Utility Infrastructure, Energy Generation & Consumption



CAROLINA NORTH

The UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Goals in a Global Context

ENERGY SOLUTIONS FOR A SUSTAINABLE WORLD

SPECIAL ISSUE AMERICAN SEPTEMBER 2006 WWW SCIAM COM

SCIENTIFIC

How to Power the Economy and Still Fight Global Warming

Energy's Future Beyond Carbon

- Cleaning up Coal
- The Nuclear Option
- Hopes for Hydrogen
- Biofuels and Renewables
- Fusion and Other Dreams



SPECIAL REPORT GLOBAL WARMING RRIED. Climate change isn't some vague future problem-it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well EARTH AT THE TIPPING POINT HOW IT THREATENS YOUR HEALTH **HOW CHINA & INDIA CAN HELP** SAVE THE WORLD-OR DESTROY IT THE CLIMATE CRUSADERS #1554 1351 110#T0 /275412) # 1446/ E8F7 0106 *26402 _____ 718 MIRHI MASS: MAJIEON .47 53911-2933



The Wedge Principle

r billion tons a year ----

25 billion tons total

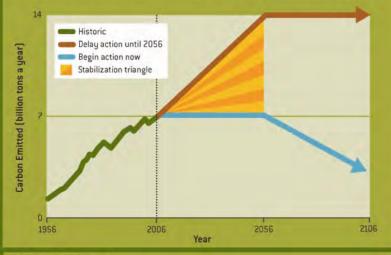
50 years -

MANAGING THE CLIMATE PROBLEM

At the present rate of growth, emissions of carbon dioxide will double by 2056 (*below left*). Even if the world then takes action to level them off, the atmospheric concentration of the gas will be headed above 560 parts per million, double the preindustrial value (below right)—a level widely regarded as capable of triggering severe climate changes. But if the world flattens out emissions beginning now and later ramps them down, it should be able to keep concentration substantially below 560 ppm.

ANNUAL EMISSIONS

In between the two emissions paths is the "stabilization triangle." It represents the total emissions cut that climate-friendly technologies must achieve in the coming 50 years.



THE WEDGE CONCEPT

The stabilization triangle can be divided into seven "wedges," each a reduction of 25 billion tons of carbon emissions over 50 years. The wedge has proved to be a useful unit because its size and time frame match what specific technologies can achieve. Many combinations of technologies can fill the seven wedges.

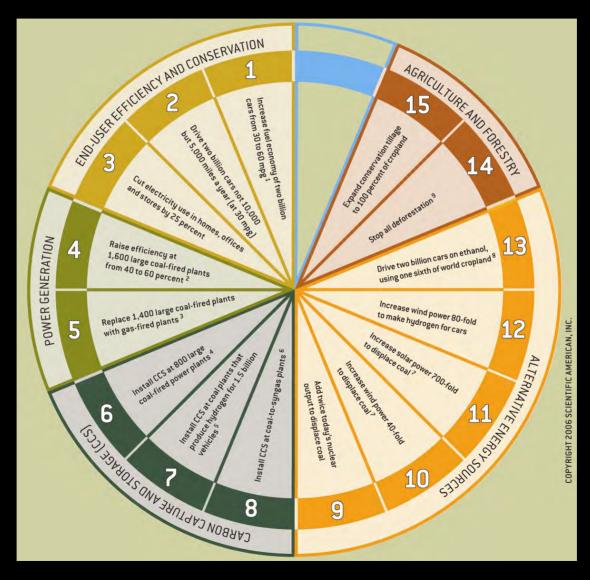
CUMULATIVE AMOUNT

Each part per million of CO₂ corresponds to a total of 2.1 billion tons of atmospheric carbon. Therefore, the 560-ppm level would mean about 1,200 billion tons, up from the current 800 billion tons. The difference of 400 billion tons actually allows for roughly 800 billion tons of emissions, because half the CO₂ emitted into the atmosphere enters the planet's oceans and forests. The two concentration trajectories shown here match the two emissions paths at the left.



Affiliated Engineers

15 Proposed "Wedges"





Opportunities

- Carbon Reduction Minimize Greenhouse Gases
- UNC / TCH CRed Pledge 60% Per Capita Reduction by 2050
- Alternative or Renewable Non-Carbon Based Fuel Sources
- Carolina North to be a Sustainable Campus
- Social Responsibility
- Maintain "Best in Class" Central Systems







Hierarchal Approach

- Individual Building Level (Typology Group)
- Highly Efficient Central Plants
- Opportunities to Reuse Excess Energy from Buildings through Plant







District Systems

- Takes Advantage of System Diversity and Reliability
- More easily Adaptable for Future Technologies
- Consider Standby Power as a Central Utility
- Hot Water is a Viable Alternative to Steam





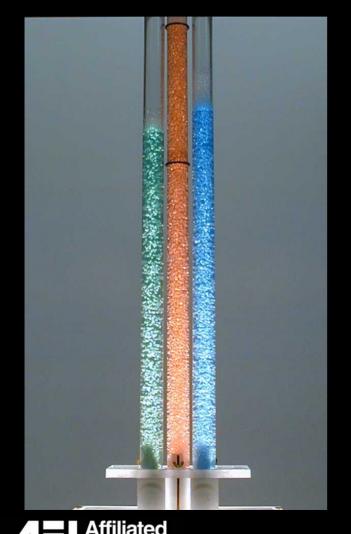
Other Issues

- Demand Side Management
- Net Energy Metering per Building
- Local Display of Building Energy and Systems Operation and Performance
- Education of Building Occupants
- Need to Study Distribution Methods





Analog Displays



Provides quick visual of building energy use by type and relative to baseline

Simple display that is cost effective

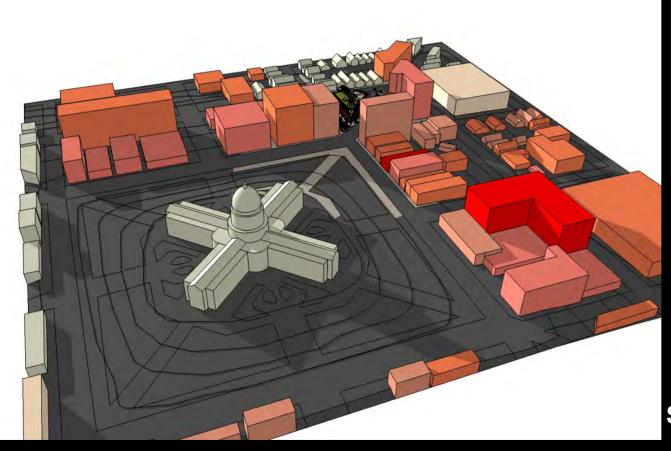
Provides dynamic visual of building energy production

Easily interpreted by non technical observers



与风同呼吸 BREATHING WITH THE WIND

Campus Context





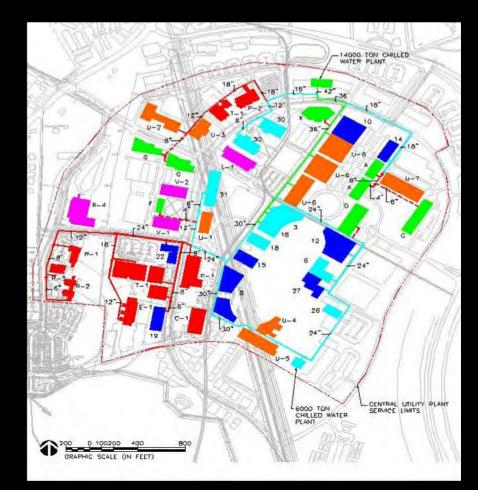
220+
180-219
140-179
100-139
60-99
Not Measured

Scale: KBTUs/GSF/Year



Central vs Regional vs Building

- Start with building level and transition to regional or central?
- Make investment in future and start with central?
- What Are Other Institutions Doing?
 - NCSU Centennial and Main Campuses
 - Duke Regional Chiller Plants
 - Virginia Tech
 - Oklahoma State
 - University of Illinois
 - University of Wisconsin
 - University of Colorado





High Efficiency Central Plant

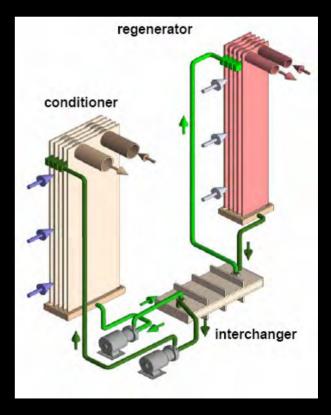
- "Right Sized not Oversized"
- Variable Speed Drives
- Chilled Water ΔT
- Hybrid Chiller Plant
- Free Cooling
- Thermal Storage
- Low Condenser Water Temperatures
- Stack Economizer
- Vent Condenser
- Alternative Heat Sinks
- Combined Heat and Power





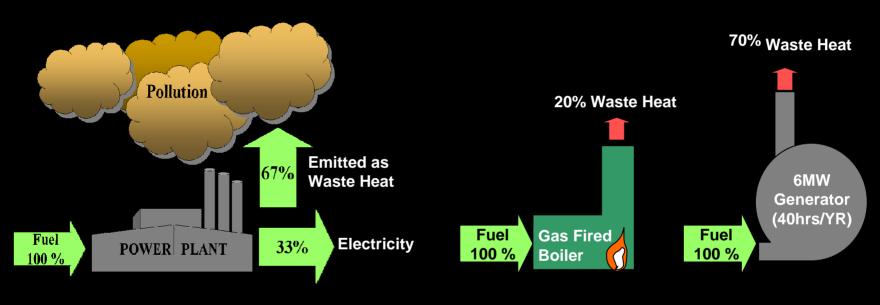
Energy Reuse at Central Plant

- Water Source Heat Pumps
- Building Integration
 - Liquid Desiccant Cooling
 - Solar Collectors
- Reclaim Water Use





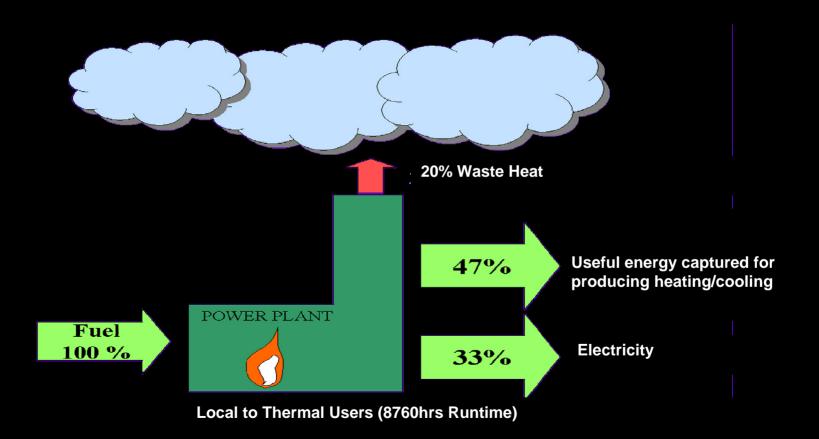
Purchased Utility Arrangement



Remote from Thermal Users



CHP Arrangement





Carbon Reduction

- Solar
- Wind
- Groundwater
- Landfill Gas
- Hog Waste
- Poultry Waste
- Woody Biomass
- Organic portion of municipal solid waste
- Energy Crops
- Algae Digesters
- Natural Gas / Propane Air





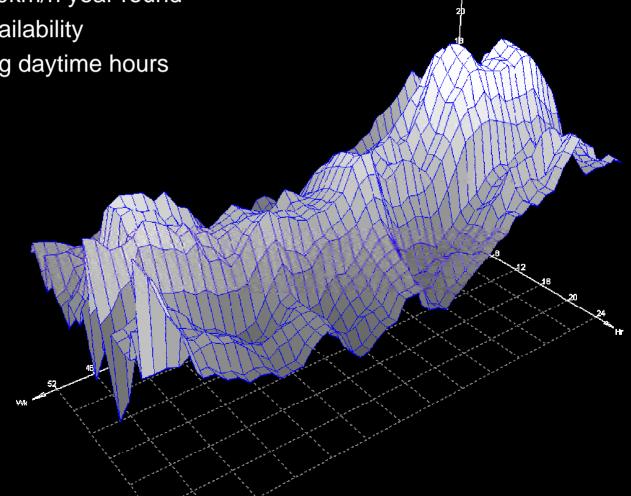






Wind Speed

- Less than 20km/h year round \bullet
- Sporadic availability \bullet
- Peaks during daytime hours



kinin



Cloud Cover

- Varies Widely Annually
- As high as 90% for periods of the year
- As low as 40% for periods of the year

Wh



Direct Solar Radiation

- Peaks at ~ 60
- Significantly less radiation than Southwestern United States (peaks above 800W/

WAR



Diffuse Solar Radiation

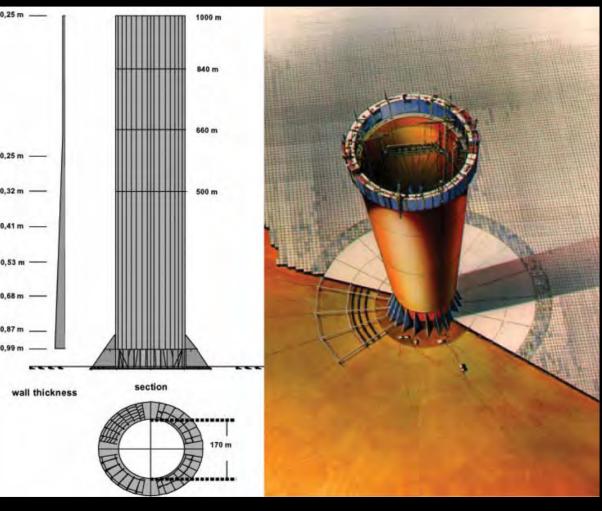
- Peaks at ~ 370 W/m²
- More than Southwestern United States (peaks ~ 270W/m²)



Innovative Energy Generation

Solar Chimney

 Uses ∆T of air in vertical shaft to induce air flow through the chimney to spin a turbine





Innovative Energy Generation

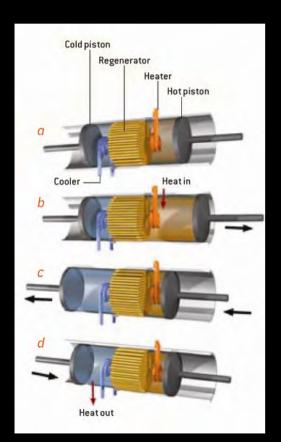
Solar Chimney

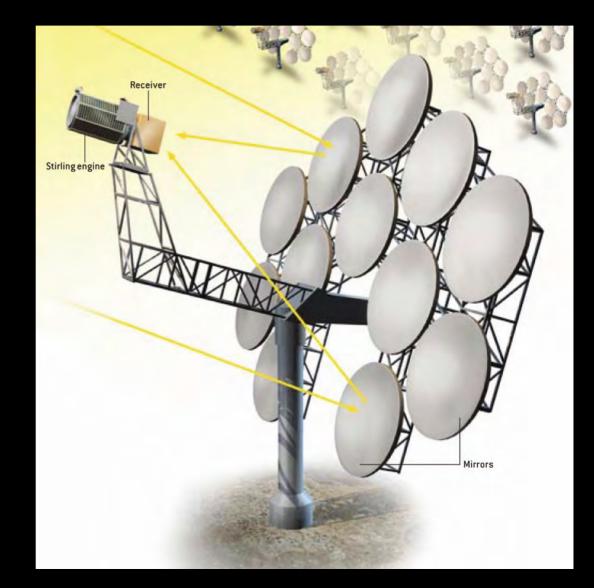
- 50KW Prototype in Manzaneres, Spain
- 200 meters tall!
- Current project in Australia to construct 1000 meter tall solar chimney to produce 200 MW
- Does it scale?
- Can it be optimized with solar concentrating technology or evacuated tubes?





Concentrated Solar Power





Concentrated Solar Power

- ~25KW per dish
- ~\$0.13 / kWh
- Due to two large scale plants currently being commissioned price per kWh is expected to drop to \$0.04 to \$0.06
- Major push by the federal government and national laboratory community to advance this technology
- Can incentives be secured for a demonstration/research project?



Concentrated Solar Power

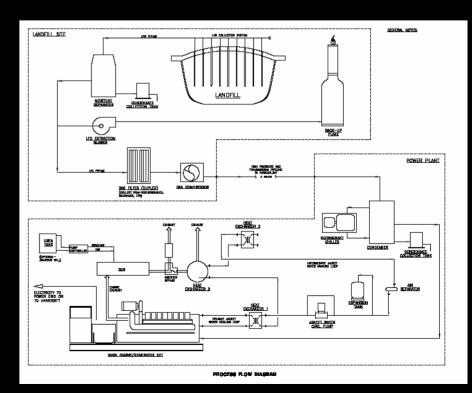
- Distributed hot water production
- Can be integrated architecturally to perform multiple functions
- Used to supplement centralized system?





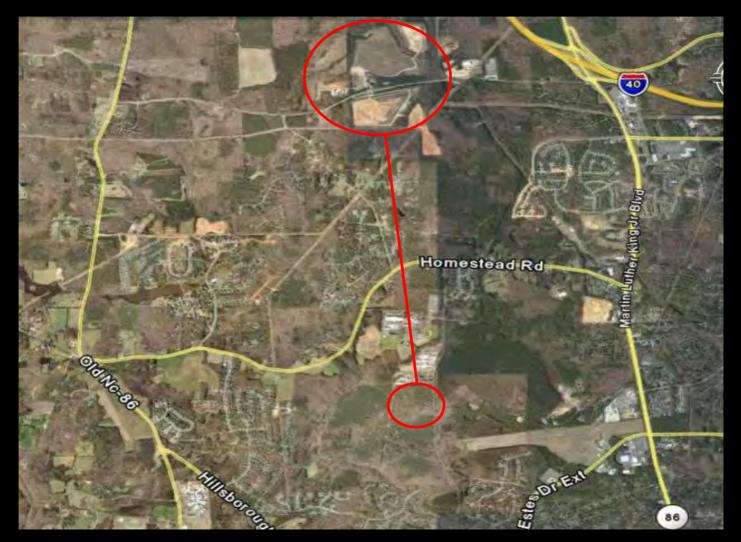
Land Fill Gas

- Orange County has two fields 2-3 miles from site
- Capacity to produce 0.75 MW of power or 100k to 200k GSF of building space
- Source will diminish over time with peak output by 2010
- Break even in 20 years due to pipeline expense
- Carbon emissions reduction credit since methane is currently vented to atmosphere



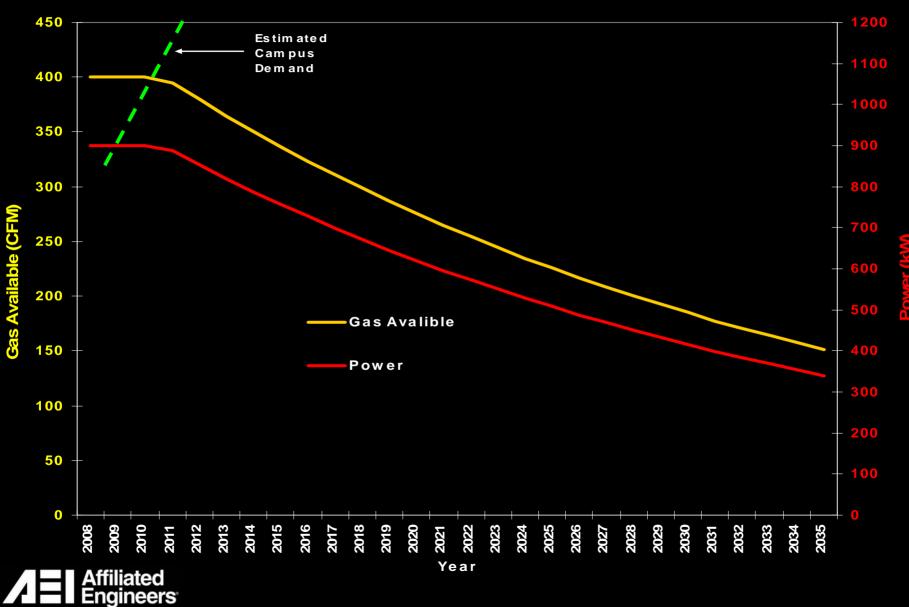


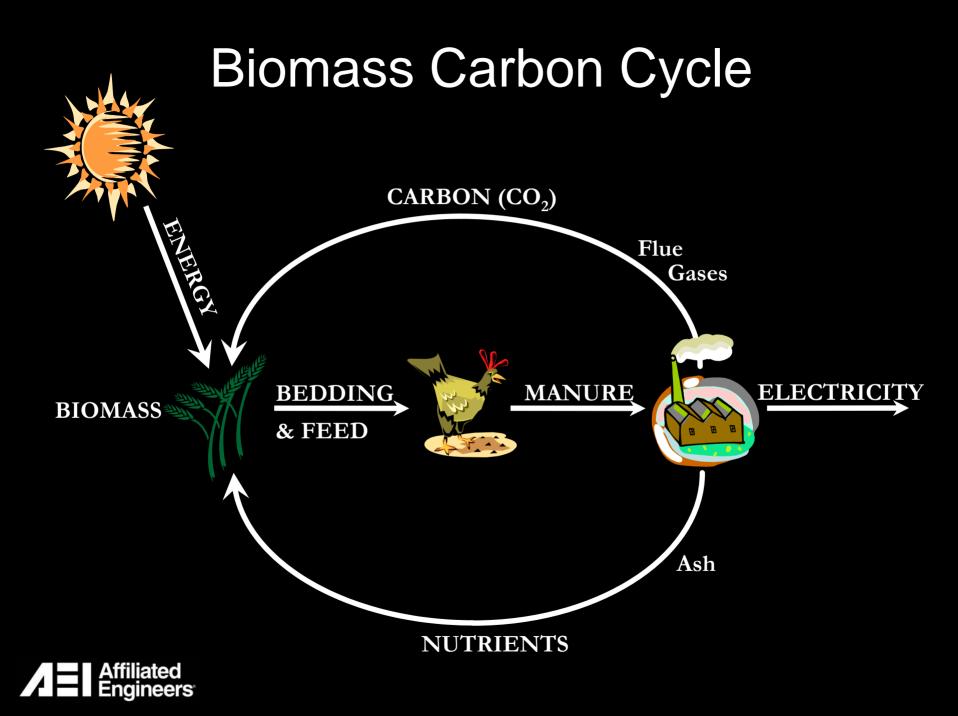
Land Fill Gas





Land Fill Gas





Distribution Methods

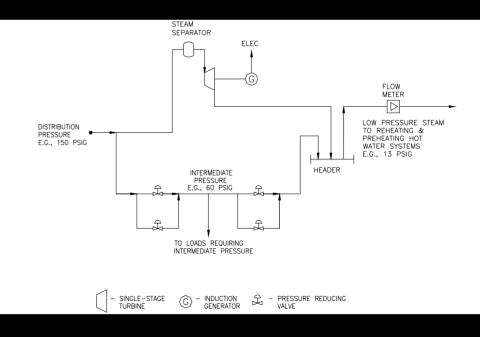
- Direct Buried
- Accessible Tunnels
- Walkable Tunnels
- Shared Utility / Service Tunnels
- Materials of Construction





Distribution Medium

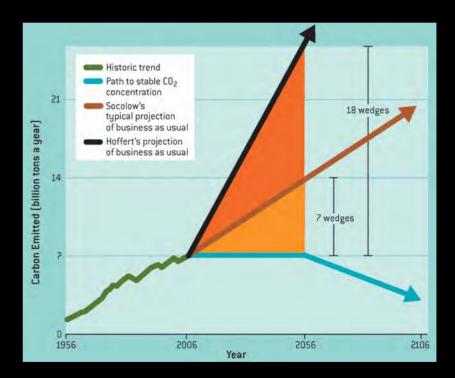
- Chilled Water
- Steam
- Hot Water
- High Temperature Hot Water





Electrical Power

- Duke Energy
 - "Green" Power Purchase
- Off-Site Generation
- Co-generation On-Site
- Renewable On-Site
- Standby Capacity as Primary Source w/ Grid Backup
- Distribution
 - Central Substation
 - Multiple Substations
 - Voltage
- Carbon Profile





Challenges / Barriers

GENERAL

- New Ideas and Technologies
 - Acceptance
 - Reliability
 - Operation and Maintenance
- Utility Ownership and Maintenance
- Reliability Expectations
- Funding of Production and Distribution Systems
- Single Source for Procurement of New Technologies
- Shared Utility Corridors Separation / Easements / Access
- Metering and Billing of Shared
 Utilities

BIOMASS RELATED

- Supply issues
 - Dispersed sources
 - Long-term contracts challenging
 - "Waste" today, "valuable resource" tomorrow
 - Fuel processing & fuel quality
 - Reliability
- Fuel handling and transportation
- Space for fuel processing & storage



Potential Goals

- CRED / Emissions
- Solar
- Other Renewable or Carbon Offset
- Central vs. Local
- Synergistic Energy Distribution
- Combined Heat and Power
- Reliability / Redundancy
- Flexibility and Adaptability
- Net Energy Metering with Local Display
- Utility Distribution Shared, Accessible Corridors
- Education

