Keeping the Lights On – What Will Power Your Homes?

Steve Riner, CHMM
Black Hills Corporation

Introduction and Disclaimers

- Environmental Scientist/Engineer with Black Hills Corporation supporting Colorado Black Hills Energy electric operations and generation
- Presentation does not reflect opinions of Black Hills Corporation
- **I don't have the answer to whether climate change is a true problem** – only an outline of the impacts of taking steps to reverse CO_2 levels in the atmosphere.

The Presentation I Almost Gave

Co-firing of biomass (wood chips) at our small coal-fired electric generation station in Cañon City.

Why I Went A Different Direction

- Interesting project --- but limited application outside the industry
- Americans – and the world – face some potentially significant issues in determining the future of energy resources
- The economy, the environment, and our quality of life may depend on making the right choices

Electricity 101:
The Electric Industry

- Investor-owned Utilities (BHE, Xcel)
- Rural Electrification Authorities (REAs/Co-ops) – (San Isabel, Intermountain)
- G & T companies (Tri-State)
- Municipals (Ft. Collins, Colo Spgs)
- Power Marketing Authorities (USDOE – hydropower distribution)

How Does a Power Plant Generate Electricity?

Virtually all electric generators consist of a shaft with a magnet spinning in a large coil. This induces a current that can be distributed to electric users.

But it takes *energy* to make that shaft rotate….

How Does a Power Plant Generate Electricity?

Turning the shaft on a generator:

- Hamsters (not very efficient)

- Force of running water (hydroelectric)

- Wind power

How Does a Power Plant Generate Electricity?

Turning the shaft on a generator --- the most common methods:

- **Steam** from a boiler turning a **turbine**. Variety of boiler fuels: coal, natural gas, petroleum fuel, wood, nuclear energy. *Most common type of electric generation.*
- Combustion gases from gas or petroleum fuel (**combustion turbine**, similar to jet engine)
- Attach the shaft directly to an internal combustion engine.

Other Forms of Generation

- **Combined Cycle** – Waste heat from combustion turbines passed through a heat recovery steam generator – coupled to steam turbine and electric generator
- **IGCC** (Integrated Gasification–Combined Cycle)–Coal is heated to decomposition forming gases (mostly CO and H_2). The combustible portion is used as fuel in a combined cycle plant. CO_2 can be separated from the gas stream before it enters the combined cycle plant.

Categories of Generating Sources

- **Electricity can't be stored for large-scale distribution** --- it has to be generated when it's needed. The demand for electricity varies greatly with weather and industrial demand.
- **Baseload units** run continuously (though the output can be adjusted up or down as needed)
  - Steam generating units are only used for baseload because boilers take a long time to come on line and use a lot of energy before they actually produce power.
  - Wind-powered units provide variable output depending on wind speed. This can't be controlled to meet demand. Additional sources needed to make up the difference.
- **Peaking units** come on or off line depending on demand.
  - Requires generation that can be brought on line quickly and kept ready with minimal energy cost
  - **Engines** and **combustion turbines** are the most commonly used for this purpose.
  - Also use "spinning reserve" – a boiler running at minimum load, just enough to stay synchronized to grid – which can have output quickly increased.

Ownership of Generating Stations

- "Rate Base"
  - Owned by distribution company or affiliated G&T
  - Most power goes to that system or series of systems – can sell excess capacity on spot market
- "Merchant" or "Independent Power Producers" (IPPs)
  - Entity separate from distribution company
  - Plants may have some/all output contracted out
  - Often have excess capacity that can be sold on spot market or short term contracts

Distributed Generation

- On-site generation by customer connected to distribution system
- Generally solar or wind generation
- Customer uses power generated on site first, any excess is sent back onto distribution system
- Net metering measures power going both ways - rebates to customer for any power sent onto system

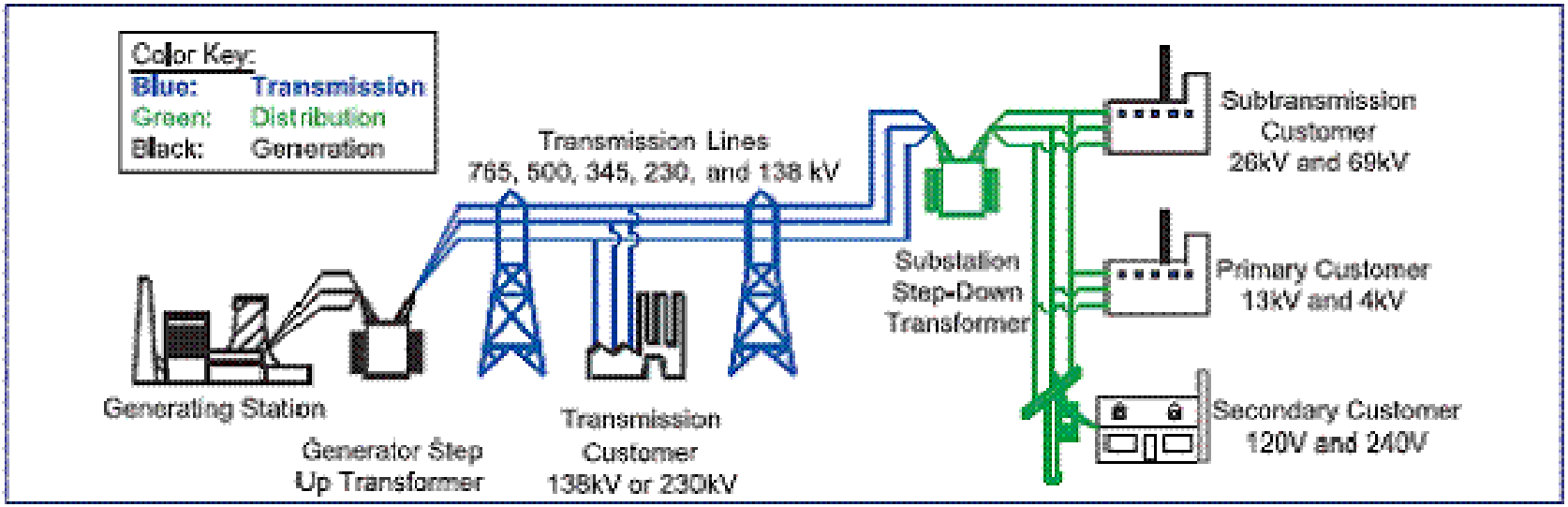
Distributed Generation (cont.)

- The 2 IOUs and some municipals in Colorado have solar rebate program including residential and small commercial customers to encourage participation.
- Strict controls on DG connections are necessary to ensure integrity and safety of distribution system.

Reliability, Dispatchability and Capacity Factors

- Reliability – the source is available (taking into account its operating characteristics) for a predictable amount each year. Applies to both baseload and peaking sources.
- Dispatchability – the source can be turned on when we need it and off when we don't. Generally refers to **peaking** sources including spinning reserve.
- Generation sources providing both criteria are needed for a reliable distribution system
- Capacity factor – the percent of rated capacity a source can be expected to provide. Fossil fuel-fired boilers have 85% + capacity factor. Wind and solar are 25-30%.

Distribution Systems



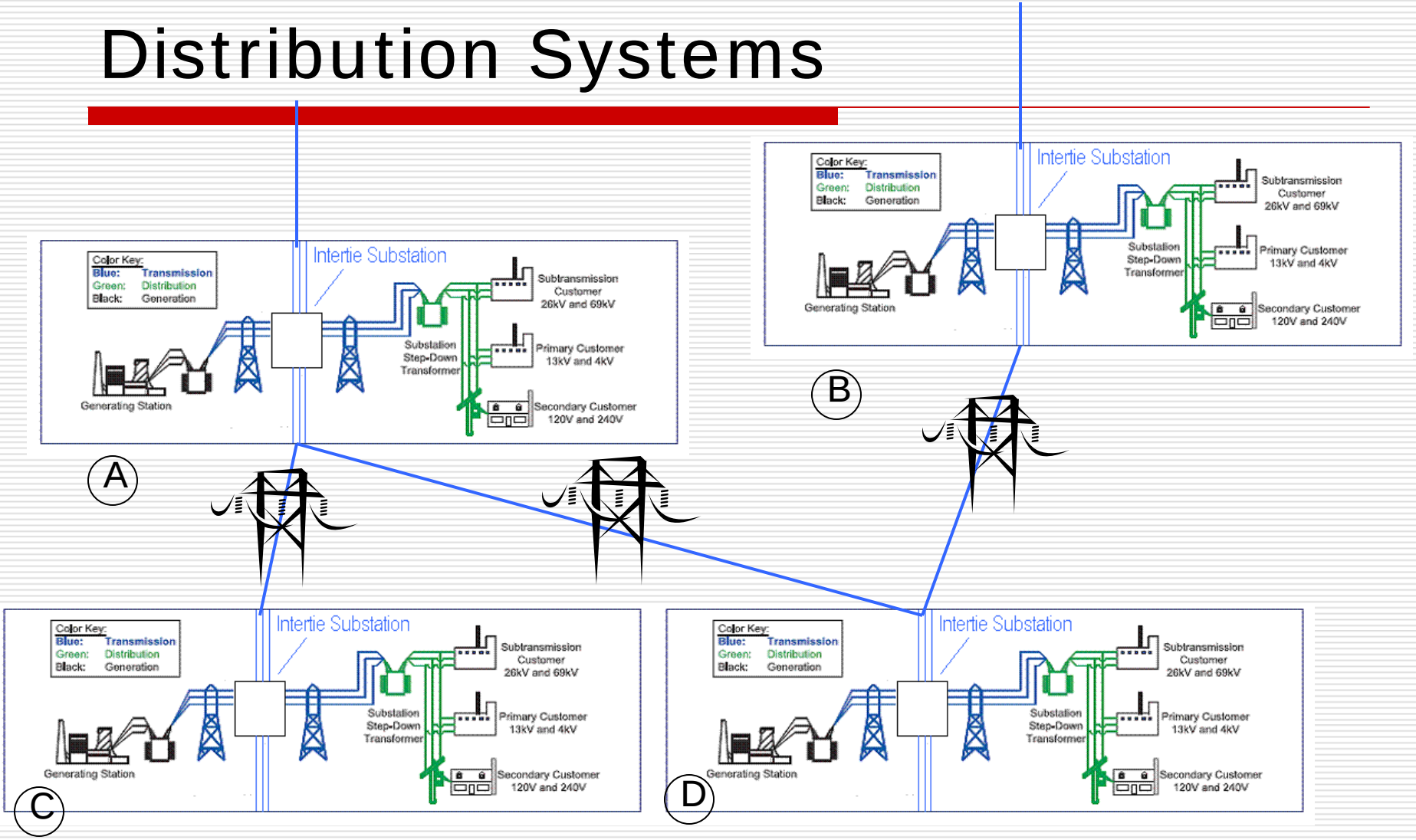
Highly oversimplified schematic of a distribution system

Distribution Systems

Few distribution systems are an island as depicted on the last slide (unless they are on an island).

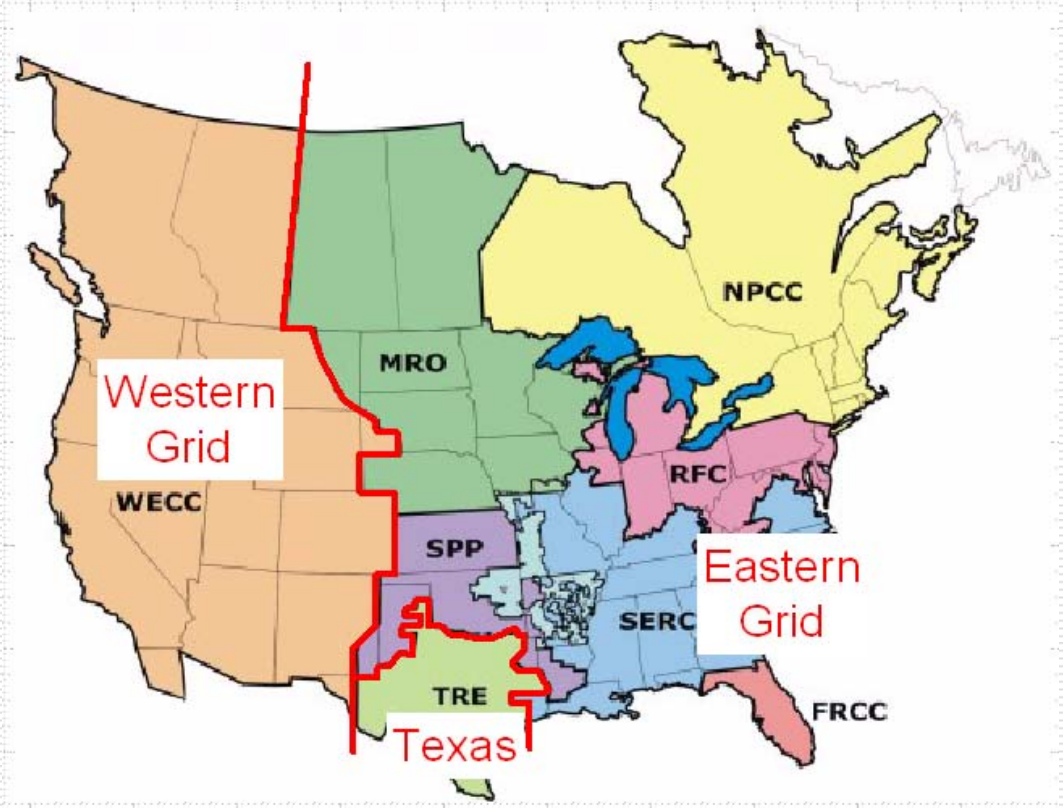
Systems are actually interconnected.

The Grid: Interconnected Distribution Systems



Even more oversimplified schematic of the grid of interconnected systems. The power plant in system B can supply customers in system C.

Transmission Regions and Grids



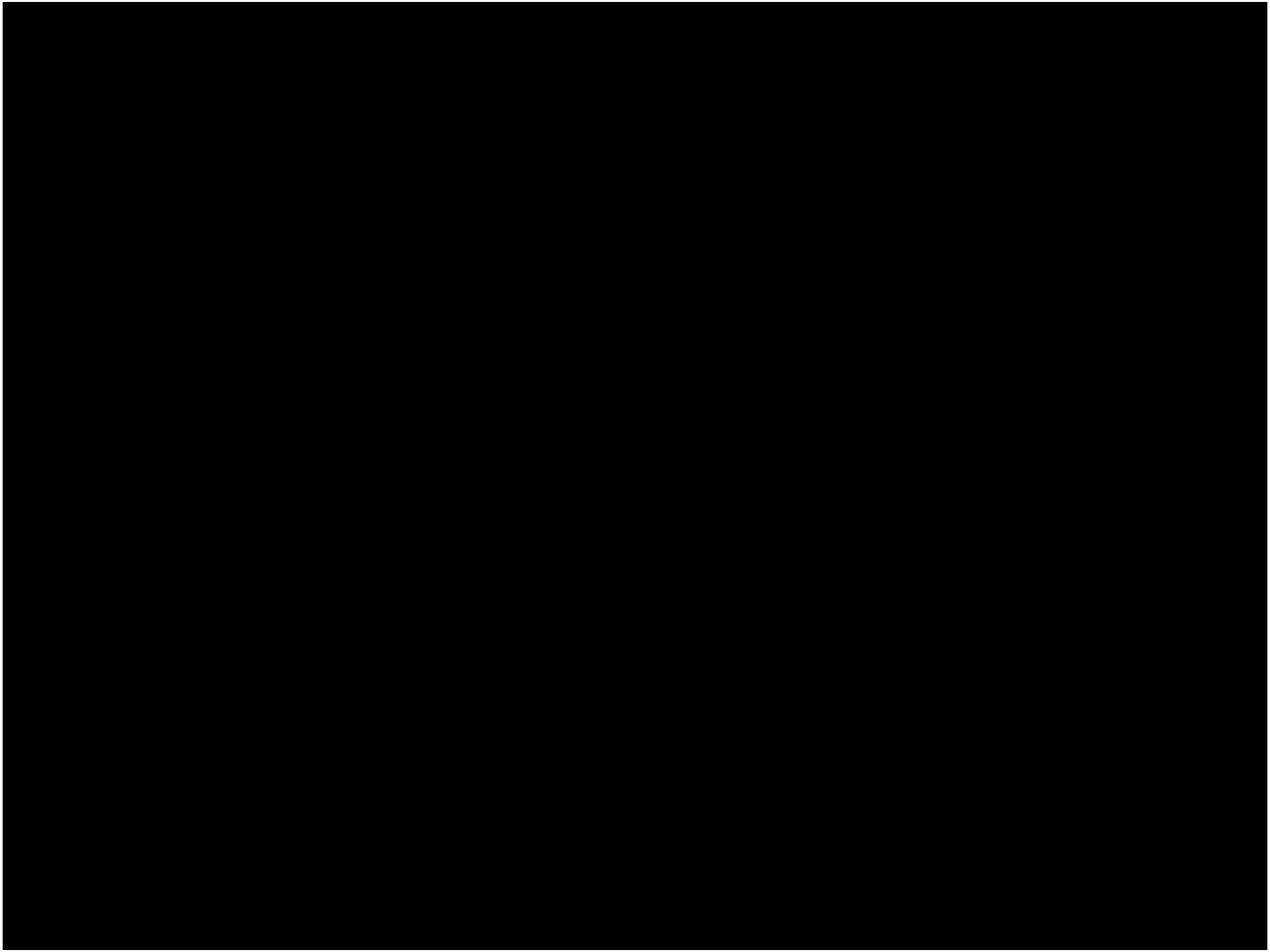
Utility systems within each grid are interconnected. There is limited connectivity between grids – requires DC intertie because of different system AC synchronization

Keeping the Grid On Line

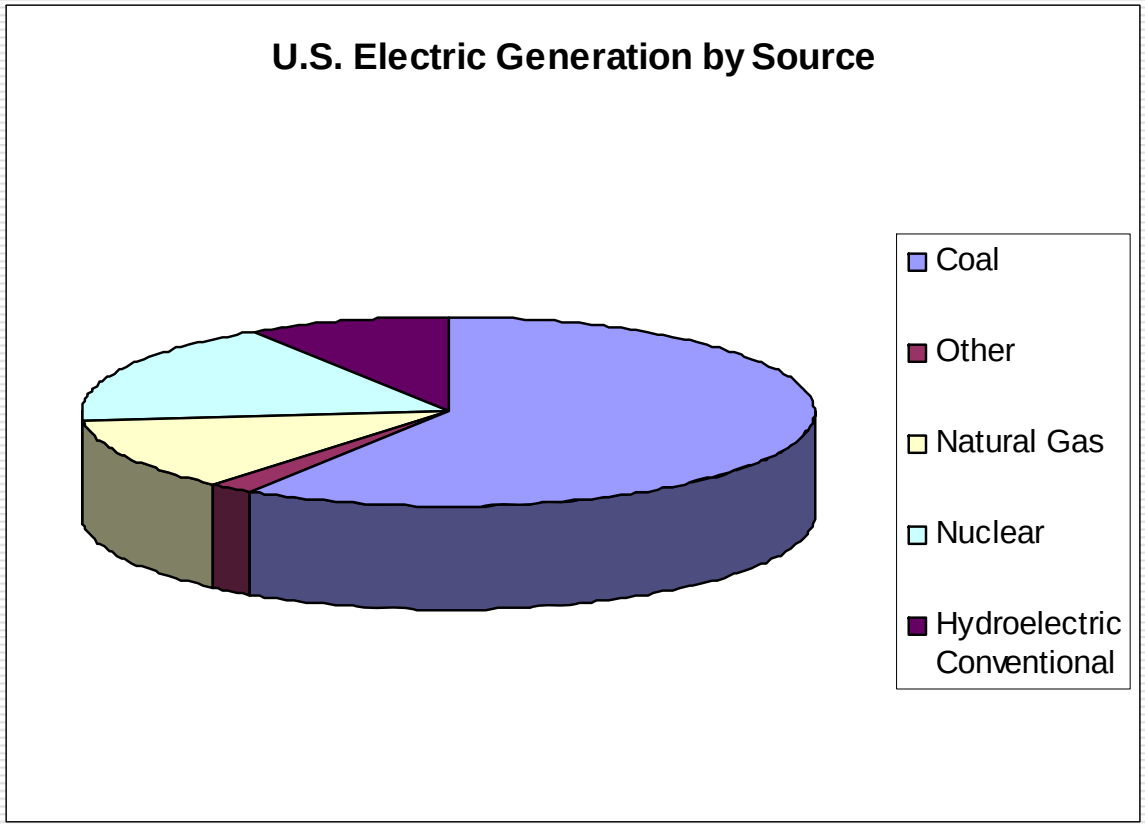
- Each distribution utility has to balance its load and generation sources exactly
- Failure to do so has caused regional blackouts (like five years ago in Ohio and surrounding states)
- When load exceeds generation capacity the distribution utility must:
  - Generate additional power from peakers
  - Buy power on the spot market ($$$)
  - Shed load

Shed Load?

An industry euphemism for…



Where Our Energy Comes From



Source: U.S. Department of Energy, 2007

Renewable Energy Sources

Photovoltaic (PV) Solar

- Generates DC with solar energy
- Variable but nearly always some generation even on a cloudy day
- Significant land need for utility-scale installations (5 acres/MW)
- Highly suitable for distributed generation

Thermal Solar

- Solar energy heats thermal transfer fluid, used to make steam for turbine
- Lag between sun intensity and generation rate more closely matches load profile and allows continued generation after sundown
- Significant land need - most suited for large-scale desert installations

Renewable Energy Sources (cont.)

Wind

- Generates when the wind blows (25% capacity factor)
- Slightly negative correlation with load
- Requires large area but compatible with agricultural land uses
- Visual or noise complaints in populated and scenic areas.

All renewable sources require transmission to points of use, often significantly raising cost of projects.

Capital costs are much higher than fossil fuel plants but operating costs are lower.

Carbon Issues

- Major CO_2 Sources
- CO_2 Removal and Sequestration
- Uncertainty of Regulatory Drivers

Sources of CO_2

Approximate Emission Rates (depending on specific technology)

Coal: 1900 lb CO_2/MWh

Gas: 1200 lb CO_2/MWh

Natural gas is “cleaner” but gas generation is still a significant source of CO_2 emissions.

Removing CO_2 From Generating Plants

- CCS = Carbon Capture and Sequestration
- Technology is just now developing
- Scrubbers with amine solutions
- Retrofits to existing plants will be difficult if not impractical
- Removal process will require 25-30% of plant output (“parasitic load”)
- Once you remove the CO_2 what do you do with it?

Where to put the CO_2?

- As replacement for CO_2 used for enhanced oil recovery
- Locate plant near area of use or pipe to location where it can be utilized
- Inject deep underground in suitable deposit
- First demonstration projects just now underway
- Mature, reliable technology is 10-20 years off

Critical questions for CO_2 storage

- Can it be reliably sequestered or will it leak out?
- Is there sufficient capacity to store the millions of tons of CO_2 needed to meet reduction goals? How do we get it to the point of storage?
- Will this endanger groundwater supplies?
- Impacts of EPA proposed UIC regulations?
- Will technological advances keep up with regulatory mandates?

Regulatory Drivers

- Supreme Court has ruled EPA can regulate CO_2 as an air pollutant under CAA
- EPA has not made formal determination to do so – yet
- At least two permits have been denied for coal plants based on failure to regulate CO_2 emissions
- There are no standards for CO_2 emissions
- Regulatory drivers are therefore extremely uncertain – timing and scope.
- Sort of complicates the resource planning process for utilities

Now If You're Not Depressed Already…

Industry Challenges

- Increased Demand

  Colorado's need for electricity will increase significantly by 2025 – by 4,900 MW

(more than 6 Comanche-3s)

Industry Challenges

- Where Will It Come From?

4,900 megawatts total need (Colorado)

980 MW (20% efficiency)
980 MW (20% rps)
- 637 MW (35% capacity factor)
1,323 MW

REMAINDER: 3,577 MW of need beyond efficiency gains / renewables

(only 4½ Comanche-3s)

Source: Western Business Roundtable

Industry Challenges

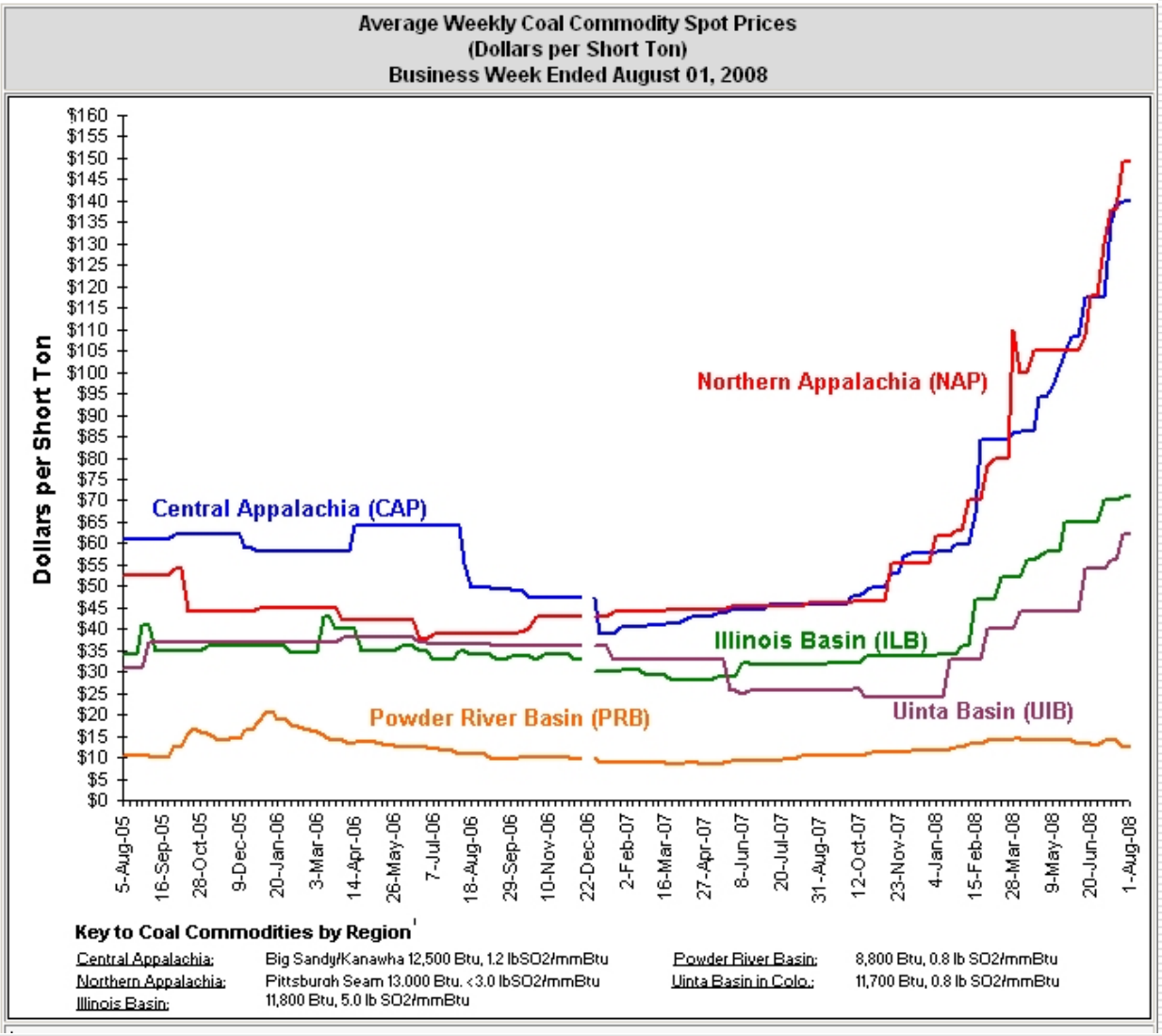
- Renewable Portfolio Standards
  - For IOUs, 20 percent by 2020
  - Funded by up to 2% charge on electric bills
- Demand Side Management Mandate – 5% based on 2006 levels by 2018
- Carbon emission fees or caps – Lieberman-Warner, carbon tax, or other.

Industry Challenges

- Skyrocketing costs
  - Construction materials
    - Duke Energy's 800 MW Cliffside 6 unit cost went from $1.4 billion to $2.4 billion in 2 years
    - Xcel Energy 750 MW Comanche 3 – $1.3 billion
    - KCP&L – 850 MW Iatan 2 up 15% to $2 billion
  - Fuels of all types
    - Natural Gas
    - Coal
    - Petroleum fuels

Coal Costs Are Rising

China is bringing one coal-fired power plant a week on line. They are as voracious a consumer of coal as of petroleum and their economy is driving the cost of coal up as well.



Coal Plant Opposition Is Too

The New York Times

Business

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION

Search Business Go

Financial Tools Select a Financial Tool

More in Business » World Business | Markets

Georgia Judge Cites Carbon Dioxide in Denying Coal Plant Permit

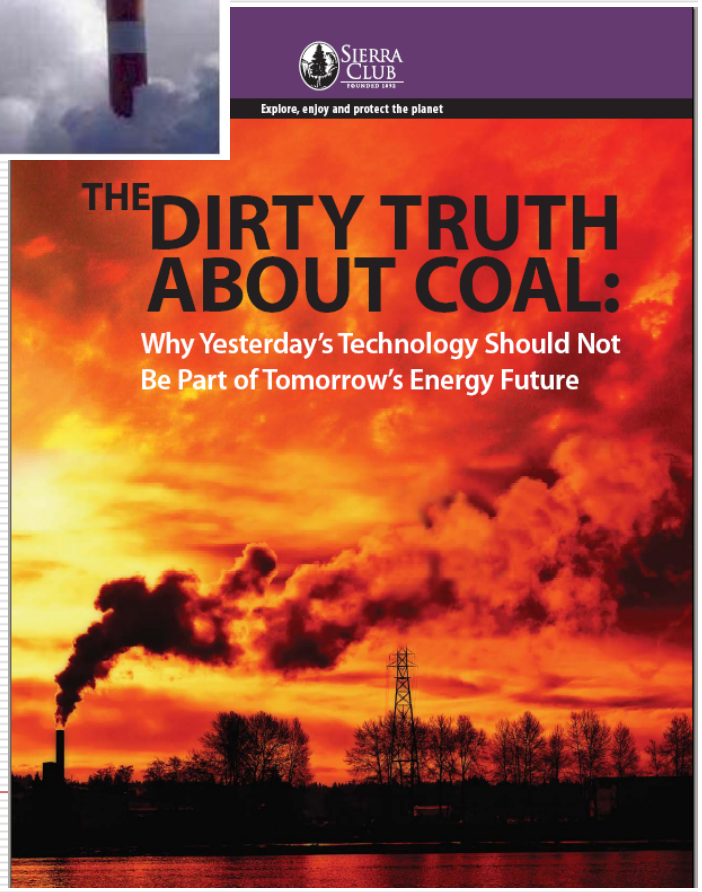
By MATTHEW L. WALD
Published: July 1, 2008

A judge in Georgia has thrown out an air pollution permit for a new coal-fired power plant because the permit did not set limits on carbon dioxide emissions.

Both opponents of coal use and the company that wants to build the plant said it was the first time a court decision had linked carbon dioxide to an air pollution permit.

The decision's broader legal impact was not clear, either for the plant, proposed to be built near Blakely, in Early County, Ga., or for others outside Georgia, but it signaled that builders of coal plants would face continued difficulties in the court system as well as with

SIGN IN TO E-MAIL OR SAVE THIS
PRINT
REPRINTS
SHARE

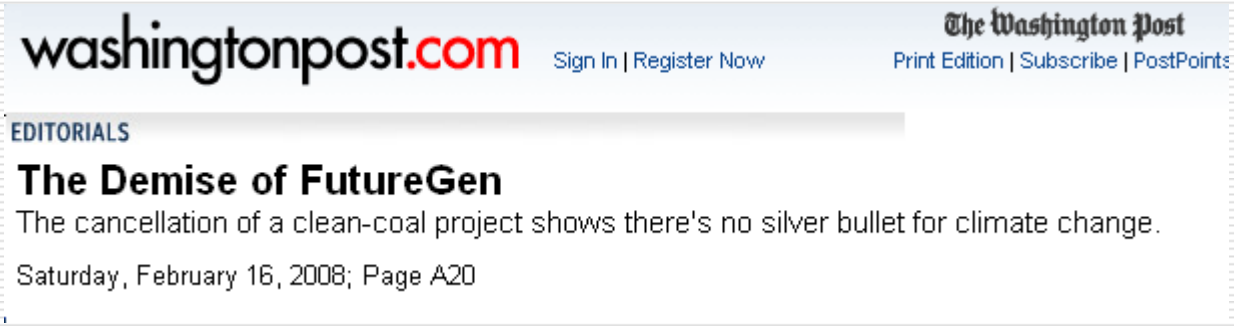


Industry Challenges

- The electric industry has an obligation to serve its customers with reliable power priced as low as reasonable.
- Government mandates make meeting both of these requirements difficult.
- Untested technologies are being touted as solutions to environmental issues – without an opportunity to bring them in slowly to refine the technologies and make them more reliable.

Industry Challenges (cont.)

- Who pays for research on new technologies?
  - "FutureGen" IGCC with CCS was cancelled and restructured by USDOE – rapidly rising costs
  - Utilities are reluctant to invest huge sums in R&D when existing technologies serve their needs



washingtonpost.com Sign In | Register Now

The Washington Post

Print Edition | Subscribe | PostPoints

EDITORIALS

The Demise of FutureGen

The cancellation of a clean-coal project shows there's no silver bullet for climate change.

Saturday, February 16, 2008; Page A20

Challenges for Renewables Too

- Production Tax Credit that makes renewable energy projects viable expires end of 2008 – renewal is currently "hostage" to offshore drilling issue
- Major thermal solar project in Arizona depends on PTC renewal
- Wind energy project in Kansas was cancelled when west Kansas coal plant was rejected – depended on transmission line constructed for the coal plant

August 14, 2008

US Leads in Wind Power Production, But Policy Uncertainty Weighs on Industry

by Christine Real de Azua, AWEA

Washington, D.C. United States [RenewableEnergyWorld.com]

U.S. wind farms now generate more electricity than those in any other nation in the world and are on track to expand by over 45% this year, but the looming expiration of the federal production tax credit (PTC) less than five months from now threatens this spectacular progress, AWEA said in its second quarter market report.

Research is Going On Though

- Babcock & Wilcox is developing an "oxy-coal" process that will enhance CO_2 capture
- IGCC + CCS holds promise if suitable demonstration facilities can be built
- Research into storing energy generated from renewables

Ideas Abound – Two Major Plans

- Pickens Plan
- Gore Plan

Pickens Plan (T. Boone Pickens)

- Replace natural gas generation (20%) with wind power from massive expansion in western plains.
- That natural gas would then be used to substitute for petroleum fuels for vehicles.
- Problem: reliable wind generation depends on gas-generated backup (CTs)

Gore Plan

- Eliminate CO_2 emissions from power generation in 10 years
- Any fossil fuel generation would require CO_2 capture and sequestration
- Heavily dependent on technologies not yet proven on large scale as major sources of power, as well as CCS
- Economic impact of retiring or retrofitting large investments in infrastructure

Impact of this on atmospheric CO_2

- U.S. is not even the largest emitter of CO_2 any more
- Without developing countries (China, India) taking the same steps to reduce CO_2, any impact on the climate will be minimal

Finally – Impact on Consumers

- Your electric bill is going to go up
- Your electric service might be less reliable
- The electric industry is probably not going to look like it does now, 10 years from now.

Good News: America Has Energy Resources If We Want to Use Them

- Untapped natural resources – wind and solar, as well as hydro and geothermal
- Conservation is a clean and efficient energy source
- Ample natural gas – but it must be constantly developed because wells have short production life
- Natural gas diverted to electric production competes with natural gas for residential heating – cost impact
- America is the “Saudi Arabia of coal.”
- Notwithstanding the CO_2 question, coal is no longer a “dirty fuel.”
- Nuclear energy is a major source of power worldwide. Waste and security issues are real but not unsolvable. Nuclear power has no CO_2 emissions.

Solving the Issue

- All options need to be on the table
- All parties need to be at the table
- Keeping the lights on is not negotiable
- All sides need to understand the technical issues and time involved with developing projects
- Mandates can promote research but can't guarantee outcome
- The issue of costs and who will pay them (who else??) needs to be a major area of discussion
- Defeating projects isn't progress

Let’s Keep the Lights On!

Discussion