gas can be produced per person per day
- 1 ft^3 of digester gas can provide 2.2 watts of power
- Heating value of digester gas is 600 BTUs per ft^3
- For each 4.5 MGD processed at a WWTP, the generated digester gas can produce 100 kW of electricity and 12.5 million BTUs of thermal energy

Thank You

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