

MU SUSTAINABLE DISTRICT ENERGY AT MIZZOU



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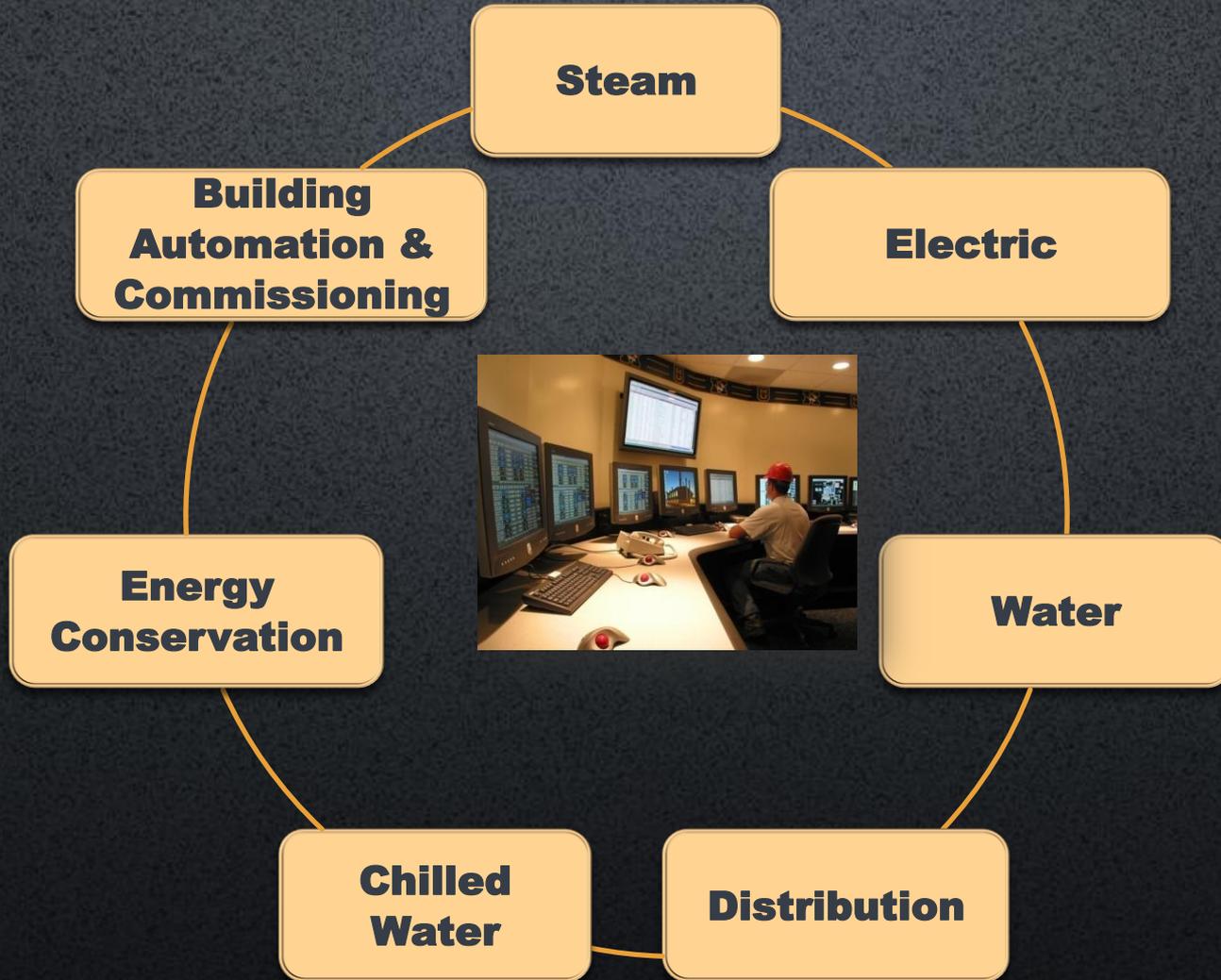


CAMPUS ENERGY 2016

The Changing
Landscape



COMPREHENSIVE ENERGY SERVICES





UTILITY PRODUCTION

66 MW GENERATION

1,100,000 LB/HR STEAM

32,000 TONS CHILLED WATER

4 MILLION GAL/DAY WATER

- CAPABLE OF RELIABLY SERVING ALL MU'S NEEDS
- EFFICIENT COMBINED HEAT & POWER PROCESS SINCE 1892



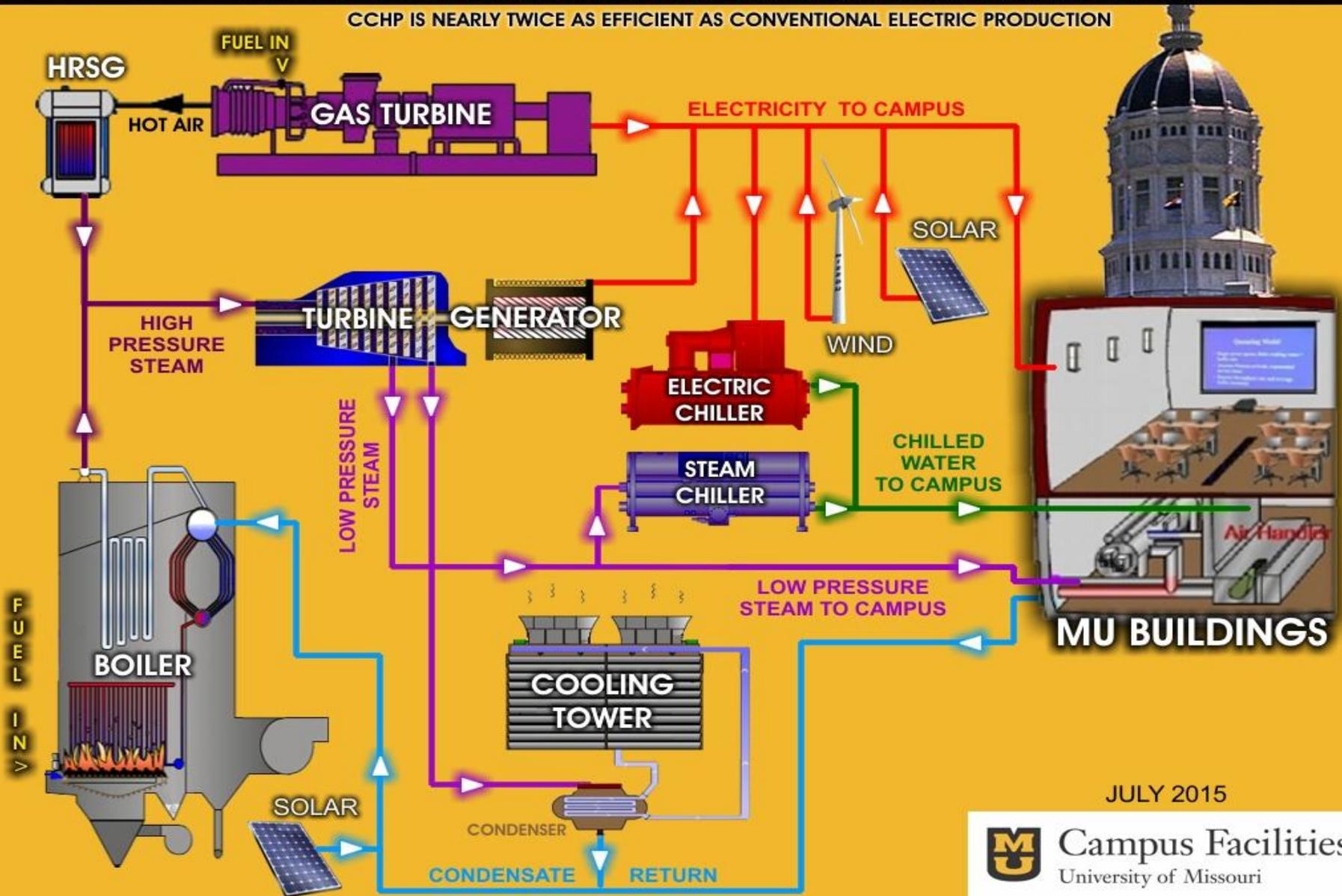


CHILLED WATER PRODUCTION



MU COMBINED COOLING HEAT & POWER DIAGRAM

CCHP IS NEARLY TWICE AS EFFICIENT AS CONVENTIONAL ELECTRIC PRODUCTION



JULY 2015

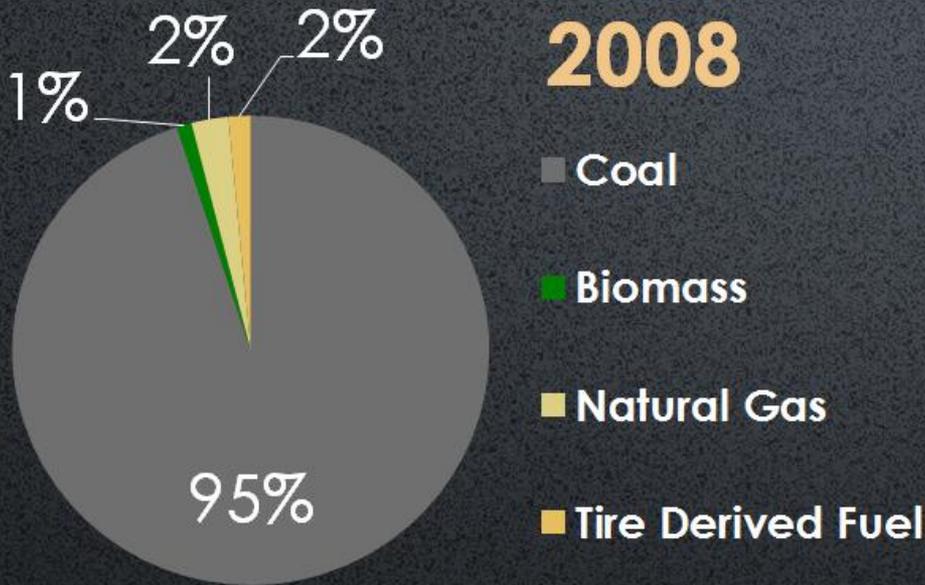


Campus Facilities
University of Missouri

2010 EPA Energy Star CHP Award Winner!



LOOKING BACK - 2008 FUEL MIX



- **Purchased Electricity (MISO)**
 - **27% Campus Needs (Economic Power)**
 - **81% Coal Based**



2008 - 2009 CAMPUS CLIMATE

- Coal Free Mizzou campaign
- American College & University Climate Commitment 2009 signatory
- 150 kpph Coal boiler needing replacement
- Growing concerns about burning coal
- Capital constraints

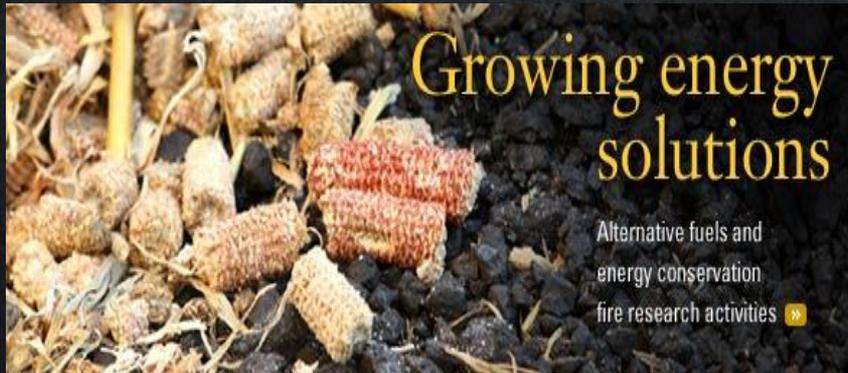




Renewable Energy Initiatives

DIVERSIFIED RENEWABLE ENERGY PORTFOLIO

- ON-CAMPUS WIND ENERGY
- ON-CAMPUS SOLAR PV
- OFF-SITE WIND ENERGY
- ON-CAMPUS SOLAR THERMAL
- BIOMASS COMBINED HEAT & POWER





WIND ENERGY

Demonstration Wind Turbine

- Rated for up to 20,000 Watts
- 98 foot pole with 16 foot blades
- Annual generation equal to supplying 2.5 homes
- Can be lowered for maintenance and tours

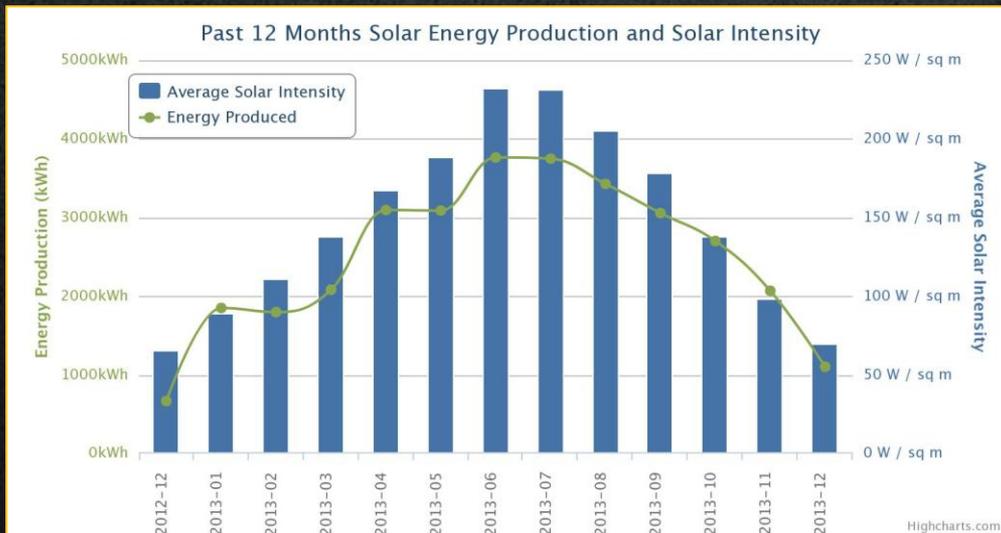




SOLAR PHOTOVOLTAIC

Power Plant Solar PV

- 144 Solar PV Panels
- Rated for 34,000 Watts
- Annual production equal to supplying 4 homes



Research Reactor Solar PV

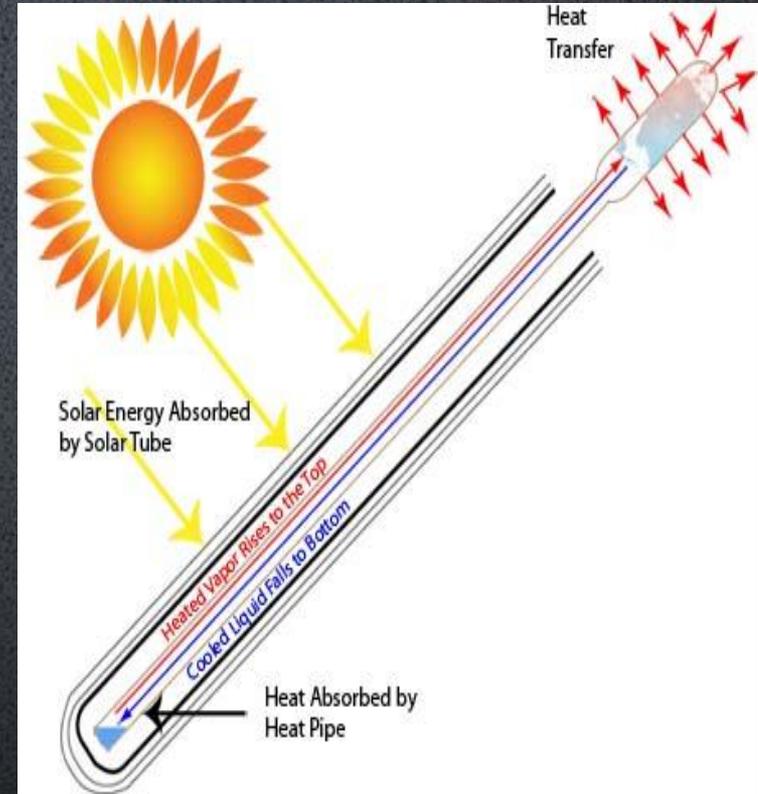
- 10 Solar PV Panels
- Rated for 2,350 Watts



SOLAR THERMAL

Power Plant Preheating

- 12 Evacuated Tube Panels and 2 Emerging Technology Panels
- Up to 600 Million Btu Annually to pre-heat boiler makeup water
- Annual production equal to heating 10 homes



Success!

Solar Thermal now installed in a new residence hall to supplement water heating



2012 Biomass Combined Heat & Power Upgrade



Project Designer
Sega

Contractor
McCarthy Builders

Boiler Supplier
B & W



Project Overview

Biomass Boiler – 150,000 lbs per hr at 950 psig / 850 F

Steam - 150,000 lb/hr at 950 psig at 850 F

Heat Input – 227 MMBtu / hr

- 21 Tons / hr
- Up to 140,000 tons of biomass per year

Primary Fuel – Wood Residues

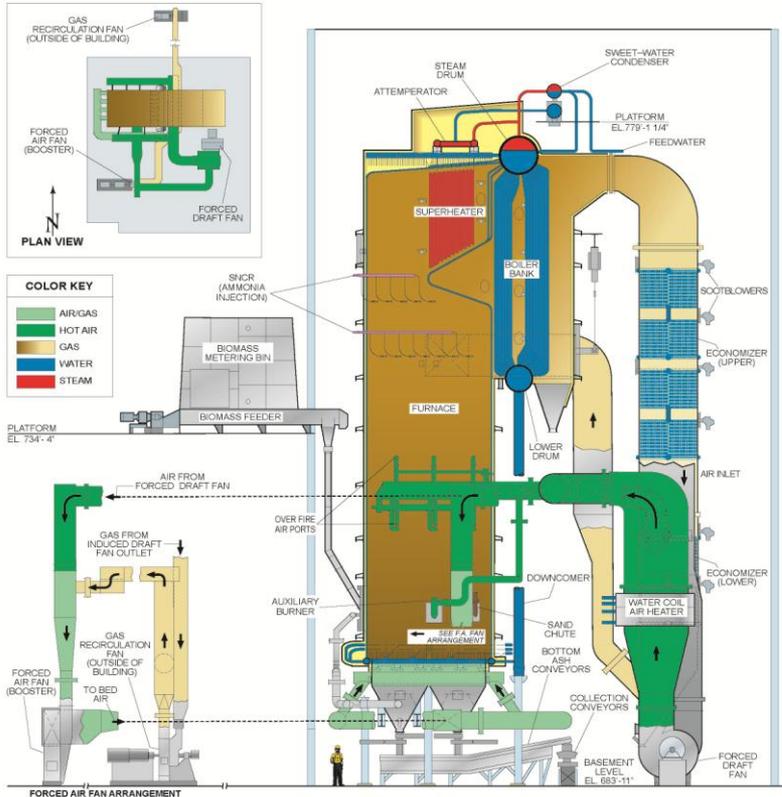
Fuel Supplier – Foster Brothers Wood Products





Bubbling Fluidized Bed Combustion

B&W babcock & wilcox power generation group



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Bubbling fluidized bed technology

Boiler burns wood wastes and other types of biomass

Emission controls:

- Pulse Jet Filter Baghouse**
- Flue Gas Recirculation**
- SNCR**

Other features:

- Sweet Water Condenser**
- Water Coil Air Heater**
- Bed Reclaim/Sifting System**
- Steam Soot Blowers**
- Air Fuel Sweep**
- Retractable Light Off Burners**



Biomass Fuels for Mizzou

CURRENT SOURCES

- MILL RESIDUES
- GROUND PALLETS
- TREE TRIMMINGS
- MANAGED FOREST THINNING



Future Sources?

- Corn Stover
- Switchgrass
- Miscanthus
- Short Rotation
- Woody Crops
- Logging Residues



SUSTAINABILITY REQUIREMENTS

Each harvesting team shall include at least one logger that has completed the Missouri Forest Products Association's Professional Timber Harvester Program



All land will be managed according to a written Forest Management Plan prepared by a professional forester

MU will NOT accept any biomass as a result of conversion from forestland to either agricultural row crops, pasture, or commercial development



BENEFITS OF BIOMASS FOR MIZZOU

- Provides local renewable fuel source for MU and helps Missouri's economy
- Supports MU's sustainability goals
- Supports academics and research in sustainable energy





First Year Challenges

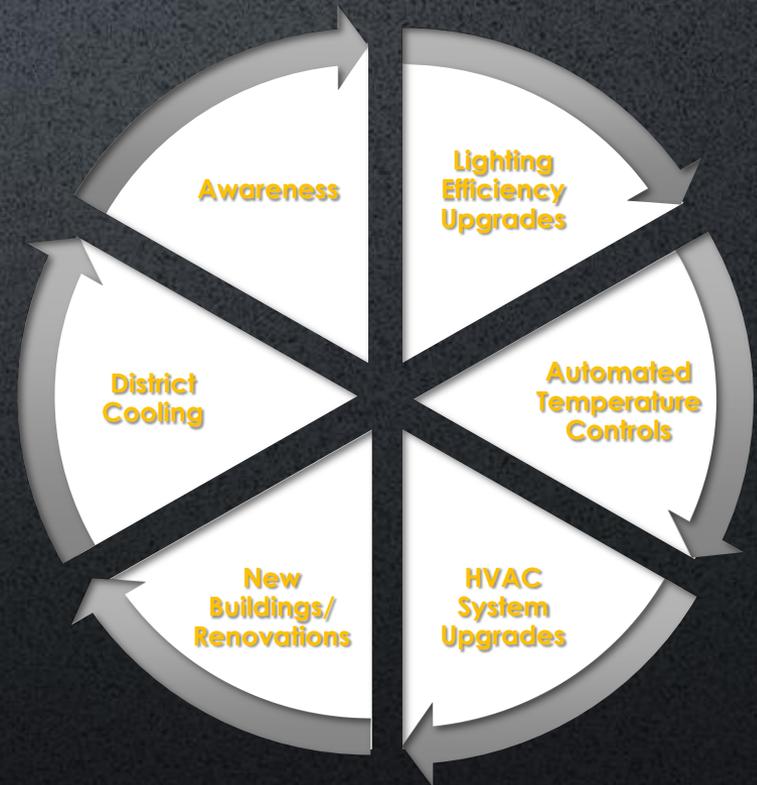
- **First Major Biomass Permit in Missouri**
- **Operating plant during construction**
- **Fixed budget**
- **Tight Schedules**
- **Limited Site Space**
- **Fuel Sourcing the Biomass**
- **Operational Challenges**
 - Biomass Silo Reclaimers**
 - Drag Conveyors**
 - Char in Ash Collection**





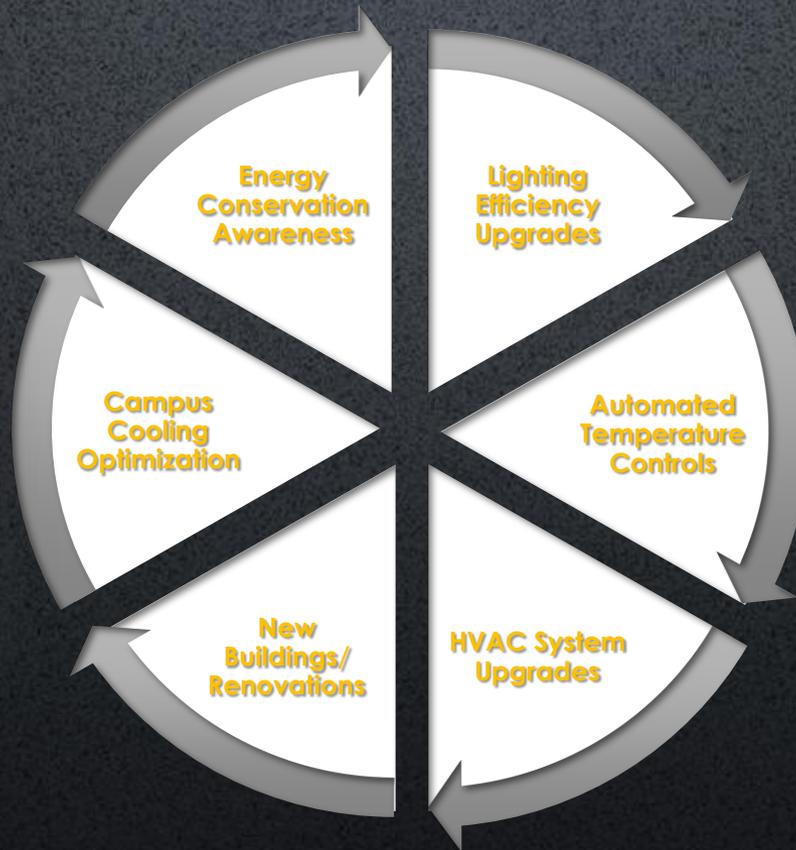
Energy Conservation Program

- Formal program started in 1990
- Energy conservation is an important part of MU's sustainability efforts
- Since 1990, energy conservation has reduced energy costs in existing space by an average of 1.5% annually





Energy Conservation Program





ENERGY CONSERVATION

20% reduction in
energy use
per sq ft

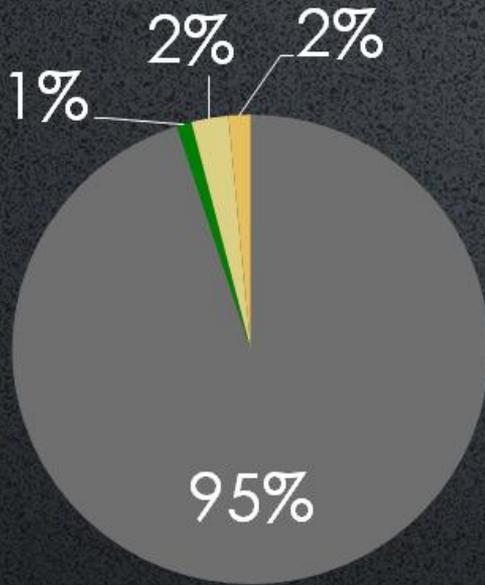
\$8.9 million annual
Cost Avoidance

\$71.2 million total
Cost Avoidance



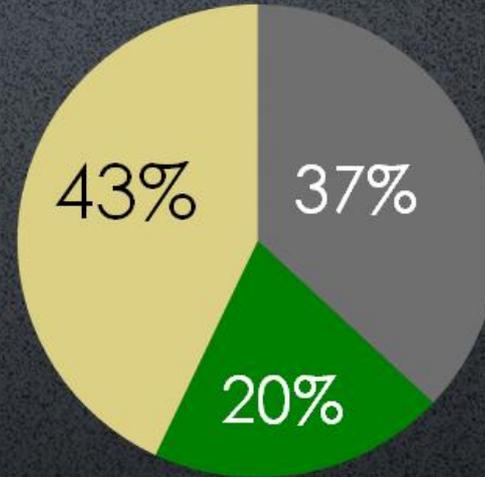


FUEL MIX TODAY!



2008

- Coal
- Biomass
- Natural Gas
- Tire Derived Fuel



2016

- Coal
- Biomass
- Natural Gas





PURCHASED POWER MIX TODAY!

2008

- 81% Coal Based

2016 Projection

- 51% Coal Based



- 37% Wind



- 12% Other





ONGOING SUCCESS

Through 2015:

- Total renewable energy portfolio – 27%
- Greenhouse gas emissions reduced by (2008 Base) – 43%
- Coal use being reduced by (2008 Base) – 54%
- Wind Power percentage of campus electric – 11%





CAMPUS COMMUNITY INVOLVEMENT

- **Energy Strategies Student Group**
 - Formed by the Vice Chancellor
 - Student Lead With Faculty & Staff Advisors
 - Advises Campus Leadership

- **Combined Heat & Power Plant Tours**
 - 850+ Students Tour Annually

- **Academic Partnerships**
 - Forestry – Sustainable Biomass Harvesting
 - Agriculture – Development of Future Biomass Fuels
 - Engineering – Thermodynamics, Electrical, Mechanical & Energy Related Fields



Thank You! Questions?

