# UNC Energy Services

## Energy Supply Alternatives

## Carolina North

# Introductions

- Carolyn Elfland – Assoc. VC for Campus Services
  - Introduction
- Jim McAdam – Manager, Chilled Water Systems
  - Heat Pump Technology & Distributed Solar
- Phil Barner – Capital Program Manager
  - Landfill Gas & Wood Products
- William Lowery – Senior Engineer, Cogeneration Systems
  - Animal Waste & Carbon Capture

# Carolina North Goals

- Cost
- Reliability
- Land use
- Aesthetics
- Carbon
- Offsite / Distribution Requirements
- Operation & Maintenance
- Resource Conservation
- Pedagogical Opportunities
- Health & Wellness

# Purpose of Presentation

- Energy Supply Alternatives, not choices
- Opportunities & Hurdles
- Key variables
  - Building mix/typology
  - Energy density
  - Competing goals

# Heat Pump Technology

# Water to Water Heat Pumps

# Current Cooling Methodology

Heat Gain

Standard Chiller

Heat Rejected

59 F

5 Units

95 F

Electricity In

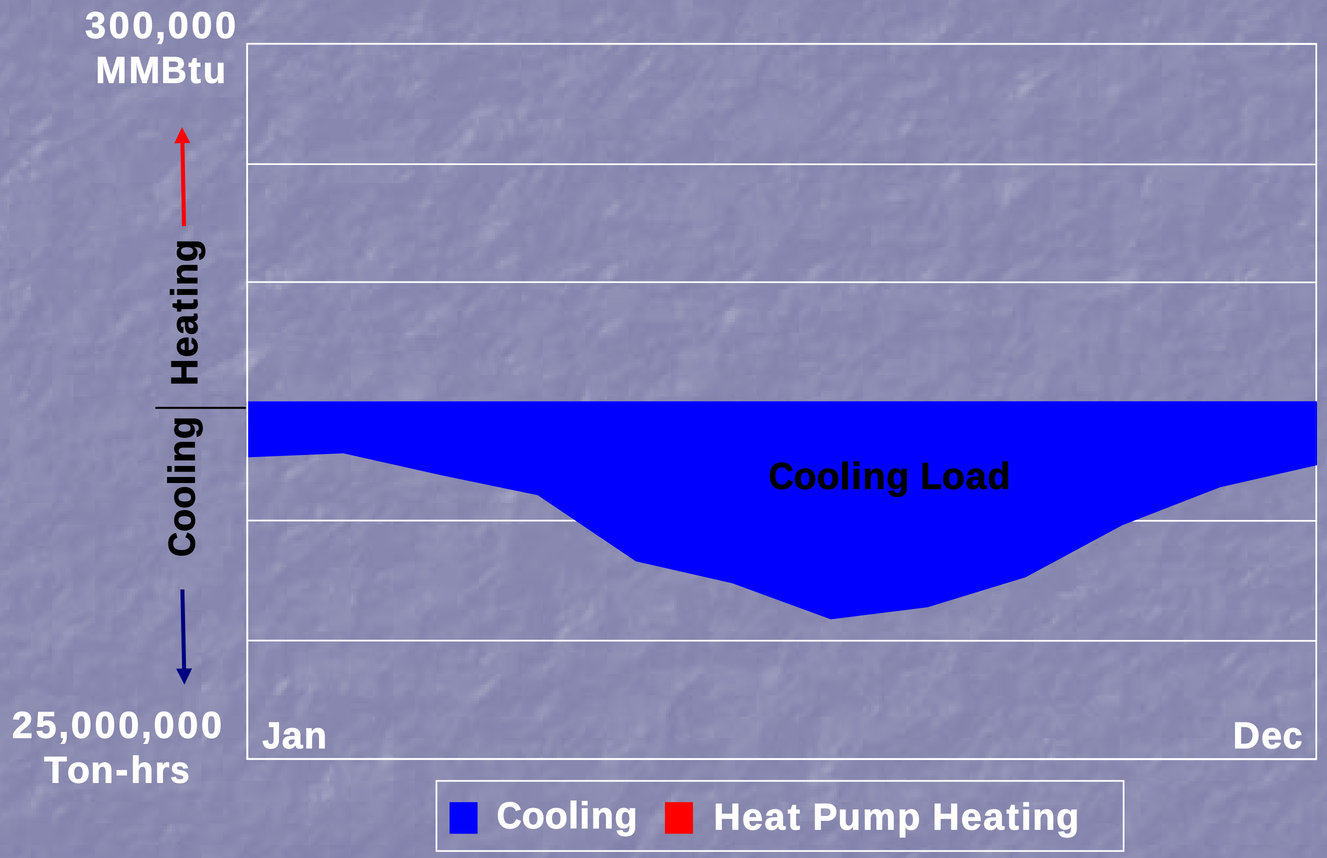
**1 Unit**

Water In

**The advantage of chillers**

**1 Unit bought = 5 Units of useful work**

# Main Campus Load Profile



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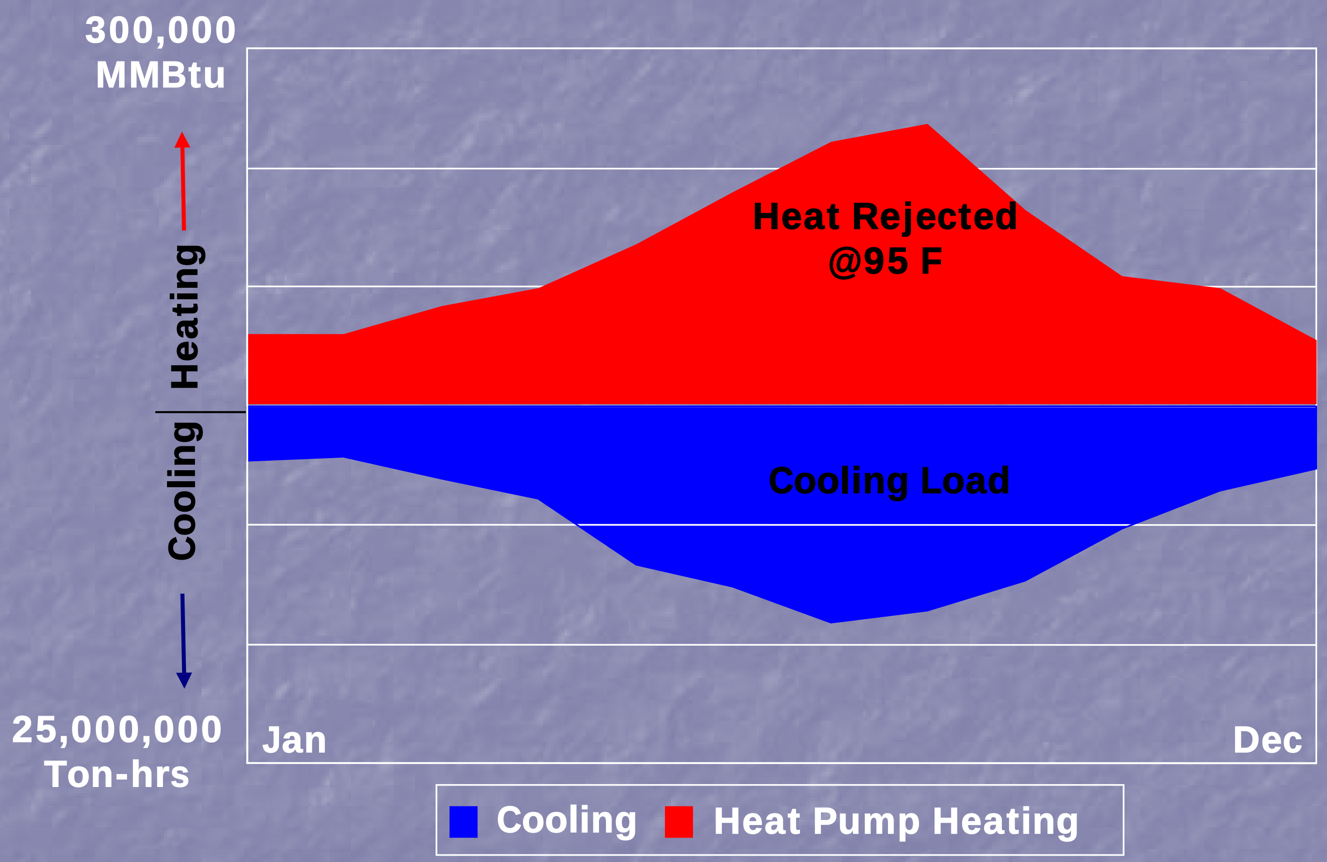

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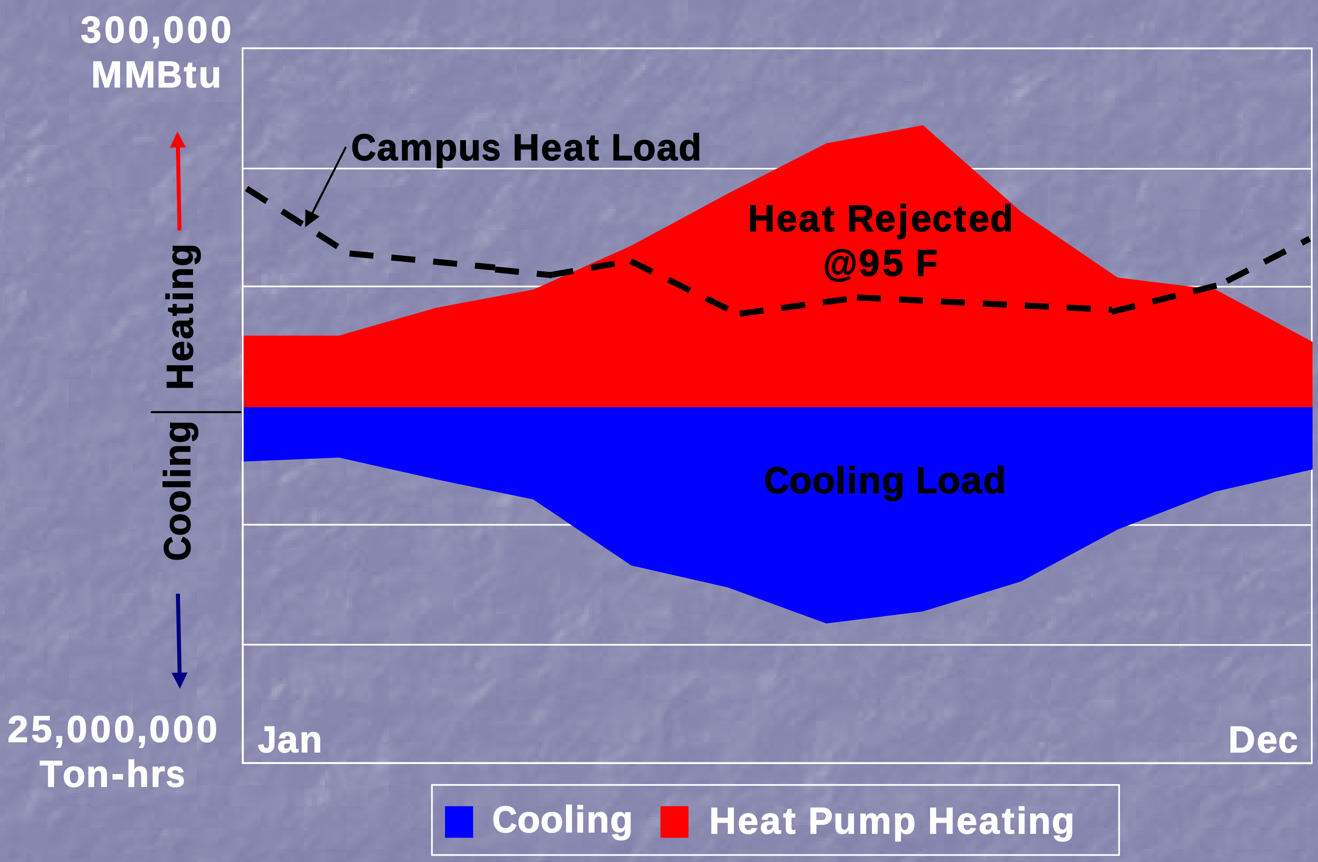


# Heat Pump Opportunity

Heat In

59 F

5 Units

"Heat Pump" Chiller

150 F

7 Units

Useful Heat

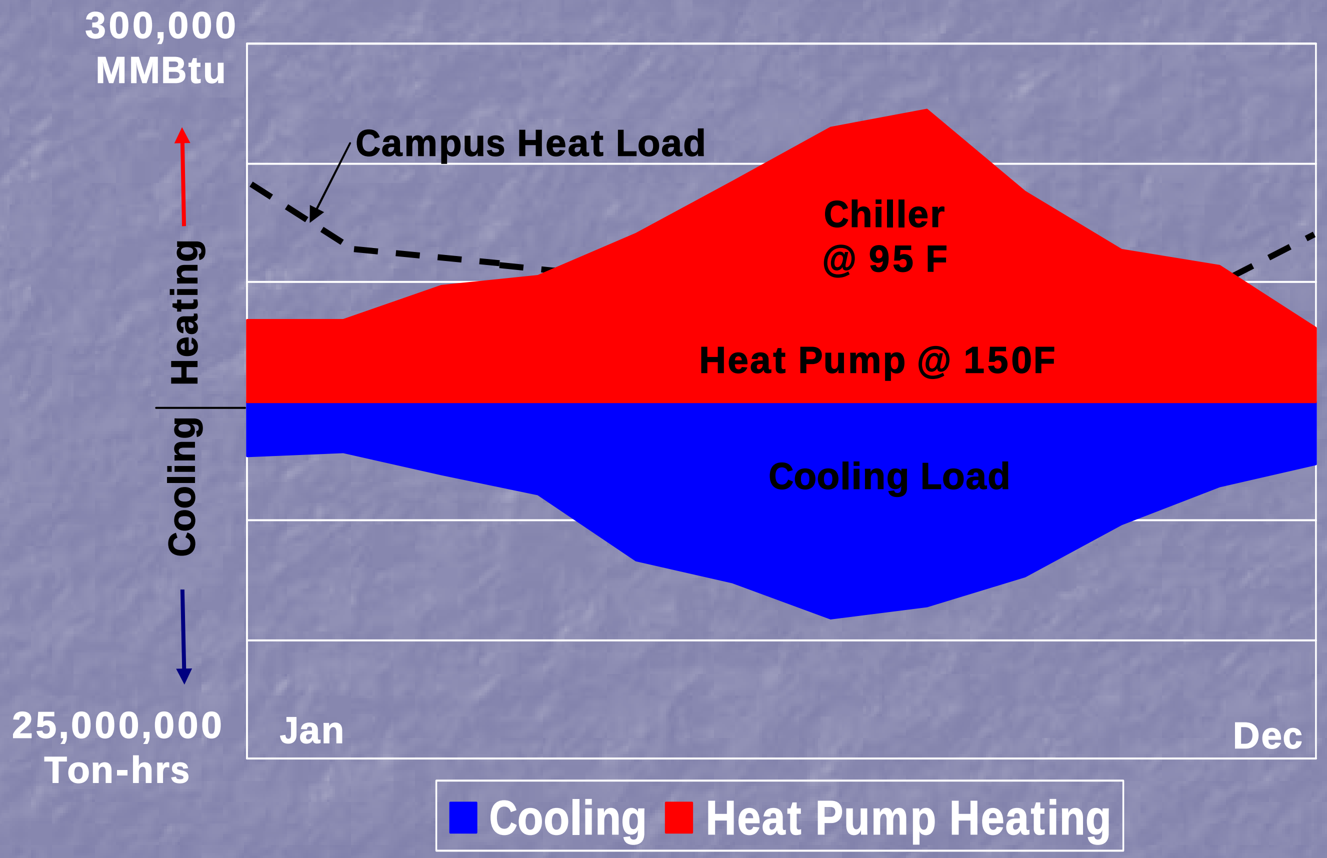
Electricity In

2 Units

**The advantage of this....**

**2 Units bought = 5 + 7 Units of useful work**

# Main Campus Load Profile



# Production Costs

ASSUMPTIONS

2MW Heat pump, 40F CWS, 155F HWS

24/7/365 operation

Gas = $8/MMBtu

Electric = $0.07/kWh

Water = $5/1,000 gal

| | Heat Pump | Gas Boiler + Chiller | Gas Cogen + Chiller |
|---|---|---|---|
| Gas | $0 | $1,752,000 | $2,657,000 |
| Electric | $1,290,000 | $554,000 | ($126,000) |
| Water | $0 | $130,000 | $158,000 |
| **Annual Cost** | **$1,290,000** | **$2,436,000** | **$2,689,000** |
| **$/MMBtu** **(heating and cooling)** | **$4.16** | **$7.81** | **$8.63** |
| **$CO_2$ (ton/yr)** | **10,377** | **17,277** | **14,621** |

# Heat Pump Technology

Requires coincident Heating & Cooling

This seems illogical – So why do we do it??

# Heat Pump Technology

## Answer: Dehumidification & Reheating

Chilled Water

(from Chiller Plant)

Steam

(from Cogen Plant)

Outside Air

Cold Air

55 F

Condensate

68 F

Tempered Dry Air

# Heat Pump Technology

Answer: Data Centers need cooling all winter...

Chilled Water

(from Chiller Plant)

Recirculated Air →

Cold Air →

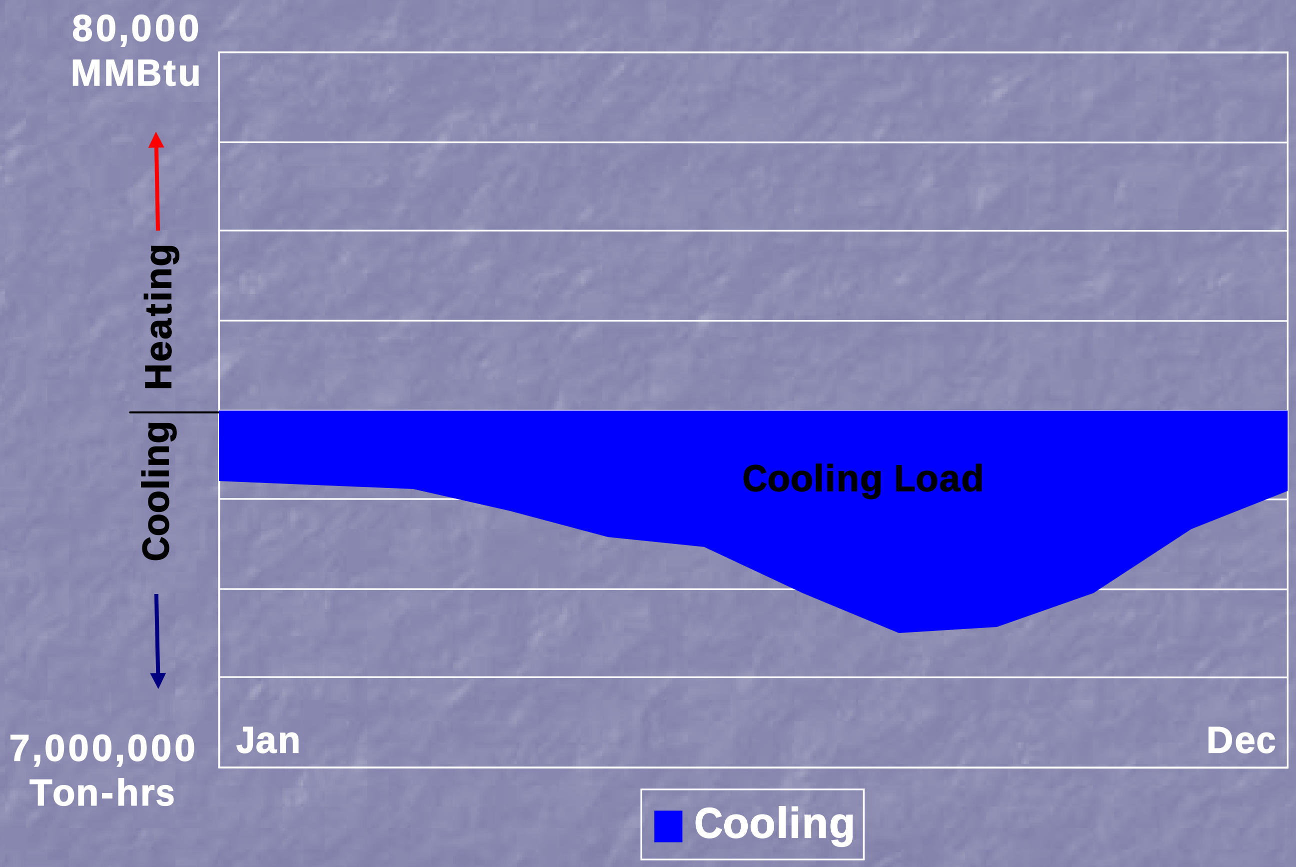
55 F

Electricity

(for Servers)

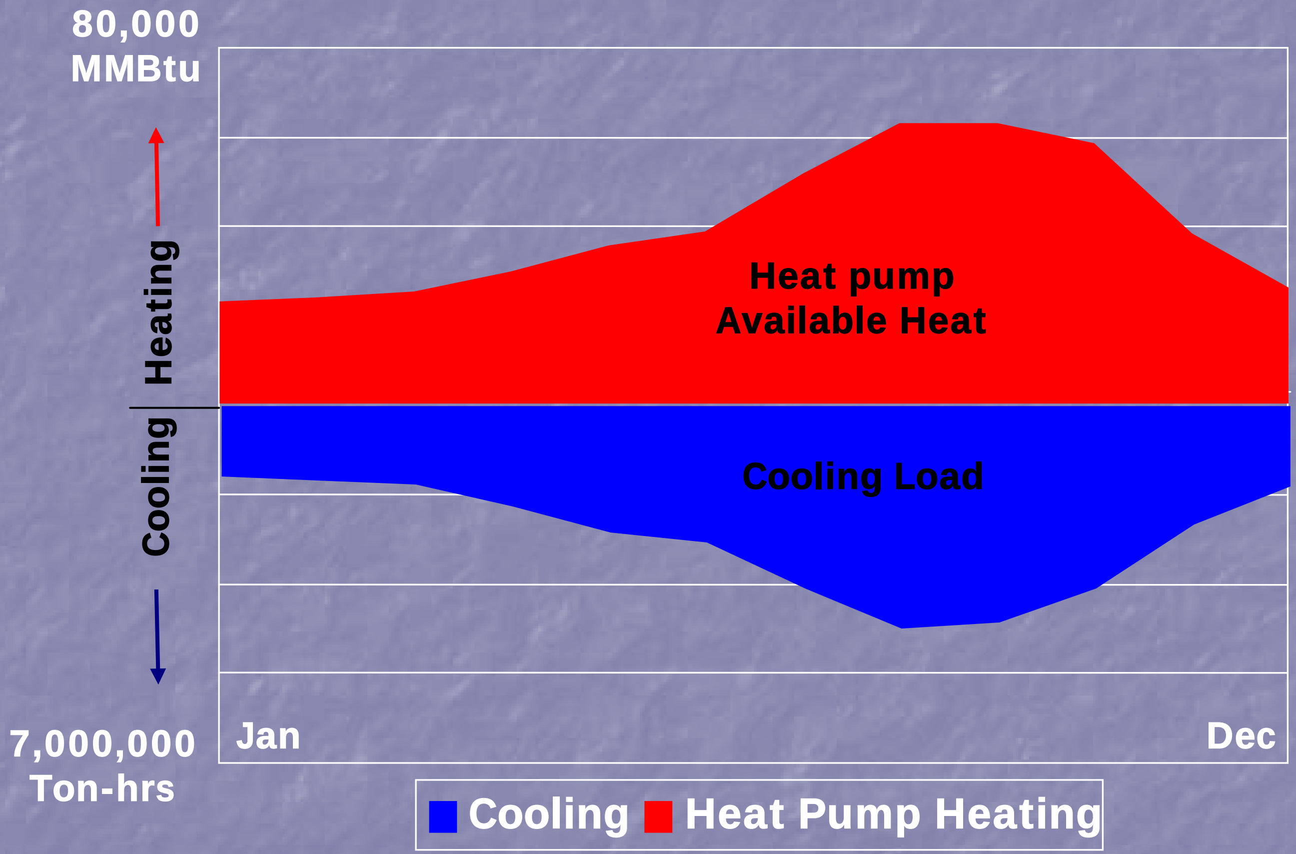
# Potential Carolina North Load Profile

( 1.5M sqft, 5MW RENCI )



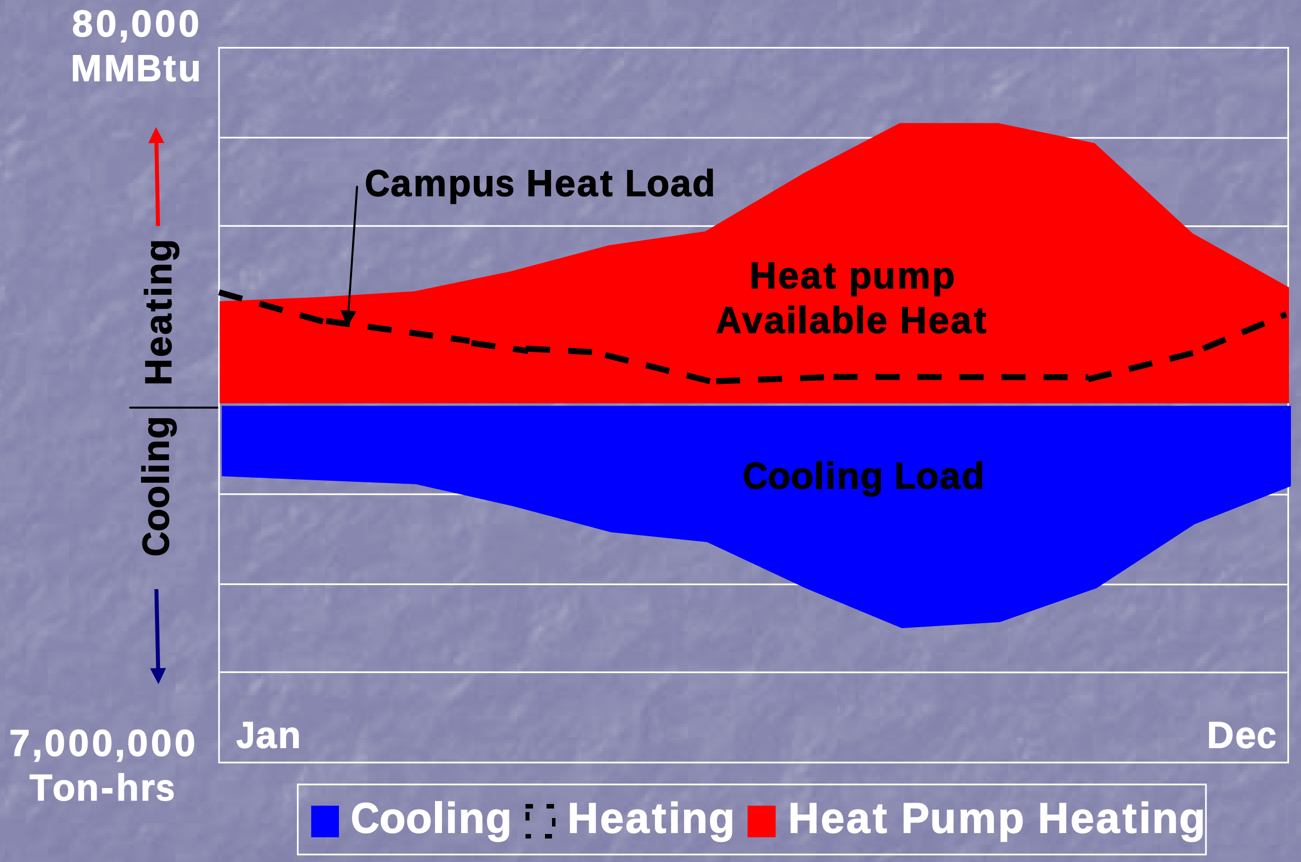
# Potential Carolina North Load Profile

( 1.5M sqft, 5MW RENCI )



# Potential Carolina North Load Profile

( 1.5M sqft, 5MW RENCI )



# Heat Pump Technology

## Opportunities

- Allows “Waste = Food” to work campus wide
- Inexpensive heat ($0 extra cost is possible in summer)
- Cooling tower water savings (30-50%)
- Reduced combustion-based heating
- Reduced CARBON emissions
- Proven technology in use today
- Low capital cost
- Good bridge solution for initial phase

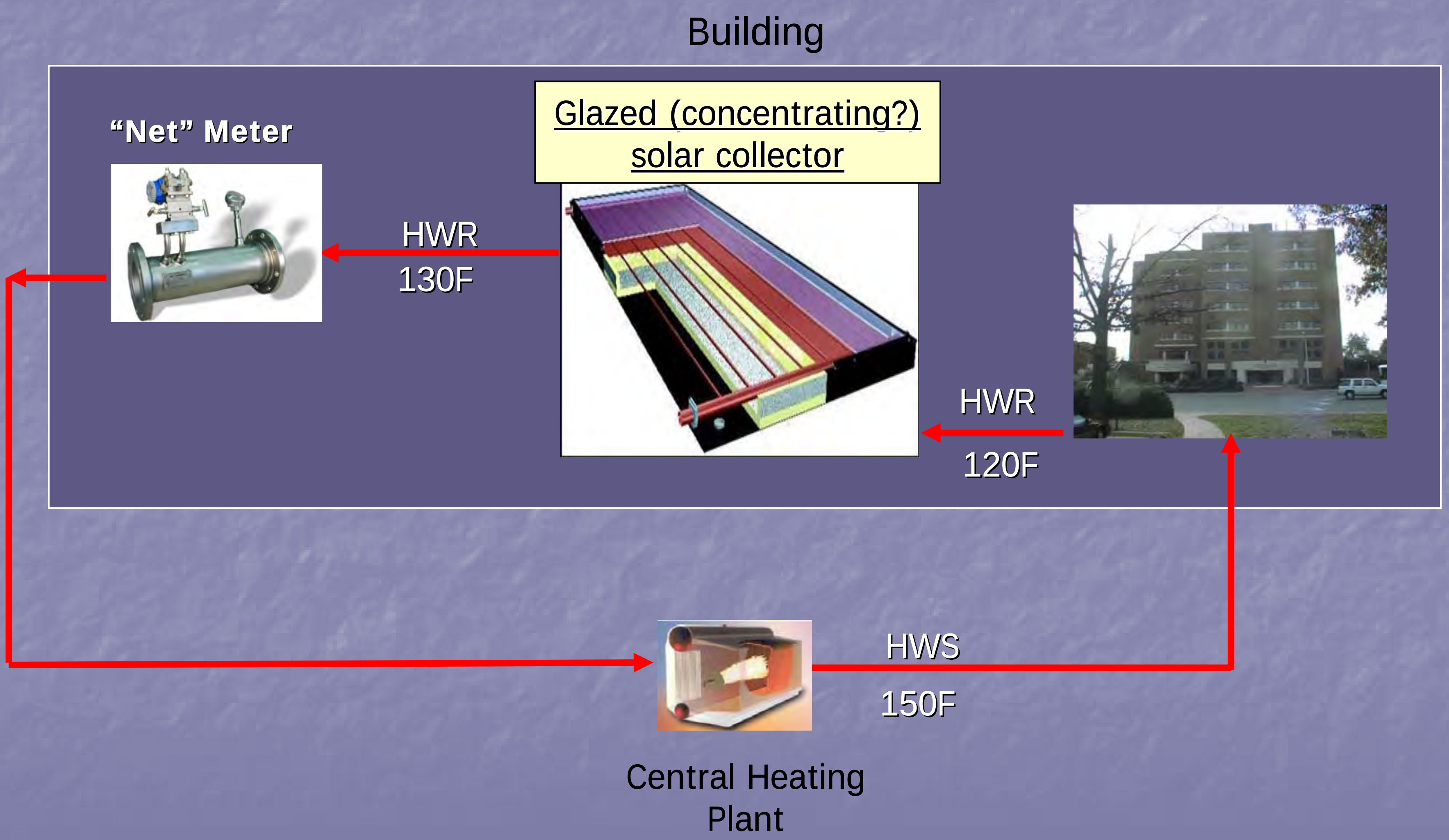
# Heat Pump Technology

## Barriers / Risks

- Electric rate sensitivity
- Reliance on Duke Energy
- Carbon offsets required to achieve carbon neutral goal
- Requires hot water distribution system, not steam
- Serves same heat load that is needed for Cogeneration

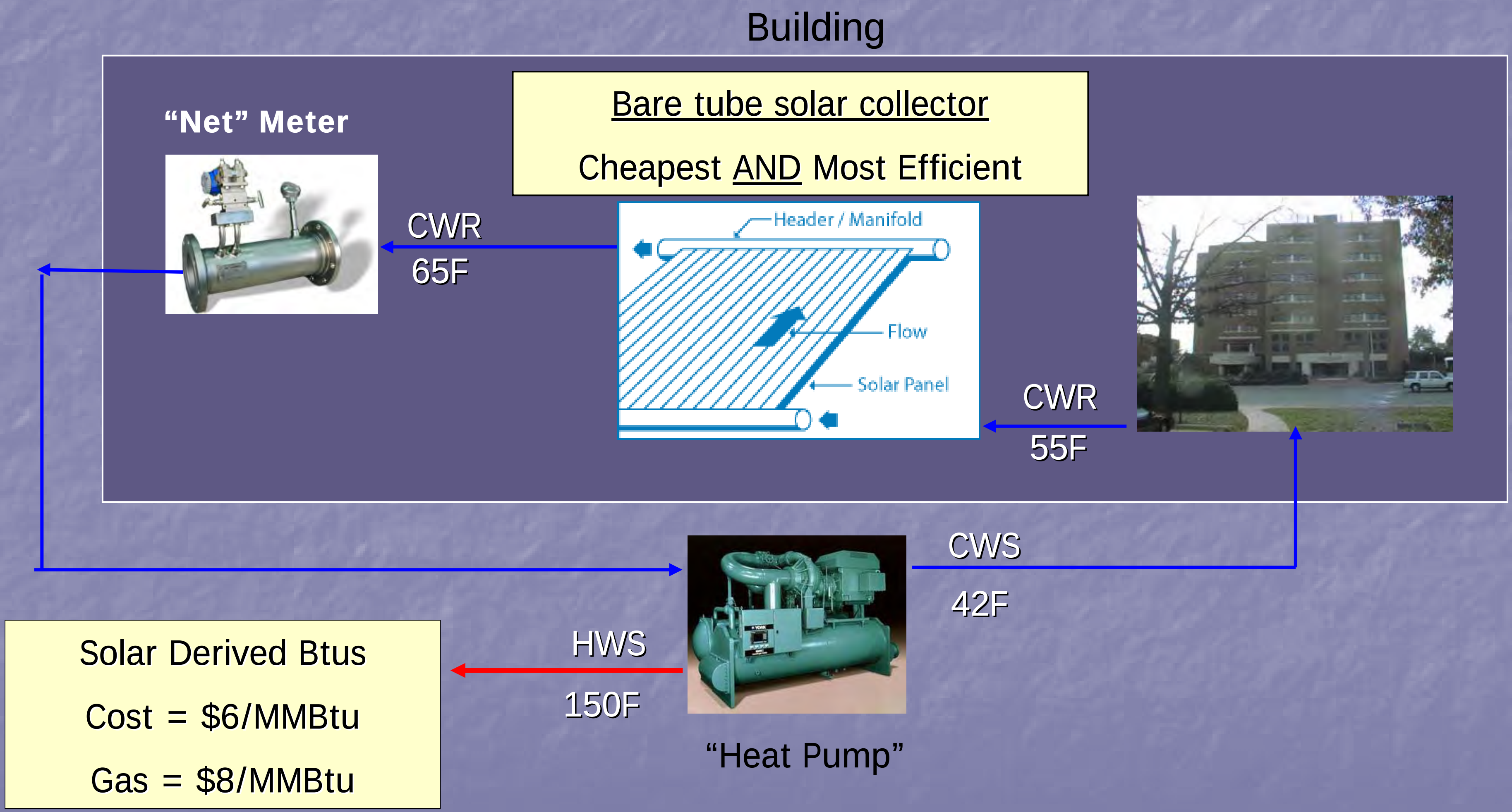
# Distributed Solar Technology

# Distributed Solar Technology



# Distributed Solar Technology

## Solar Assisted Heat Pump



# Distributed Solar Technology

## Opportunities

- Solar is 100% renewable and available onsite
- Grid connection lowers installed cost and maximizes economic benefits
- All solar energy is used and no local storage is required
- Potential to finance significant building-level renewables with utility rate

# Distributed Solar Technology

## Barriers / Risks

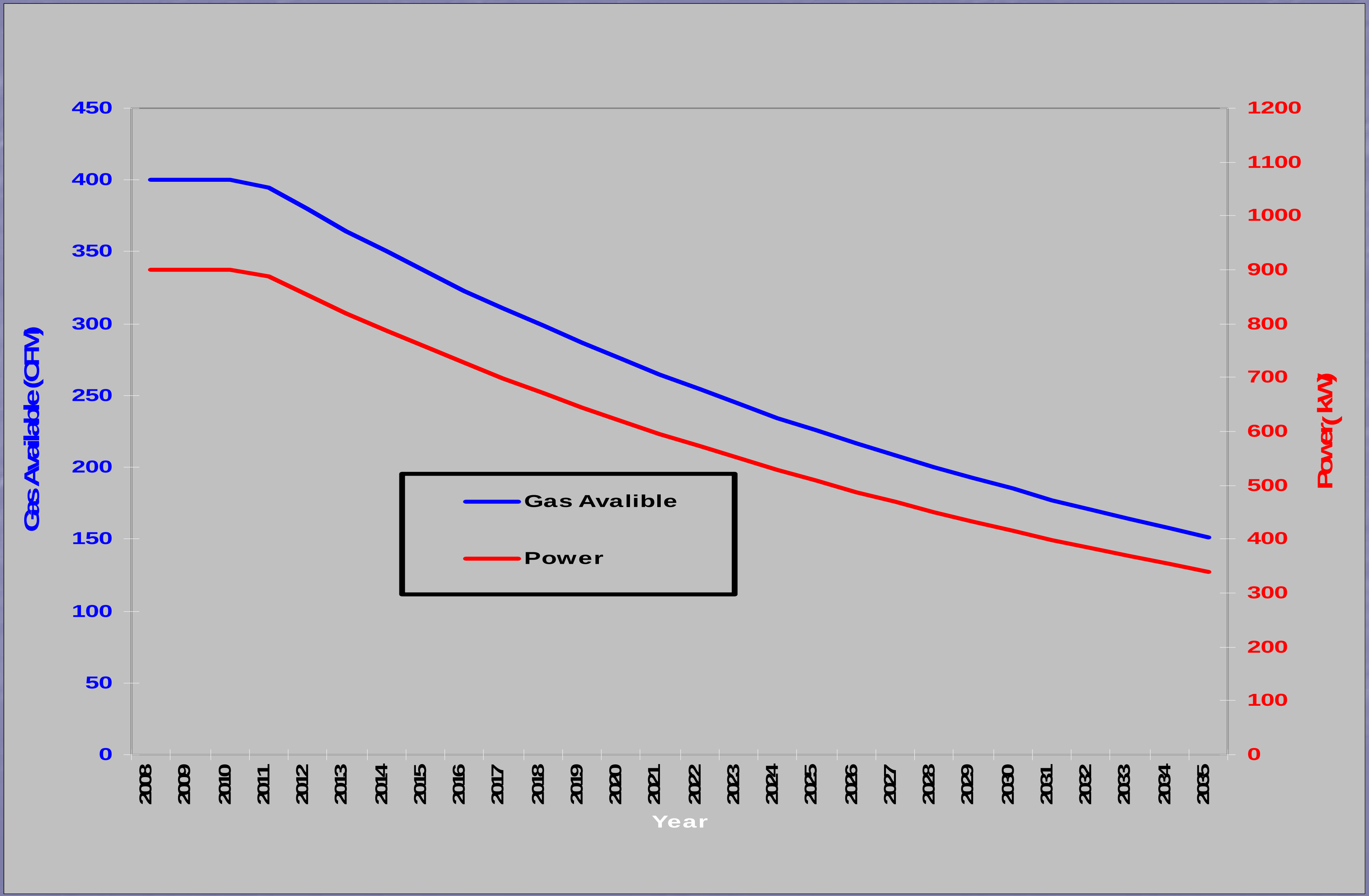
- Possible central plant/grid disruption
- Interconnections standards needed
- Metering complexity

# Landfill Gas

# Landfill Gas

- Orange County Eubanks Road Landfill
- ~ 2 miles from Carolina North Site
- Capacity to produce 0.75 MW of power and heat 100k to 200k GSF of building space
- Source will diminish over time with peak output around 2010

# Landfill Gas



# Wood Waste

# Wood Waste

- Use Urban Waste Wood and Forest Residue from ~ 50 mile radius
- Combustion Technology well understood
- Gasification possibility
- Intermediate to Long Term Solution, depending on supply

# Wood Waste

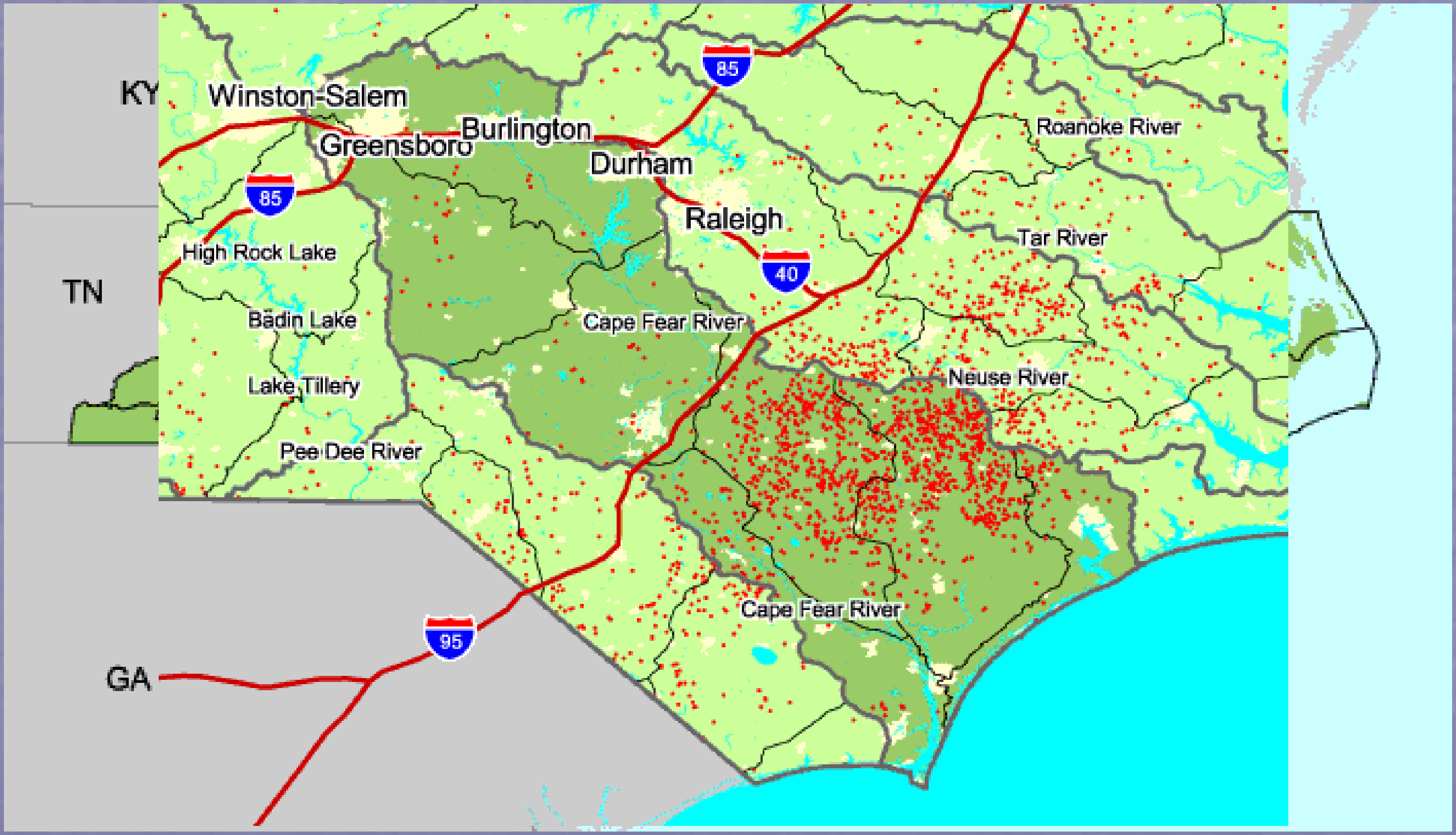
- Requires Large Fuel Handling and Preparation area – Can be Offsite
- Local Supply (~50 mile radius) required
- Local Supply appears adequate

# Animal Waste

# Hog Waste

- Mid 80's:  over 15,000 farms, 2.4 million hogs
- Mid 90's:  3600 farms, 8 million hogs
- Currently:  2400 farms, 10 million hogs
- Second leading producer behind IOWA (16 million)
- 11 lbs of manure per hog per day
- 4000 to 6000 Btu / lbm (when fresh ☺)

# Hog Waste



KY
Winston-Salem
Greensboro
Burlington
Durham
Raleigh
85
85
40
95
Roanoke River
Tar River
High Rock Lake
TN
Badin Lake
Cape Fear River
Neuse River
Lake Tillery
Pee Dee River
Cape Fear River
GA

# Hog Waste Solids

# Hog Waste Solids

## Opportunities

- Renewable source of energy located in NC
- Mitigates other environmental problems
- Legislative incentives
- Boost to economically depressed portion of the State

## Hurdles

- Lots of solids handling, energy, effort to create pellet
- Expensive, specialized boiler technology for clean burn
- Solids handling at the boiler facility, before and after the combustor
- Storage degrades the Btu content

# Hog Waste Biogas

# Hog Waste Biogas

## Typical Biogas

| | |
|---|---|
| Methane, $CH_4$ | 55 – 75% |
| Carbon Dioxide, $CO_2$ | 25 – 45% |
| Nitrogen, $N_2$ | 0 - 0.3% |
| Hydrogen, $H_2$ | 1 – 5% |
| Hydrogen sulphide, $H_2S$ | 0 – 3% |
| Oxygen, $O_2$ | 0.1 - 0.5% |
| Ammonia, 2 $NH_3$ | 0 – 2% |

# Hog Waste Biogas

## Hog waste Biogas

- 60% Methane, 40% $CO_2$
- 0.4% Hydrogen Sulphide
- 0.5% Ammonia
- 100% Saturated Moisture Content

# Hog Waste Biogas

## Gas Advantage (over solid waste)

- No solids handling off the farm, final solids as fertilizer
- Clean burning, commercial product
- Lots of standard equipment can use the fuel
- Storage and delivery is well understood
- 75 MW of gas, possibly more with superbugs

## Hurdles

- Get the waste to centralized large scale digesters
- Farms could us much of the gas onsite if done at each farm
- Supply goes away if industry goes away

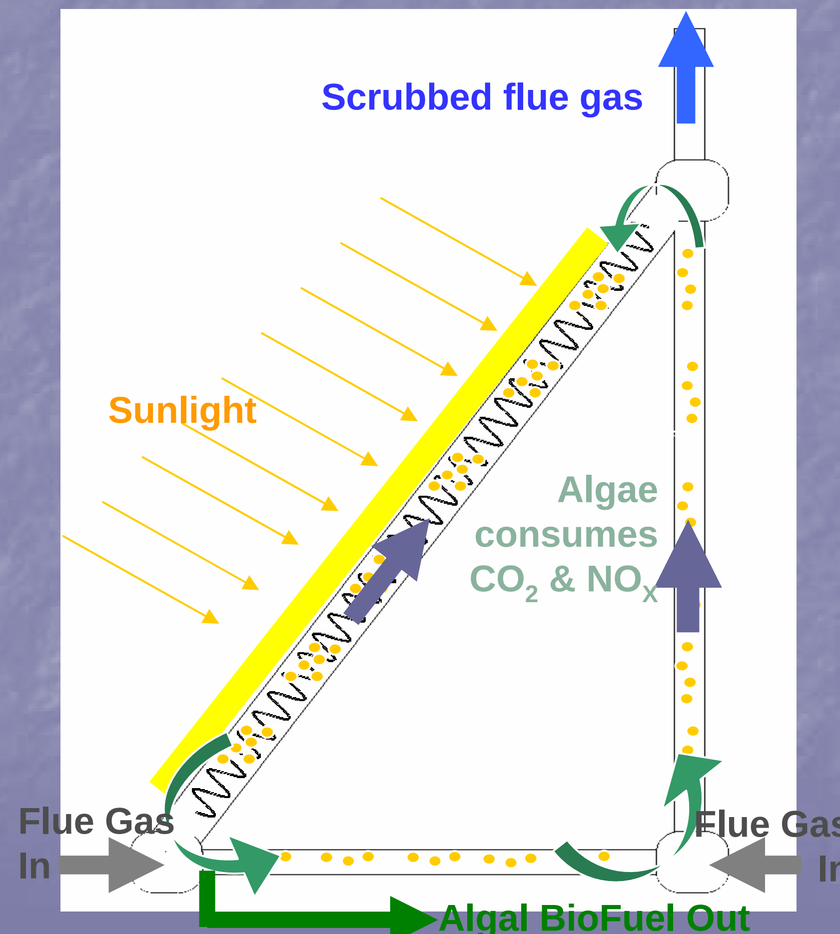
# Carbon Capture

# Carbon Capture

- Mid 70's to Mid 90's DOE studies algae for fuel production
- Identifies 300 varieties of green algae and diatoms
- Best ones blue-green algae 50% oil by weight
- Concluded 15,000 gal / acre of biodiesel is possible

# Carbon Capture

Green Fuel Technologies (Cambridge Mass.)



# Carbon Capture

## Green Fuel Technologies (Cambridge Mass.)

- Small scale pilot project
- Capture average 86% NOx
- Capture average 50% of $CO_2$, peak capture of 82%
- Sequester or produce fuel
- Estimated 1000 MW plant – 40 million gal. of biodiesel and 50 million gal. of ethanol are possible

- Requires 2000 acre farm next to plant

# Carbon Capture

Greenshift Corporation (New Jersey)

- Algae based filter
- Prototype handles 140 cubic meters of flue gas per minute
- 3 megawatt power plant

# Thank You for Your Time !

- Questions ???