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Opening Remarks

Tony DePrima

Public Sector Co-Chairman
Energy Services Coalition, Delaware Chapter, and
Executive Director, Delaware Sustainable Energy Utility

2016 Delaware Energy Conference

Remarks

Senator Harris McDowell

Chairman, Committees on Energy and Transit; Finance; and Children, Youth and Families
Delaware State Senate

Morning Keynote

David Terry

Public Sector Vice-President, National ESC
Executive Director, National Association of State Energy Officials

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Exceeding Expectations
20 YEARS

2016 Delaware Energy Conference

Panel One:

Emergent Technologies Delaware

Bryan Tracy, CEO White Dog Labs,
US Department of Energy Grant Recipient
Pam Frank, Vice President, Gabel Associates
Bill O'Connell, LC, LEED AP, Technical Sales Manager, LEDVANCE

Moderator: **Suzanne Sebastian**, Program Manager,
Delaware Sustainable Energy Utility

White Dog Labs

Biochemical Platform to Address Global Sustainability Challenges

3rd Annual Delaware Energy Conference
October 19, 2016

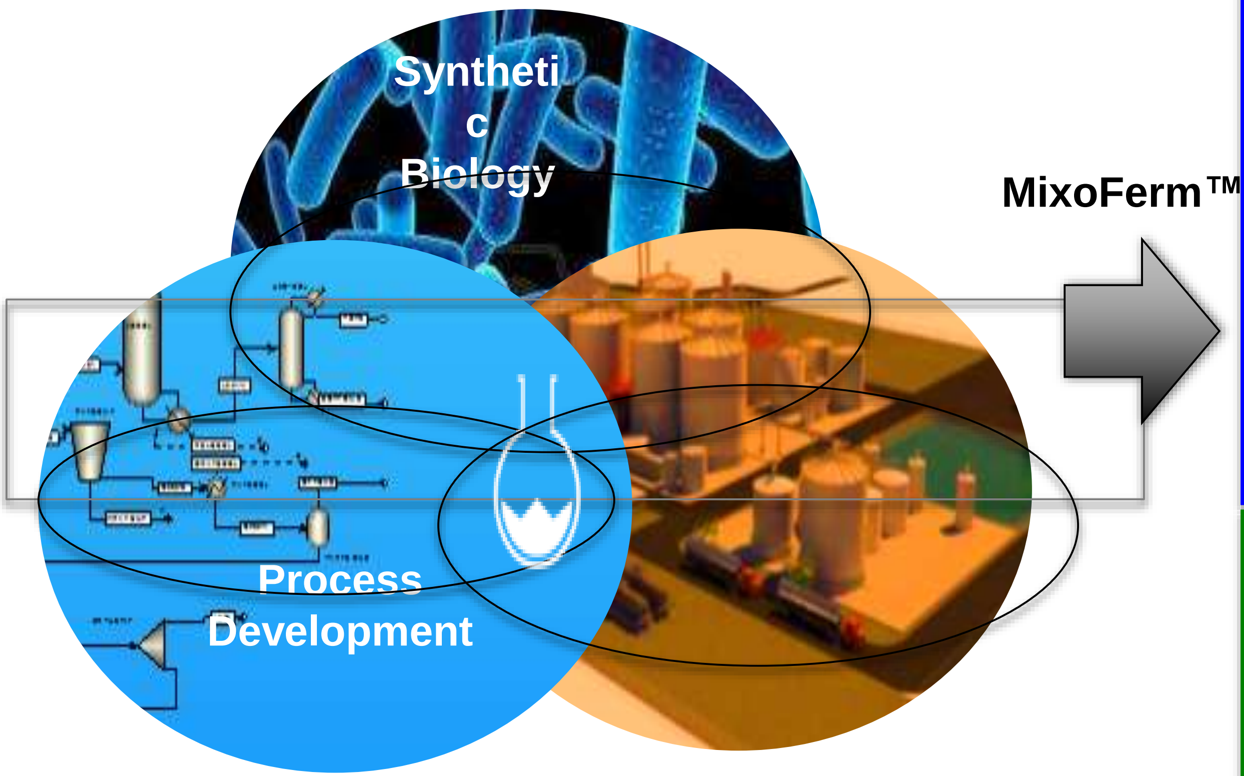
Enhancing Nature's Yield

White Dog Labs – What's in the name?

Bourbon before barrel aging is called "White Dog"

White Dog Labs

Biotechnology Company



Direct Competition to Petroleum

Cellulosic Fuels

Mitigating climate change without affecting food supply

Biochemicals

Reducing price volatility and delivering carbon credit to brand owners

Protein & nutritional products

Sustainably addressing the protein needs of a growing global population

Minimal Competition to Petroleum

White Dog Labs

MUSEAVENTURES

- Cofounded by Talli Somekh and Bryan Tracy
- Funded by father and son team committed to do both good and well through the Somekh Family investments
- Sass Somekh, Chairman – retired executive from the semiconductor industry. Silicon Valley Engineering Hall of Fame and awardee of SEMI Lifetime Achievement Award
- Delaware based with 40K sqft facility housing laboratory, pilot and demonstration activities.

Elcriton

University of Delaware spin-out

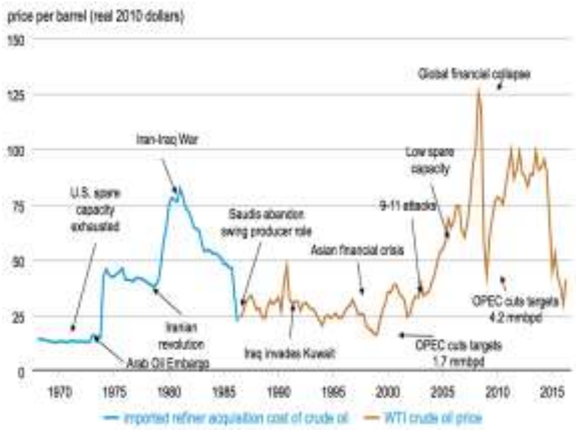
- Cofounded by Terry Papoutsakis (Eugene DuPont Chair Professor) and Bryan Tracy

NSF National Science Foundation WHERE DISCOVERIES BEGIN

BIRD Israel-U.S. Binational Industrial Research and Development Foundation

U.S. DEPARTMENT OF ENERGY

What Motivates White Dog Labs?



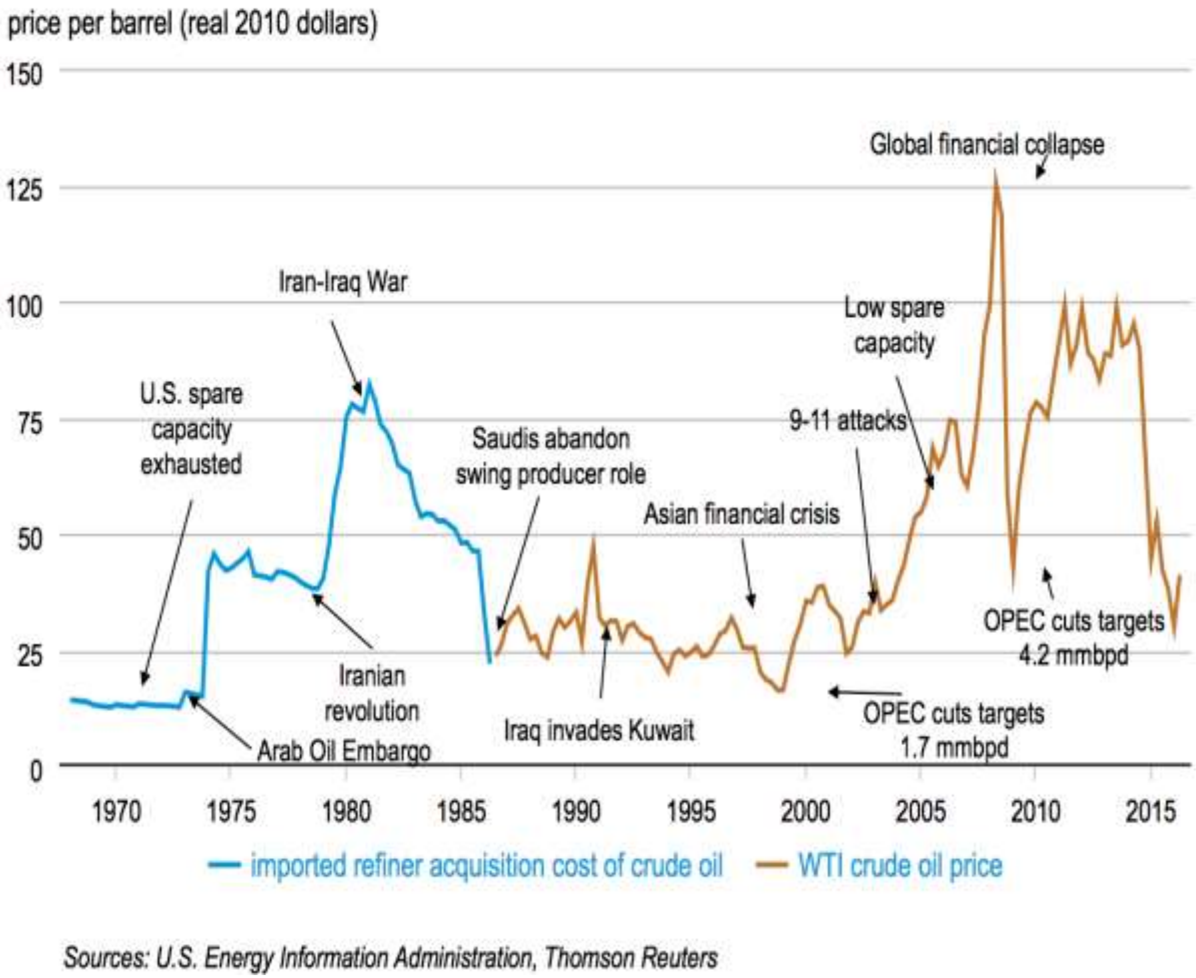
Era of Extreme Petroleum Volatility

Accelerating Global Warming

New Law Carbon Regulatory Regimes

Continued Population Growth

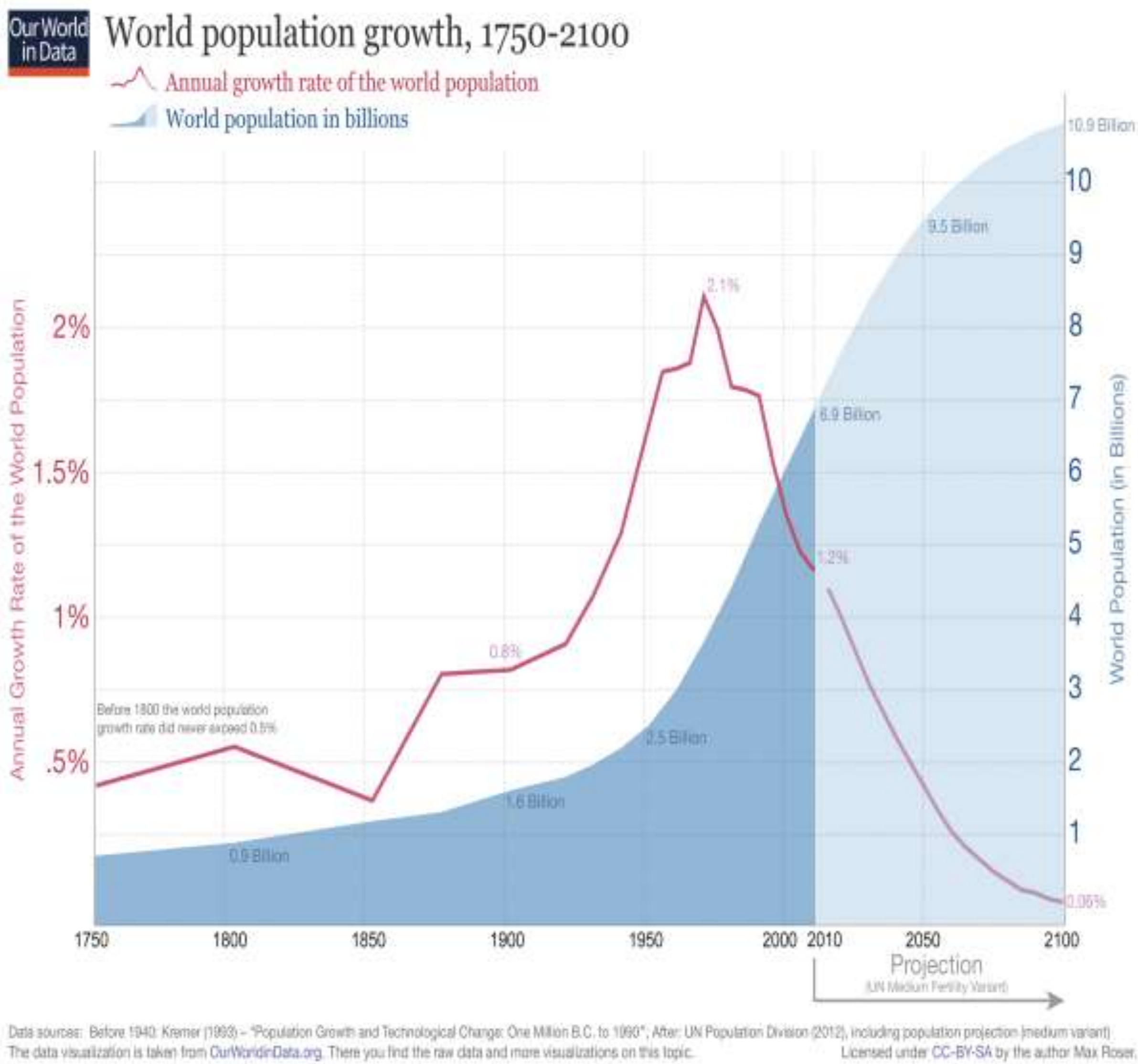
Era of Petroleum Volatility



Extreme volatility - even more unpredictable than the 1970s.

Unsettled influence of shale gas/oil technology, and perhaps stability by US and Canada playing the swing producer.

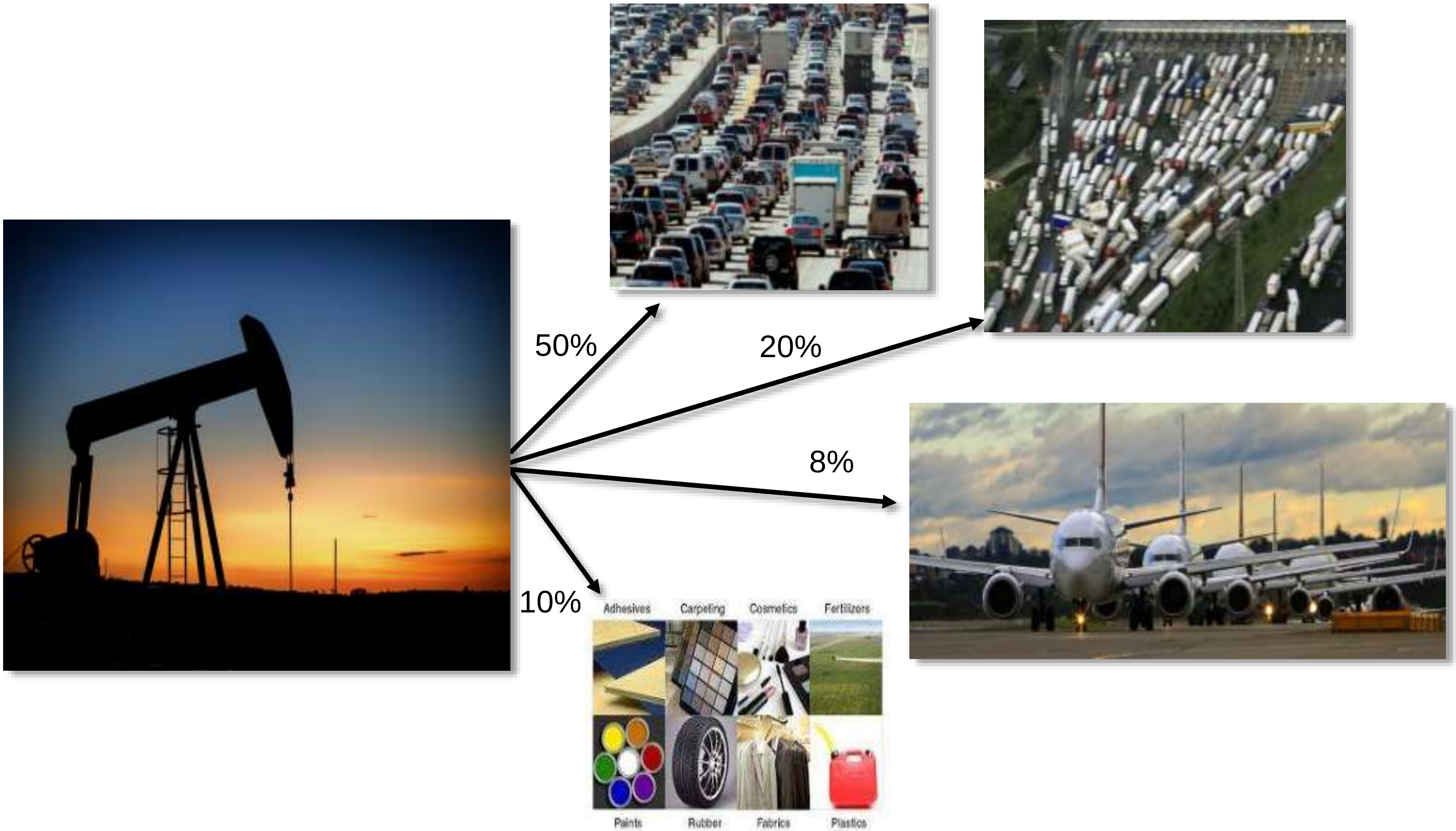
Rapid Population Growth



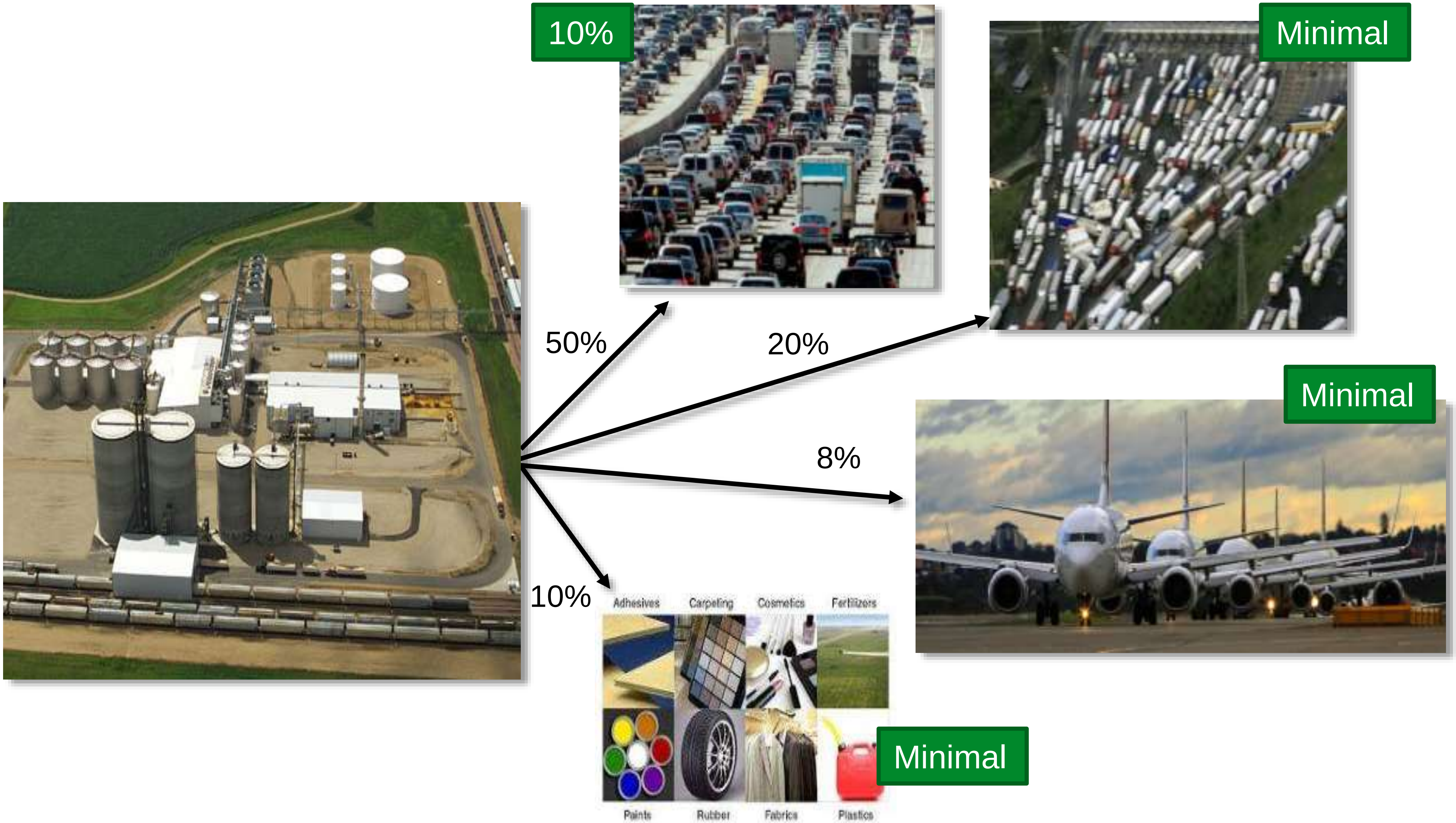
Global population expected to exceed 9B people by 2050, placing further pressure on food supply.

Fish protein consumption rate increasing 2X faster than population growth.

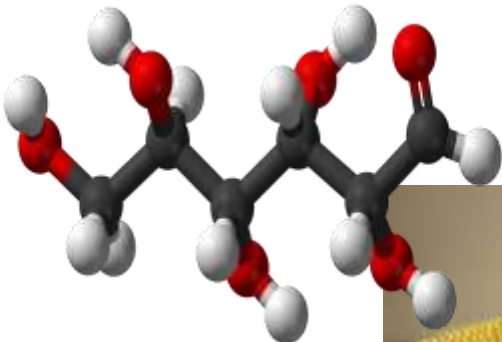
Where to Start?

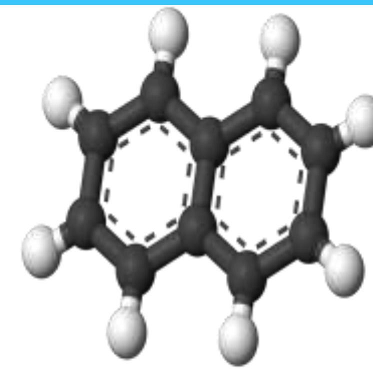


Towards a Bioeconomy



Bioeconomy Conundrum



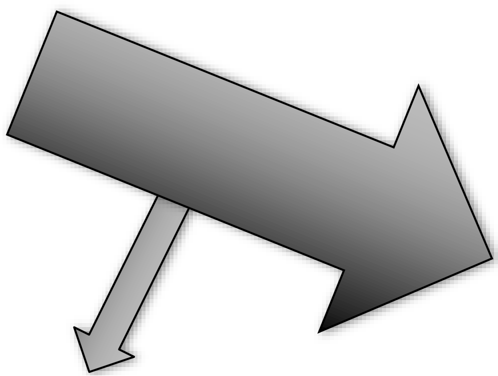


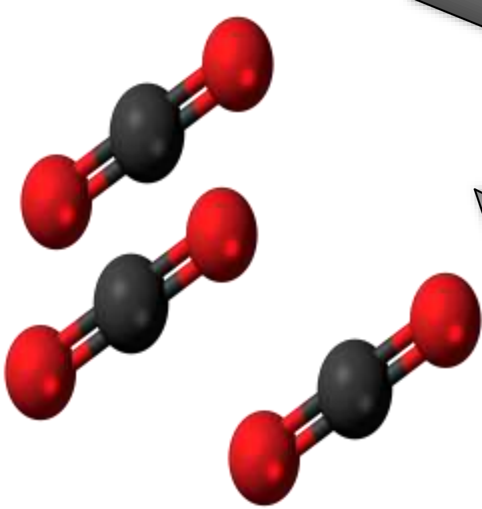
1:1 Oxygen to Carbon molecular ratio (**oxidized**)

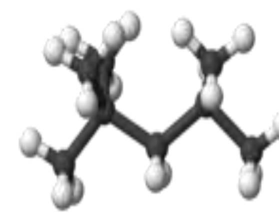
Energy = 17 MJ/kg

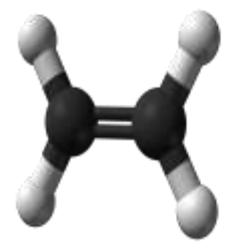
Essentially no oxygen and a lot of hydrogen (**reduced**)

Energy = 46.3 MJ/kg





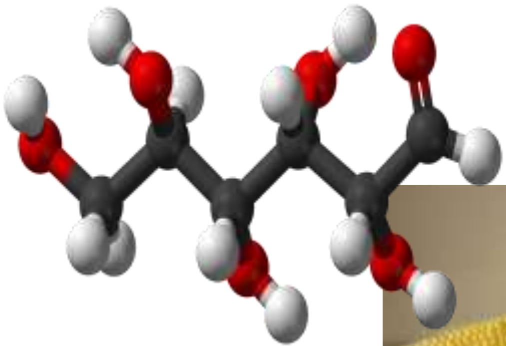


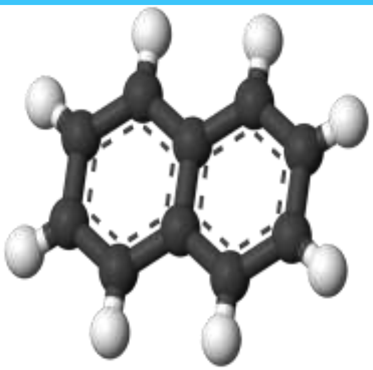


Drop-in replacements

3 – 5 tons of sugar per ton of chemical/fuel produced

Bioeconomy Conundrum





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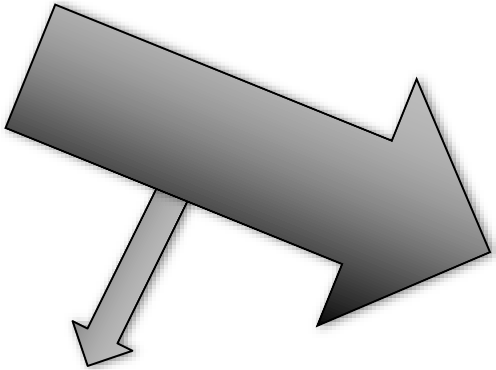
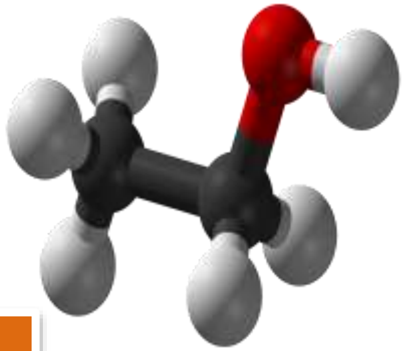
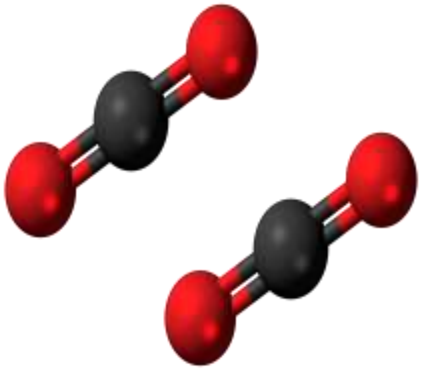


Ethanol

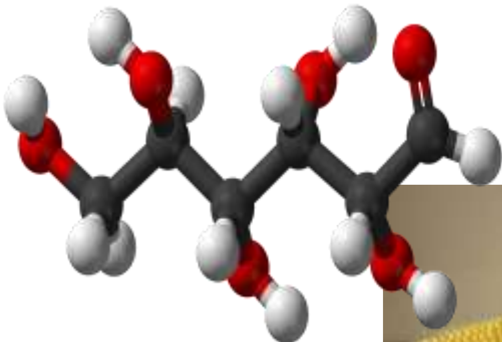


New product replacements



2 tons of sugar per ton of ethanol

Bioeconomy Conundrum

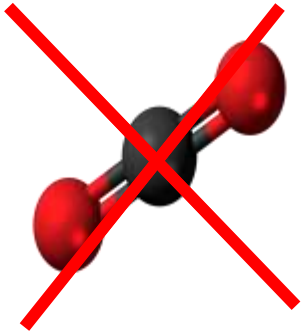


1:1 Oxygen to Carbon molecular ratio (**oxidized**)

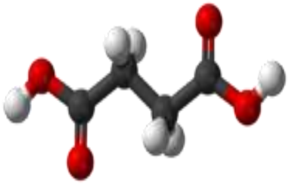
Energy = 17 MJ/kg

- Undeveloped markets
- Must be higher performance than what is being replaced
- Must be more economical
- Must integrate into entire supply chain – upstream and downstream

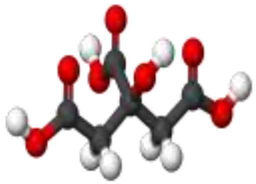
No CO_2



Succinic Acid



Citric Acid

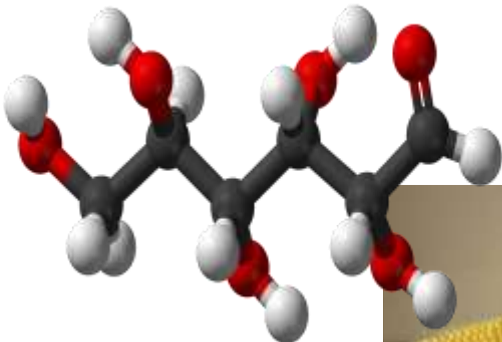


Lactic Acid

New product replacements

1 ton of sugar per ton of product

MixoFerm™ Motivation



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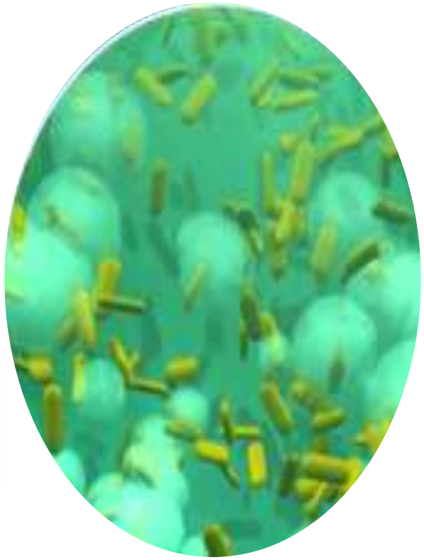
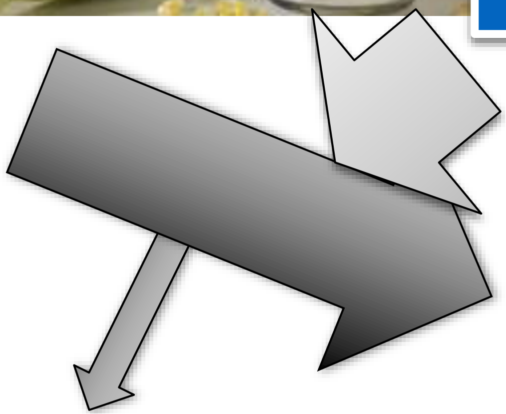
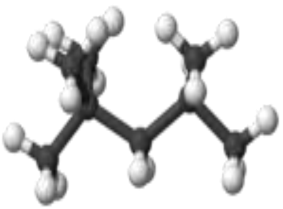
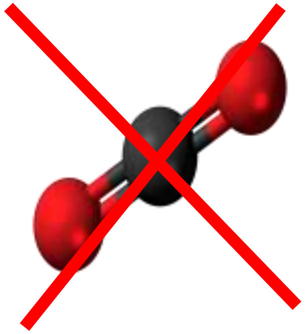


Energy rich gases – H_2 and CO – or methanol

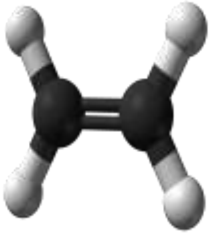




No CO_2

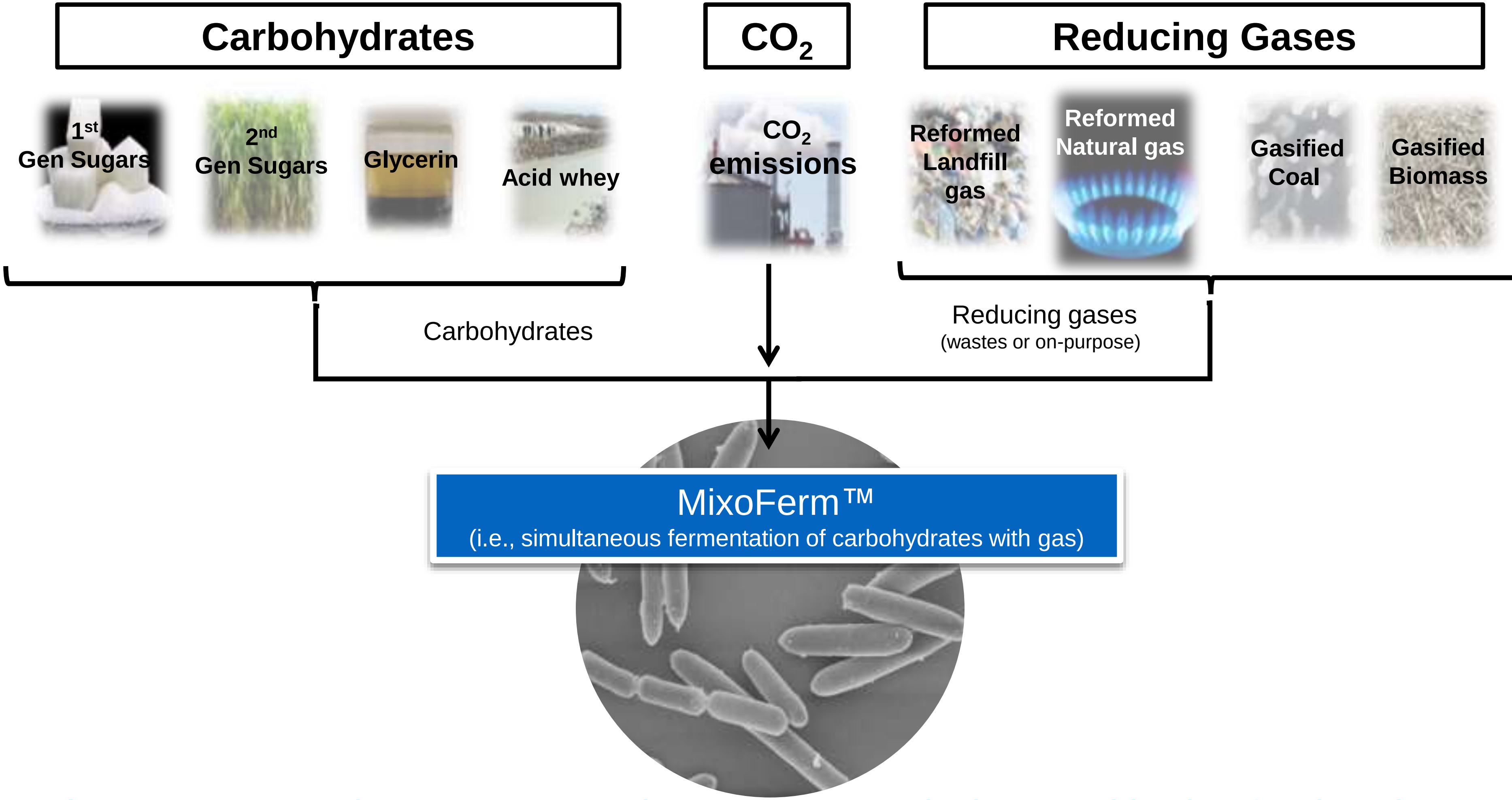


Drop-in replacements



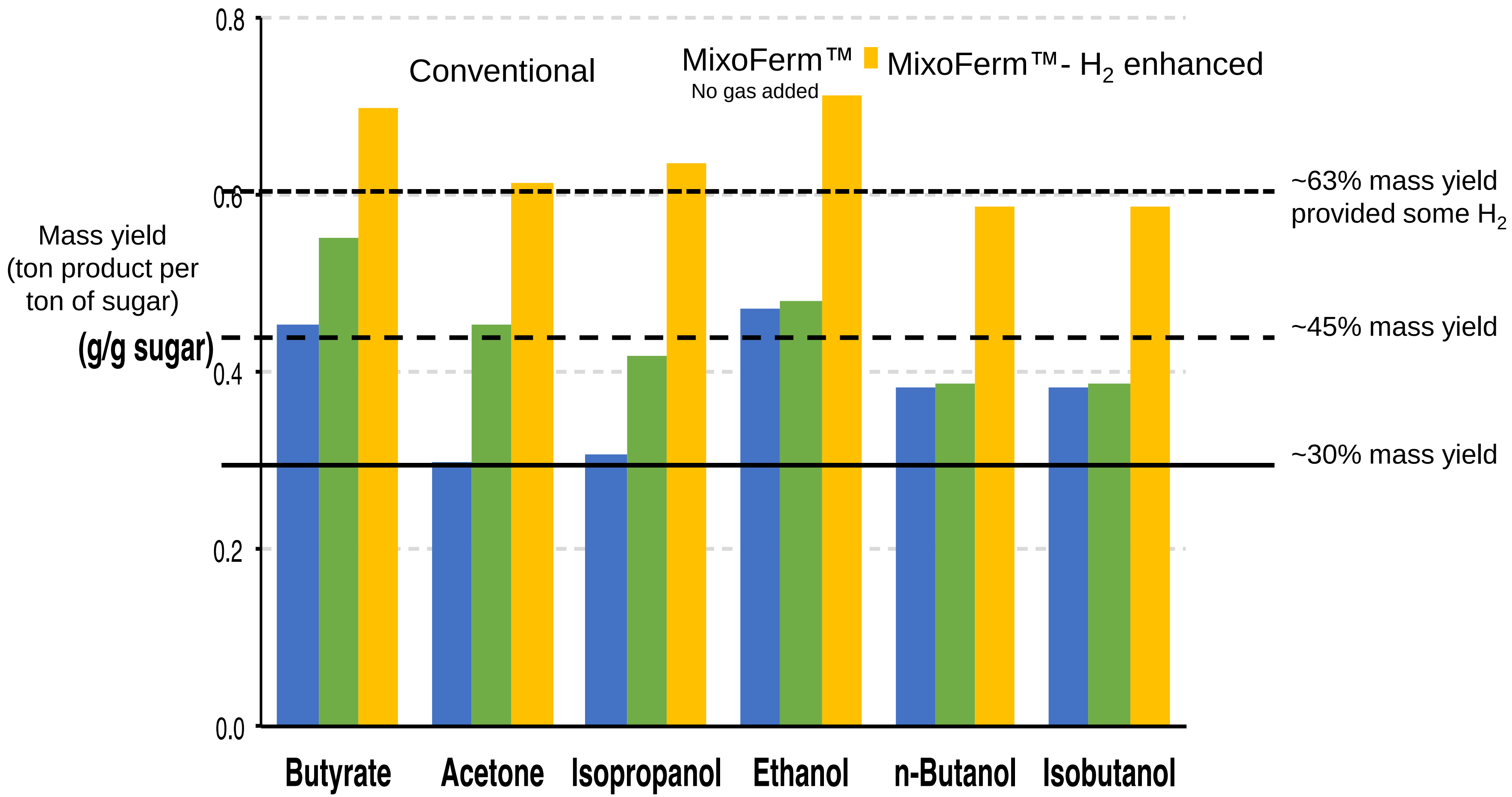
All bio-carbon converted to product

WDL's MixoFerm™ Technology



MixoFerm™ - can increase output, improve CO_2 emissions and hedge feedstock costs.

MixoFerm™ Applies to Many Biochemicals



WDL's pipeline is practically unlimited

Recognition for a New Technology

In Press

"CO_2 fixation by anaerobic non-photosynthetic mixotrophy for improved carbon conversion"

by
Shawn Jones, …, and Bryan Tracy

U.S. DEPARTMENT OF ENERGY

The DOE announced funding for six projects representing innovative technologies to advance bioenergy development.

…potentially breakthrough approaches and technologies…

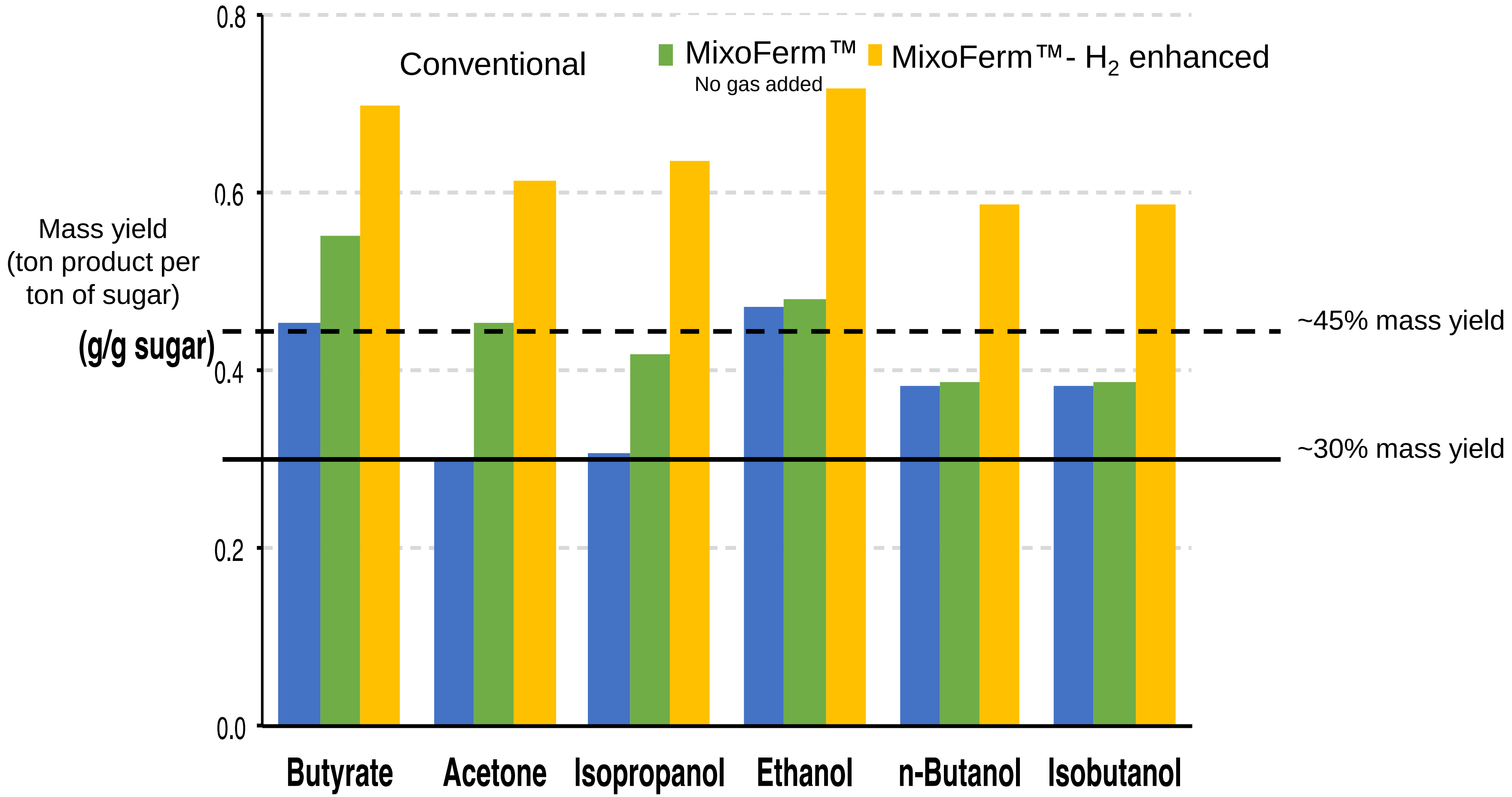
White Dog Labs:
…can concurrently consume a cellulosic sugar feedstock and CO_2, thus limiting the amount of CO_2 released from the process…

http://energy.gov/eere/articles/doe-announces-10-million-innovative-bioenergy-research-and-development

White Dog Labs CEO, Bryan Tracy
http://ethanolproducer.com/articles/13404/sugar-plus-co2-equals-more-ethanol

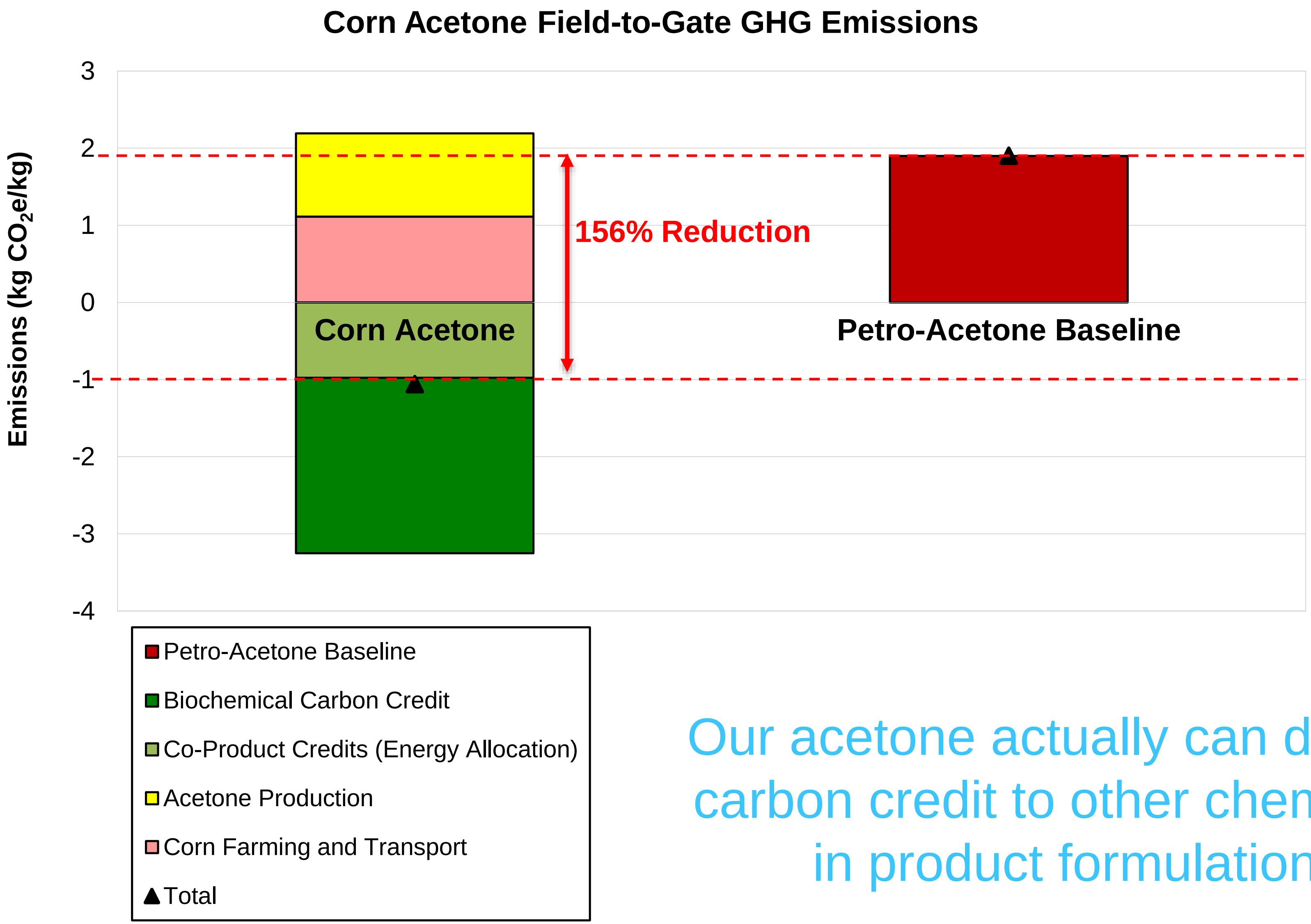
MixoFerm™ - enhancing nature's yield through sugar and gas fermentation

MixoFerm™ - Where to Start?



Acetone and IPA are our first commercial targets

Acetone CO_2 Life-Cycle Assessment (LCA)



Our acetone actually can donate carbon credit to other chemicals in product formulation

Acetone/IPA Commercialization Activities

Initial products are acetone and IPA

- Large volume markets 7M and 2M tons/year, respectively

Completed plant design and applied for a DOE loan

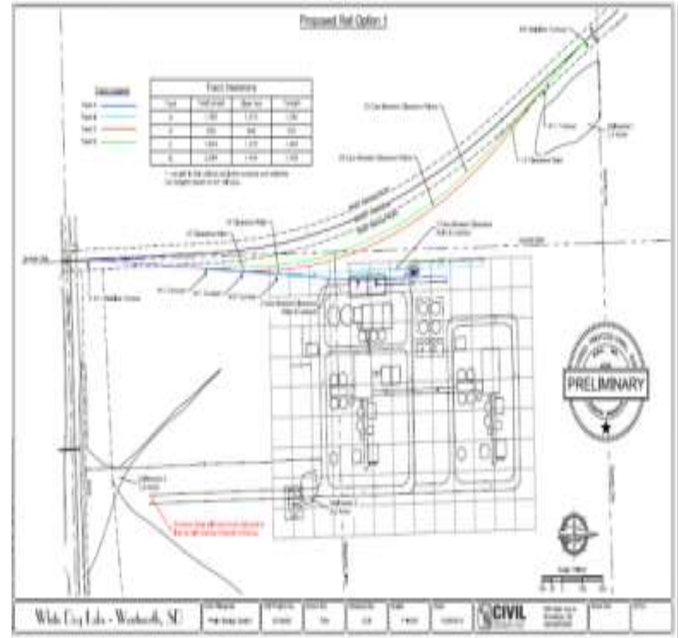
- ~$150M plant
- Startup target of 2020

Received off-take LOI for Acetone

- Acetone off-take from a major chemical company for most of the plants production

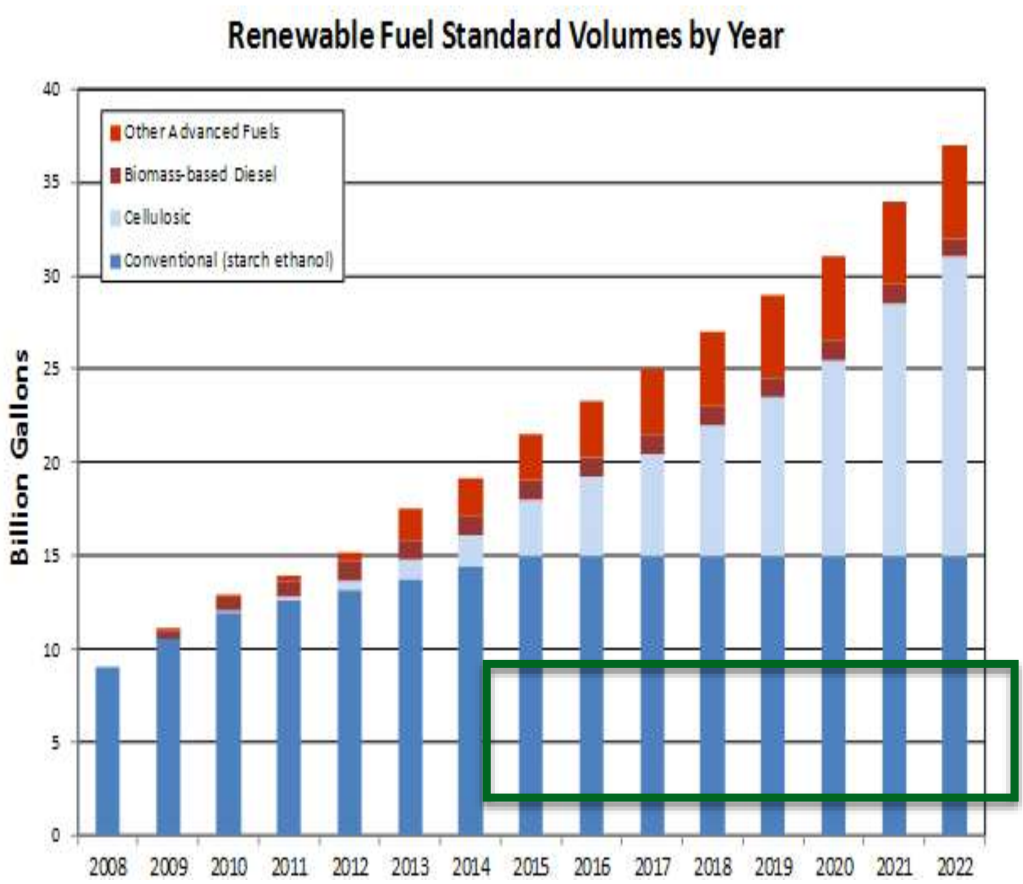
Secured options to sites in SD and MN

Completing Demonstration at our Delaware facilities



Plant IRR is 44% at 2015 average prices ($52/barrel oil)

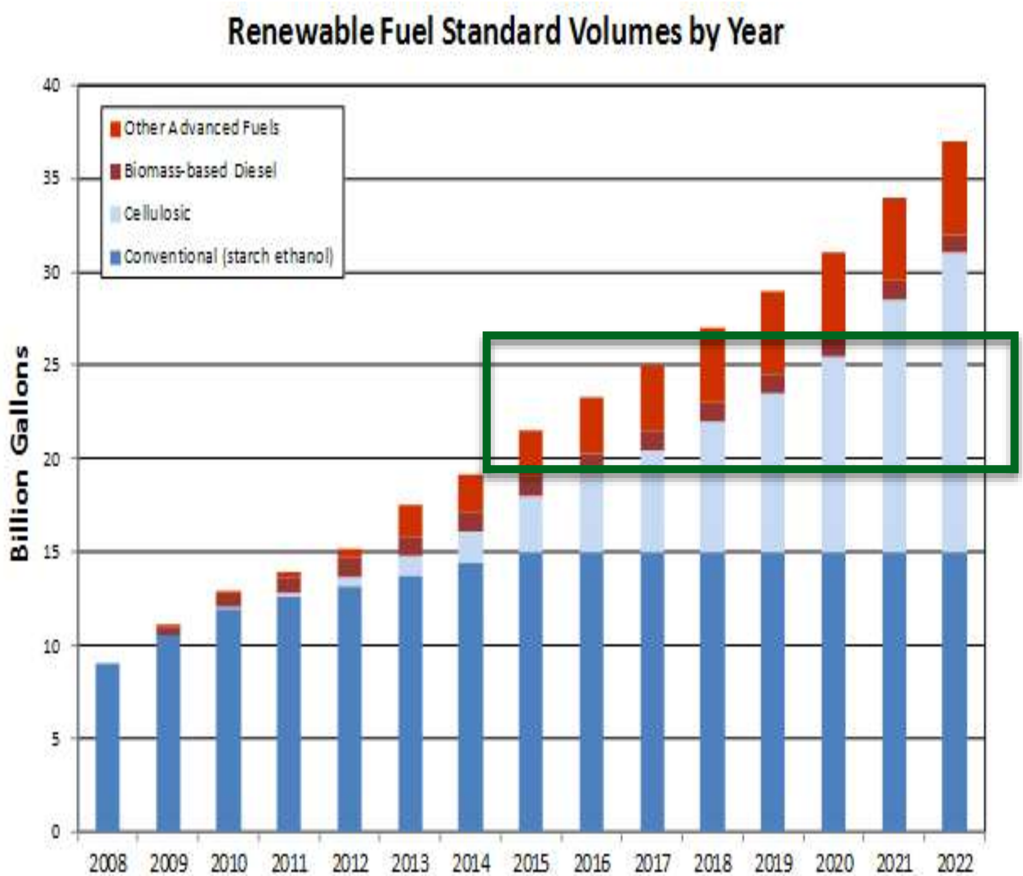
Cellulosic Ethanol Troublesome Status



15 billion gallons per year of conventional ethanol → We've done it!

So where do we stand in regards to cellulosic ethanol?

Cellulosic Ethanol Troublesome Status



15 billion gallons per year of conventional ethanol → We've done it!

16 billion gallons per year of cellulosic ethanol by 2022…

This year, projections are for <0.1 billion gallons. ***Target was 4.5 billion.***

Converting cellulose to sugar is operationally expensive and has very high capital cost.
(e.g., \$2.5/gallon conventional ethanol vs \$15 – 20/gallon cellulosic ethanol)

Does not convert ~1/3 of the reducing energy to ethanol (i.e., lignin).

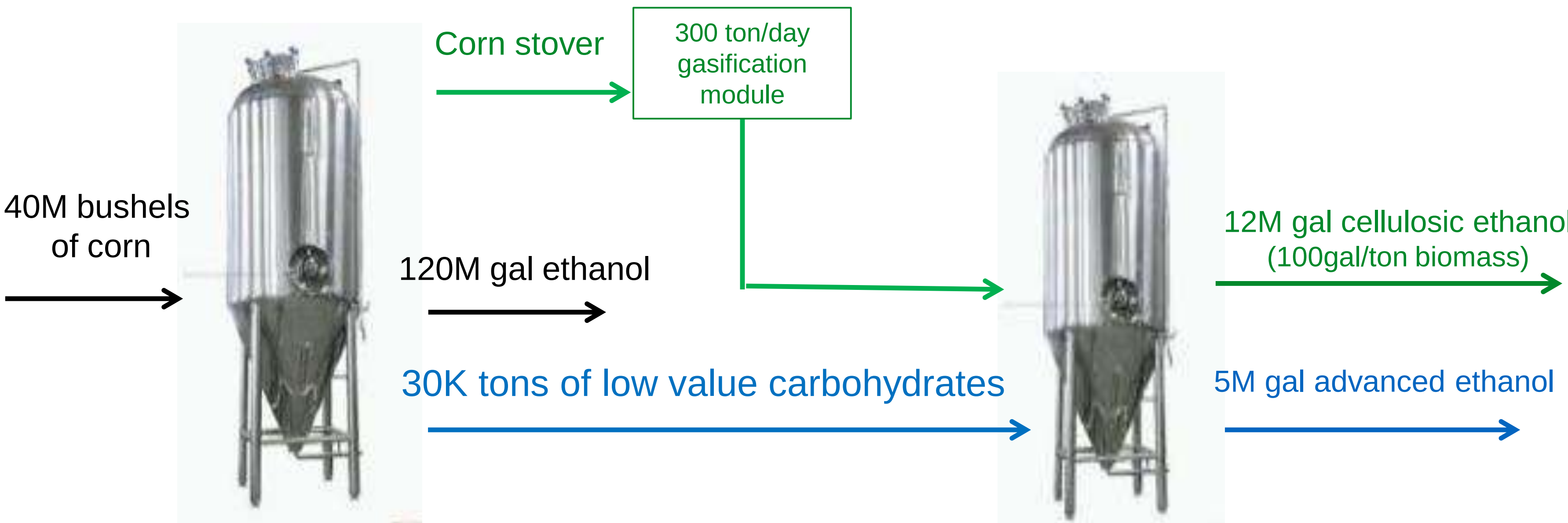
Must reduce capital costs and convert all energy in the biomass to ethanol.

MixoFerm™ Cellulosic Ethanol Approach

Existing corn Ethanol plant

“Co-located cellulosic plant”

MixoFerm™ gasification-syngas **augmented**



Existing plant
120Mgy corn ethanol

Co-located plant
5Mgy corn ethanol +12Mgy Cellulosic

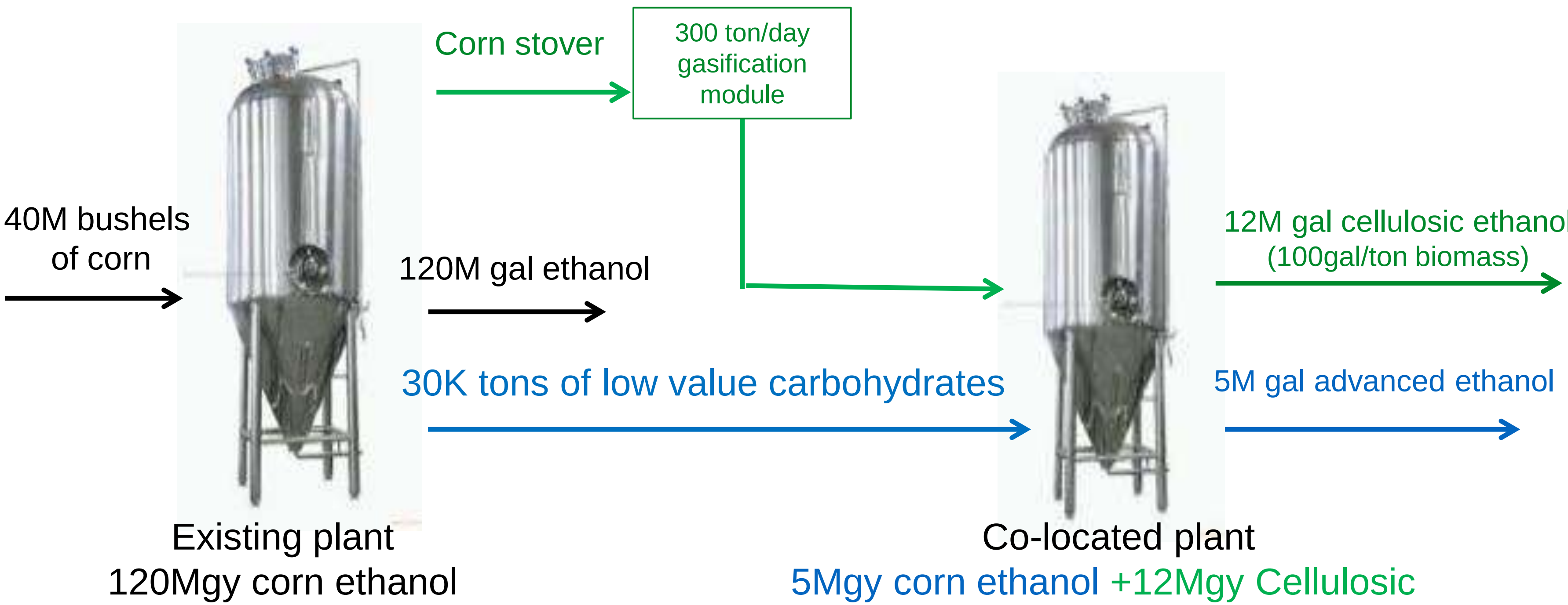
Capital estimate for new plant is $4-5/gallon and <$1.25/gallon operational cost.

MixoFerm™ Cellulosic Ethanol Approach

Existing corn Ethanol plant

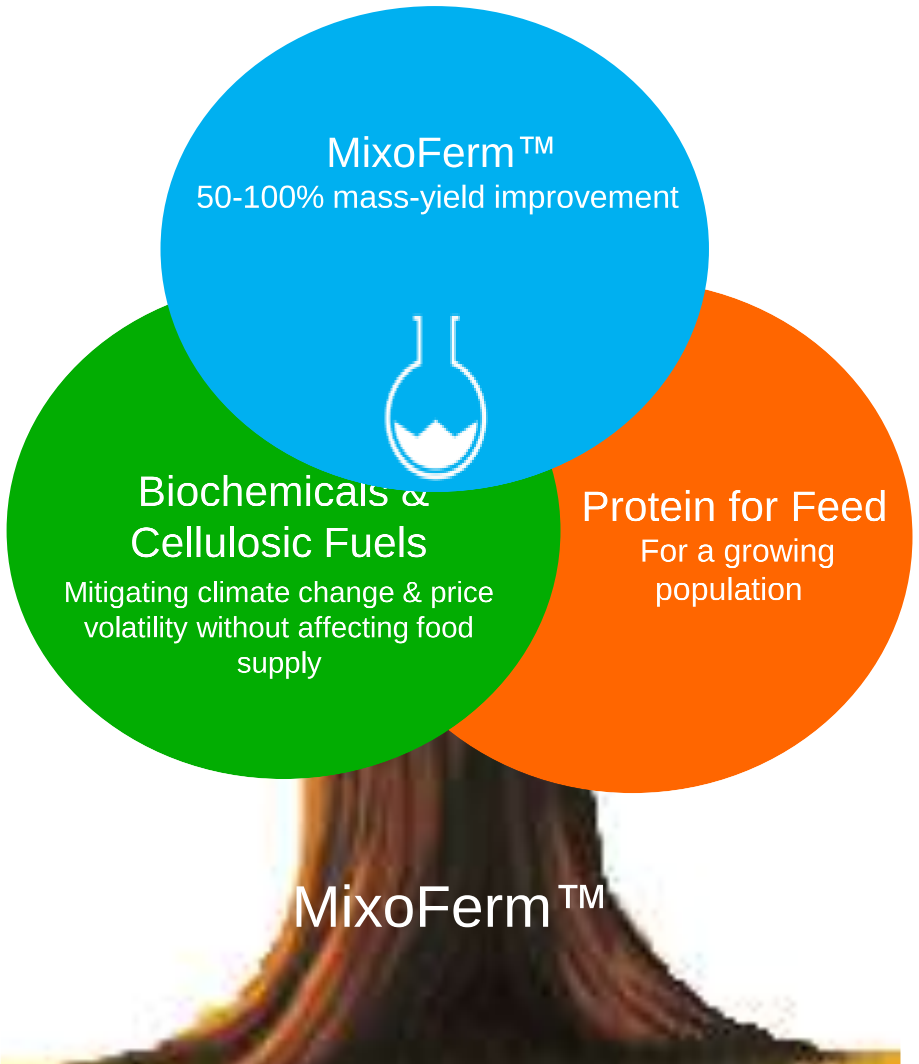
“Co-located cellulosic plant”

MixoFerm™ gasification-syngas **augmented**



Integrate with existing ethanol industry to make 2Bgy of cellulosic ethanol

White Dog Labs Summary



Industrial Biology 2.0 – Frugal, Efficient, Competitive

Pam Frank

Bill O'Connell, LC, LEED AP

LED LIGHTING – AN EMERGED TECHNOLOGY

Quote

» LED stands for “Light Emitting Diode”, but to most people it really means “Less Energy, Dude” «

Bill O’Connell

Agenda

1. Performance Improvements of LED Chips Over Time
2. Performance Improvements for LED T8 Lamps (TLEDs)
3. Performance Improvements for LED A19 Lamps
4. Performance Improvements for LED PAR38 Lamps
5. Summary and Conclusions

LED Efficacy Over Time

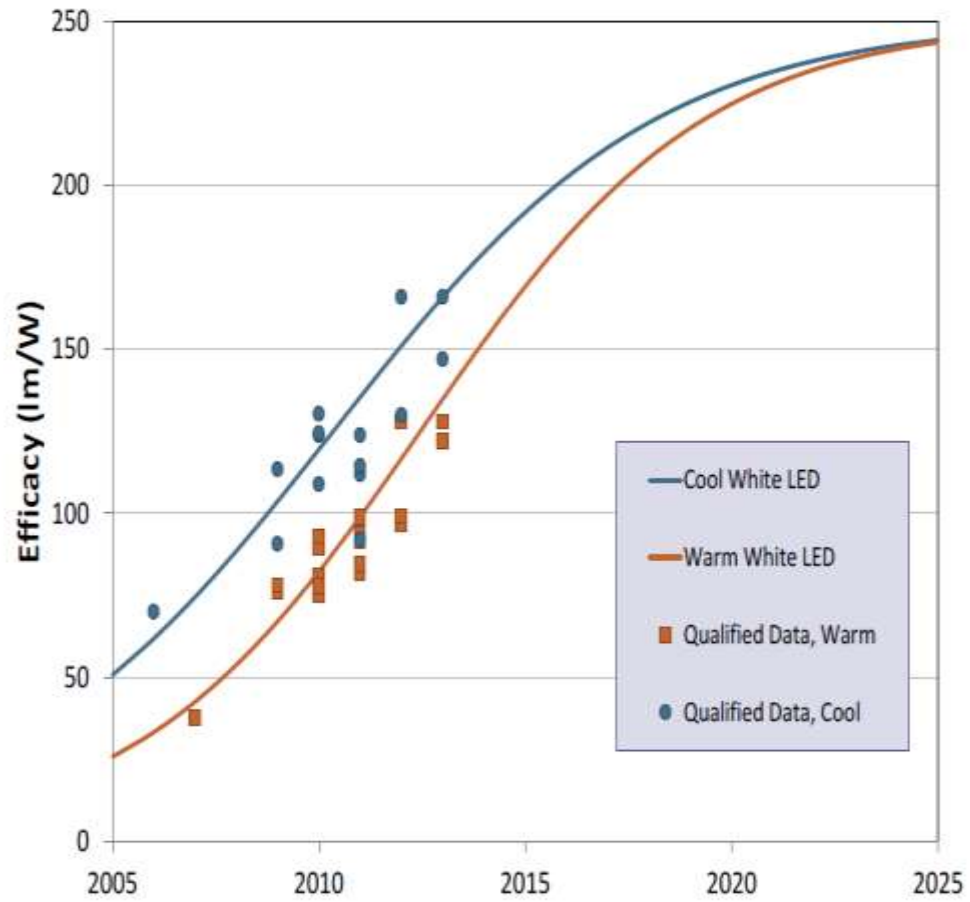
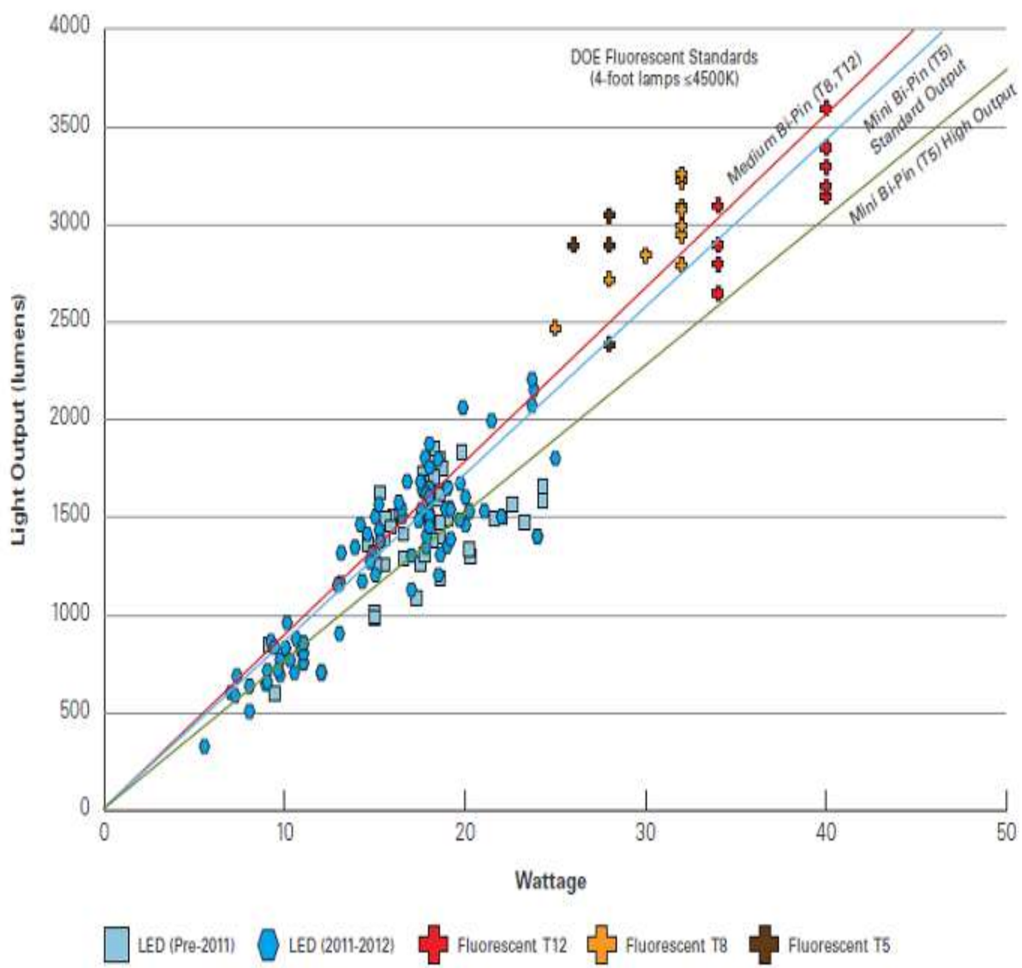


FIGURE 4.1 WHITE-LIGHT PC-LED PACKAGE EFFICACY PROJECTIONS FOR COMMERCIAL PRODUCT

- Efficacy has more than doubled over less than 10 years
- Predicted Maximum Output is > 200 Lumens per Watt in the 2020's
- There is currently a predicted theoretical maximum efficacy of 250 lm/W
- Graph Source: US Department of Energy Solid State Lighting Research and Development Multi-Year Program Plan, May 2014

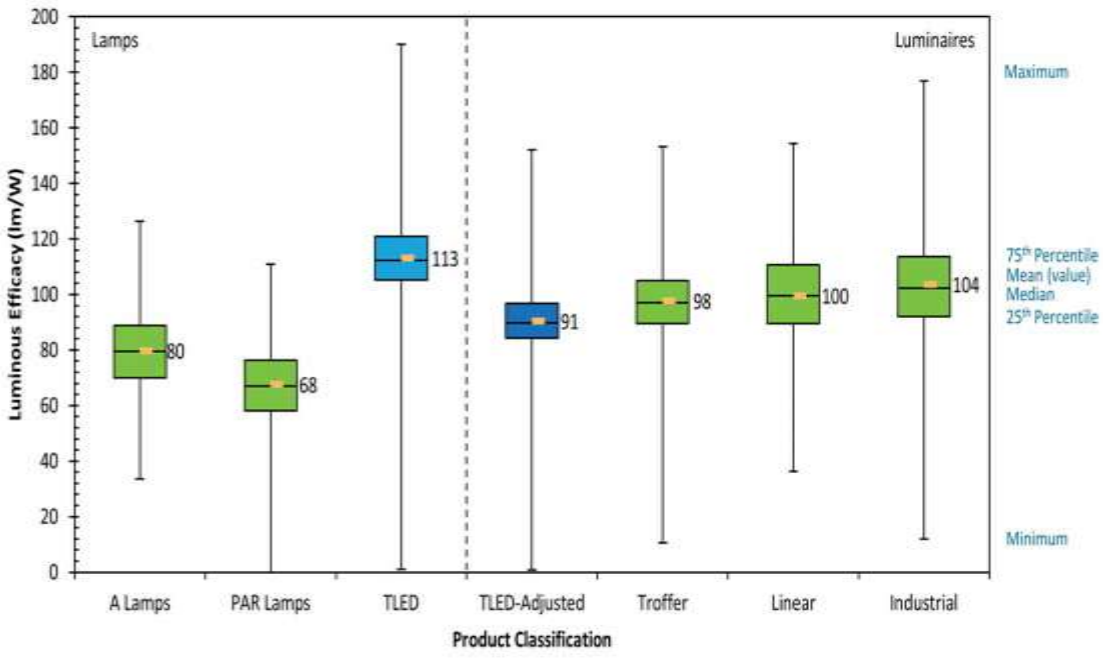
LED T8 (TLED) Performance - 2012

Figure 12: Performance of 4-Foot Linear Fluorescent and LED Replacement Lamps



- Only four years ago, no LED T8 could outperform a standard fluorescent
  - Most did not even meet Federal efficacy requirements for Fluorescent lamps
- Graph Source: Product Snapshot: LED Replacement Lamps, July 2012, US DOE

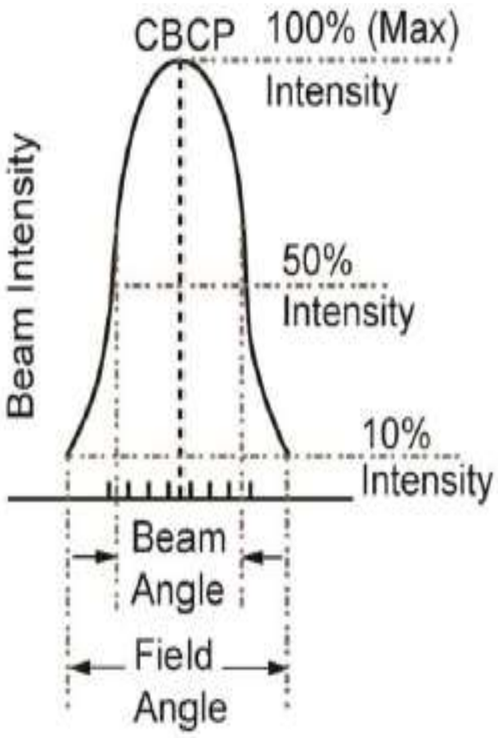
TLED Performance 2016



- In four years, TLEDs now outperform all of the standard fluorescent lamps
- DOE uses a correction factor of 80% to simulate use in a fixture to compare to LED fixtures
- Despite the very large total range (from 190 LPW to almost zero) 50% of the lamps are clustered between ~ 108 and 120 LPW
- Graph Source: US DOE CALiPER Snapshot: Linear Lamps (TLEDs), June 2016

Other Product Changes for TLED Lamps

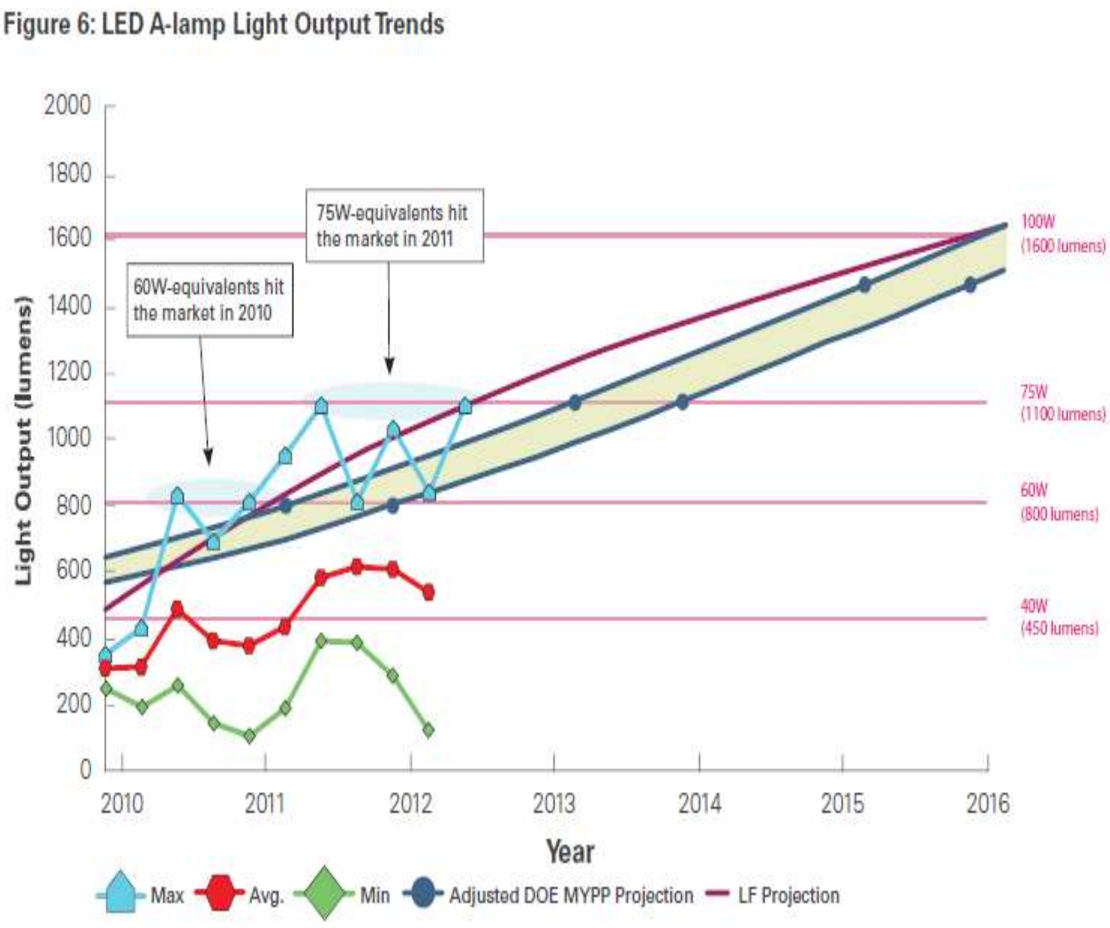
- Many TLED lamps are now made of glass rather than plastic
  - This has resulted in an increase in the beam angle for emitted light
- There are now four different lamp types available on the market
  - Type A – compatible with electronic fluorescent ballast
  - Type B – integral power supply – works off line voltage wired around ballast
  - Type C – external power supply – requires a power supply in place of the ballast to work
  - NEW – Type A and Type B



LED A Lamp Performance - 2012

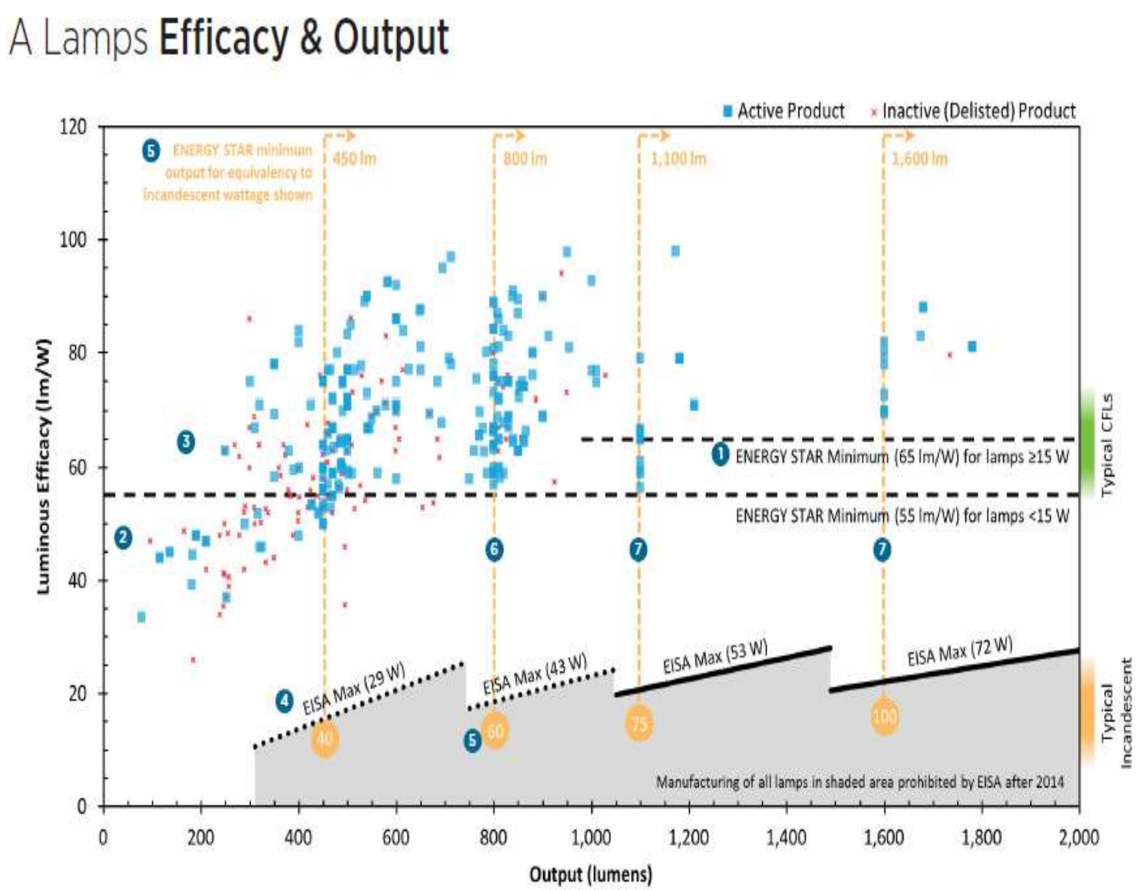
- Four years ago – no replacements for 100W incandescent lamps
- Compact Fluorescent lamps were typically higher lumen output
- Lamps were typically very directional as well
- Note the EISA 2020 line!
- Graph Source: Product Snapshot: LED Replacement Lamps, July 2012, US DOE

LED A19 Lamp Performance Trends – Summer 2012



- 75W Lamps had just reached the market
- DOE Projected date for 100W lamps was 2016
- Graph Source: Product Snapshot: LED Replacement Lamps, July 2012, US DOE

LED A19 Lamp Performance – Fall 2013



- 100W equivalent lamps already on the market
  - 3 years earlier than predicted
- Most lamps now more efficacious than typical CFL lamps
- Most lamps well above the 45 LPW EISA 2020 line
- Graph Source: US DOE CALiPER Snapshot: “Light Bulbs”, October 2013

LEDVANCE

LED A19 Lamps Circa 2014

LED A19 Lamps Circa 2016

- Lamps are now shaped like A19 lamps
- Many lamps can now be found with efficacy > 100 LPW
- Lamp weight has decreased dramaticly

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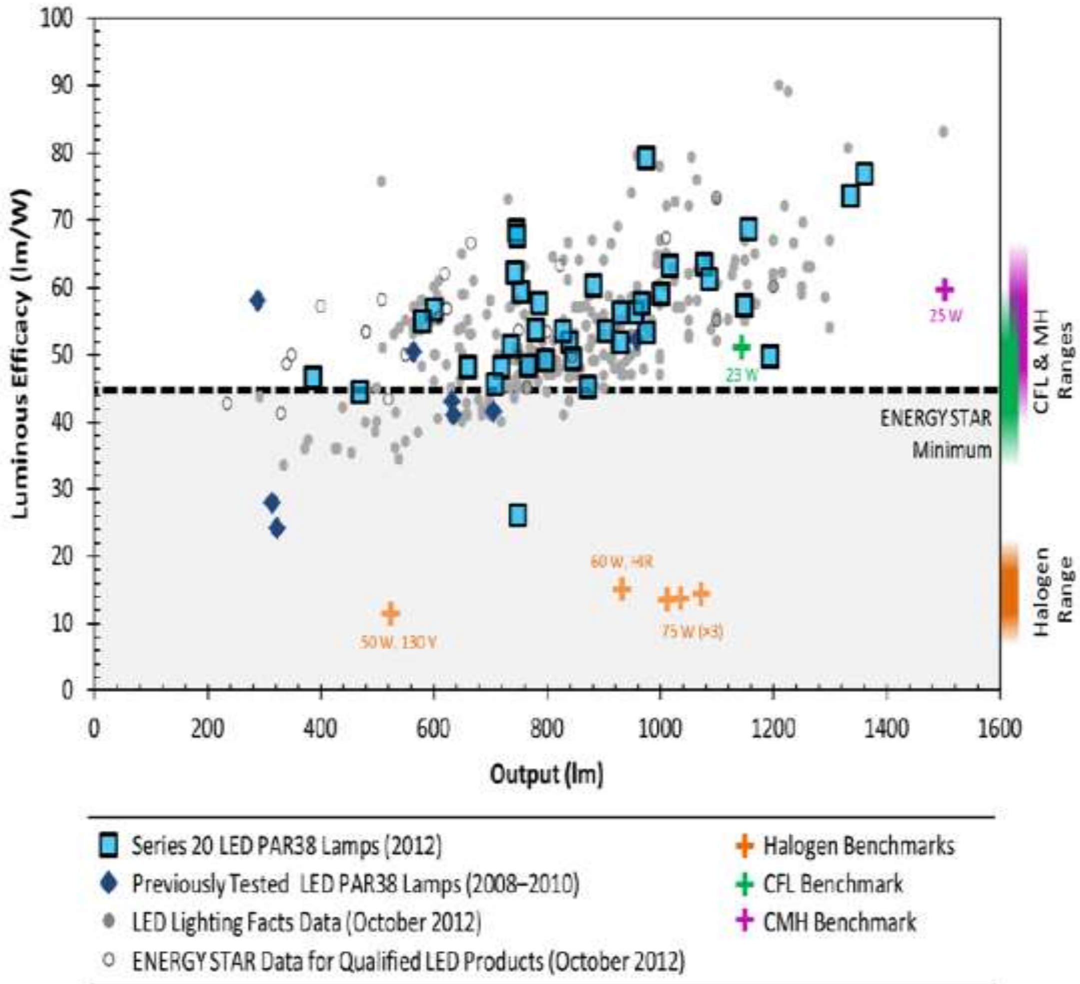
PAR38 Lamp Performance – Fall 2013



- Note the shift from previously tested lamps – moving above the EnergySTAR line
- Most lamps now more efficacious than typical CFL lamps
- Also more efficacious than sample metal halide lamp, though not as bright
- Graph Source: US DOE CALiPER Application Summary Report 20: LED PAR38 Lamps, September 2013

LEDVANCE

LED A19 Lamps Circa 2012

LED A19 Lamps Circa 2016

- Glass lamps that look like standard halogen PAR lamps
- High output PAR lamps that compete with HID versions
  - Best on the market is now ~3000 lumens
- Lamp weight is once again similar to that of halogen lamps

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LEDVANCE

Summary

- In the past six years, LED replacement lamps have made incredible advances
  - In efficacy – in some cases nearly tripling
  - In cost – which is decreasing at an astounding rate
  - In appearance
- Because of these changes, projects that even two or three years ago did not make sense, may now pay back in a reasonable time period
  - Utility incentives can make this even better
- LED Fixtures (not discussed today) have, of course, made similar improvements in the same time period

SYLVANIA

LET’S START ADVANCING LIGHT

THANK YOU

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Networking Break

Governors Hall

2016 Delaware Energy Conference

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Exceeding Expectations
20 YEARS

2016 Delaware Energy Conference

Panel Two:

Energy Resiliency

Richard Sweetser, President, Exergy Partners Corporation
Lori Van Der Voort, Director of Engineering, PWI Engineering
Dave Turner, Chief Operating Officer, Tangent Energy Solutions

Moderator: **Lauren Ryan**, Energy Services Project Developer,

Seiberlich Trane Energy Services

Resilient & Hybrid Microgrids CHP: A Key Component

Delaware Energy Conference 2016

Richard Sweetser

Senior Advisor

US DOE Mid-Atlantic CHP Technology Assistance Partnership

U.S. Department of Energy
CHP Technical Assistance Partnerships

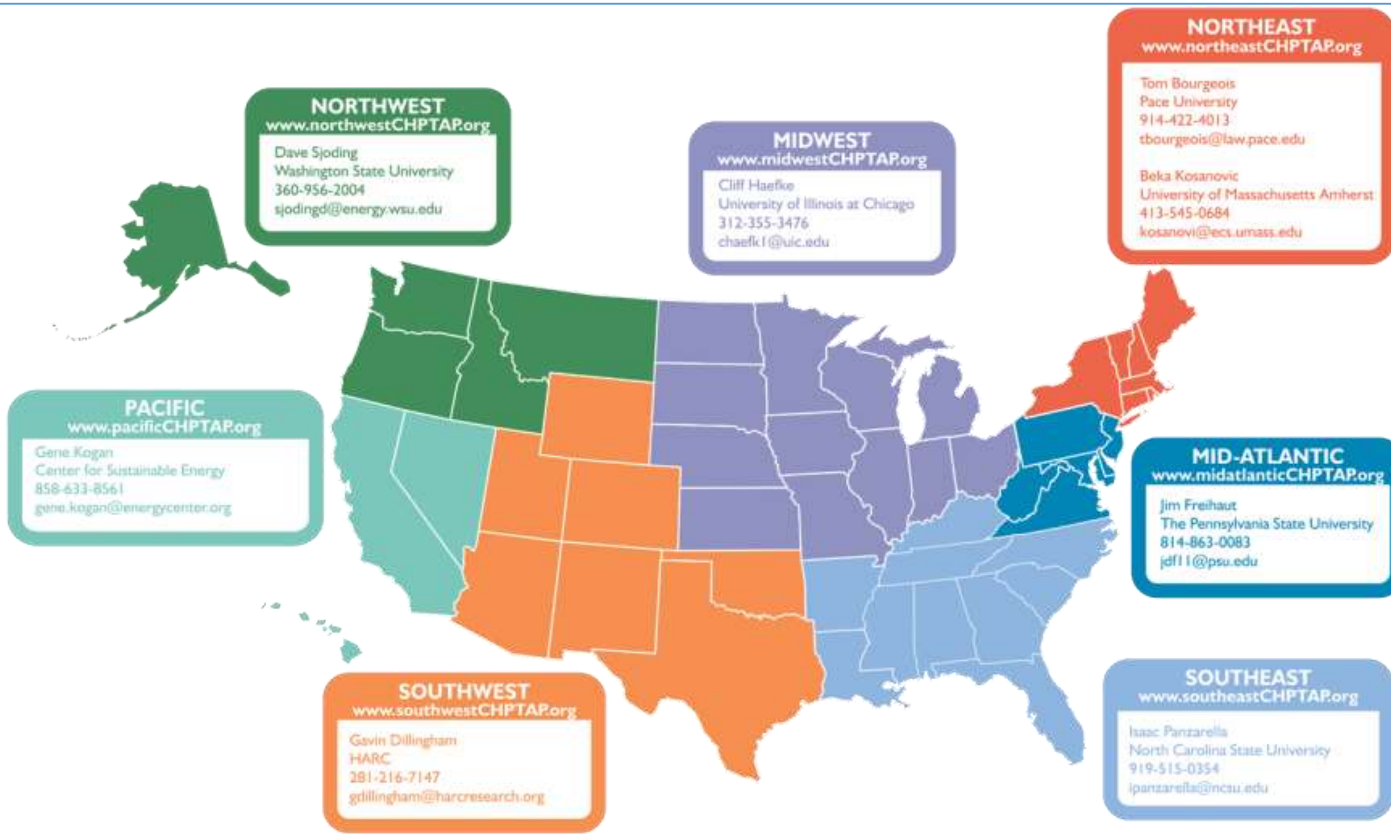
U.S. DOE CHP Deployment Program

www.energy.gov/chp

- **Market Analysis and Tracking** – Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors.
- **Technical Assistance** through DOE's CHP Technical Assistance Partnerships (CHP TAPs) – Promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP throughout the United States
- Just Launched **Combined Heat and Power (CHP) for Resiliency Accelerator** - Collaborating with Partners to support consideration of CHP and other distributed generation solutions for critical infrastructure resiliency planning at the state, local, and utility levels
- **Packaged CHP System Challenge** (under development) - Increase CHP deployment in underdeveloped markets with standardized, and warrantied packaged CHP systems driven by strong end-user engagement via Market Mover Partners, such as cities, states, and utilities


East Bay
Municipal Utility District

DOE CHP Technology Assistance Partnerships



DOE CHP Technical Assistance Partnerships (CHP TAPs): Program Contacts

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U.S. Department of Energy
CHP Technical Assistance Partnerships
MID-ATLANTIC

CHP Technical Assistance Partnerships

Technical Assistance
Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility and to help them through the development process from initial CHP screening to installation.

Education and Outreach
Providing information on the energy and non-energy benefits and applications of CHP to state and local policy makers, regulators, end users, trade associations, and others.

Market Opportunity Analysis
Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors

Agenda

- Definitions
- Microgrid Drivers
- CHP and Microgrids
- Key Microgrid Policy Issues: Legal and Regulatory
- Microgrid Case Study – Princeton University

Definitions

Resiliency

Resilience is "the ability to become strong, healthy, or successful again after something bad happens."

…….Merriam-Webster

Microgrid

Microgrid

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Key Attributes

- Grouping interconnected loads and distributed energy resources
- Can operate in island mode or grid-connected
- Can connect and disconnect from the grid
- Acts as a single controllable entity to the grid

Source: https://building-microgrid.lbl.gov/microgrid-definitions

Microgrid Basics

The Load

Base Load = Load that exists 85% of all facility operating hours
Peak Load = Maximum demand during 12-month period
Critical Load = Minimum load demand to operate critical functions

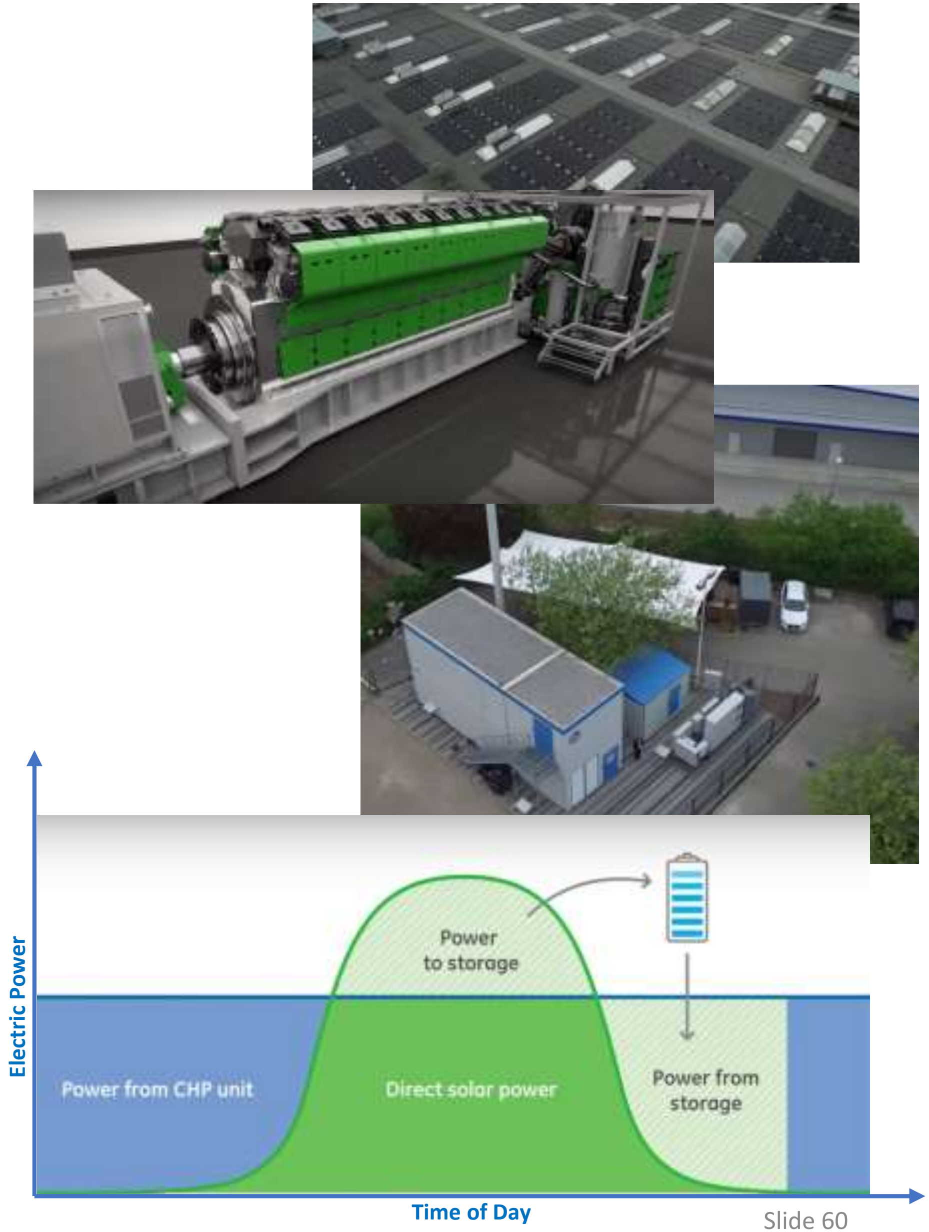
Distributed Generation (DG) = Creates power to operate independent of utility grid.

“**Island Mode**” = separated from utility grid, all loads supplied with power from DG.

“**Parallel Mode**” = DG resources operating in parallel with utility grid.

Resilient/Hybrid Microgrid

Hybrid microgrids (a.k.a. clean microgrids) combine high efficiency CHP systems, renewable energy generators and batteries to provide power and thermal energy.

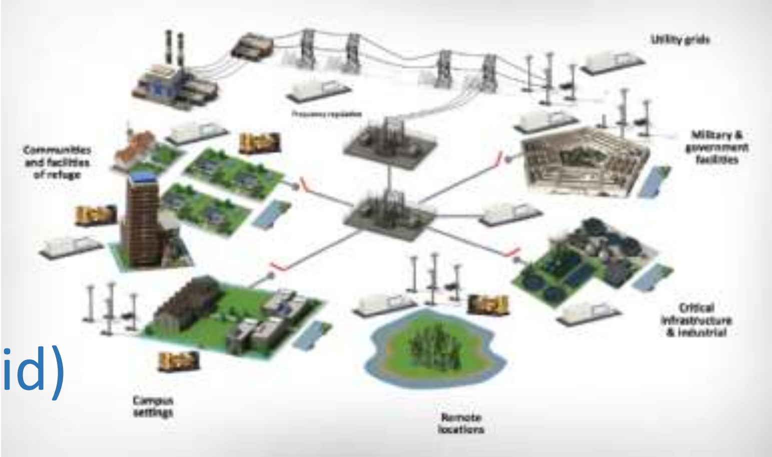


Source: http://microgridmedia.com/ge-berlin-hybrid-power-plant-combines-chp-solar-and-smart-battery-storage/

Resilient/Hybrid Microgrid

A Resilient Microgrid consists of many components:

- CHP
- Standby/DR DG
- Solar PV, Wind (for Hybrid)
- Thermal Storage
- Power Storage (required for Hybrid)
- Smart Switchgear
- Power Distribution (multiple buses)
- Load/Power Management Controls
- Parallel/Island Mode Utility Interconnection



Source: http://www.eaton.com/FTC/healthcare/MicrogridEnergySystems/index.htm

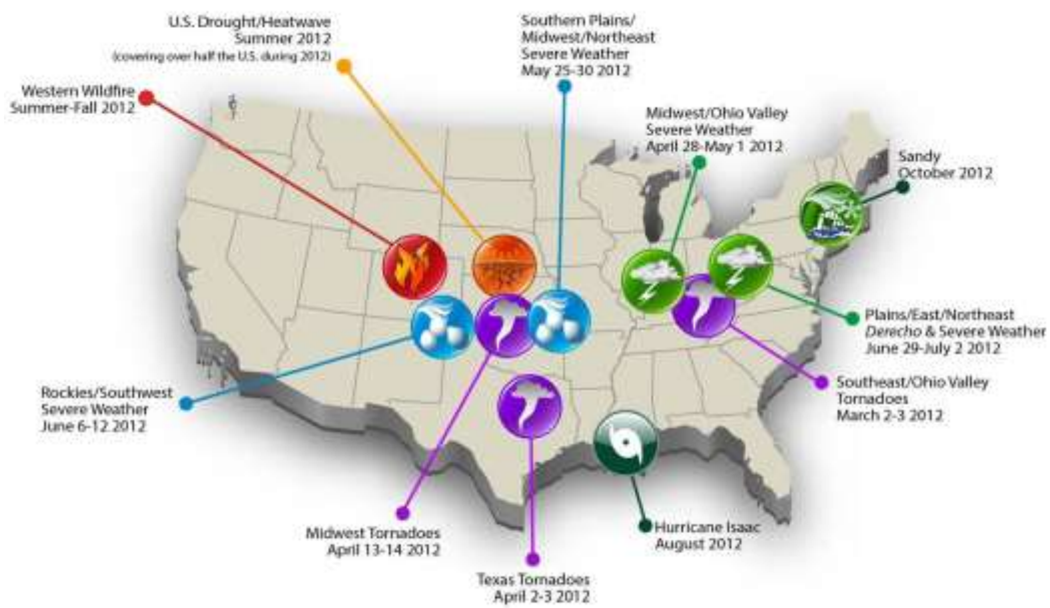
Source: DOE CHP TAP

Microgrid Drivers

The Impact of Extreme Weather on the Electrical Grid

According to the U.S. Department of Energy, outages caused by severe weather such as thunderstorms, hurricanes, and blizzards account for 58 percent of outages observed since 2002 and 87 percent of outages affecting 50,000 or more customers.

U.S. 2012 Billion-dollar Weather and Climate Disasters



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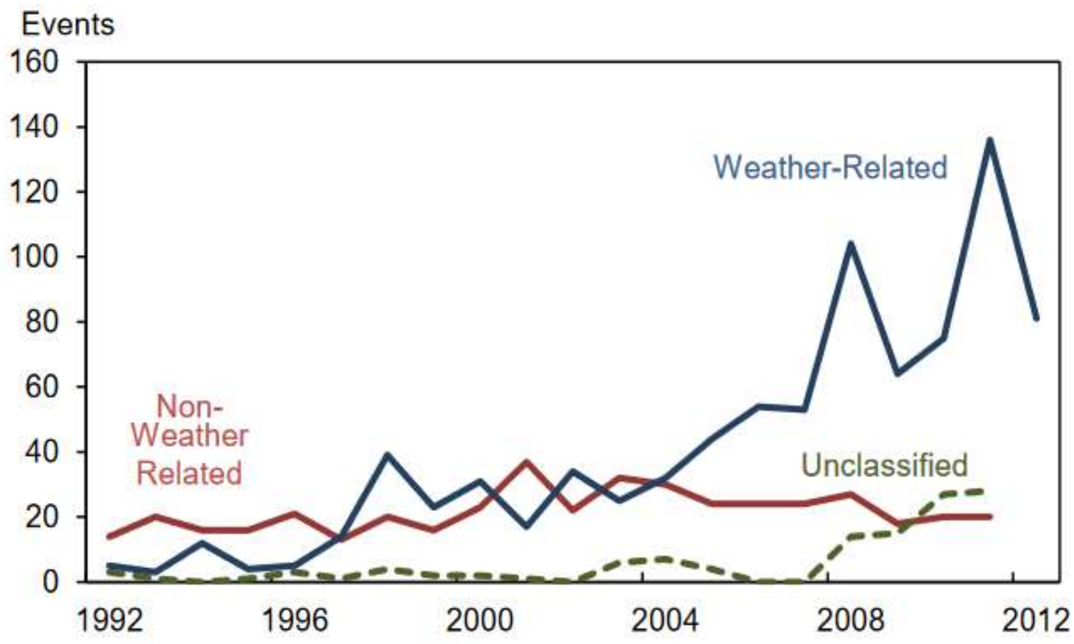
Source: National Oceanic and Atmospheric Administration

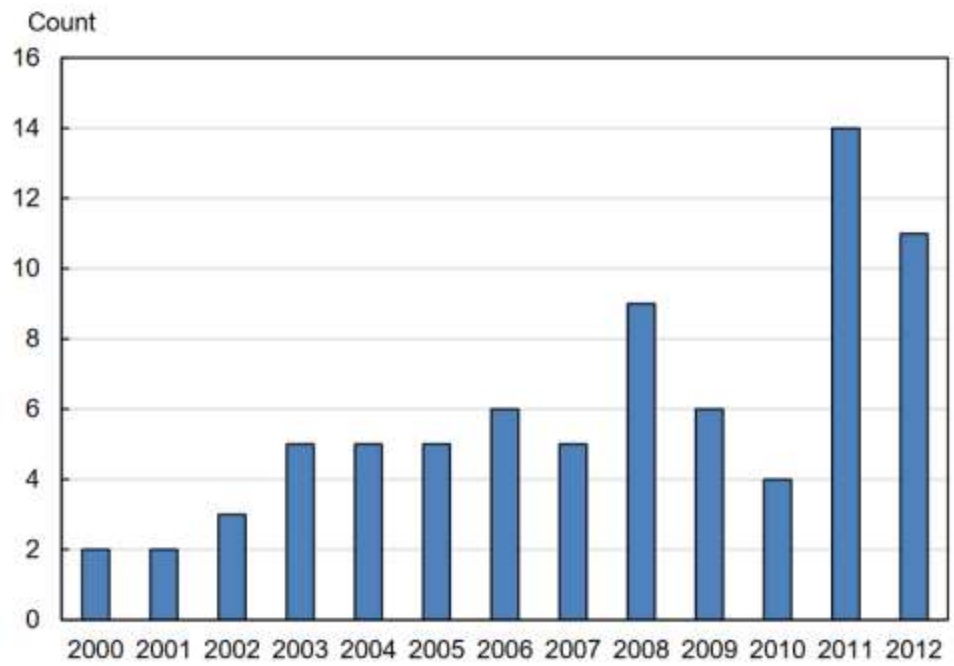
Observed Outages to the Bulk Electric System, 1992 - 2012



Source: Energy Information Administration

Billion - Dollar Weather/Climate Disasters

Seven of the ten costliest storms in U.S. history occurred between 2004 and 2012 (U.S. DOC 2012)



Source: National Oceanic and Atmospheric Administration (NOAA)

U.S. DEPARTMENT OF ENERGY
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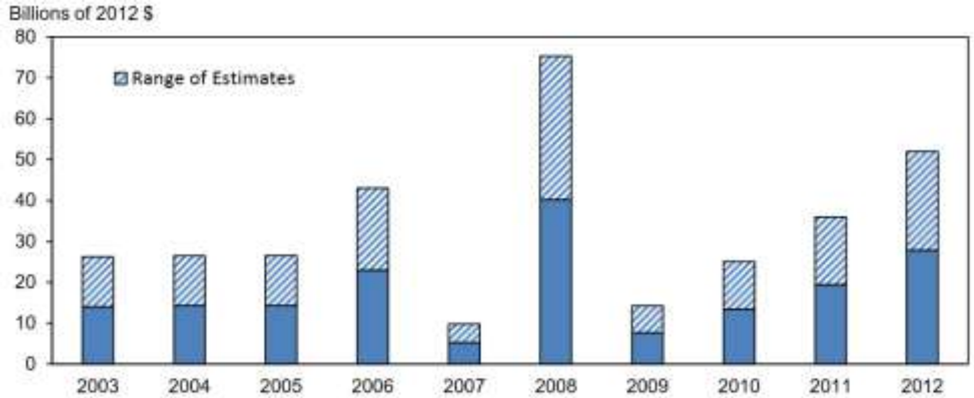
Estimated Costs of Weather - Related Power Outages

These estimates account for numerous costs associated with power outages including: lost output and wages, spoiled inventory, inconvenience and the cost of restarting industrial operations. The value of lost output can be calculated separately using the DOE MRDS and additional aggregate wage and output data. When calculated, the calculations show that between 20 and 25 percent of the annual cost of weather-related power outages are due to lost output.



Source: Source: CEA estimates using data from Census Bureau, Department of Energy , Energy Information Administration, Sullivan et al 2009

Microgrids are Focusing on Critical Infrastructure

"Critical infrastructure" refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety."

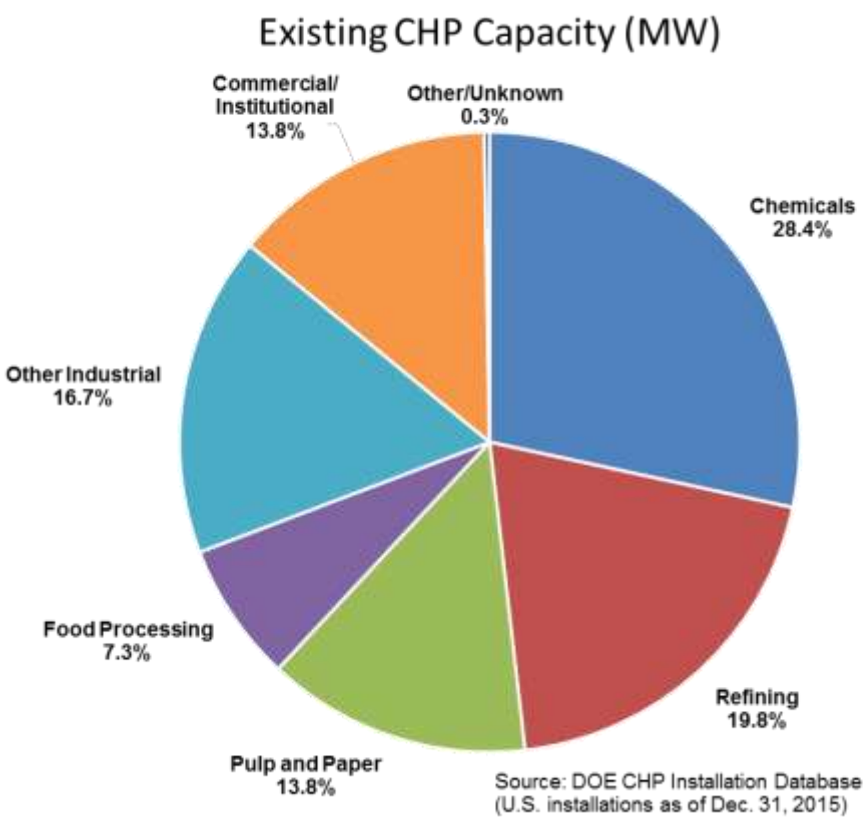
- Patriot Act of 2001 Section 1016 (e)
- Applications:
  - Hospitals and healthcare centers
  - Water / wastewater treatment plants
  - Police, fire, and public safety
  - Centers of refuge (often schools or universities)
  - Military/National Security
  - Food distribution facilities
  - Telcom and data centers

CHP and Microgrids

Microgrids & CHP

- CHP can be the keystone of Resilient Microgrids:
- CHP provides reliable dispatchable power
- CHP provides thermal energy during grid outage
- CHP results in daily operating cost savings that can significantly help offset costs of resilient microgrids
- CHP reduces GHG emissions
- CHP can offset some capital costs associated with investments in traditional backup power

CHP Today in the United States



- 81 GW of installed CHP at over 4,300 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than 1.8 quadrillion Btus of fuel consumption annually
- Avoids 241 million metric tons of CO2 compared to separate production

U.S. Department of Energy
CHP Technical Assistance Partnerships
Mid-Atlantic

CHP Saves Energy and Reduces Emissions

Category	10 MW CHP	10 MW PV	10 MW Wind
Annual Capacity Factor	85%	25%	34%
Annual Electricity	74,446 MWh	21,900 MWh	29,784 MWh
Annual Useful Heat	103,417 MWh_t	None	None
Capital Cost	$24 million	$45 million	$24.4 million
Annual Energy Savings	343,747 MMBtu	225,640 MMBtu	306,871 MMBtu
Annual CO_2 Savings	44,114 Tons	20,254 Tons	27,546 Tons
Dollars/Ton CO_2 Savings	$544/Ton	$2,222/Ton	$886/Ton

Based on: 10 MW Gas Turbine CHP - 30% electric efficiency, 70% total efficiency, 15 PPM NOx
Electricity displaces National All Fossil Average Generation (eGRID 2010) -
9,720 Btu/kWh, 1,745 lbs CO_2/MWh, 2.3078 lbs NOx/MWH, 6% T&D losses
Thermal displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NOx emissions

Source: Combined Heat and Power and the Clean Power Plan, NARUC 2015 Winter Meeting February 16, 2015, Bruce Hedman, Institute for Industrial Productivity

Favorable Characteristics for CHP Applications

Important

- Concern about energy costs
- Concern about power reliability
- Concern about sustainability and environmental impacts
- Long hours of operation
- Concurrent thermal loads
- Central heating and cooling distribution system

Vital

Helpful

- Future central plant replacement and/or upgrades
- Future facility expansion or new construction projects
- EE measures already implemented
- Access to nearby renewable fuels
- Facility energy champion

Designing for Reliability

Two Generator Types

- Induction
  - Requires external power source to operate
  - When grid goes down, generator goes down
  - Less Complicated and Costly to Interconnect
- Synchronous
  - Self Excited (Does not need grid to operate)
  - Generator can operate thru Grid outages
  - More Complicated and Costly to Interconnect

Uninterrupted Operation Requirements

- Black start capability
  - Allows the system to start up independently from the grid
- Generators capable of grid-independent operation
  - The system must be able to operate without grid power signal
- Ample Carrying Capacity
  - System size must match critical loads
- Parallel utility interconnection and switch gear controls
  - The system must be able to disconnect from the grid, support critical loads, and reconnect after an event

CHP & Electric Resiliency

	Backup Generator	CHP
System Performance	• Only used during emergencies	• Designed and maintained to run continuously with high reliability
Fuel Supply	• Limited by on-site storage and transportation availability	• Natural gas typically not impacted by severe weather
Transition from Grid Power	• Quick pickup meets most requirements	• Lower block load capacity may necessitate additional switchgear
Energy Supply	• Electricity	• Electricity & Thermal
Emissions	• Commonly burn diesel fuel	• Typically natural gas fueled resulting in Lower emissions

Resilient CHP versus Traditional CHP

- CHP is typically designed for the thermal load and may require additional DG to meet CI load requirements
- Block loading capabilities of gas engines may require additional switchgear – can be significant
- Gas engines cannot meet some power restoration requirements so may require diesel engines to comply
- Energy cost offsets do not increase with complexity or cost of resiliency without LOL remuneration

Key Policy Issues: Legal and Regulatory

Key Policy Issues: Legal and Regulatory

- Clarity on the regulatory treatment of the project: are the onsite generation plant(s) qualifying facilities?
- Organizing / Synchronizing / Contracting multiple unaffiliated entities to participate.
- Determining how microgrid affects safe & reliable operation of the macrogrid (both positive and negative).
- Structure standby rates to fair market value reflective of time of use and load requirement of facility taking from and providing to the grid; should include impact of lost load on other customers-- positive and negative
- Project risks and responsibilities of owner/operators and those served require clear definition.
- Interconnection: what design and operating requirements should be imposed on DG of certain sizes and types to support the macrogrid?

Policy actions can increase the economic potential and reduce perceived risks of CHP

- Include CHP as a qualified resource in energy efficiency resource standards and rate-payer efficiency program
- Include CHP in existing and new energy and environmental incentive programs and credit initiatives
- Standardized interconnection requirements
- Fair and reasonable standby rates designed based on contractual cost of service
- Allow for utility ownership
- Clean Power Plan compliance option
- Continue to lead by example with inclusion of CHP and other DG in government buildings (like the recent federal AFFECT FOA for federal buildings)

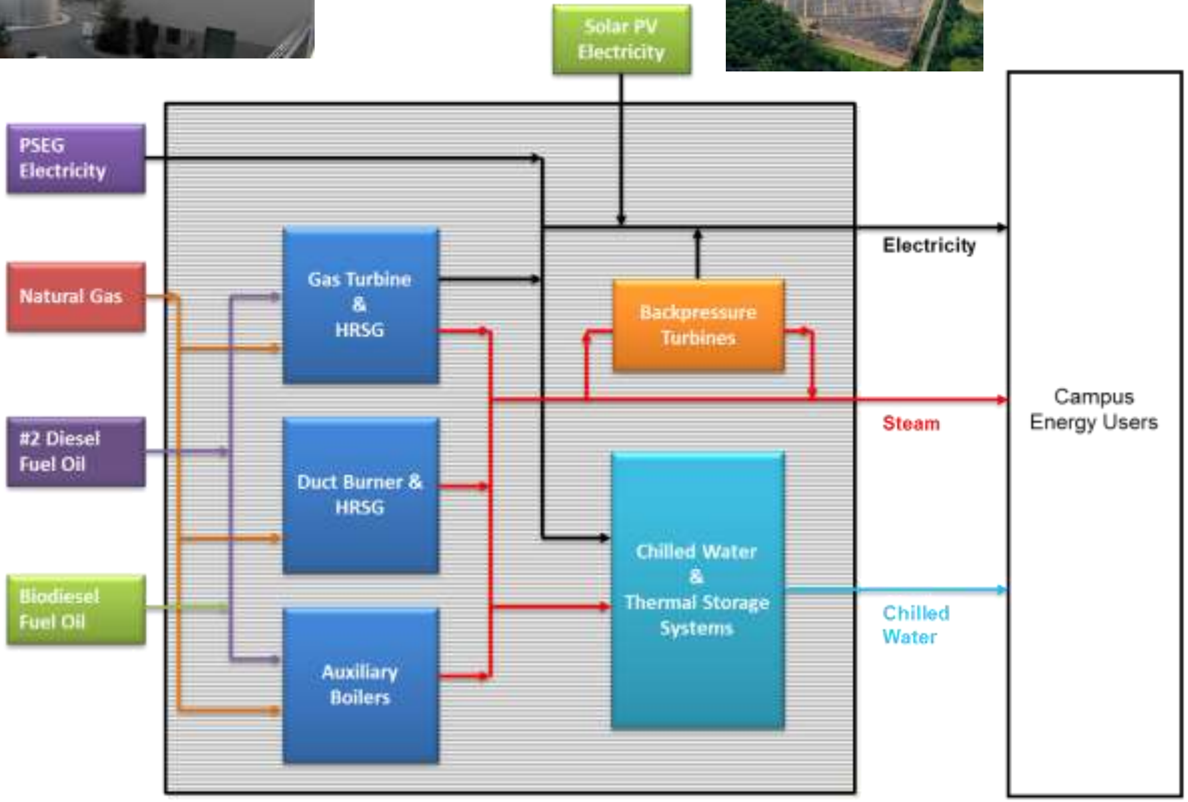
CHP as a Clean Power Plan Compliance Option

- Deployment of CHP reduces electricity demand and overall emissions from affected electric generating units (EGUs), similar to the emissions reductions impacts of other end-use energy efficiency measures.
- CHP provides long-term, persistent savings and is:
  - Measurable
  - Enforceable
  - Quantifiable
  - Verifiable
- Best practices exist in terms of crediting emissions savings from CHP, state programs to promote CHP markets, and in EM&V

Case Study

Princeton University

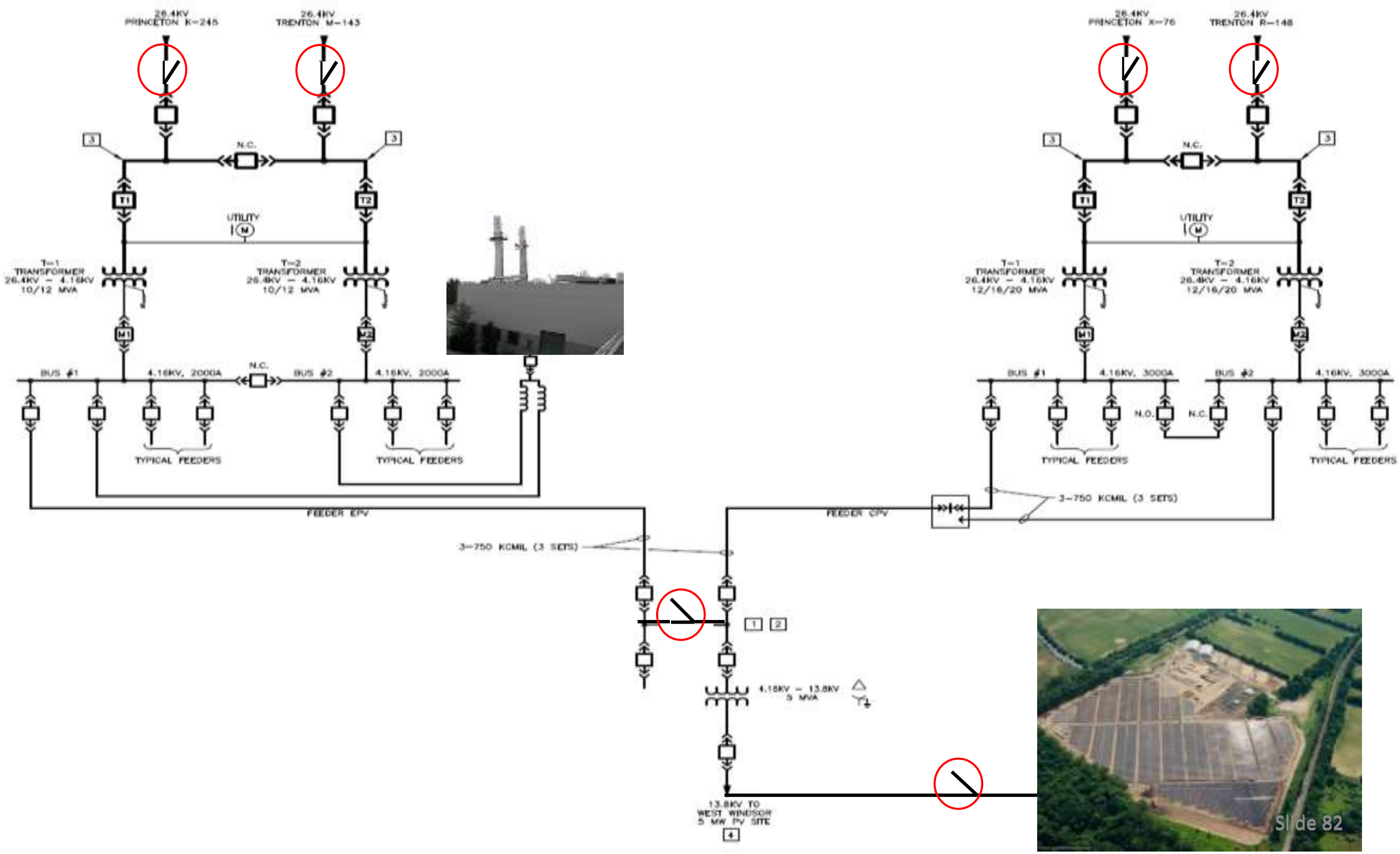
Princeton University Microgrid



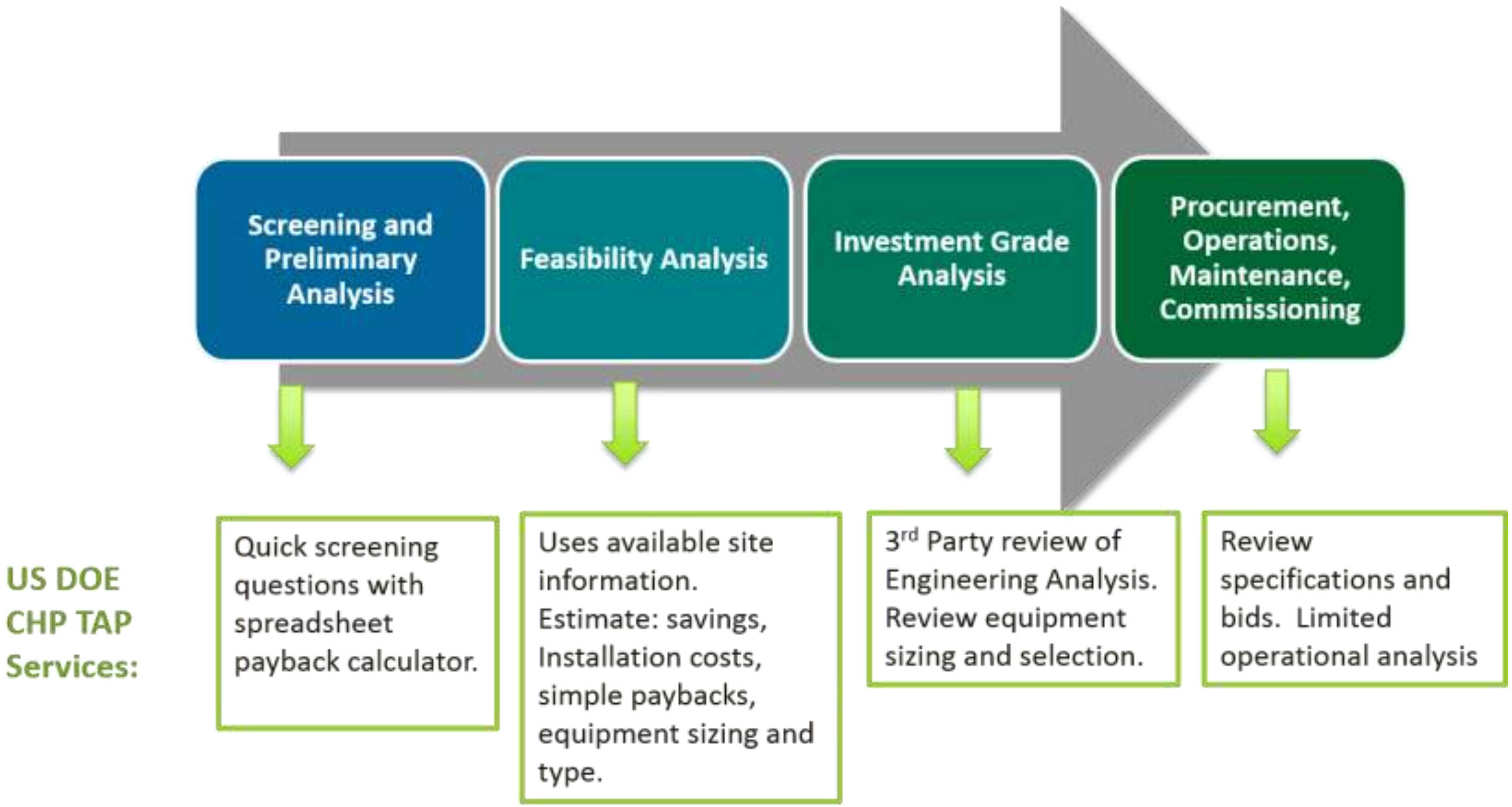
Princeton University - Superstorm Sandy

Elm Drive Substation

Carlton Street Substation



CHP TAP Technical Assistance



Summary

- CHP is a proven technology providing energy savings, reduced emissions, and opportunities for resiliency
- Many existing CHP sites today are referred to as Microgrids
- Emerging drivers are creating new opportunities to evaluate Microgrids
- Numerous examples exist to learn more about developing and operating CHP systems within microgrids
- Resources are available to assist in developing CHP Projects

Next Steps

- Contact the US DOE Mid-Atlantic CHP TAP to:
  - Perform CHP Qualification Screening for a particular facility
  - Identify existing CHP sites for Project Profiles
  - Additional Technical Assistance

Thanks You for your Kind Attention.
Do You Have any Questions?

Richard S. Sweeter
Senior Advisor
Mid Atlantic CHP TAP
TEL: 703-707-0293
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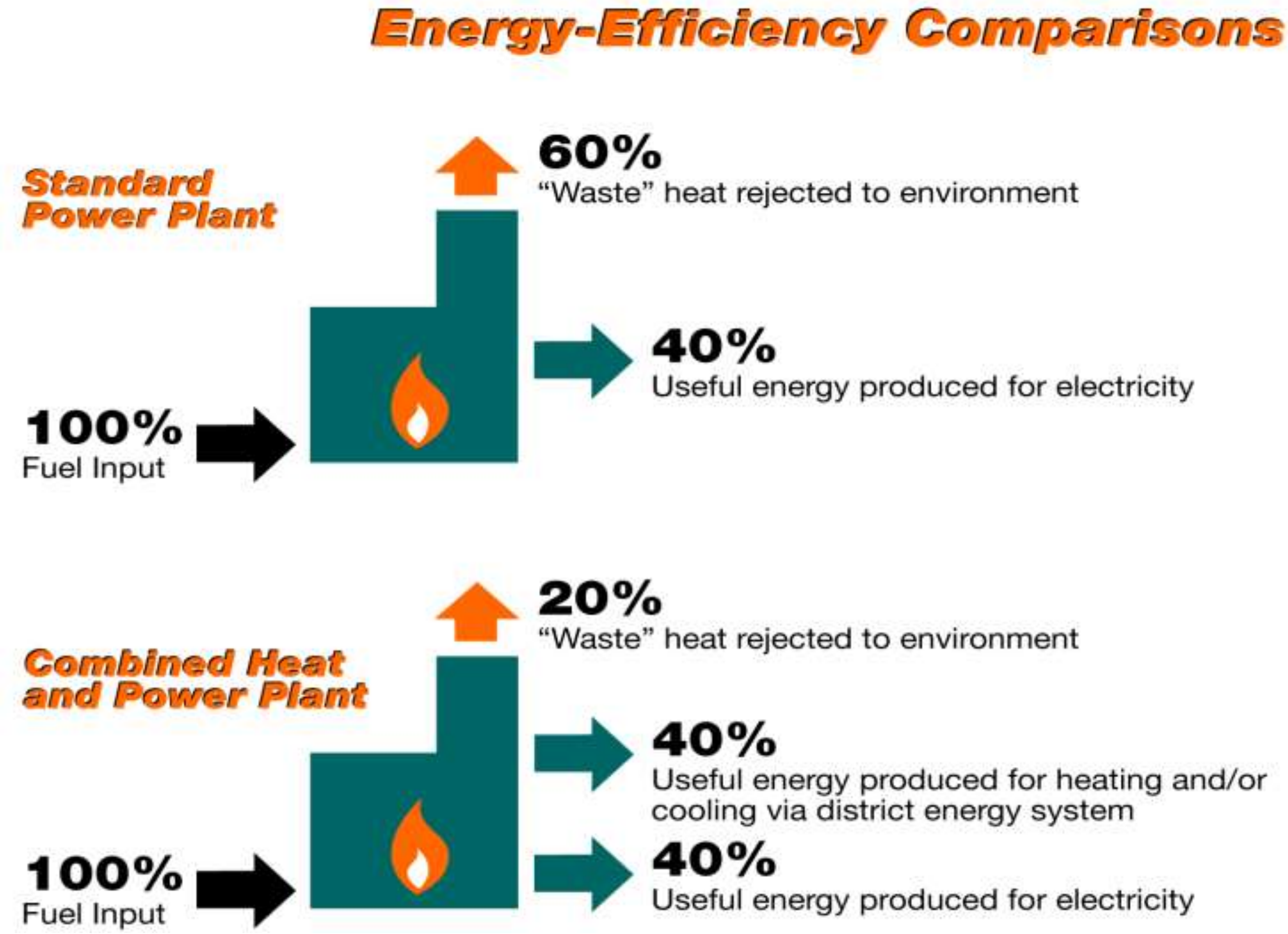
Combined Heat and Power

October 2016

Agenda

- CHP Overview
- Technologies
- Case Study
  - Assumptions
  - Site Energy Profiles
  - Economics
  - Sensitivity Analysis
  - Timeline
- Christiana Care Virtual Tour

Combined Heat and Power (CHP)



Micro-Turbines

Reciprocating Internal Combustion Engines

Combustion Turbines

Technology Comparison

Micro Turbine

- Electric: 480v
- Heat: 309°
- Electric Efficiency 29%
- Total Efficiency 60%

Reciprocating Engine

- Electric: 480v – 15Kv
- Heat:
  - Engine: 190°
  - Exhaust: 950°
- Electric Efficiency 40%
- Total Efficiency 80%

Combustion Turbine

- Electric: 480v – 15Kv
- Heat: over 1000°
- Electric Efficiency 35%
- Total Efficiency 75%

Stick Built CHP Construction

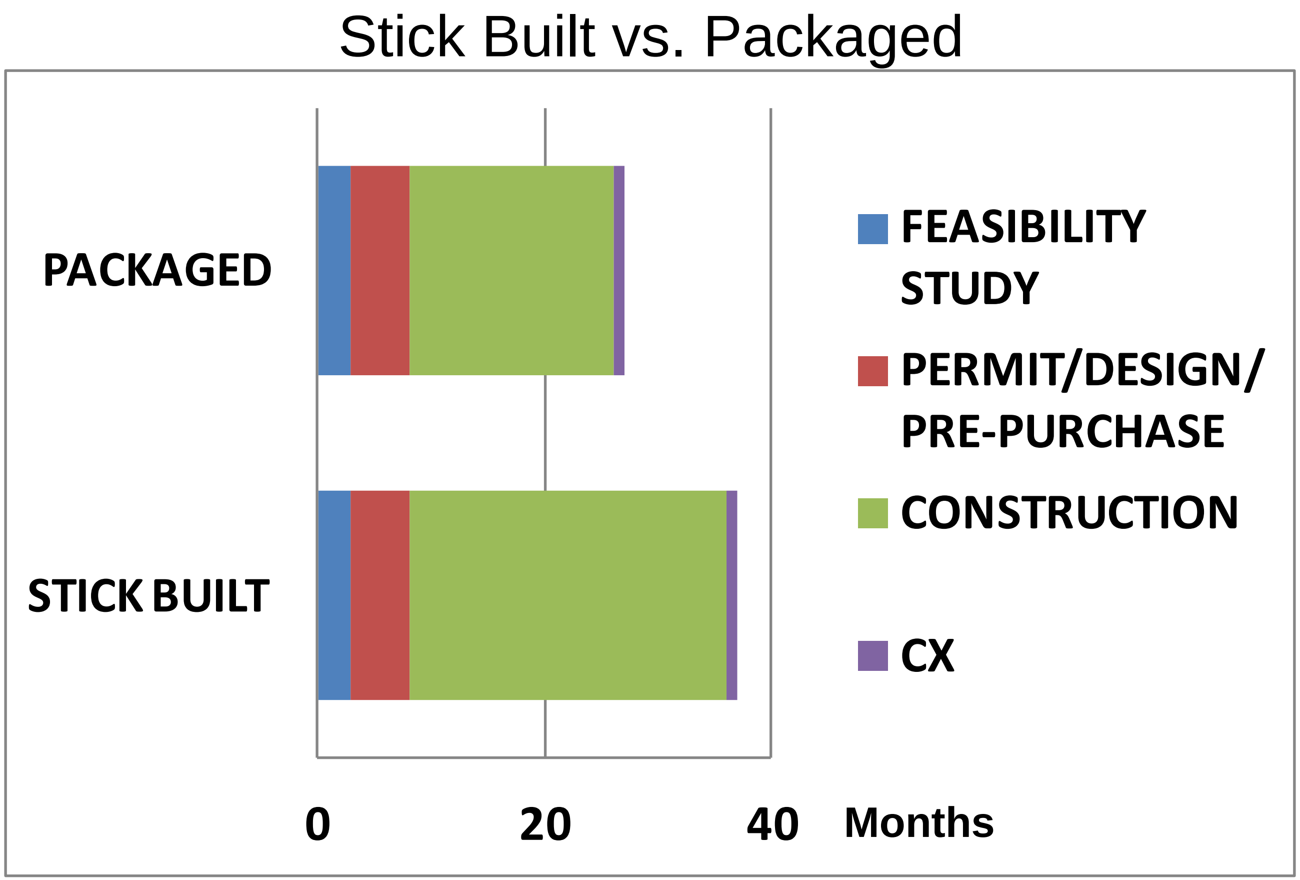
Packaged CHP Construction

(CHP in a BOX)

Packaged CHP Construction

(CHP in a Box)

Project Schedules



Project Costs and Payback

1.0 MW TRIGEN Plant

	STICK BUILT	PACKAGED
DESIGN	$600,000	$500,000
PERMITTING	$50,000	$50,000
CONSTRUCTION	$4,500,000	$3,500,000
GRANTS	$1,000,000	$1,000,000
CAPITAL COST (AFTER GRANTS)	$3,500,000	$2,500,000

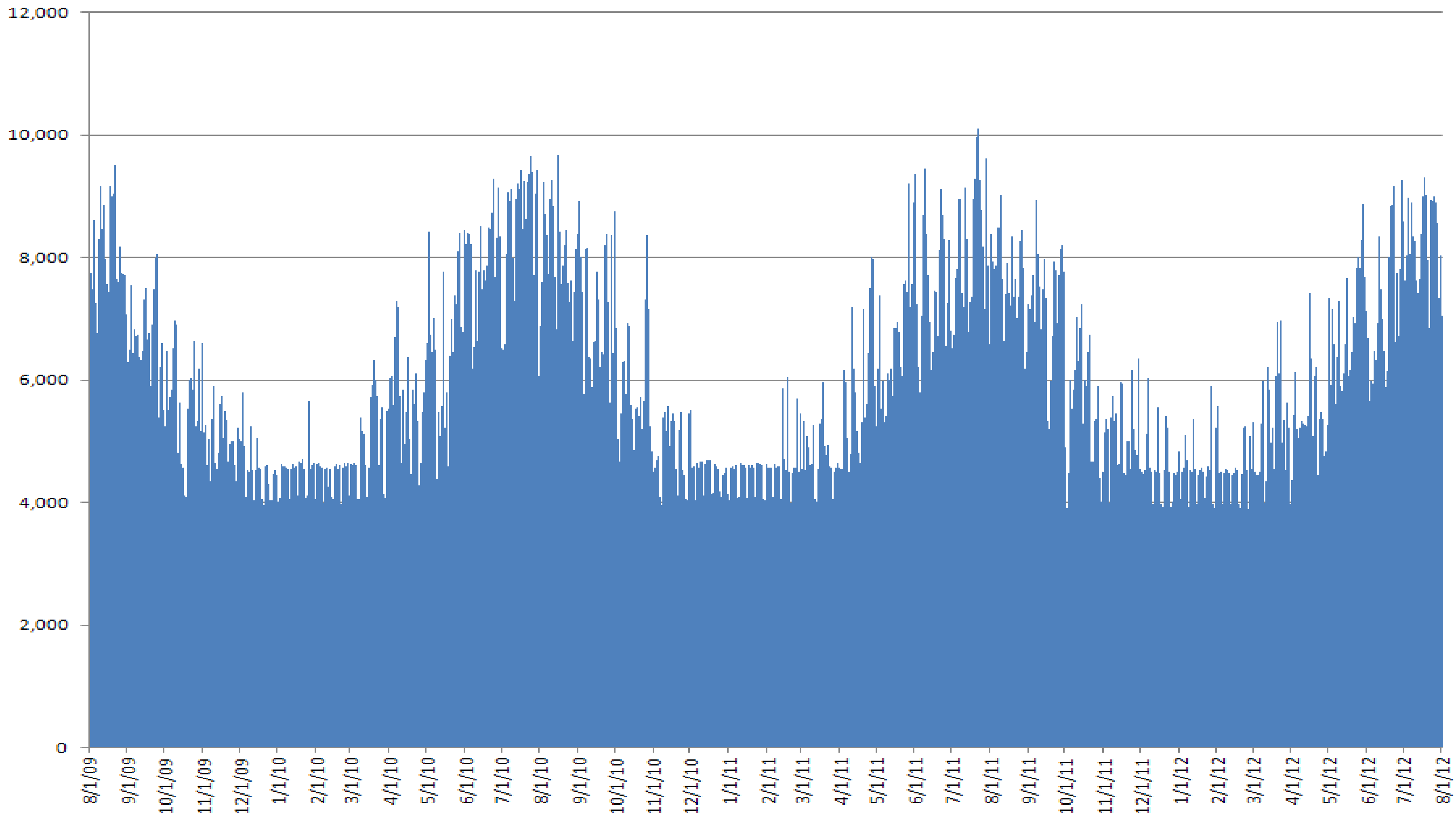
Christiana Hospital Energy Center

Case Study

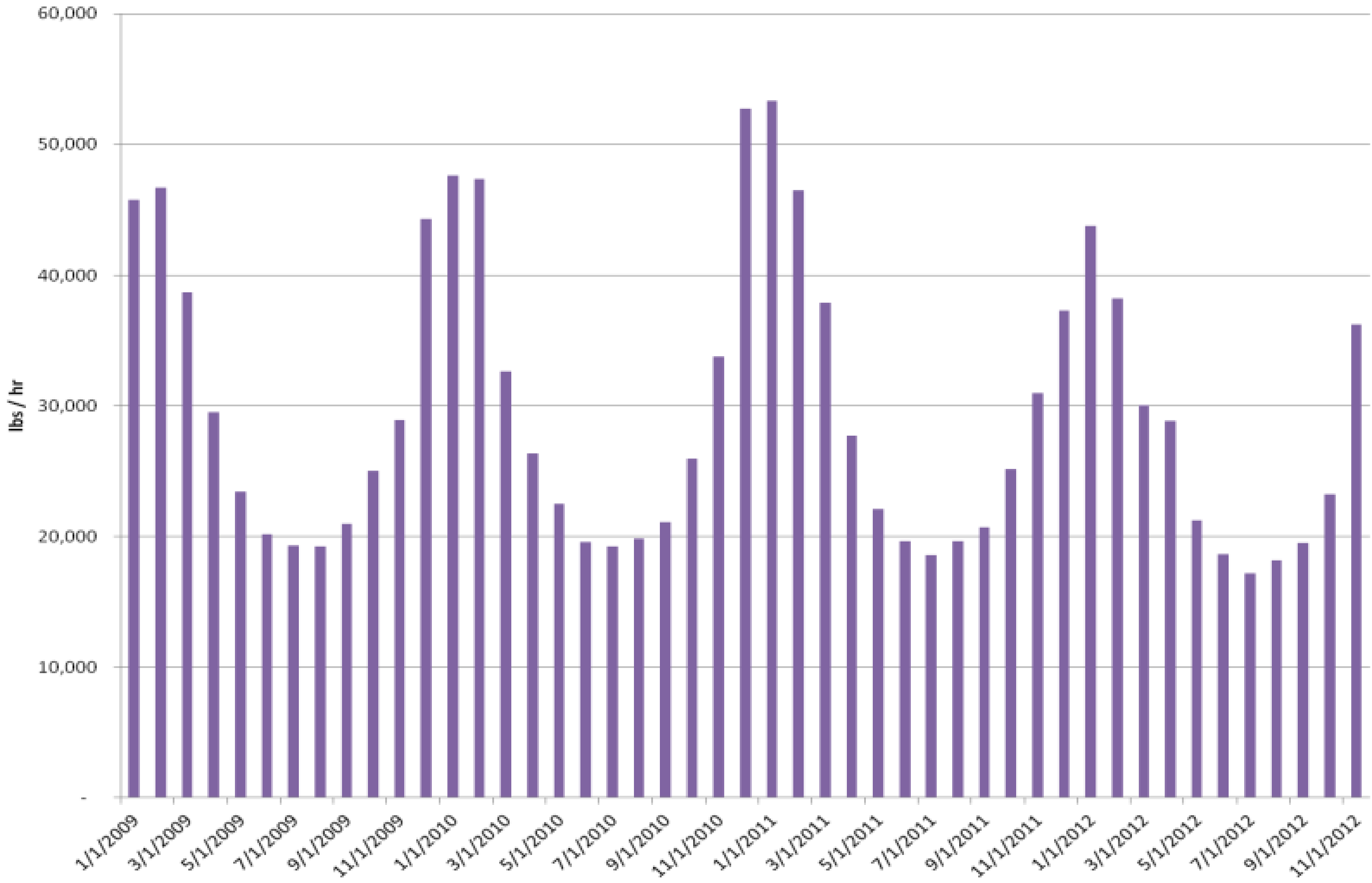
Assumptions

- Electric Distribution & Supply
  - Unit Cost: $0.08478 / kWh
- Gas Distribution & Supply
  - Unit Cost: $7.00/MMBTU
    * Future: $5.50 / MMBTU
- Steam Generation
  - Boiler Plant Efficiency: 80%
  - Minimum Steam Flow: 6,000 lbs/hr
- Maintenance for 4 weeks annually
- Inflation of 3% annually

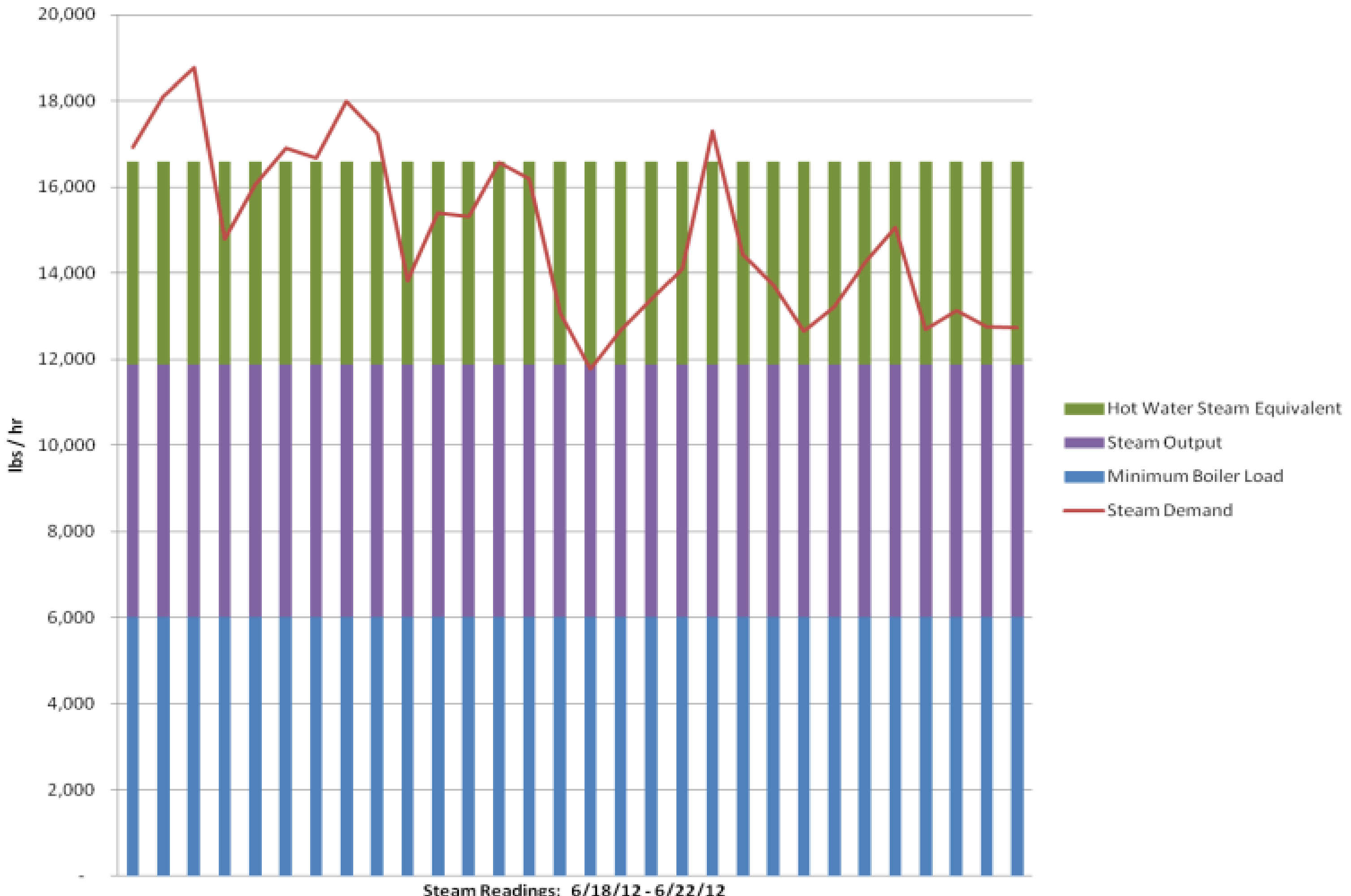
Hourly Electric Profile



Hourly Thermal Profile



Hourly Thermal Profile



We had the opportunity to meter HW demand on the hottest week of the year in 2013.

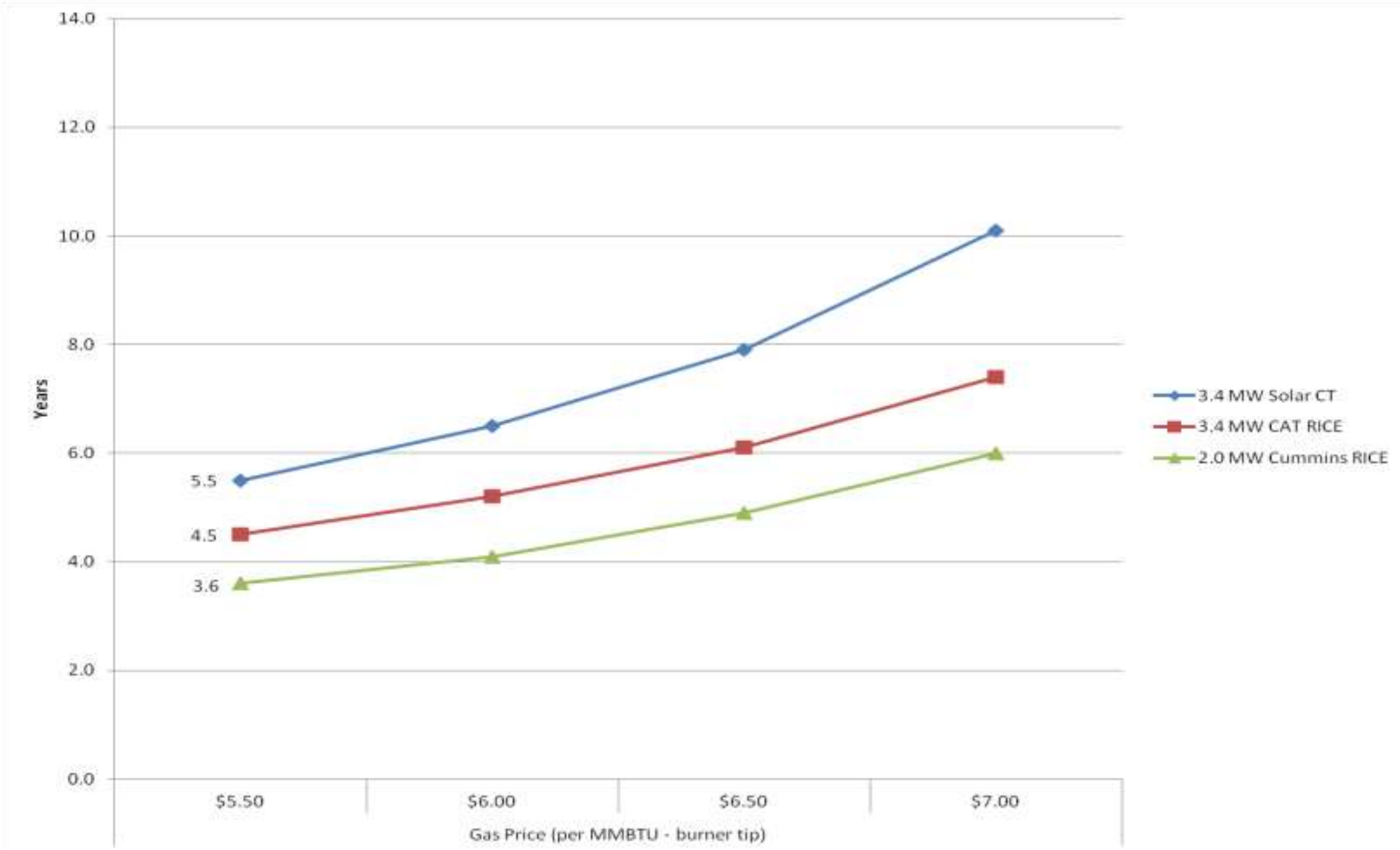
CHP Economics

	Current	2 MW RICE	3.4 MW RICE	3.4 MW CT
ELECTRIC	$ 4,406,436	$ 2,888,687	$ 1,765,566	$ 2,015,822
CHP GAS	$ -	$ 851,310	$ 1,416,050	$ 1,861,632
BOILER GAS	$ 1,735,224	$ 899,696	$ 851,622	$ 505,995
OPERATING COSTS	$ -	$ 305,670	$ 501,877	$ 330,000
ANNUAL TOTAL	$ 6,141,660	$ 4,945,363	$ 4,535,114	$ 4,713,449
ANNUAL SAVINGS		$ 1,196,297	$ 1,606,546	$ 1,428,211

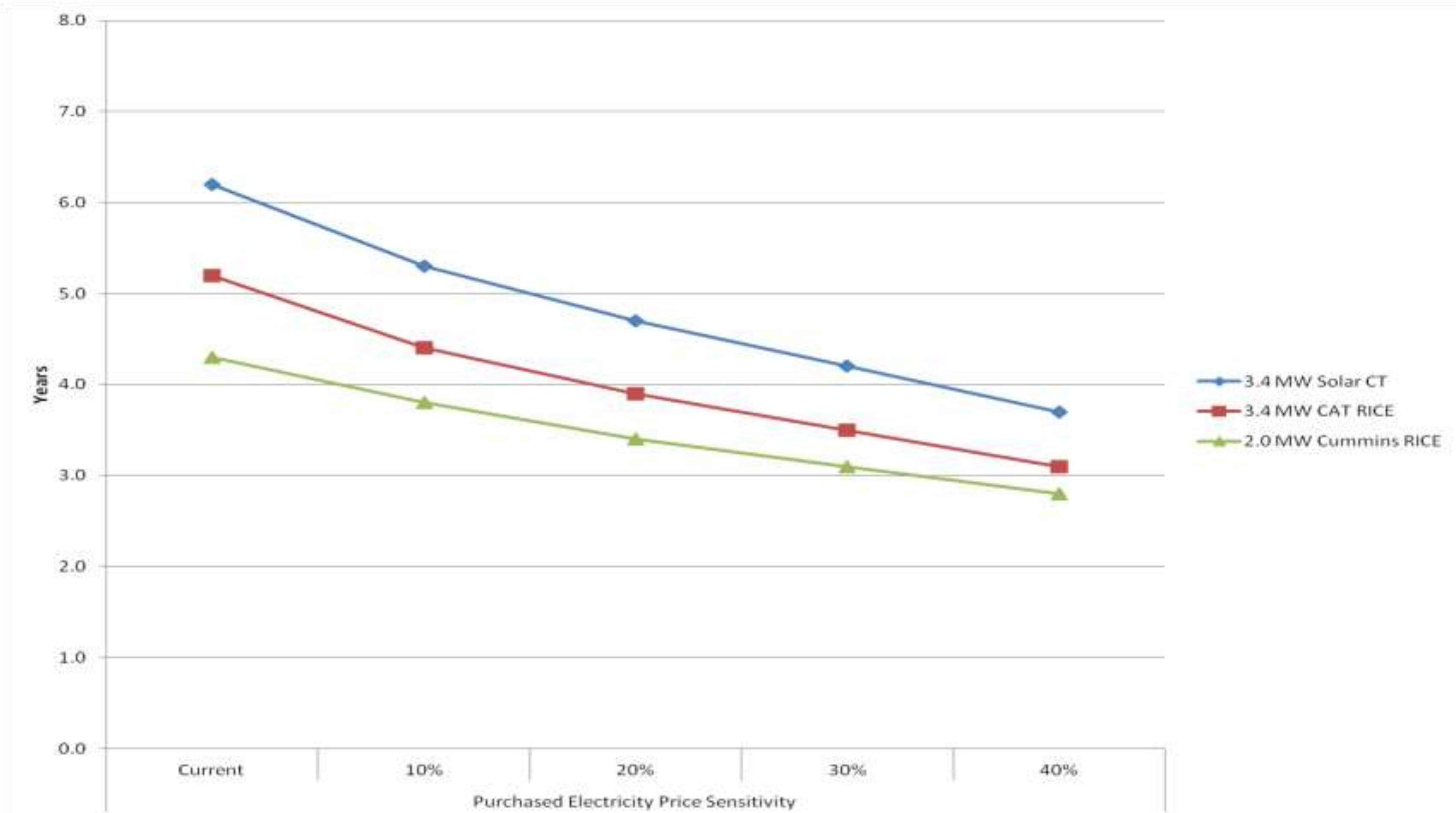
CHP Economics

	2 MW RICE	3.4 MW RICE	3.4 MW CT
SAVINGS	$ 1,196,297	$ 1,606,546	$ 1,428,211
INCENTIVE	$ 1,000,000	$ 1,000,000	$ 1,000,000
CAPITAL OUTLAY	$ 5,116,791	$ 8,286,262	$ 8,904,389
PAYBACK	4.3 years	5.2 years	6.2 years

Natural Gas Sensitivity Analysis



Electricity Sensitivity Analysis



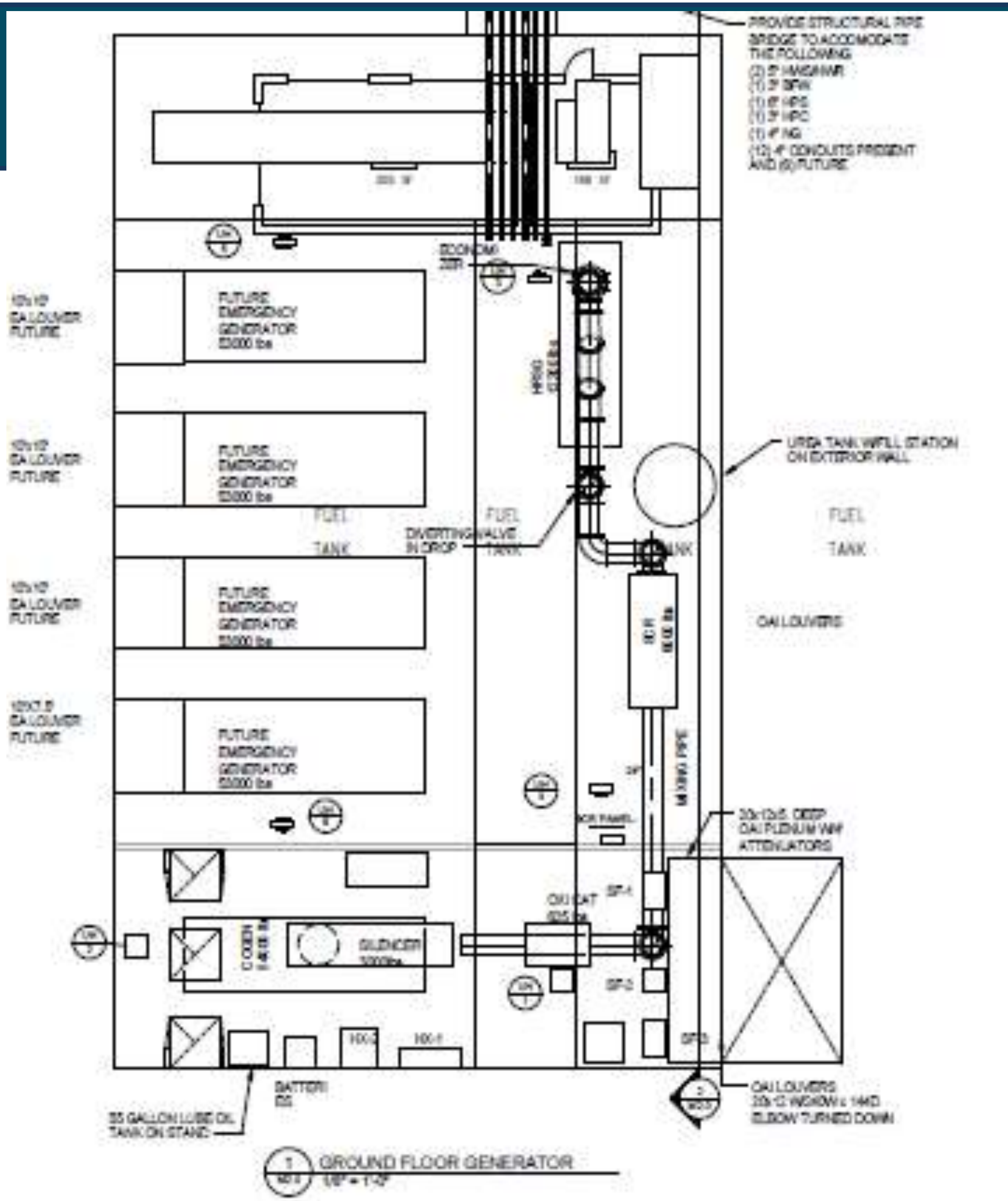
Typical Timeline

Pre-purchase Specs and Bidding	9/13-12/13
Air Permitting	4/14-12/14
Design	10/13-6/14
Fabrication and Delivery	6/14-2/15
Construction / Commissioning	7/14-9/15

No combustion equipment can be on site until the air permits are approved.

Using Lessons Learned in This Design

- No matter how good the CHP Design is, it has to interface with an existing hospital.
- Accurate metering is invaluable to design and operation.
- There is a thermal dead zone that needs to be considered in the sizing thermal load, retrofitting the existing boiler(s), or adding a smaller boiler.
- It is a power plant! Experienced operations and maintenance personnel are key to project success. Conduct in depth interviews.
- Value Engineering can be Counter Productive – Less Efficient.
- There are benefits to redundancy.
- The best payback is always based on thermal optimization.
- When combined with other projects, there can be avoided costs


PROVIDE STRUCTURAL PIPE BRIDGE TO ACCOMODATE THE FOLLOWING
FUTURE EMERGENCY GENERATOR
FUTURE EMERGENCY GENERATOR
FUTURE EMERGENCY GENERATOR
FUTURE EMERGENCY GENERATOR
FUEL TANK
FUEL TANK
FUEL TANK
DIVERTING VALVE IN DROP
UREA TANK W/FILL STATION ON EXTERIOR WALL
OAI LOUVERS
MIXING PIPE
ATTENUATORS
SILENCER
55 GALLON LUBE OIL TANK ON STAND
GROUND FLOOR GENERATOR

South West View

Engine Room

HW Heat Recovery

Steam Heat Recovery

Maintenance Access

Connection to the Central Plant

Other Hospital CHP Projects

Hospital	Capacity
Lancaster General Hospital, Lancaster, PA	3.5 MW*
Abington Memorial Hospital, Abington, PA	4.5 MW
Williamsport Regional Medical Center, Williamsport , PA	1.9 MW
Holy Redeemer Hospital, Meadowbrook, PA	2.0 MW
Jersey Shore University Medical Center, Neptune, NJ	3.8 MW
Geisinger Medical Center, Danville, PA	4.5 MW
Reading Hospital, Reading, PA	9.0 MW
Aria Torresdale Hospital, Philadelphia, PA	1.1 MW
Doylestown Hospital, Doylestown, PA	1.5 MW
Cancer Treatment Centers of America, Philadelphia, PA	2.0 MW
Guthrie Health System, Sayre, PA	2.0 MW*
University of Pittsburgh Medical Center, Pittsburgh, PA	3.5 MW

* In design or construction

Discussion

INTELLIGENT DER INTEGRATION PREVENTS THE SMART GRID FROM BECOMING A

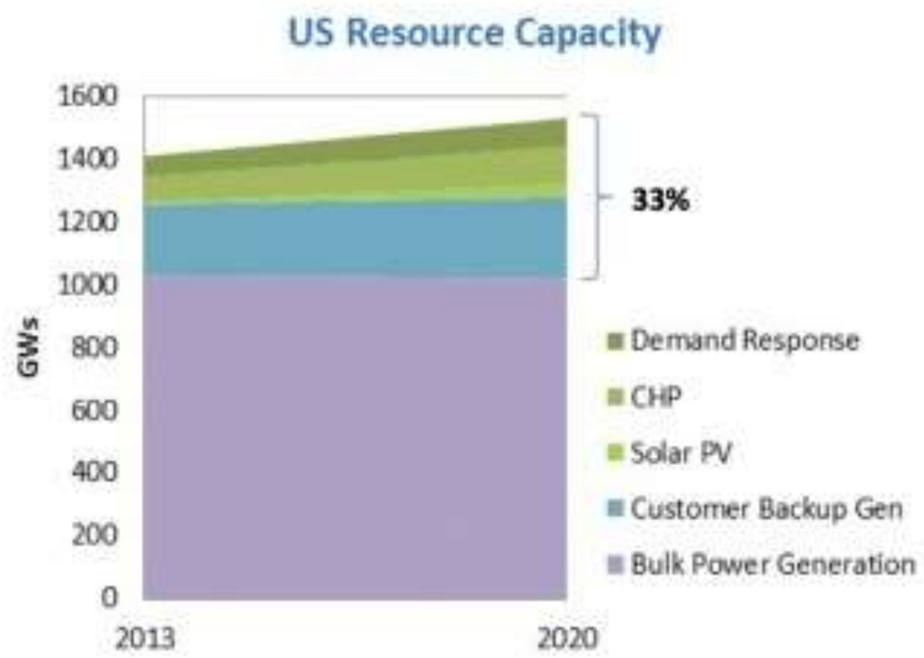
BRIDGE TO NOWHERE

DG/Microgrid Discussion
Tangent Energy Solutions
October 19, 2016

DER will be 33% of the U.S. energy stack by 2020

Distributed Energy Resources (DER)

Effectively all incremental growth in capacity will come from customers



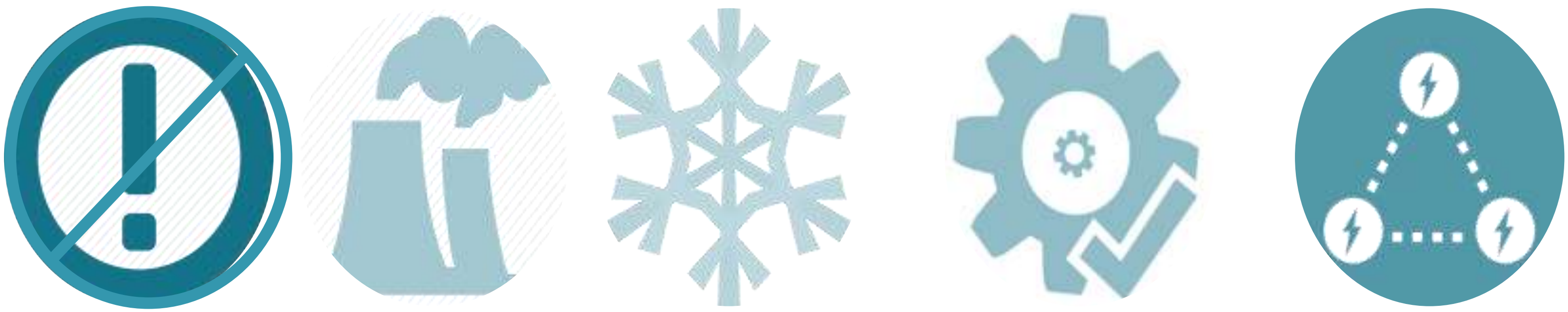
Sources: EIA, EPA, DOE, FERC, Carnegie Mellon, GlobalData

Backup Generation:	**240 GW**
CHP:	**122 GW**
Demand Response:	**90 GW**
Solar PV:	**40 GW**
Other DG:	**15 GW**
Dist. Storage:	**3 GW**
Potential DER Total:	***500 GW***

Tangent energy solutions

Drivers of an increased role for DERs

A centralized grid needs customer support to meet emerging trends, EPA requirements and regulatory challenges



Fall of DR
- Onerous commitments
- Rule changes

Plant Retirements
- EPA
- Cost recovery

Polar Vortex
- Reliability issues
- Shift to LSEs

Regional Price Increases
- Capacity & Transmission
- ISO NE, PJM

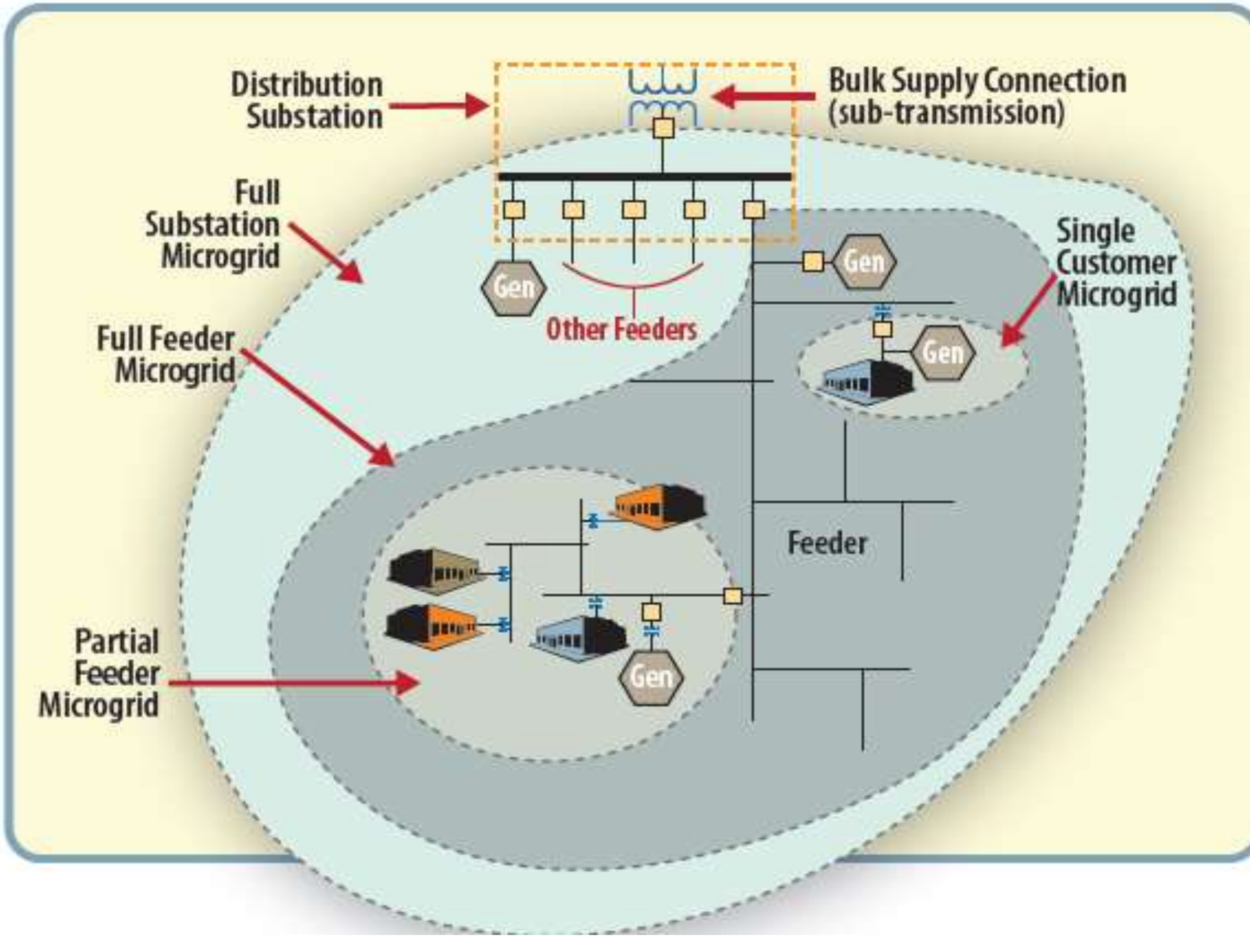
Rise of DG
- Lower priced solar
- Cheaper gas
- Sustainability

Microgrid Options

Ownership Models

- Private
- Hybrid
- Utility

Deployment Levels



Tangent energy solutions

Microgrid Modes of Operation

Normal Grid Operations:

- Utility maintains control of grid & network
- DERs dispatched for customer/site economics or participation in grid-based programs.
- 97% of the time

Constrained T&D Periods:

- Utility maintains control of grid & network
- Utility provides instructions to dispatch DER's for grid support 2.9% of the time – 25 hours per year

Extended Grid Outages:

- Autonomous operations
- Micro-grid controller controls network and assumes control of DERS for frequency and voltage control, stability, and safety.
- Less than .1% of the time – 40 hours in 5 years

DER Roles - Current

Operations Mode			
DER	**Normal**	**Constrained**	**Outage**
Gas Generator	• Capacity tag reduction • Supplement energy during high cost hours	No change	Off-line unless configured to supply back-up
Back-up Diesel Generator	Off-line; not permitted to run	Requires emergency declaration to allow operation.	Supplies dedicated critical loads
Solar Arrays & Wind	Supply supplemental energy to host or grid	No change	Off-line
Storage	• Regulation market • Capacity tag reduction • Demand charge management • TOU price arbitrage	No change	Off-line unless configured to supply host site support.

DER Roles – with Microgrid

Operations Mode			
DER	**Normal**	**Constrained**	**Outage**
Gas Generator	• Capacity tag reduction • Supplement energy during high cost hours	Dispatched to supply energy or shutdown at utility request	Supply compliant base load generation to the microgrid
Back-up Diesel Generator	Off-line; not permitted to run	Dispatched to isolate site and supply energy at utility request (if allowed)	Supplies black start capabilities and fast response generation to the microgrid
Solar Arrays & Wind	Supply supplemental energy to host or grid	Inverters dispatched to supply VARs energy or shutdown at utility request	Supplies supplemental energy to the microgrid
Storage	• Regulation market • Capacity tag reduction • Demand charge management • TOU price arbitrage	Dispatched to charge/discharge or regulate at utilities request	Supplies energy and regulation capability to maintain balance

Infrastructure Requirements to Achieve Microgrid

Operations Mode			
	Normal	**Constrained**	**Outage**
Utility	None	Communications link to DER manager	• Microgrid controller with ability to communicate with utility SCADA & DMS • Communication network connecting sites and DERs
Host Sites	None	Remote monitoring and control capability if it does not exist	Microgrid controllers at each DER

Assumes that sufficient DERs exist to enable microgrid operation during outages. If not, additional DER must be added by utility or utility tariffs and/or incentives must be created to encourage development of DERs by third parties.

Drive customer adoption at the grid edge

Combining assets, technology and a customer-centric approach to motivate and empower customer participation in grid economics

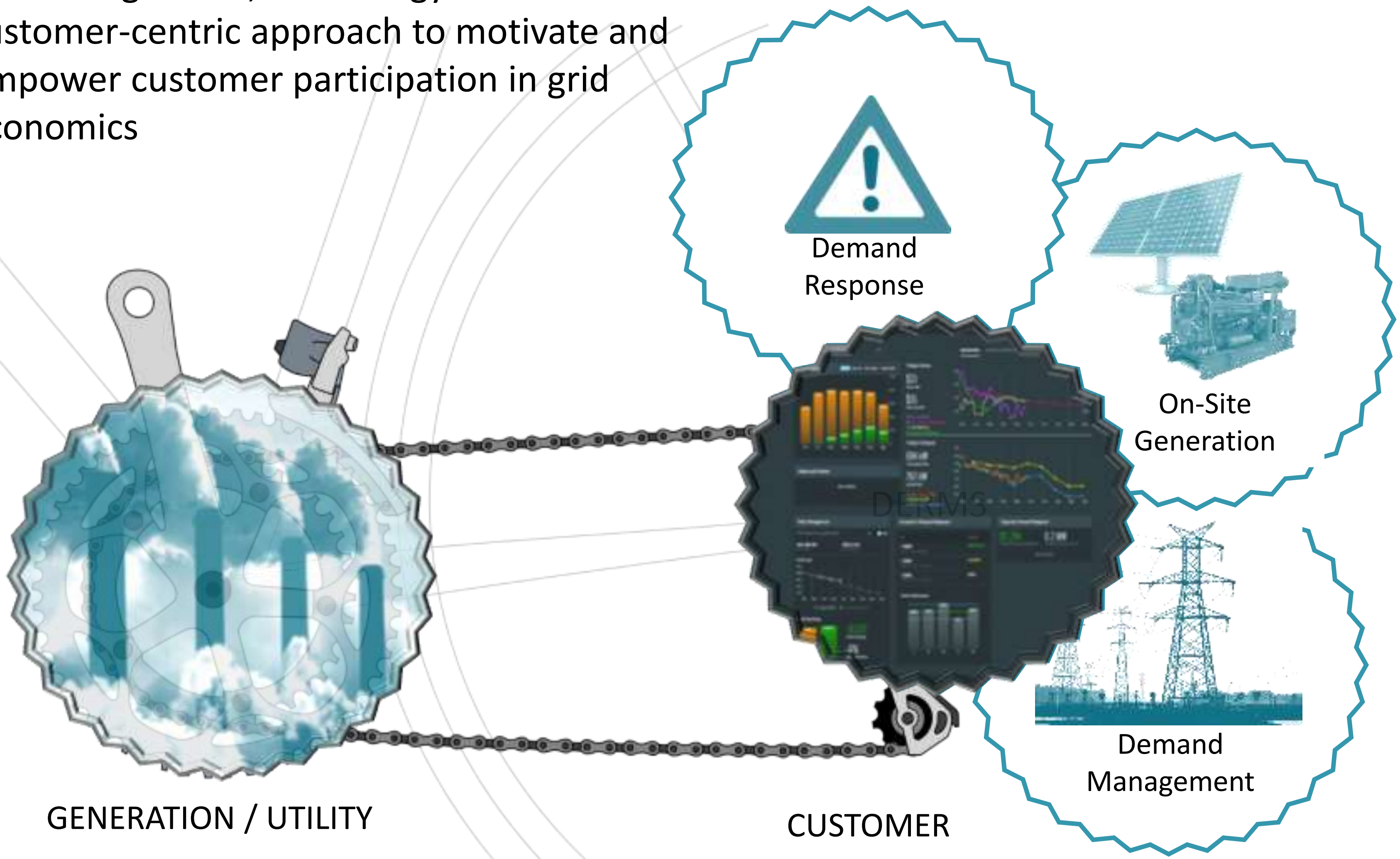
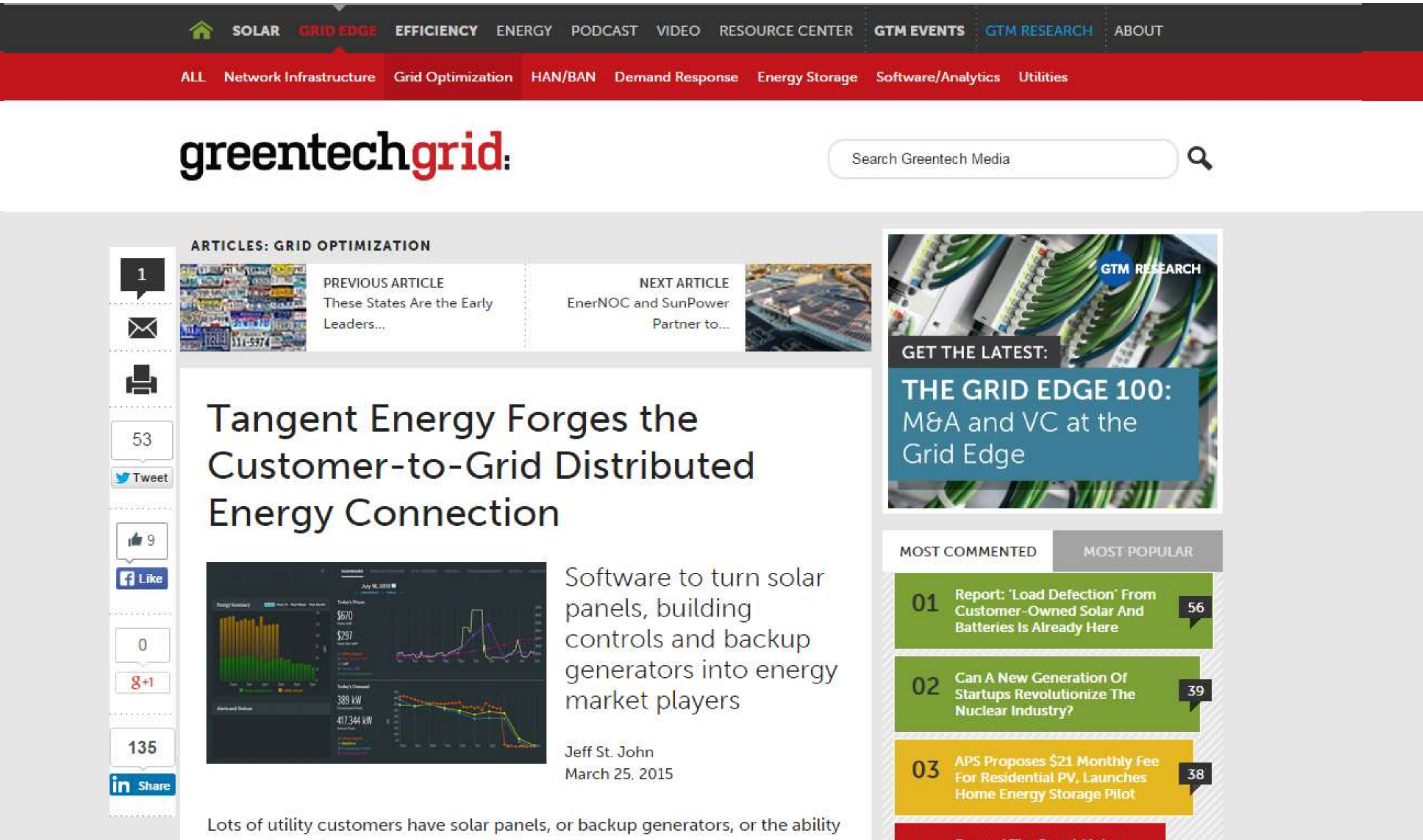


Image Credit: Creative Commons Keithonearth

Integrate DER into the energy grid



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Tangent Energy Forges the Customer-to-Grid Distributed Energy Connection

Software to turn solar panels, building controls and backup generators into energy market players

Jeff St. John
March 25, 2015

Lots of utility customers have solar panels, or backup generators, or the ability

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Beyond The Smart Meter:

Tangent energy solutions

Technology features and functionality

continuous inputs | *predictive analysis and clear UI* | *cost reducing results*

Grid status

Facility load

Weather

Tangent AMP™

- Accurately predicts peaks and alerts customers to act
- Integrates into existing EMS / BMS systems
- Measurement, verification

Tangent AMP → predicts, alerts, and actively manages high value energy hours, and integrates with utility and power pool systems

Steel Mill

~$2,000,000 in savings from reduced capacity obligation

Municipal Utility

~$500,000 per year of found revenue from an established Cummins asset.

Food Manufacturer

$300,000 capacity charge reduction from Tangent AMP™ microgrid deployment

ANALYSIS | **USAGE SUMMARY** | INDEX PRICING | ISO/RTO BASELINE | DR PERFORMANCE | ALERTS

1 Meters

- [x] *unselect all*
- [x] TOTAL SITE METER
- [x] FACILITY DEMAND
- [x] ON-SITE GENERATION
- [x] SITE METER SUB #1
- [x] SITE METER SUB #3
- [x] SOLAR OUTPUT
- [x] BIO GAS OUTPUT

2 Start and End Dates

START 2014-09-01 15:00

END 2014-09-05 15:00

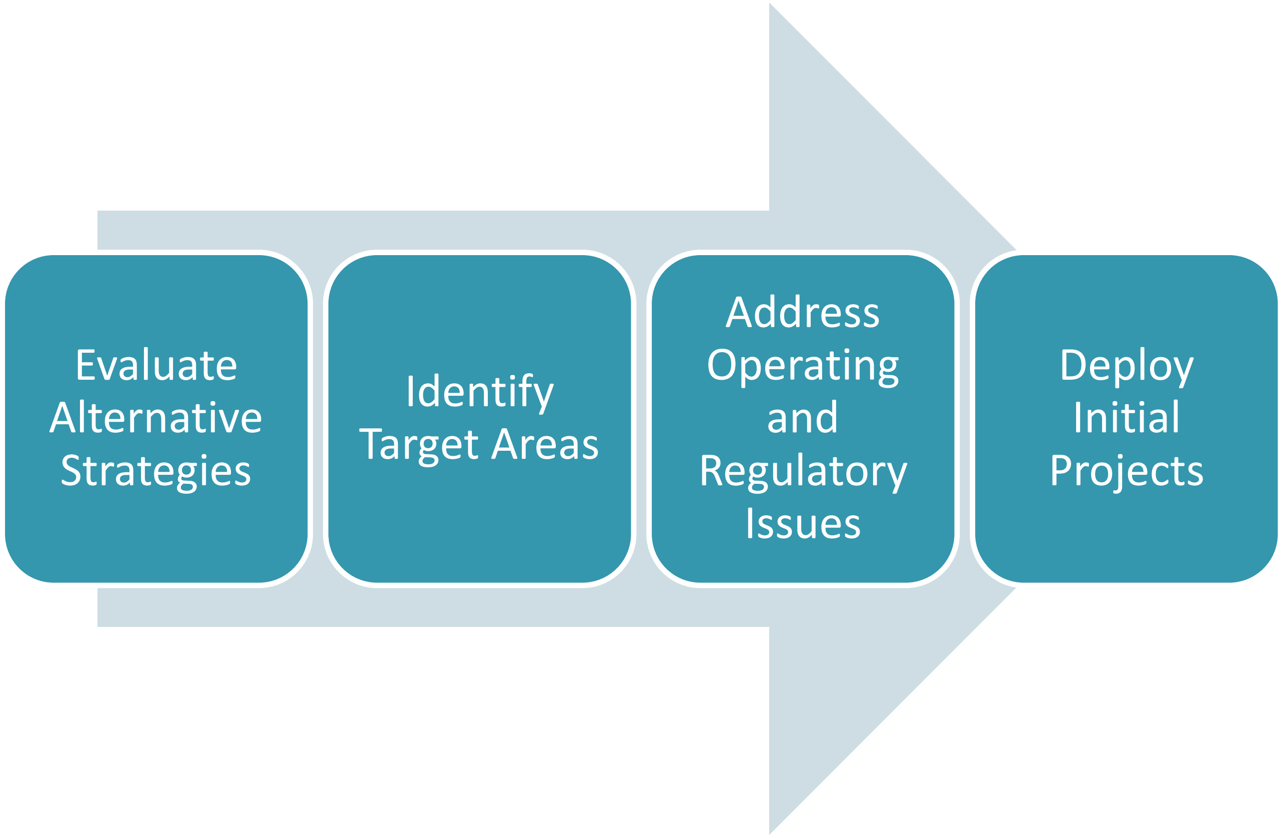
3 Output Format

Screen Export

Usage Summary

Meter	Usage (kWh)	Demand Peak (kW)	Peak Time
Total Site Meter	1481673.60	21150.72	2014-09-04 21:00 (Thu)
		20805.12	2014-09-04 22:15 (Thu)
		20623.68	2014-09-05 00:15 (Fri)
Facility Demand	1789131.80	21260.32	2014-09-04 21:00 (Thu)
		21134.56	2014-09-03 22:00 (Wed)
		21130.88	2014-09-03 22:30 (Wed)
On-Site Generation	307458.20	9264.80	2014-09-03 15:15 (Wed)
		9170.00	2014-09-03 14:45 (Wed)
		9133.20	2014-09-03 14:00 (Wed)
Site Meter Sub #1	1065744.00	14428.80	2014-09-05 00:45 (Fri)
		14428.80	2014-09-05 01:00 (Fri)
		14428.80	2014-09-05 00:30 (Fri)
Site Meter Sub #3	415929.60	7032.96	2014-09-03 03:15 (Wed)
		7024.32	2014-09-04 21:00 (Thu)
		7007.04	2014-09-03 03:30 (Wed)
Solar Output	181207.00	7312.00	2014-09-03 14:00 (Wed)
		7312.00	2014-09-03 15:15 (Wed)
		7280.00	2014-09-03 14:45 (Wed)
Bio Gas Output	126251.20	2259.20	2014-09-03 12:00 (Wed)
		2242.00	2014-09-03 12:15 (Wed)
		2174.00	2014-09-04 00:15 (Thu)

Next Steps – Lead or be Led



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Governors Hall

2016 Delaware Energy Conference

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2016 Delaware Energy Conference

Panel Three:

Energy Programs & Incentives

Tony DePrima, Executive Director, Delaware Sustainable Energy Utility
Dave Resler, Account Executive, CPower Energy Management
Ed Jackson, Principal, Affinity Energy Management

Moderator: **Anne Kirby**, Clean Energy Consultant

Property Assessed Clean Energy (PACE) Financing Concept for Delaware

Delaware Sustainable Energy Utility

Outline

Delaware Sustainable Energy Utility

- *What is PACE?*
- *PACE Benefits*
- *Commercial PACE Market*
- *PACE in Delaware – DEVACE*

PACE Basics

Delaware Sustainable Energy Utility

Assessment Based Financing

- ✓ Statewide legislation to enable – January 2017?
- ✓ Financing dollars come from public or private sources
- ✓ Assessment collected to pay debt service similar to property assessments
- ✓ PACE assessment survives sales, including foreclosures
- ✓ Future PACE assessments can assumed in the future by whomever buys the building

Source: PACENation

What Makes a PACE Project?

A Building Owner

Source: PACENation

What Makes a PACE Deal?

A Project…. And a Contractor

Source: PACENation

What Makes a PACE Deal?

Someone to Fund the Project

Consent from the Mortgage Lender

Source: PACENation

What Makes a PACE Deal?

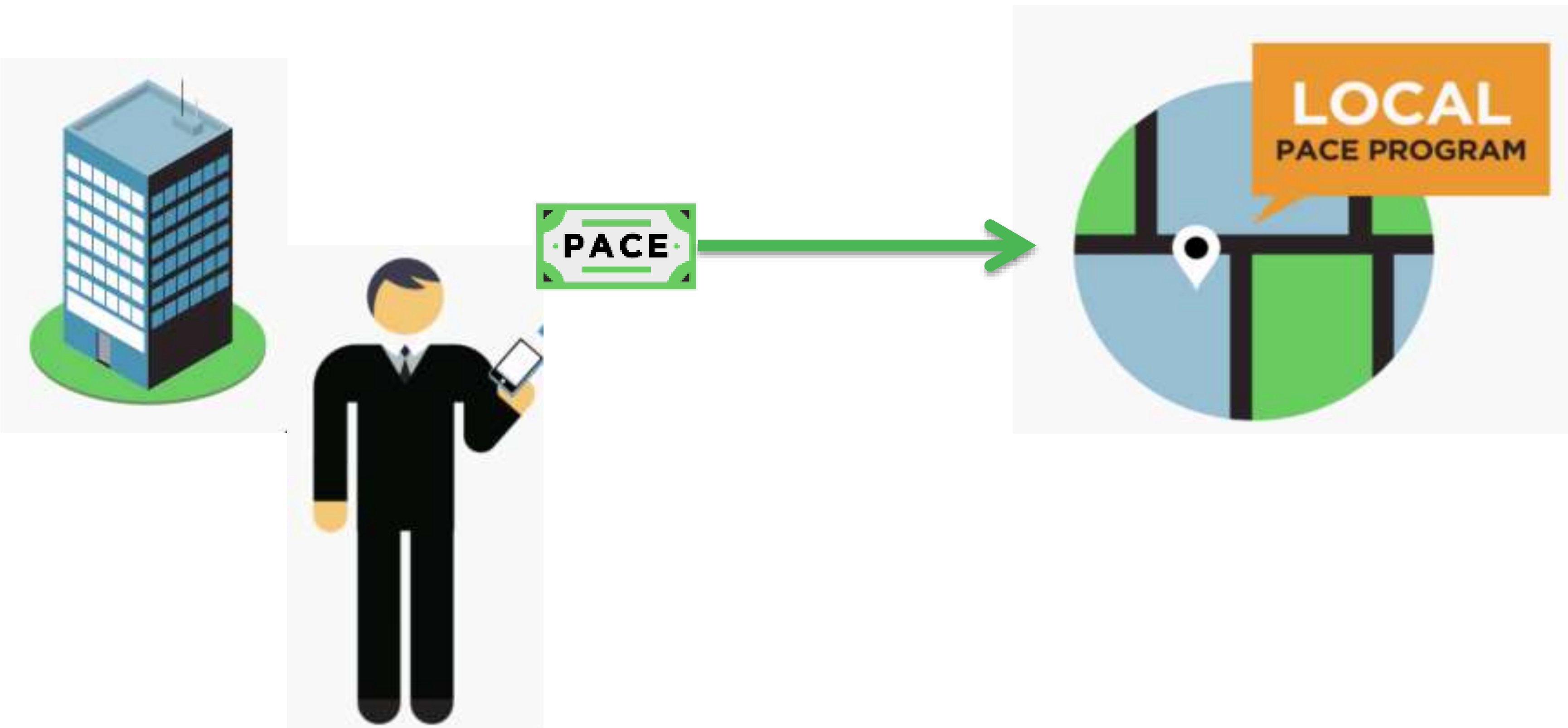
Local Government to "Service" the Financing

What makes PACE, PACE!

Source: PACENation

What Makes a PACE Deal?

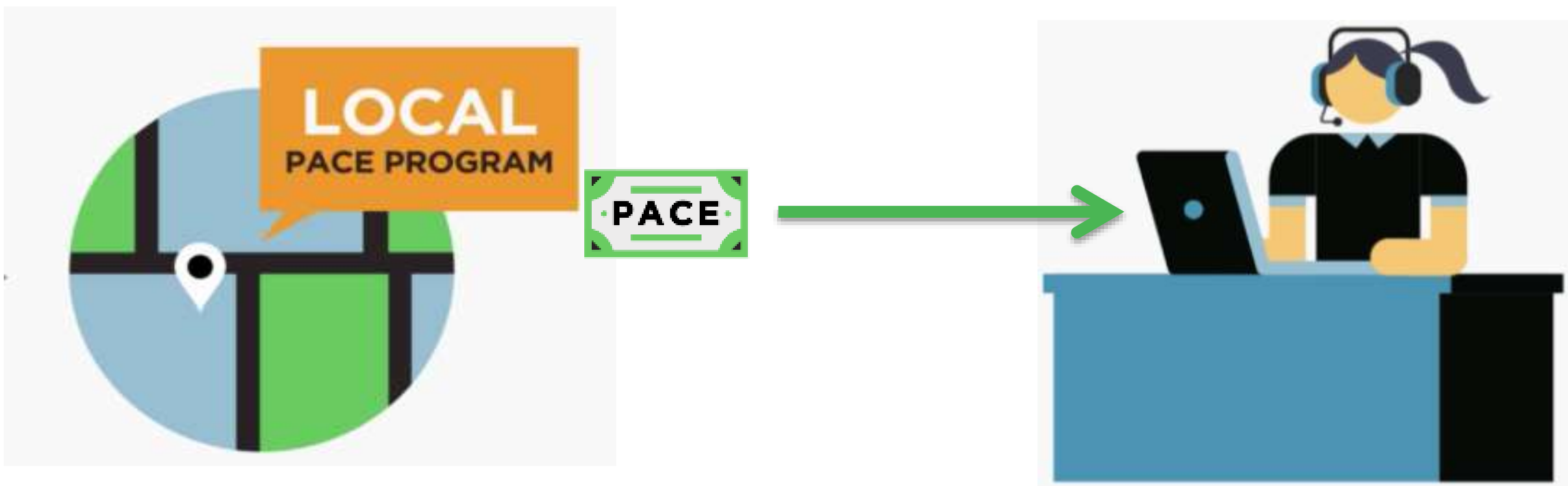
Building Owner Repays with an Assessment



Source: PACENation

What Makes a PACE Deal?

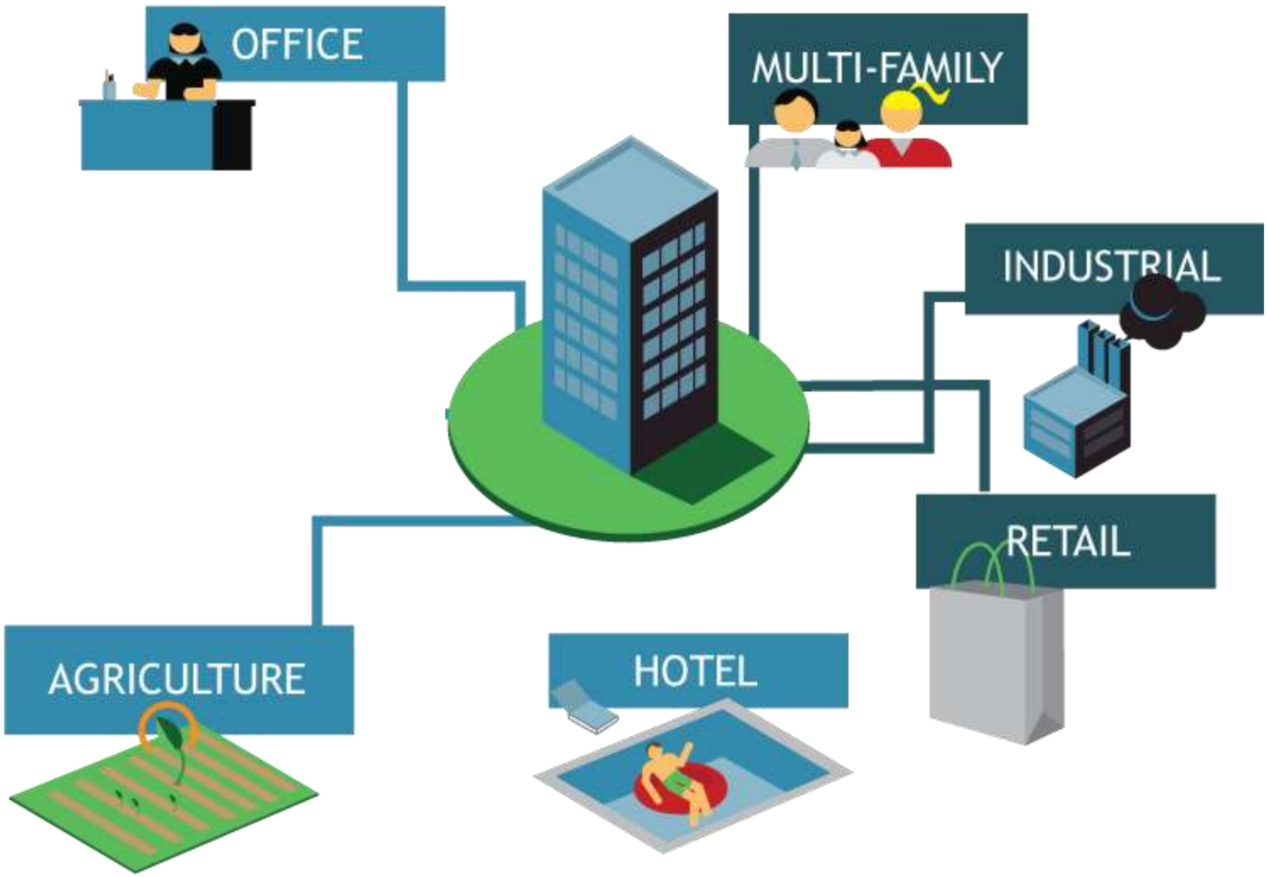
Assessment Repays Project Funder



Source: PACENation

Who can use PACE?

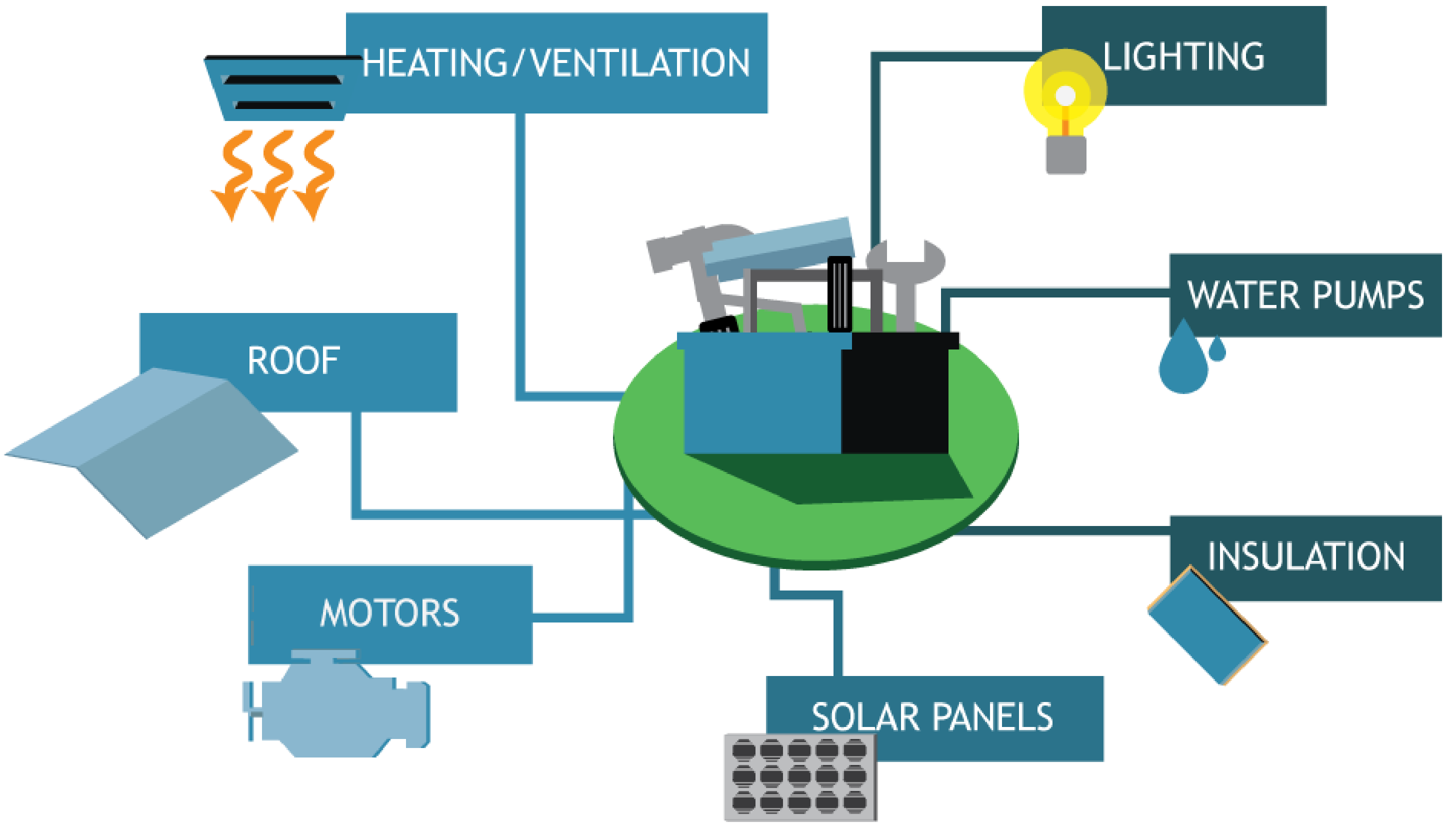
Almost Any Building – Including Non-Profits



Source: PACENation

What For?

Projects that Save or Generate Clean Energy



Source: PACENation

Why do Lenders Like Pace?

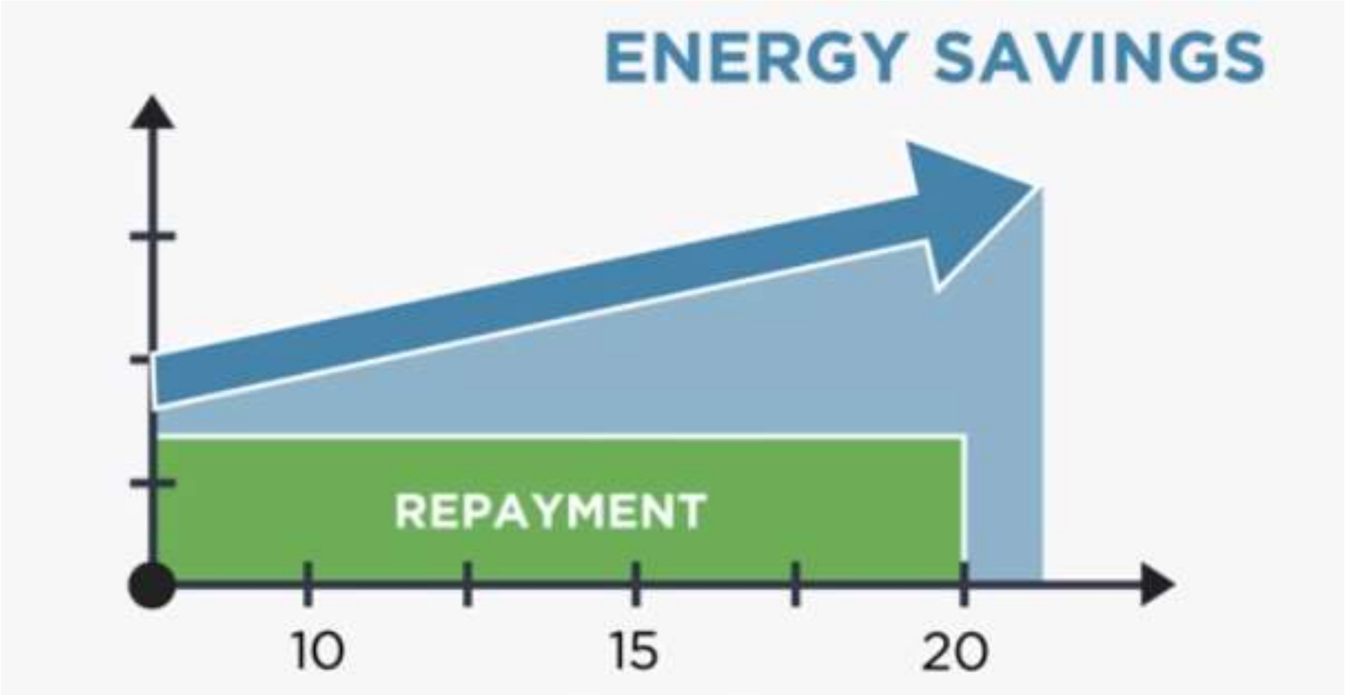
- *Stronger collateral*
- *Lower default rates*
- *Spreads costs and benefits to the tenants*
- *Opens new markets*

Why Building Owners Like PACE

- *Long-term payback – up to 20 year funding*
- *No money out of pocket – 100% funding*
- *Makes long payback projects work – can be implemented on a positive cash flow basis*
- *Increases property value*
- *PACE can transfer on sale*
- *Share benefits and costs with tenants – eliminates split incentive*

Why are Mortgage Lenders Giving Consent?

Over 100 Different Lenders to Date, Nationwide

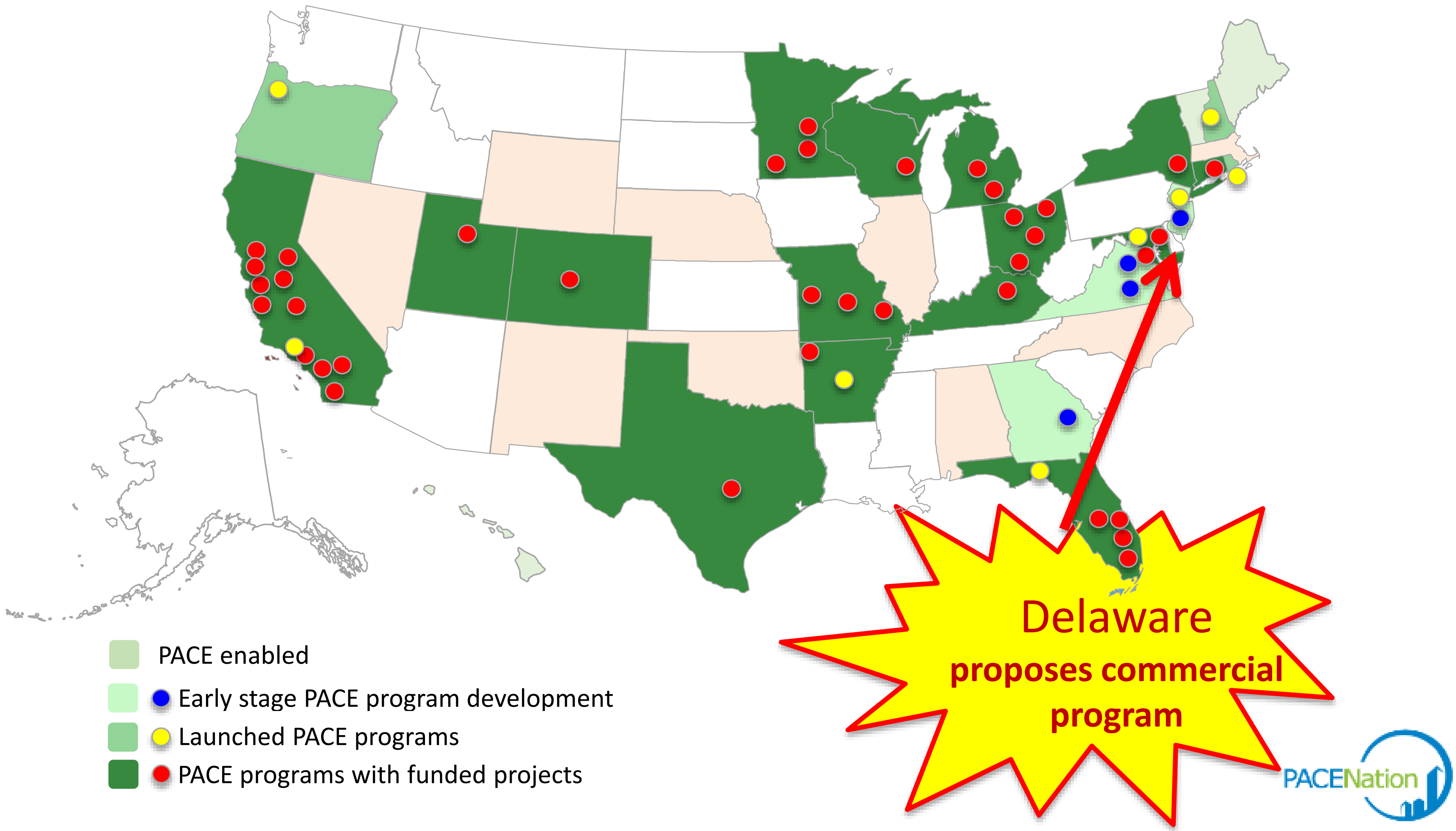


1. PACE project makes the building – the lender's collateral – more valuable
2. Only PACE assessment in arrears is senior – future assessments do not accelerate
3. Underwriting standards make sure projects are appropriate
4. Lender can always say NO…

Source: PACENation

PACE Programs Today

32 States + DC with PACE legislation; 19 states + DC with active programs



Market Data

C-PACE OVERVIEW

$292

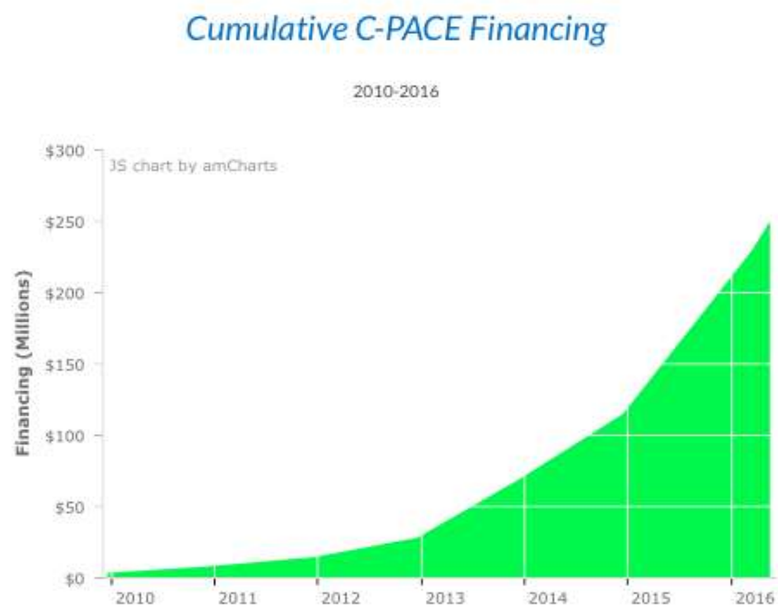
Millions

795

Commercial projects

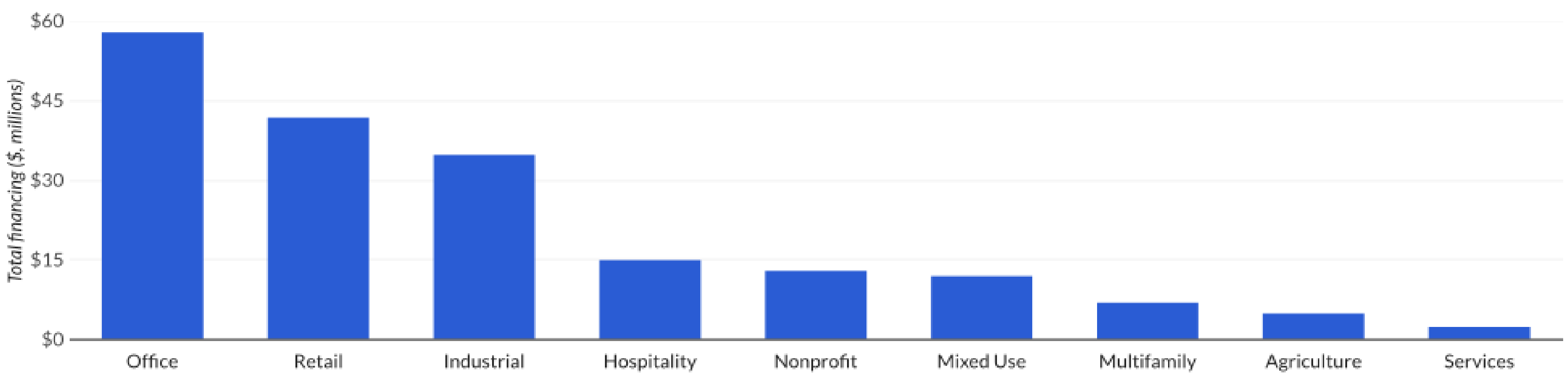
3,500

Jobs created



C-PACE dollars funded by building type

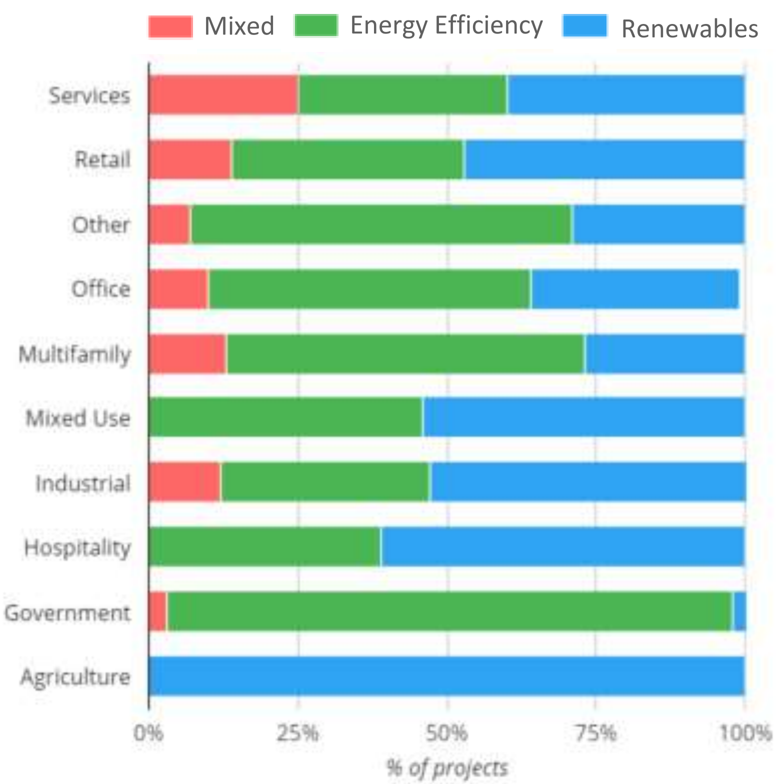
(By $ funded)



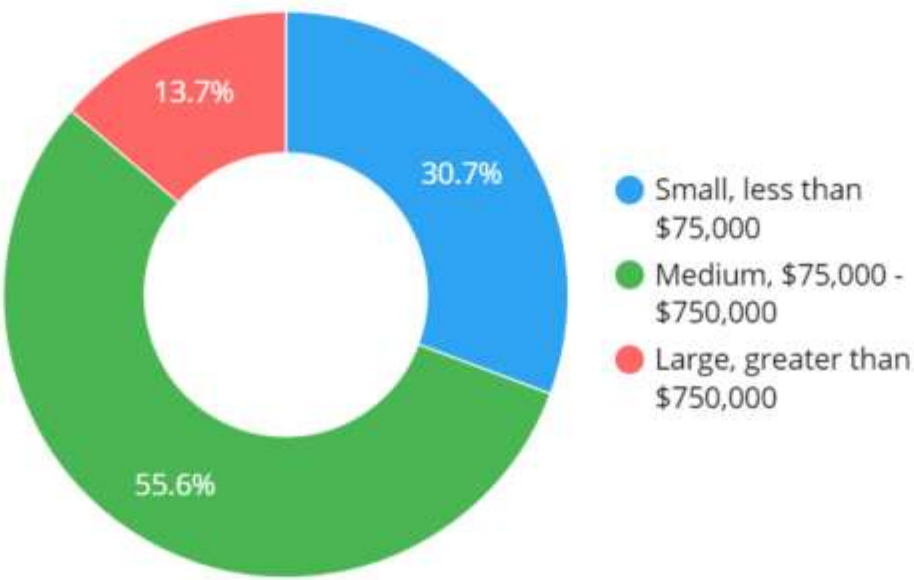
PACE Commercial Market Stats

Broad Applicability

Improvement type by building type



Number of projects by project dollar amount (categorized)



(Based on data available from 71% of commercial projects)

Source: PACENation

Voluntary Access Clean Energy in Delaware (D-VACE)

- SEU serves as Program Administrator
- D-VACE proposes county tax offices and Wilmington to volunteer for loan servicing. Can collect a fee for service.
- The Project benefit assessment shall constitute a lien

✓This lien is superior to any other liens and;
✓May remain with the real property upon sale
✓Requires underlying mortgage holder approval

D-VACE in Delaware

- The SEU or third party lenders provides loans to D-VACE participants

- D-VACE will not be operational until the SEU publishes guidelines in collaboration with DNREC and after a public hearing

- SEU collects fees to offset costs associated with executing the program.

D-VACE in Delaware

- SEU requires an approved energy audit or feasibility analysis – including a credit evaluation

- SEU develops requirements and conditions on the financing to ensure timely repayment
  - ✓ Requires the property owner to provide written notice of intent to participate in the D-VACE program to any mortgage holder of the property not less than 30 days prior
  - ✓ Requires that written consent for a superior lien be obtained before any improvements are financed or made

D-VACE in Delaware

Voluntary is Key Phrase

- **Voluntary for Local Governments to Participate**
- **Voluntary for Borrower**
- **Voluntary for Lender**
- **Voluntary Approval of Primary Mortgage Holder**

Next Steps

- Meet with Stakeholders
  - Bankers
  - County Officials
  - Realtors
- Educate Interest Groups
  - Sustainability
  - Economic Development
- Educate the Public

Any Questions?

Delaware Sustainable Energy Utility

Anthony DePrima Executive Director
tony.deprima@deseu.org
Phone: (302) 883-3048
www.energizedelaware.org

David Resler

Energy Procurement Opportunities for Savings

Ed Jackson

October 19, 2016

Today's Topics

Natural Gas

- Delmarva Power
- Chesapeake Utilities

Saving Money

Electricity

- Delmarva Power
- DE Electric Co-op
- DEMEC (i.e. City of Newark, Dover, etc.)

Natural Gas Choice

True or False

Any commercial or industrial gas customer in DE can select a competitive gas supplier.

False

Natural Gas Choice

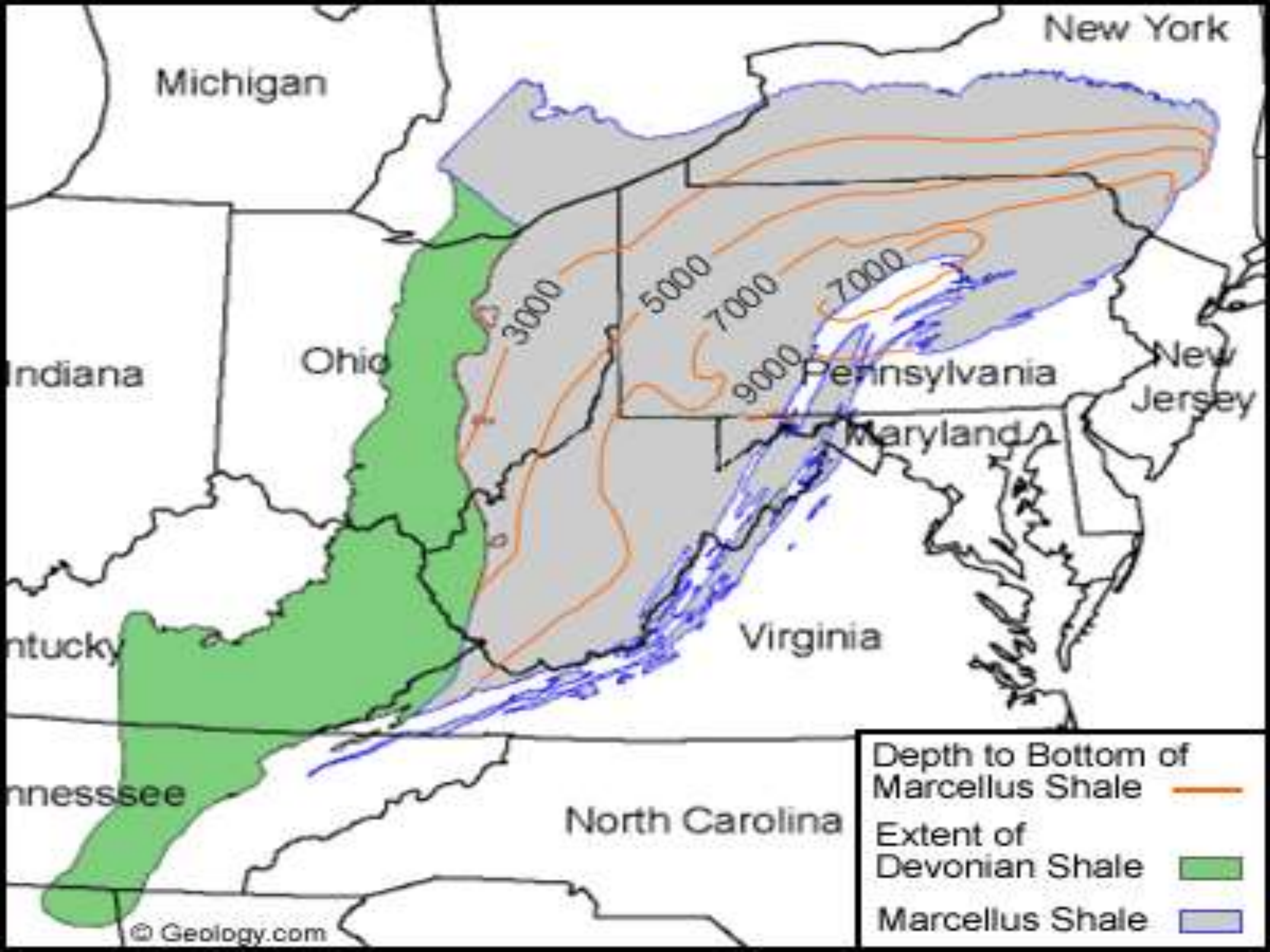
Chesapeake Utilities (Kent & Sussex)

- Min. of ~$30,000 per year per meter to qualify
- Smaller gas ACs can be combined if contiguous
- Good savings available by shopping right now
- Watch Your Units – MCFs, CCFs, Therms, etc.

Natural Gas Choice

Delmarva Power (New Castle County)

- Min. of ~$40,000 per year per meter to qualify
- No grouping of ACs allowed to qualify
- Phone line & outlet req'd. at gas meter
- Marginal savings by shopping right now
- New fees implemented Nov. 1st for customers that "transport"


New York
Michigan
Ohio
Indiana
ntucky
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North Carolina
Virginia
Maryland
Pennsylvania
New Jersey
3000
5000
7000
7000
9000
Depth to Bottom of Marcellus Shale
Extent of Devonian Shale
Marcellus Shale
© Geology.com

Electricity Procurement Opportunities

True or False

Any customer in DE can select a competitive electric supplier.

False

Electric Supply Rates in DE

Most Expensive to Least Expensive

- Municipalities (DEMEC)
  - Not allowed to shop
- Delmarva Power
  - Almost all customers should shop . . . ***most years***
- Competitive Supply Options
- DE Electric Co-op
  - Allowed to shop but no savings

Current Business Rate Structures
(Delmarva Power - DE)

- Small General Service
  - – No demand charges
- Medium General Service
  - – Includes demand charges
  - – Most small/med. size businesses are on this rate
- Large General Service & General Service Primary
  - – Includes demand charges
  - – On and off peak billing periods

Factors Impacting Competitive Energy Rates

- Timing – when you buy and how long you lock-in . . . ***Timing trumps technique***
- Load Profile – a flatter, more consistent load is less expensive than loads with significant peak demands
- Volume – a larger load will get a better price

Competitive Supply Options

True or False

There are now over 145 licensed competitive electric suppliers and brokers operating in DE.

True

Residential Supply Options

- Several suppliers have both fixed and floating rate options available in DE
- Check DE Public Service Commission web site for list of suppliers
- Watch out for “multi-level marketing” schemes & floating/variable priced plans
- Be sure you know what Delmarva’s supply rates are (i.e. Price to Compare)
    - Residential - **$0.0958/kwhr**
    - Residential Space Heating - **$0.0752/kwhr**

PJM Summer 2016 Peak

<u>True or False</u>

This summer's excessive heat caused the PJM power grid to reach an all time peak demand.

False

PJM Historical Peak Loads

- Summer 2016 – 151,945 MWs
  - – Thursday, Aug. 11th, 3:00 - 4:00 pm
- Summer 2015 – 144,336 MWs
- All Time PJM Peak – 163,721 MWs
  - – July 2011

Is On-site PV Solar Compatible With Competitive Supply Contracts?

True or False

I installed PV Solar behind my meter that covers 1/3 of my annual load so I can't be in a competitive supply contract.

False

Is On-site PV Solar Compatible With Competitive Supply Contracts?

- Delmarva’s Net Metering only addresses net energy usage (kWh) and you are still billed for actual peak demands (kw).
- A competitive electric supply contract will protect you from the majority of Delmarva’s peak demand charges.
- On-site PV system that covers all of your load is <u>not</u> compatible with a competitive supply contract.

How Else Can I Support Renewable Energy?

True or False

I don't have space or $ to install PV Solar behind my meter so there's no way for me to buy green energy for my building.

False

How to “Green-up” Your Energy

- Customers can elect to purchase RECs or SRECs as a way to buy up to 100% green energy for their facility.

- The cost is very affordable at a small premium of < $0.0025/kwhr for 100% green energy (wind) RECs

Unbundling Your Supply Charges

- If you are implementing energy efficiency projects and/or expect your peak demands will be declining over time you should
  - "pass through" electric supply costs associated with your peak demand charges i.e. Capacity & Transmission components

Thank You !

Ed Jackson

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Closing Remarks:

Tony DePrima

Public Sector Co-Chairman
Energy Services Coalition, Delaware Chapter, and
Executive Director, Delaware Sustainable Energy Utility

Thank You!