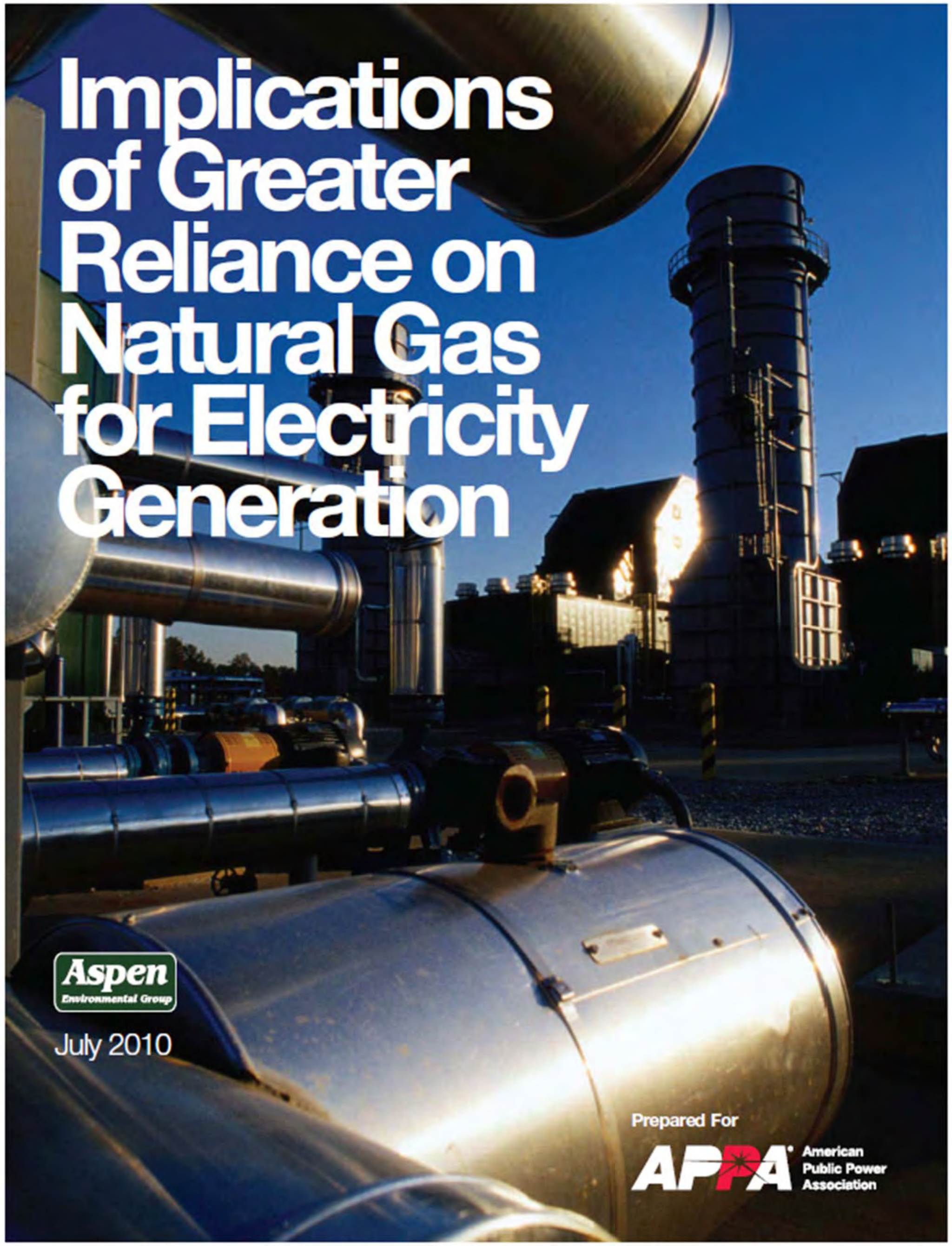
“Implications of Greater Reliance on Natural Gas For Electric Generation”

USEA Policy Briefing
September 2, 2010
2:00 pm

Theresa Pugh, Director,
Environmental Services, APPA

J.P. Blackford, Senior Environmental
Services Engineer, APPA

American Public Power Association


Implications of Greater Reliance on Natural Gas for Electricity Generation
Aspen
Environmental Group
July 2010
Prepared For
APPA
American
Public Power
Association

Study Identifies Challenges from Large Switch to Gas by EG

- Natural Gas Demand & Supply Level Unprecedented
- Infrastructure Requirements: Interregional Pipeline & Underground Gas Storage
- Operational Challenges
- Retrofitting Means Replacement
- Effort and Investment to make switch work
- Study Commissioned by APPA with support from UARG

Aspen Environmental Group

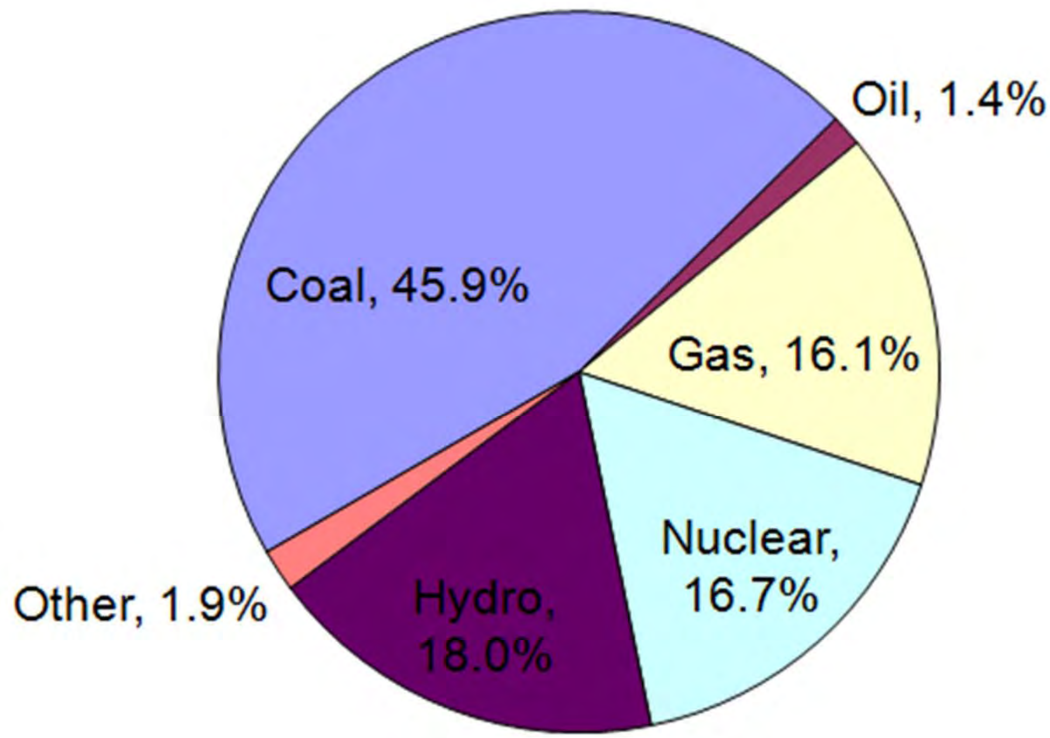
APPA American Public Power Association

What is APPA

- The American Public Power Association (APPA) is the national service organization representing the interests of the more than 2,000, not-for-profit municipal and other state and local community-owned electric utilities that collectively provide electricity to approximately 45 million Americans. These utilities, or "public power" systems, are among the most diverse of the electric utility sectors, representing utilities in small, medium and large communities in 49 states (all but Hawaii), Puerto Rico, American Samoa, and Guam. Seventy percent of public power systems are located in cities with populations of 10,000 or less. Created in 1940 as a non-profit, non-partisan organization, APPA's purpose is to advance the public policy interests of its members and their consumers, and to provide member services to ensure adequate, reliable electricity at a reasonable price with the proper protection of the environment.

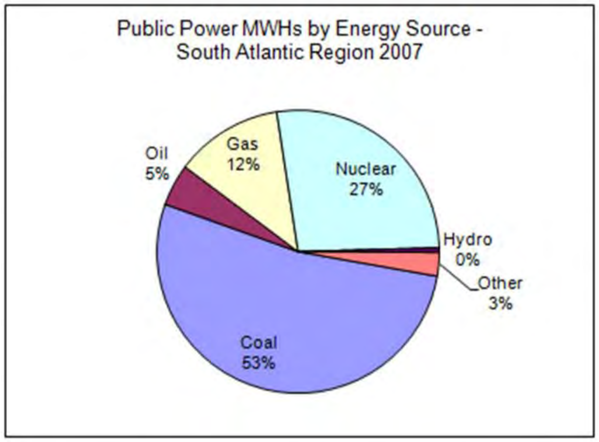
- Overall, public power accounts for about 15 percent of all kilowatt-hour sales to retail electricity consumers. Approximately 46% of the megawatt hours of electricity produced by public power systems are generated using coal. In addition, the majority of communities operating public power utilities also manage water utilities that provide drinking water to residential, institutional, commercial and industrial customers.

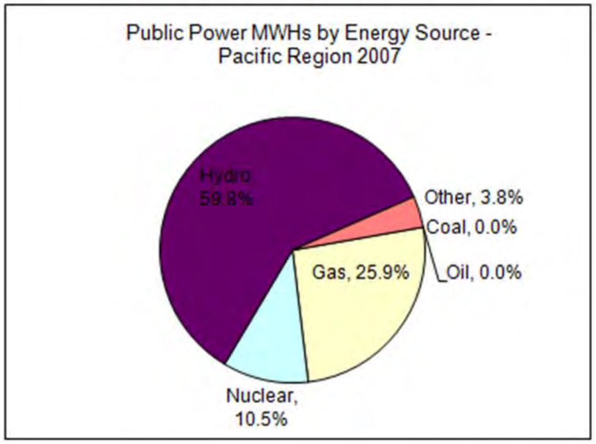
Public Power MWHs by Energy Source
National (2007)

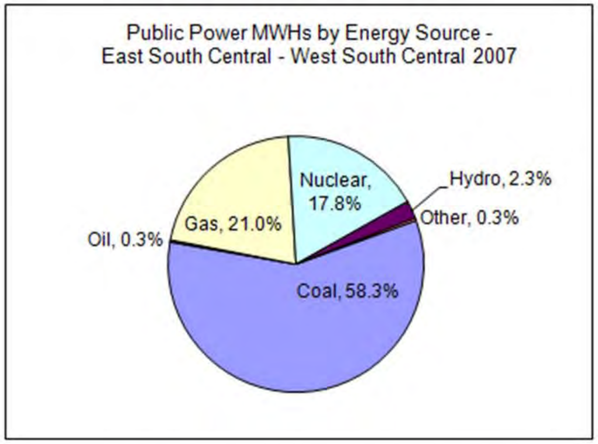


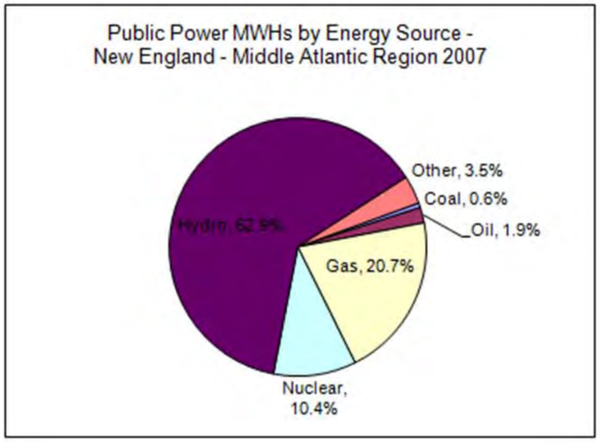
Source: Ventyx (formerly Energy Velocity) Database

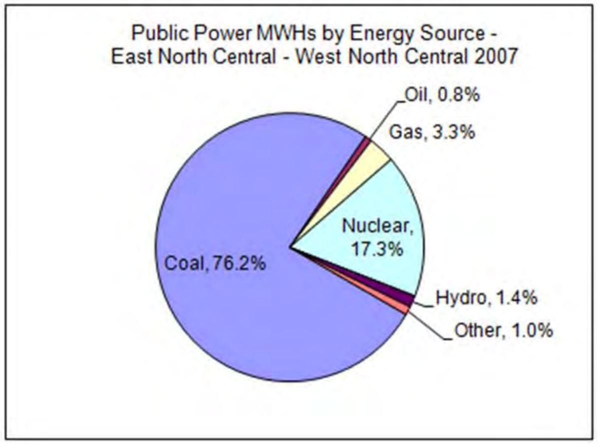
Public Power Generation By Region

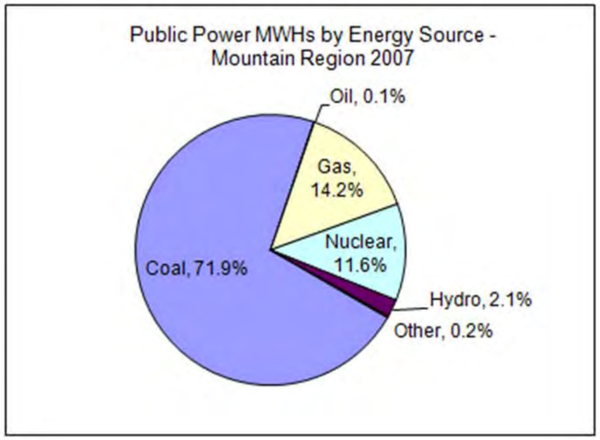






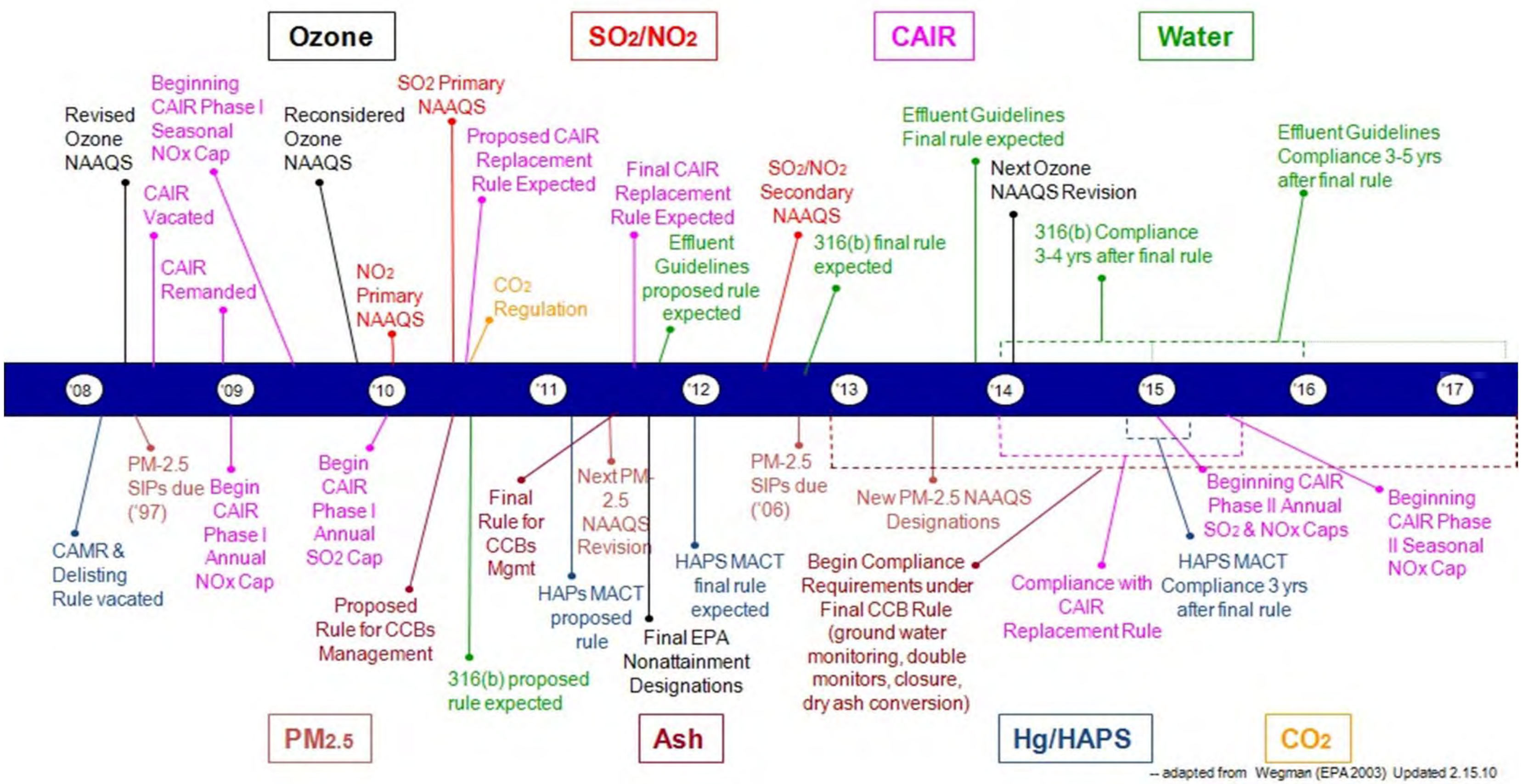






Source: Ventyx (formerly Energy Velocity) Database

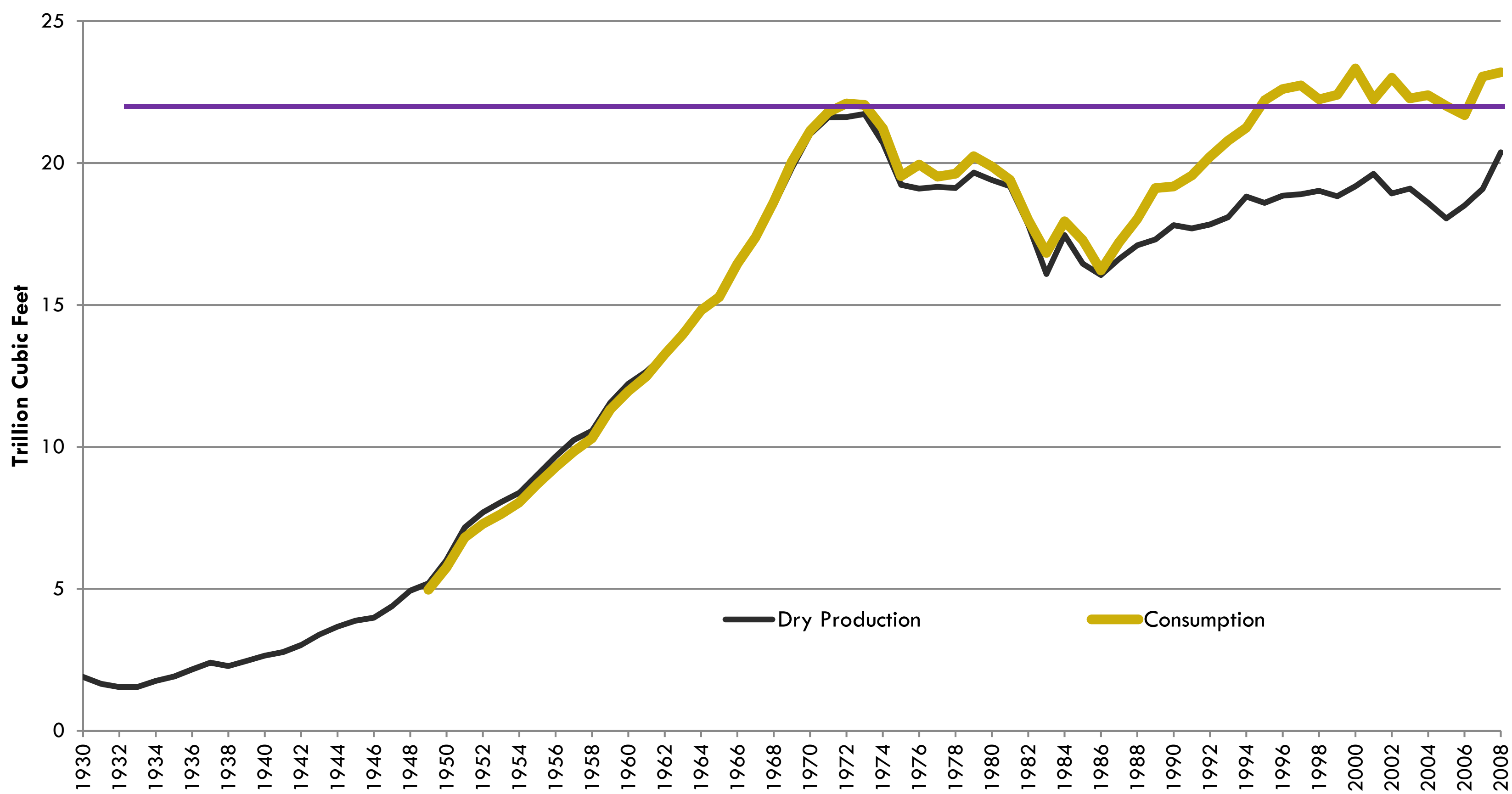
Many EPA Rules Driving Utilities to Fuel Switch to Gas for Baseload Power



Aspen Environmental Group

APPA American Public Power Association

U.S. Natural Gas Demand and Supply Never Higher than 23 Tcf



Aspen Environmental Group

APPA American Public Power Association

Range of Potential Gas Demand

	2008	EPA L-W	EPA W-M	AEO 2010 Ref Case	NICCPP	INGAA
Load Growth	1.5%	0.8%	0.41%	1.00%	0.2%	1.4%
Nuclear	20%	24%	23%	17%	20%	21%
Renewables	3%	13%	11%	11%	20%	8%
Coal	48%	18%	37%	44%	13%	40%
Coal CCS	0%	12%	3%	0%	20%	2%
NatGas	21%	25%	19%	21%	20%	23%
Petroleum	1%	2%	2%	1%	1%	1%
Hydroelectric	6%	5%	6%	6%	6%	5%
Total	100%	100%	100%	100%	100%	100%
Emissions in 2030		1,500	2,306	2,500	700	2,505
Gas Burn for EG in 2036 (Tcf)	6.9	10.80	7.7	8.8	7.4	10.7
Gas Burn for EG in 2030 (Tcf)	6.9	9.26	6.84	8.3	6.0	9.0
Total US Gas Demand	22.9	26.8	23.7	24.3	23.4	27
Allowance Prices ($2008)	n/a	83.7	38.8	n/a	80	40

Aspen Environmental Group

APPA American Public Power Association

Takes a Lot of Gas to Replace Existing Baseload Coal

- Existing Coal-Fired Capacity ~ 335,000 MW

335,000 MW x 7 MMBtu/MWh x .72 x 24 hrs

= 39 Bcf per day

x 365 days

= **14.1 Tcf per year**

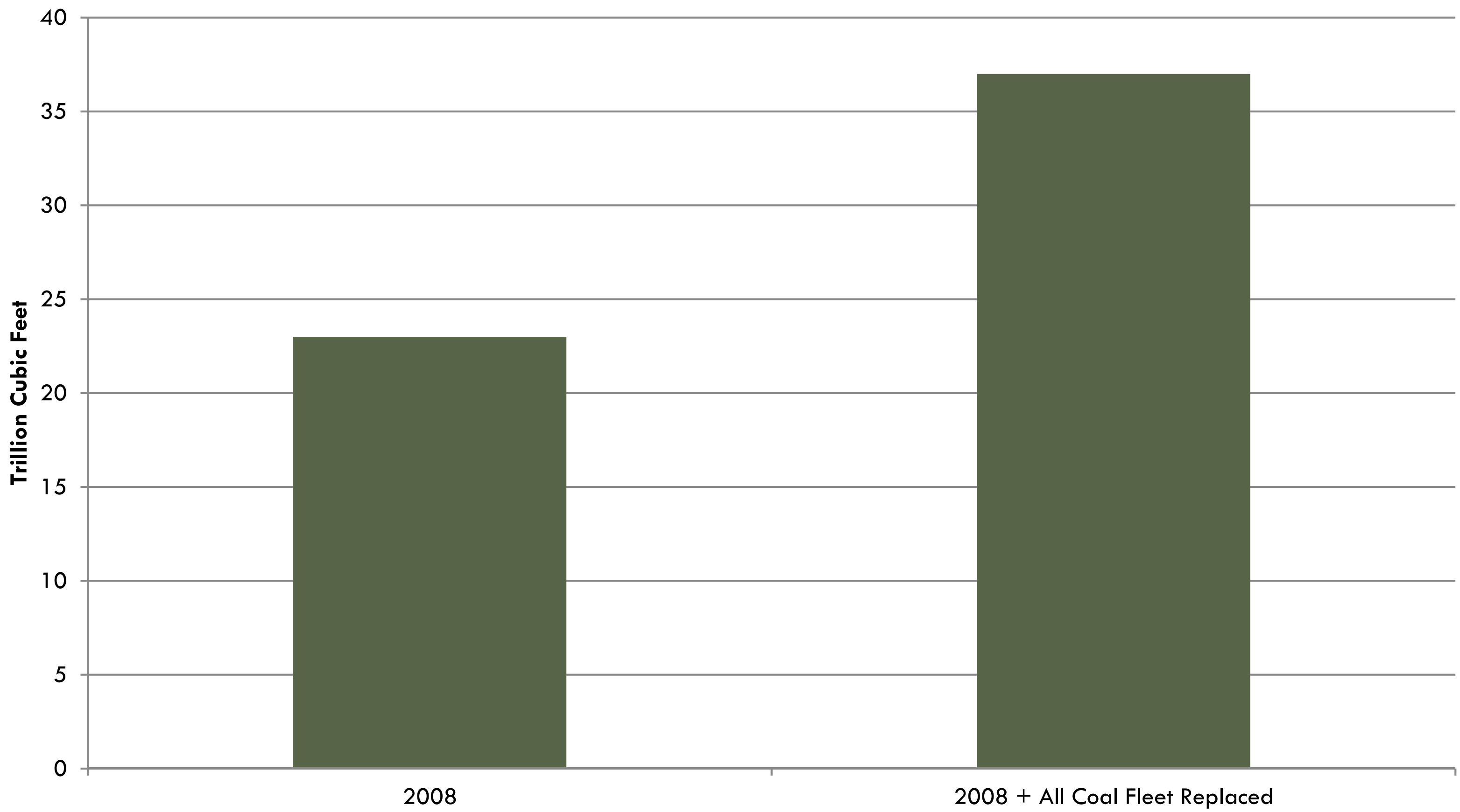
- Change in Gas Demand:

	2008	All Coal Switched to Gas	% Change
Daily (Bcf)	63	102	62%
Annual (Tcf)	23	37	61%

Aspen Environmental Group

APPA American Public Power Association

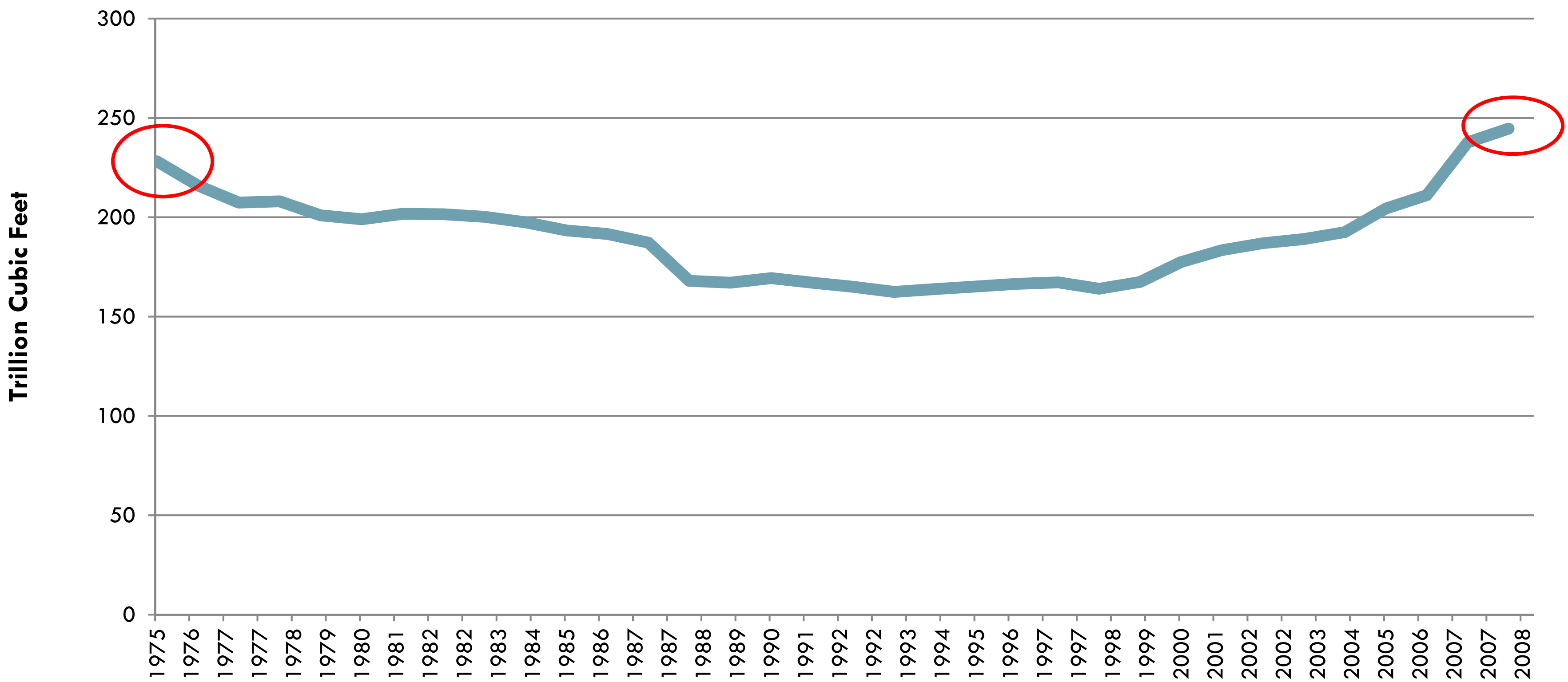
Gas Demand Would be Not Quite Double That of Today



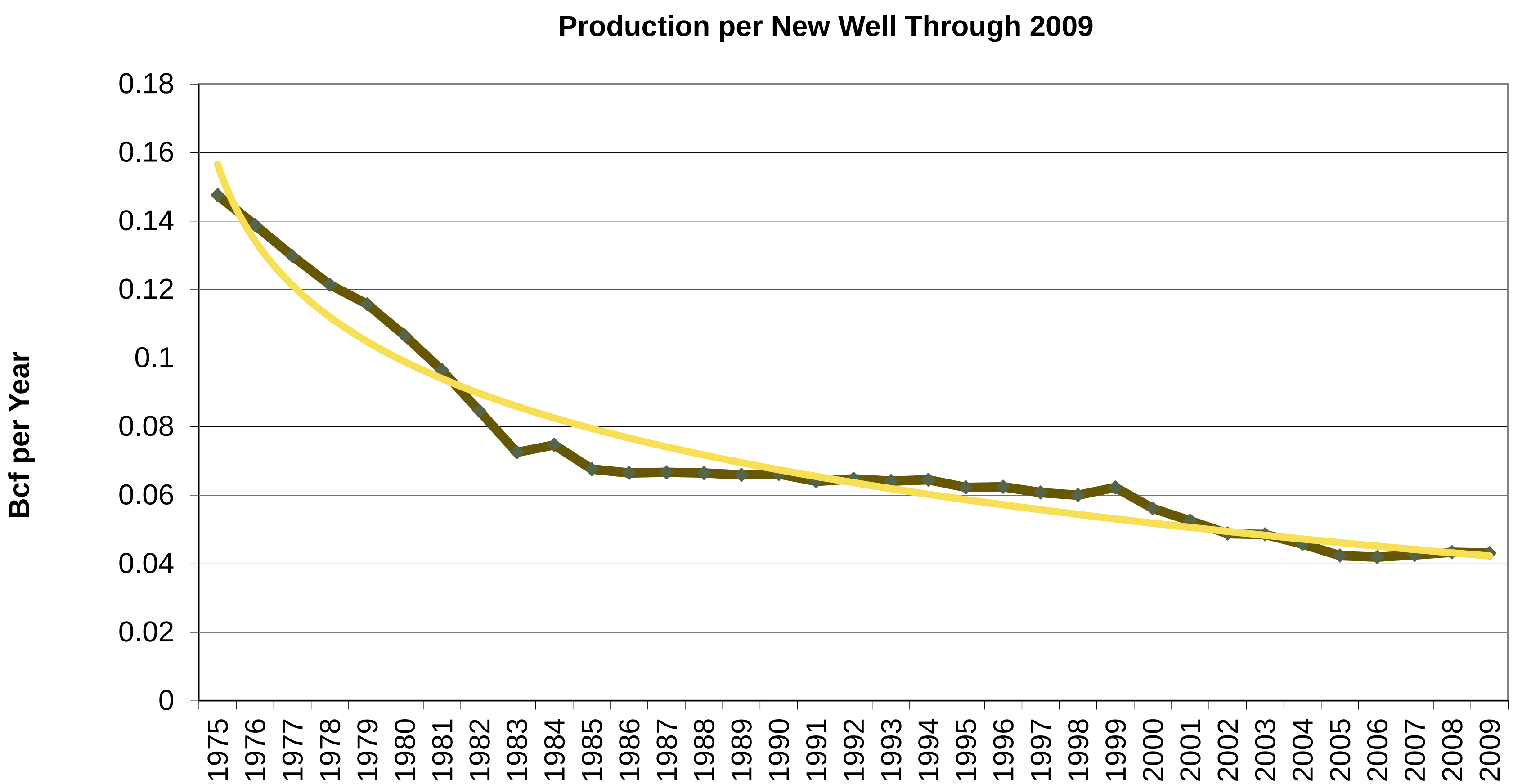
Is there enough Supply?

- Record-level proved reserve additions in 2007, but view should be tempered by recognizing:
  - Not much higher than 1975
  - Not many were new discoveries
  - Downward trend in production per NEW well not yet reversed
- Objections to hydraulic fracturing create uncertainty
  - Uses lots of water
  - Contamination concern if fracing liquids migrate
  - Seismic activity
  - Claims that emissions may be higher
  - Exxon-Mobil has opt out on XTO if Frac Act passes

Proved Reserves Just over 1975's



Regrettably, Shale Has Not Reversed Decline in Production per New Well



Aspen Environmental Group

APPA American Public Power Association

Can Anyone Really Predict Price of NatGas to Utility Sector from 2011-2035?

- Price quoted are often prices of $5-7 mcf to WELLHEAD not to the utility
- To what extent is the shale production receiving cross commercial subsidy for liquids, virtual gasoline, ethanes, butanes etc.
- To what extent is oil also found in shale gas formation?
- To what extent is the investment incentivized by the Section 199 IRS tax incentives
- To what extent is drilling motivated to avoid expiring leases (often 3 year leases) before having to re-negotiate the lease terms with mineral rights owner/land owner
- How much will the produced water & environmental costs run up shale drilling expenses over time? *(Not every state is Texas)*

General Rule of Thumb: Barnett Shale needs $5-7 mcf sustained over time

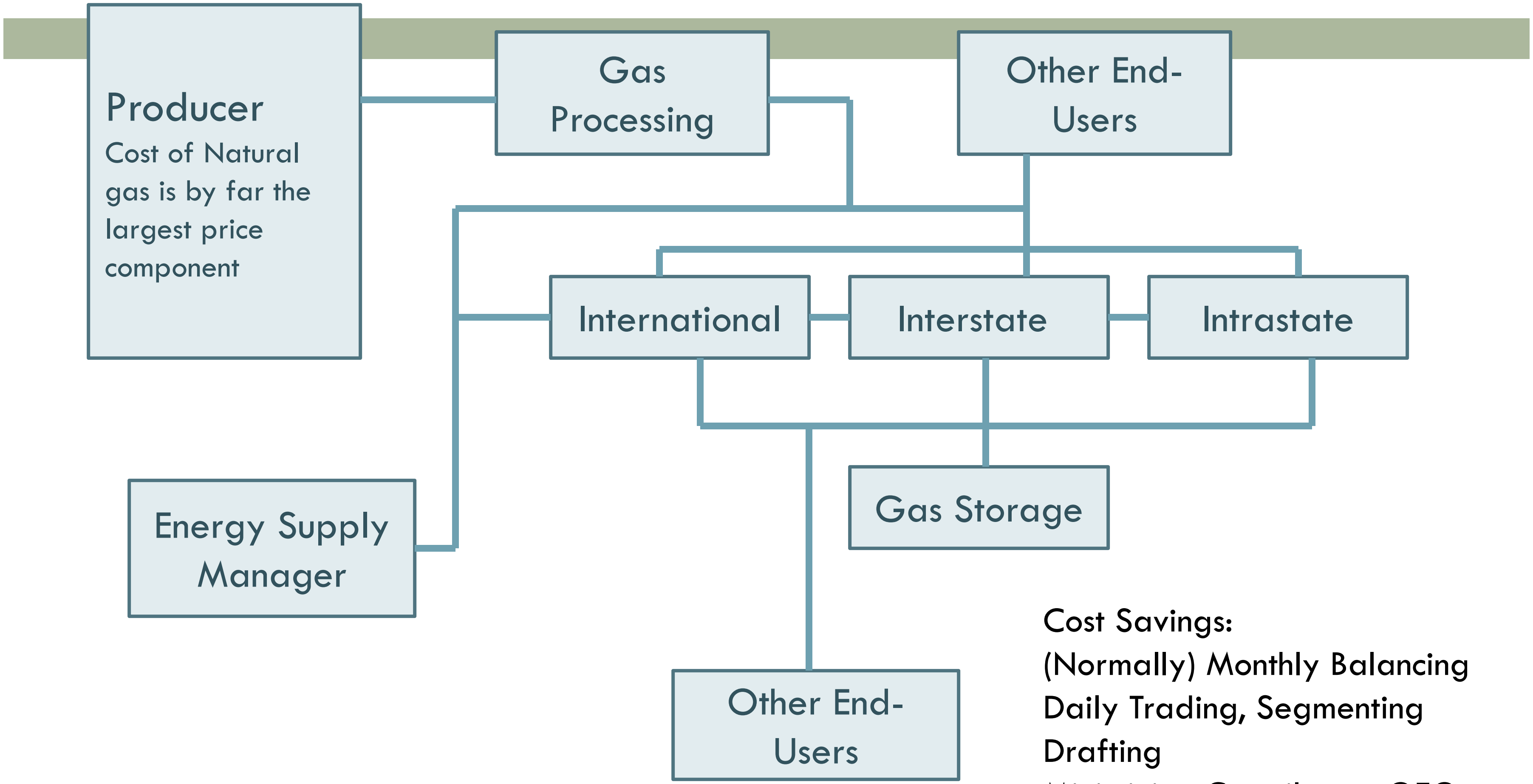
Aspen Environmental Group

APPA American Public Power Association

Infrastructure Requirements:

Interregional Pipeline & Underground Gas Storage

Infrastructure Basics



Cost Savings:
(Normally) Monthly Balancing
Daily Trading, Segmenting
Drafting
Minimizing Curtailment, OFO
Entitlement
Applying Risk Management

Could Need 70 Bcfd more Interregional Pipeline Capacity

Case	2036 Incremental EG Gas Demand[1] (Tcf)	Equivalent Number of 1000 MW Coal-Fired Plants[2]	Pipeline Transmission Capacity Requirement (Bcf per day)	Miles of Pipe	% Increase Over Current Interregional Flow	Cumulative Cost ($ Billion)
INGAA Low	-0.5		21	28,900	16%	108
INGAA Base	3.8	88	25	37,700	20%	129
INGAA High	6.6	153	37	61,600	28%	163
AEO 2010	1.9	44				
Alt 1	6.9	160	*Slightly Higher Than INGAA 's High Case*			
Convert Existing Coal	14.1	328	70			348

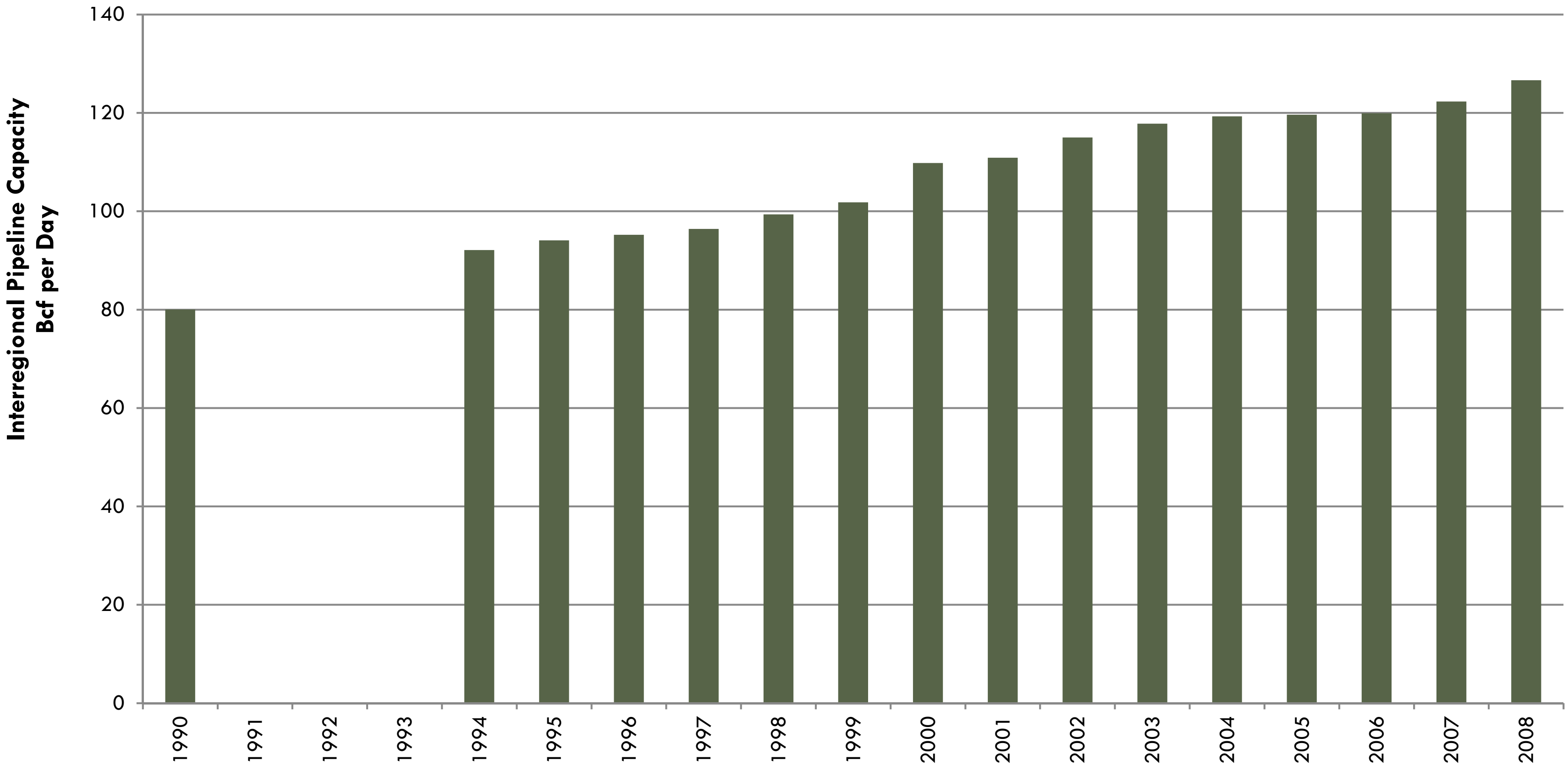
[1] The INGAA cases go out to 2030; the other cases either went out to 2036 or the data was extended to 2036. The "Convert Existing Coal" case is simply the gas burn that would result today if existing coal-fired generation were replaced with new, efficient combined-cycled gas-fired generation.

[2] At 72% capacity factor U.S. coal-fired plants operated at in 2008.

Aspen Environmental Group

American Public Power Association

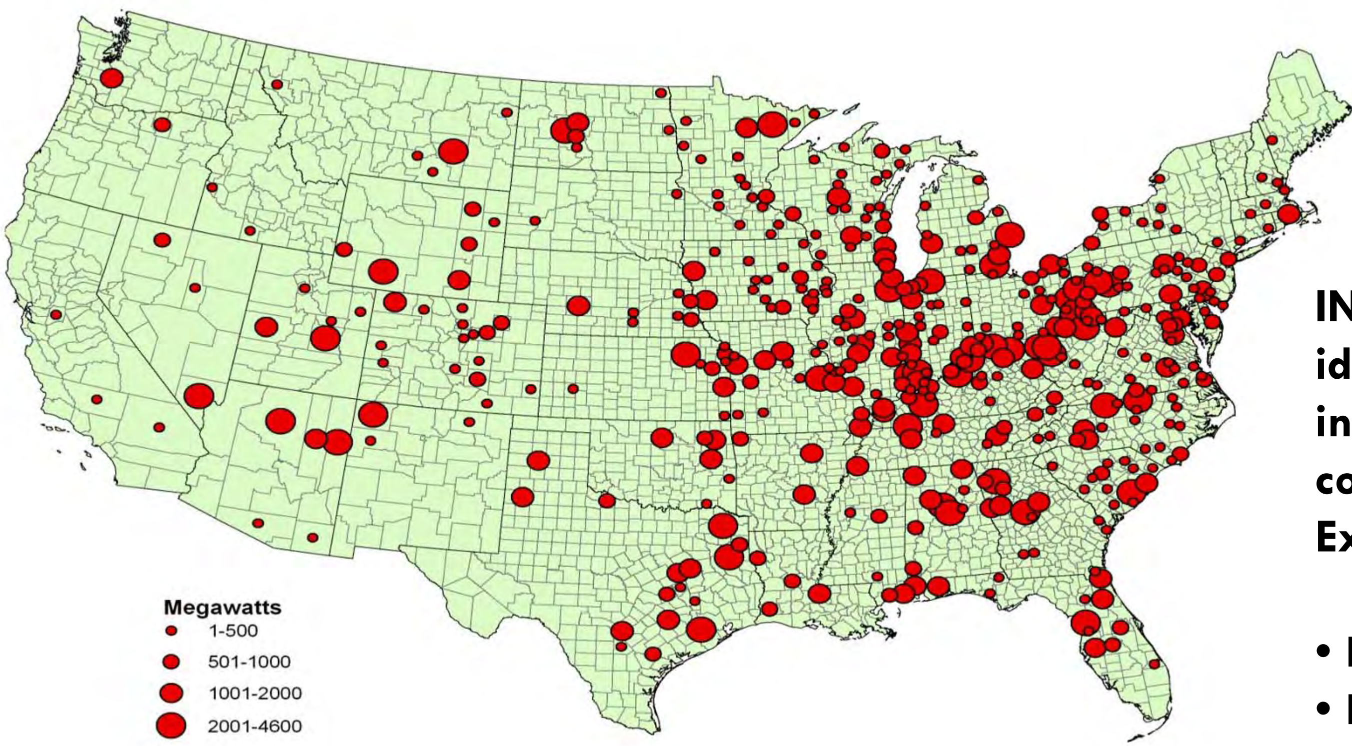
70 Bcf/d is far more than the 45 Bcf/d added 1990 to 2008



Aspen Environmental Group

APPA American Public Power Association

Not All of the Coal Plants Located Along Expansion Corridors



INGAA's study identified 5 key interregional pipeline corridors for Expansion:

- Rockies to NE
- Rockies to CA
- Mid-Cont to No. LA
- Alberta to Chicago
- Gulf Coast to FL

Aspen Environmental Group

APPA American Public Power Association

21 States will Need More Gas Pipeline Capacity Into the State

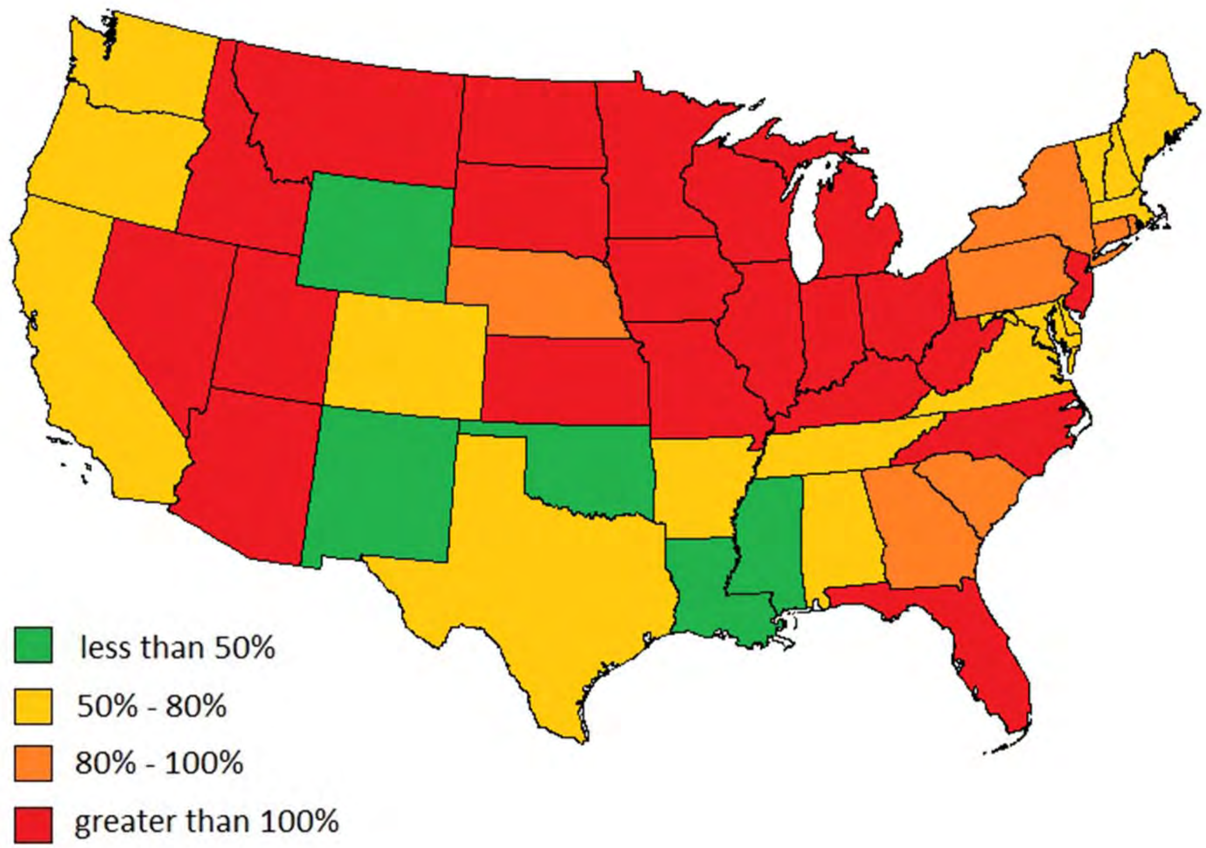
- Compared 2008 gas use by state to burn if coal replaced with gas
- In 16 states the gas to replace coal alone would be more than the state burns today
- In 21 states the gas to replace coal combined with current demand would push pipeline load factors well over 100% in peak **month**
- In Alaska* and Hawaii and the territories, that gas would have to be LNG

Aspen Environmental Group

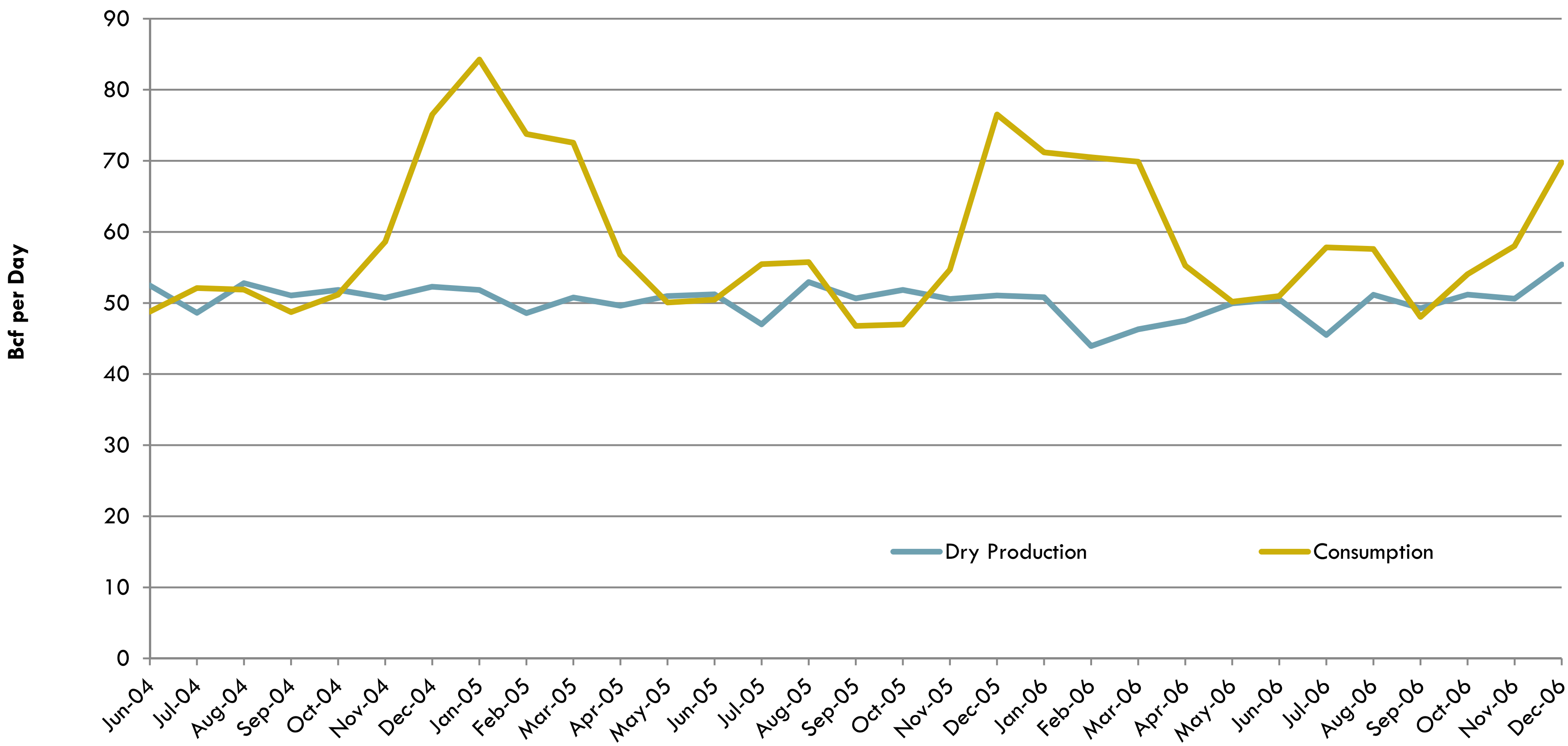
APPA American Public Power Association

6 States Will Have Utilization > 80% in Peak Month (so likely need capacity)

Doesn't include need for new LDC capacity.



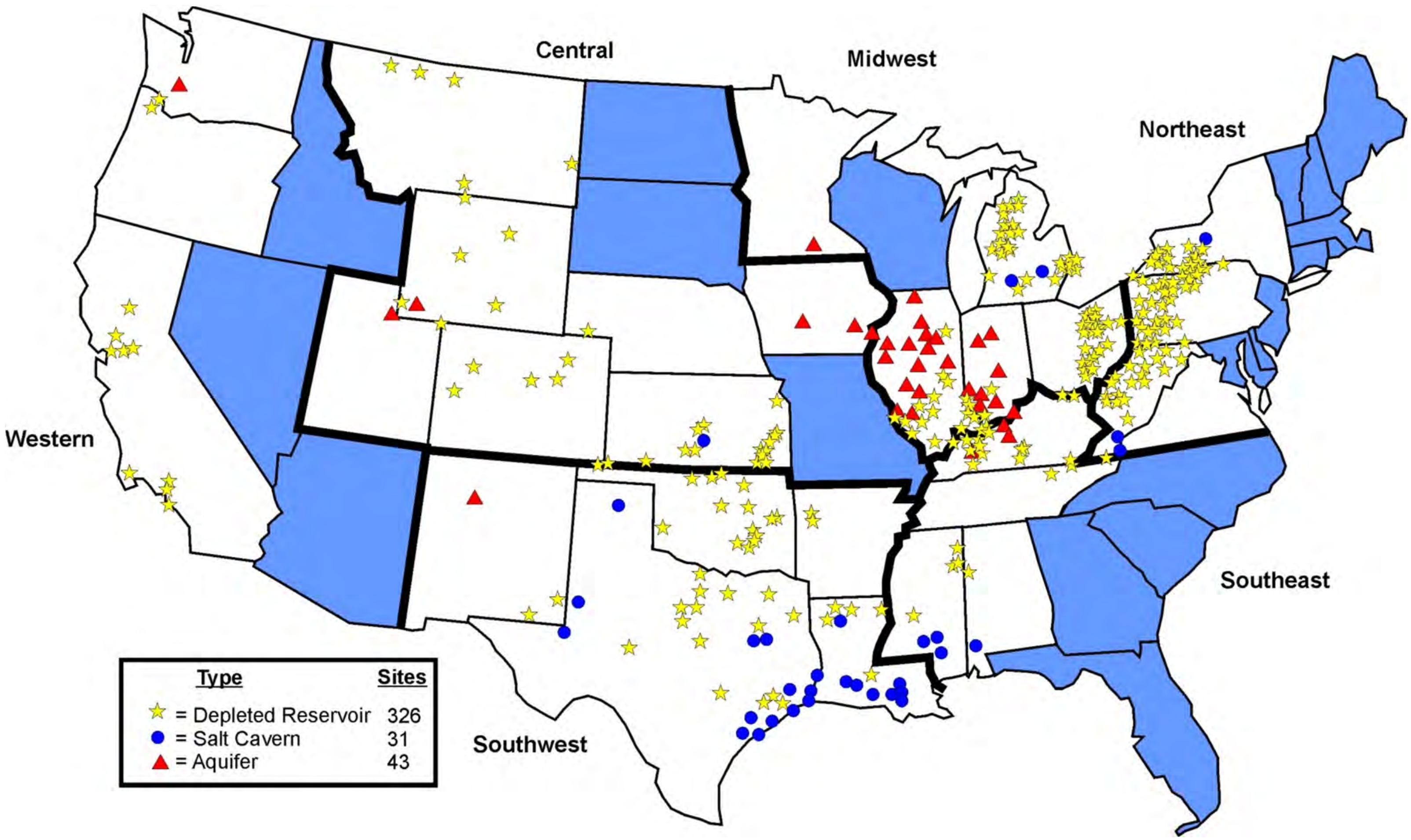
Traditional Reservoir Storage Built to Address Winter Peak Load Profile



Aspen Environmental Group

APPA American Public Power Association

Not Every State has Gas Storage Within Easy Reach and Few Are High Deliverability



Aspen Environmental Group

APPA American Public Power Association

Less Than 10% of Existing Storage Capacity is Likely High Deliverability

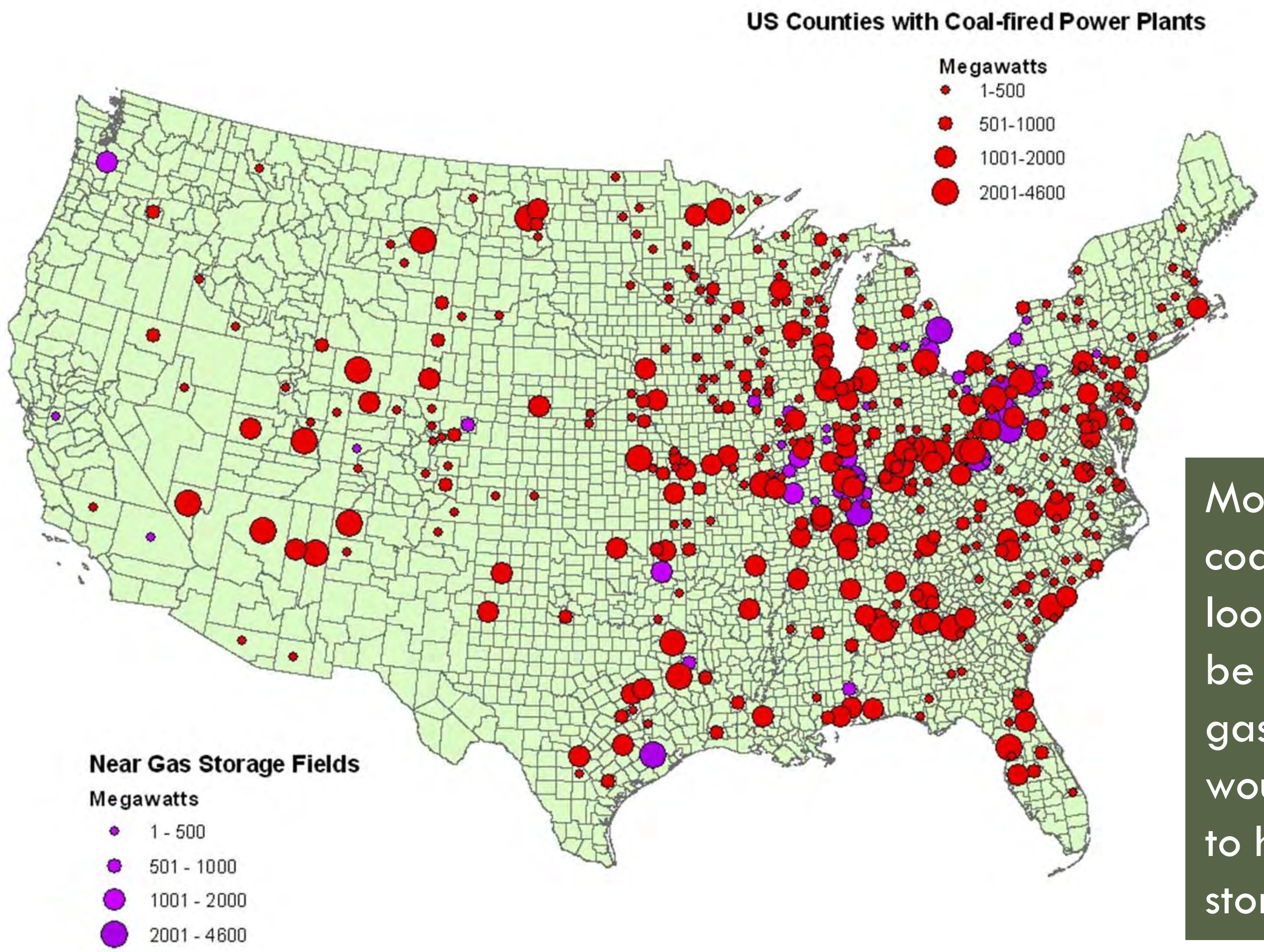
Type	Reservoir/Aquifer	Salt Cavern
Characteristic	Single Turn	Multi-Turn
Owner	LDC or Pipeline	Independent
User	LDC	Marketers/EG
Purpose	Seasonal Demand	Arbitrage or Daily Peak
Price	COS	Option Value
Sites	369	**31**
Working Gas (Bcf)	3,918	**173**
Maximum Daily Withdrawal (MMcf/d)	74,523	**13,703**

[1] Some reservoirs can be configured for multi-turn high-deliverability storage. They cost more because achieve higher deliverability by adding more injection and withdrawal Capability. Need geologic characteristics to withstand higher operating pressure, too. CCS will be looking for similar characteristics.

Aspen Environmental Group

APPA American Public Power Association

Utilities Need High Deliverability Storage to Manage Imbalances, Reliability, and Price



Most of the existing coal-fired generation looks like it may not be located near existing gas storage and very little would have access to high deliverability storage.

Aspen Environmental Group

APPA American Public Power Association

A Number of Pipelines Don't Appear to Have Much Storage

- Florida Gas Transmission
- Kern River Gas Transmission
- Southern Natural
- Transco
- Iroquois
- Maritimes & Northeast
- Alliance
- Gas Transmission Northwest
- Northern Border
- Trailblazer
- Transwestern
- El Paso Natural Gas
- Williston Basin Pipeline

Virtually all of these pipelines look like they would end up with new gas-fired generators to serve if utilities switched existing coal over to natural gas.

Pipelines without storage impose much stricter balancing rules and make power plant operations more difficult.

Aspen Environmental Group

APPA American Public Power Association

Adding Storage Not So Easy

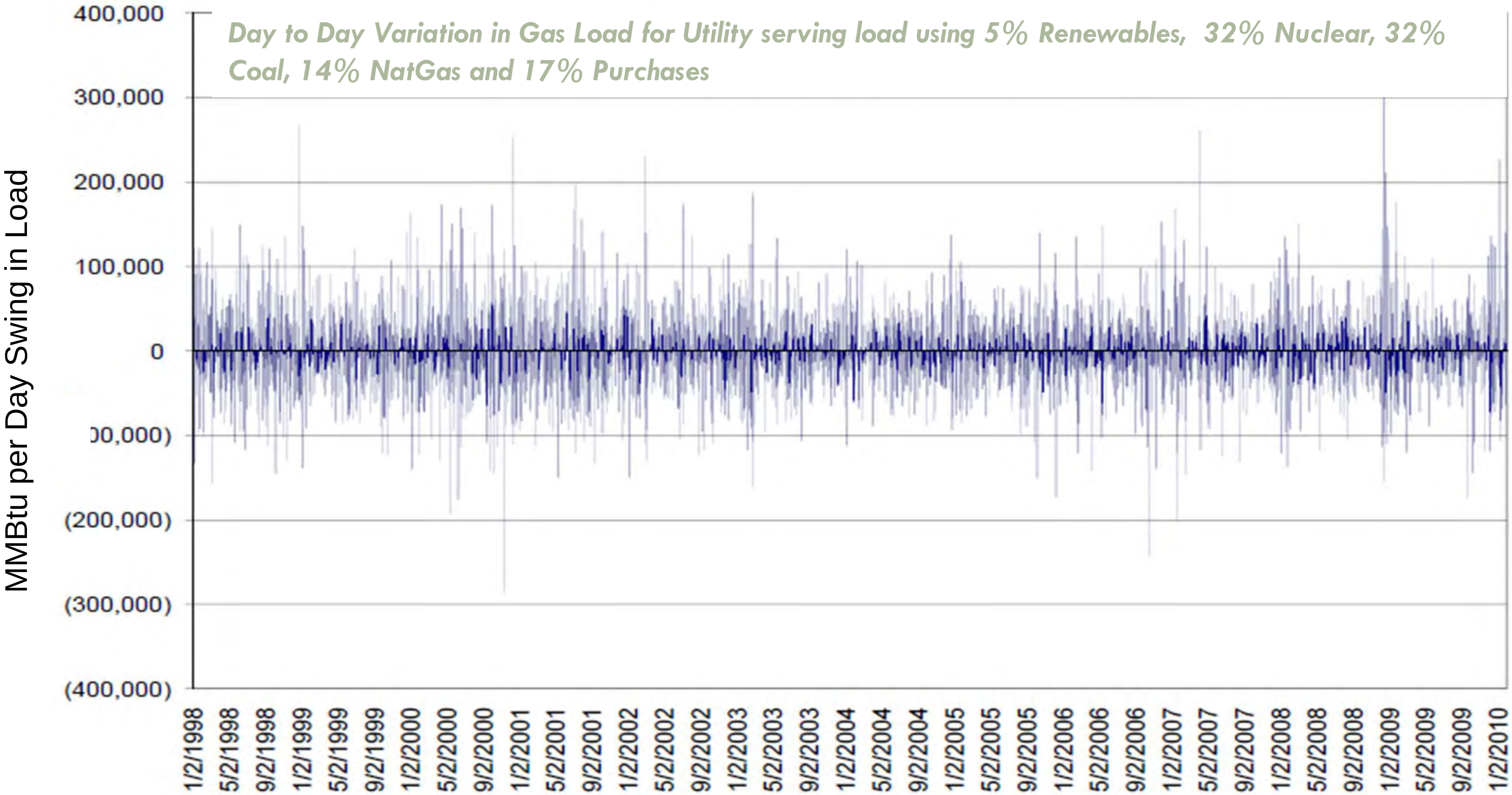
- FERC has tried to encourage more storage and banks prepared to finance
- Geology and market access define opportunity
- Some issues with salt brine disposal
- Is relatively expensive (cushion gas cost plus more inject and withdrawal capability)
- Independent Developers want to sell for option value instead of at cost of service plus return
- Requires sophisticated buyers

Operational Challenges

Operational Details Need Attention to Help Utilities and Pipelines Adapt

- Increased MDQs to avoid cold day interruption
- Review of curtailment order and/or contingency planning in event of supply or capacity shortfalls
- More flexibility in nomination windows and rules allowing bump
- More flexibility in balancing rules; more standardization be helpful/embed more storage in transport rates so tolerances can be bigger
- Massive staff training effort

Combined Utility Gas Load Not Flat; Electric Utility Sector Exacerbates



Aspen Environmental Group

APPA American Public Power Association

Retrofitting, Converting, Switching Really Means **Replacement**

Switching means REPLACE by building new NGCC

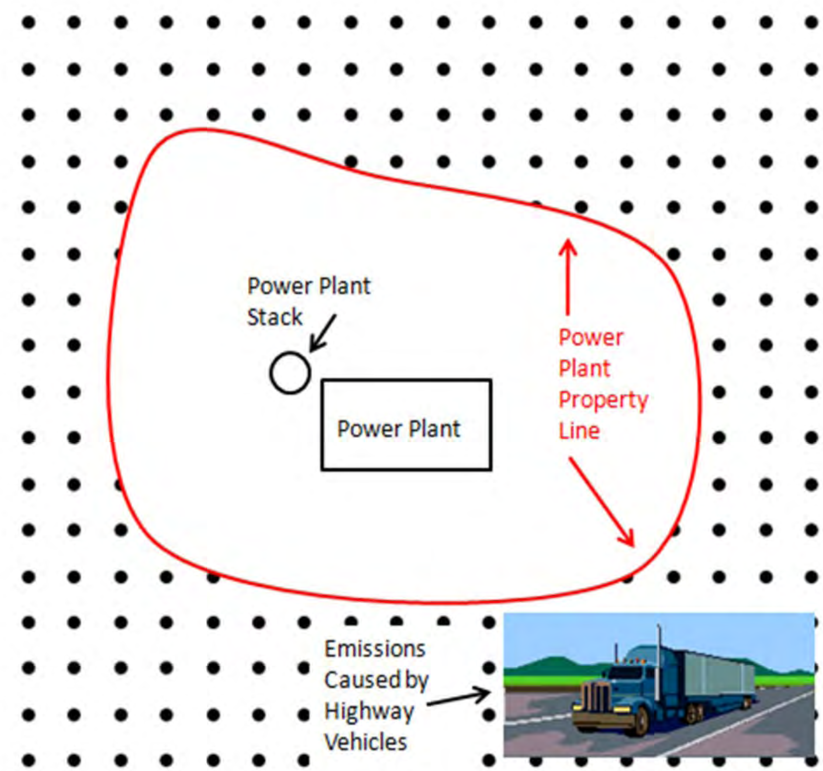
- Best way is not to retrofit or repower coal units to burn gas
  - Retrofitting results in 10% -15% poorer heat rate
  - GAO, ORNL & LBL say not economic
  - References to switching in press reports and PUC applications are shorthand
- Not clear that repowering old boilers will meet various NOx emission standards (under tighter EPA standards)

Gas-Fired Replacement Plants Will Face Some Permitting Issues

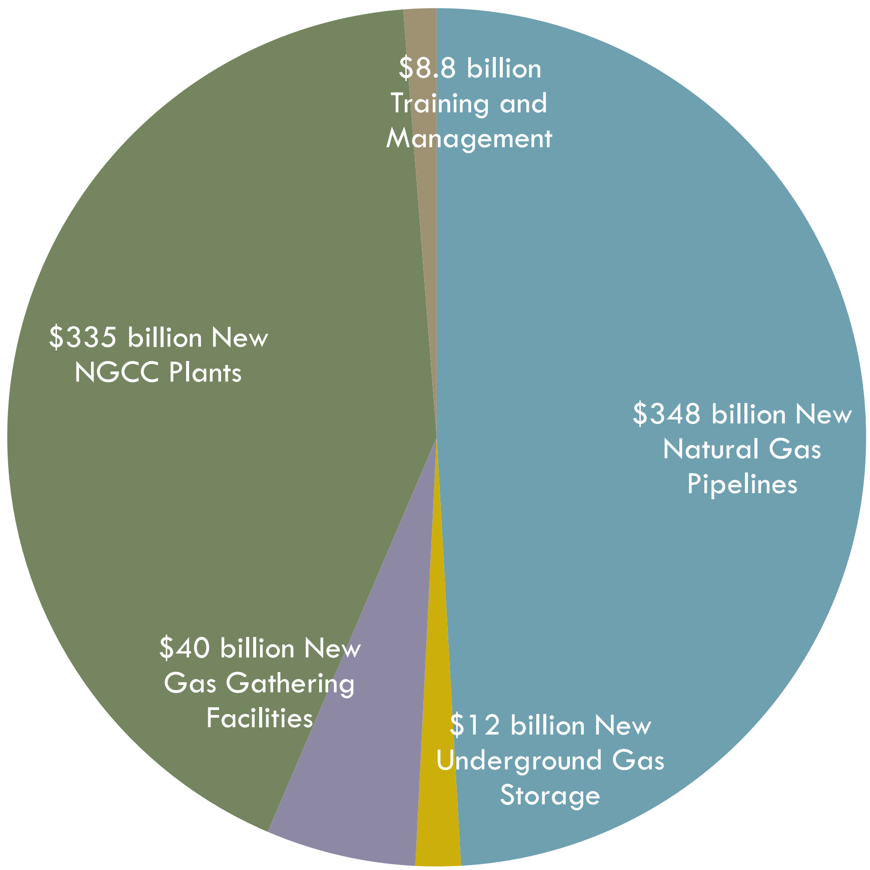
- Pending coal ash rule, if triggered, requires review and remediation of all waste within facility fenceline
- Water depends on scope of changes to existing effluent and intake stream/volume
- Air easier for gas than coal, BUT
  - scope of changes *wrt* MWs or planned operations could trigger new PM permit
  - is a new EPA rule on NO_2 nonattainment counties and requirement for dispersion modeling

Even if you convert a coal-fired plant to natural gas…

- Once you convert a coal-fired power plant to Natural Gas, you will still be regulated for CO_2
- New proposed NOx hourly Primary Standard of 100 ppb will require dispersion modeling in attainment areas (to be determined by EPA's new monitoring)
- Stack Height and Location?
- Dispersion Modeling Challenges?



Cost Close to $750 Billion and Lots To Do to Make It Work



Excludes higher commodity costs to expand gas supply, or local pipeline and LDC expansion or higher MDQ costs.

Aspen Environmental Group

APPA American Public Power Association

Detailed Slides 33-37 For Reference

(Not Pugh’s area of expertise—Aspen’s area of expertise)

Nominations 4 Times per Day

- 4 nomination windows across today and tomorrow for tomorrow's gas deliveries
  - Initial nom due **before** day-ahead electricity scheduling done
  - EG gas requirement changes with air temperature

Nomination		Hour CCT	Day
Timely		11:30 AM	Day PRIOR to gas flow
Evening		6:00 PM	Day PRIOR to gas flow
Intraday 1		10:00 AM	Day OF gas flow, effective @ 5pm Day OF
Intraday 2		5:00 PM	Day OF gas flow, effective @9pm Day OF

Aspen Environmental Group

APPA American Public Power Association

Some Utilities Will Need Higher Maximum Daily Quantity

- Paying pipeline reservation charges to meet abnormal peak day demand is expensive
- MDQ set lower than peak day with expectation to fuel switch/curtail gas-fired electricity generation
- If cannot switch away from gas must increase MDQ and pass through higher cost to customers
- Local delivery capability may need expansion

What IS Balancing?

- Pipelines require:

  Q delivered = Q nominated = Q burned

- Leaving an imbalance on the system = free storage or can cause operating problems
  - too much pressure pipeline goes "boom" or gas release
  - too little pressure, gas stops moving
- Standards different each Pipeline or LDC
- Many pipelines require even hourly nominations and even hourly burn + nom on Friday for Sat/Sun

Curtailment Order Needs Revisit to Assure Reliability of Electric Supply

- Interstate pipelines unlikely a problem other than MDQ
  - firm is firm/pipelines only sell as firm what the pipe can deliver
  - BUT on constrained pipes, EGs often buy IT and may or may not have alternate fuel capability
- LDCs: power plants often lowest priority to protect service to human needs customers
  - LDC may need higher MDQ as well as pipe to remedy
  - Expanding to serve cold day capacity requirement likely costly (reason not done to date)
- Extreme Event Interruption risk

Aspen Environmental Group

APPA American Public Power Association

Many Electric Utilities Have No Experience With Key Gas Tasks

- Assess Gas Requirements and Plan Operations to Minimize Electricity Cost/Maximize Reliability
- Purchase Natural Gas, Transportation and Storage
- More Detailed Monitoring of Natural Gas Market Conditions
- Submit and Modify Daily Gas Nominations
- Manage Imbalances
- Manage Gas Price Risk (i.e., hedge)
- Monitor and Participate in Gas Regulatory Cases Manage Contract Execution, and monthly or daily Accounting and Settlement

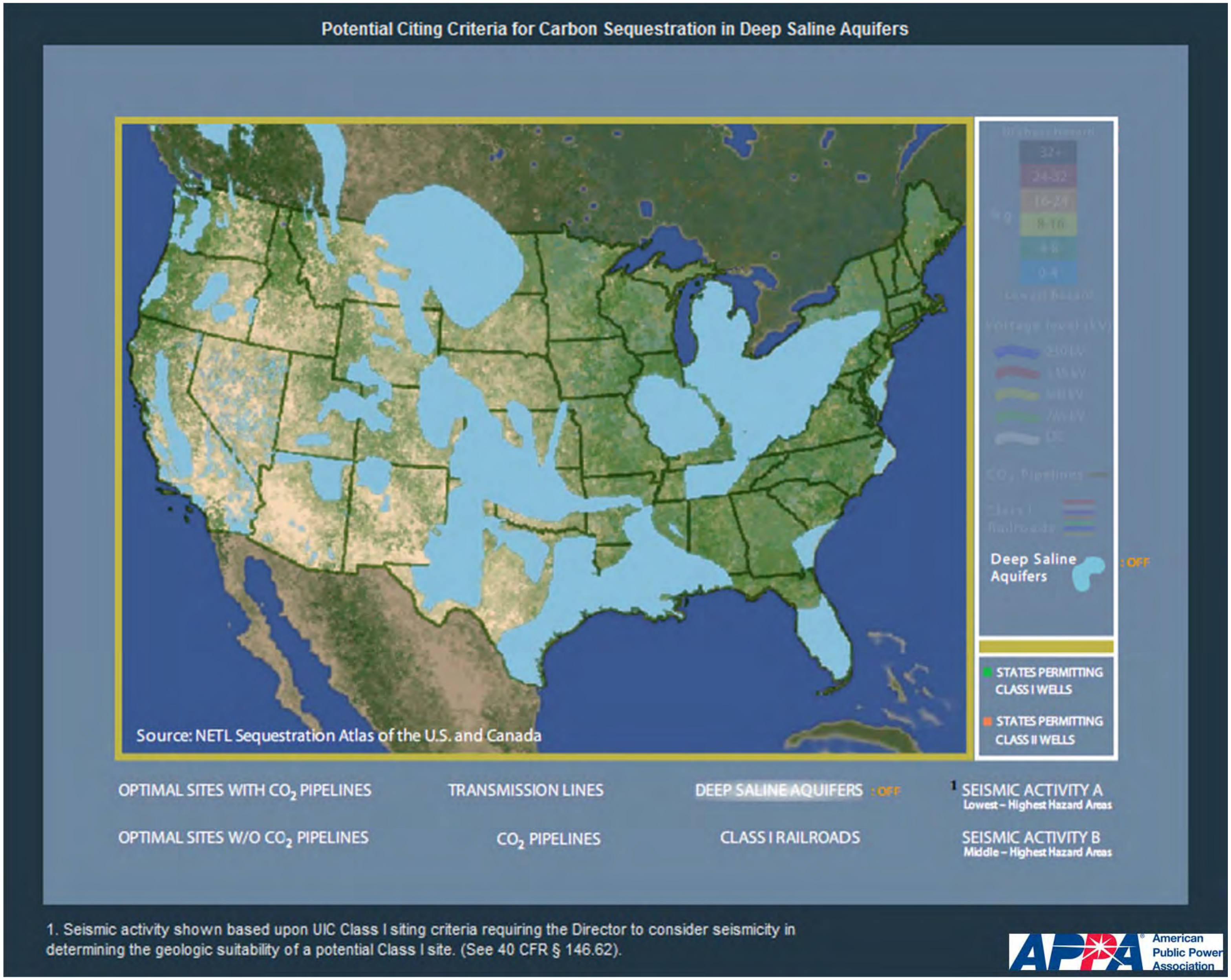
Even if Utilities Switch to Gas—What About Controlling CO_2 from Gas?

- Same problems with CCS lacking commercial demonstrations on 500,000 -1 million TPY level
- Natural gas derived CO_2 emissions are probably tougher to capture at power plant
- Parasitic power loss for CO_2 capture—15 *plus*%?
- All the CO_2 injection issues might get even more peculiar on a local level if deep saline aquifers must be used for either natural gas storage, water storage, natural gas storage, or produced water storage (after treatment)

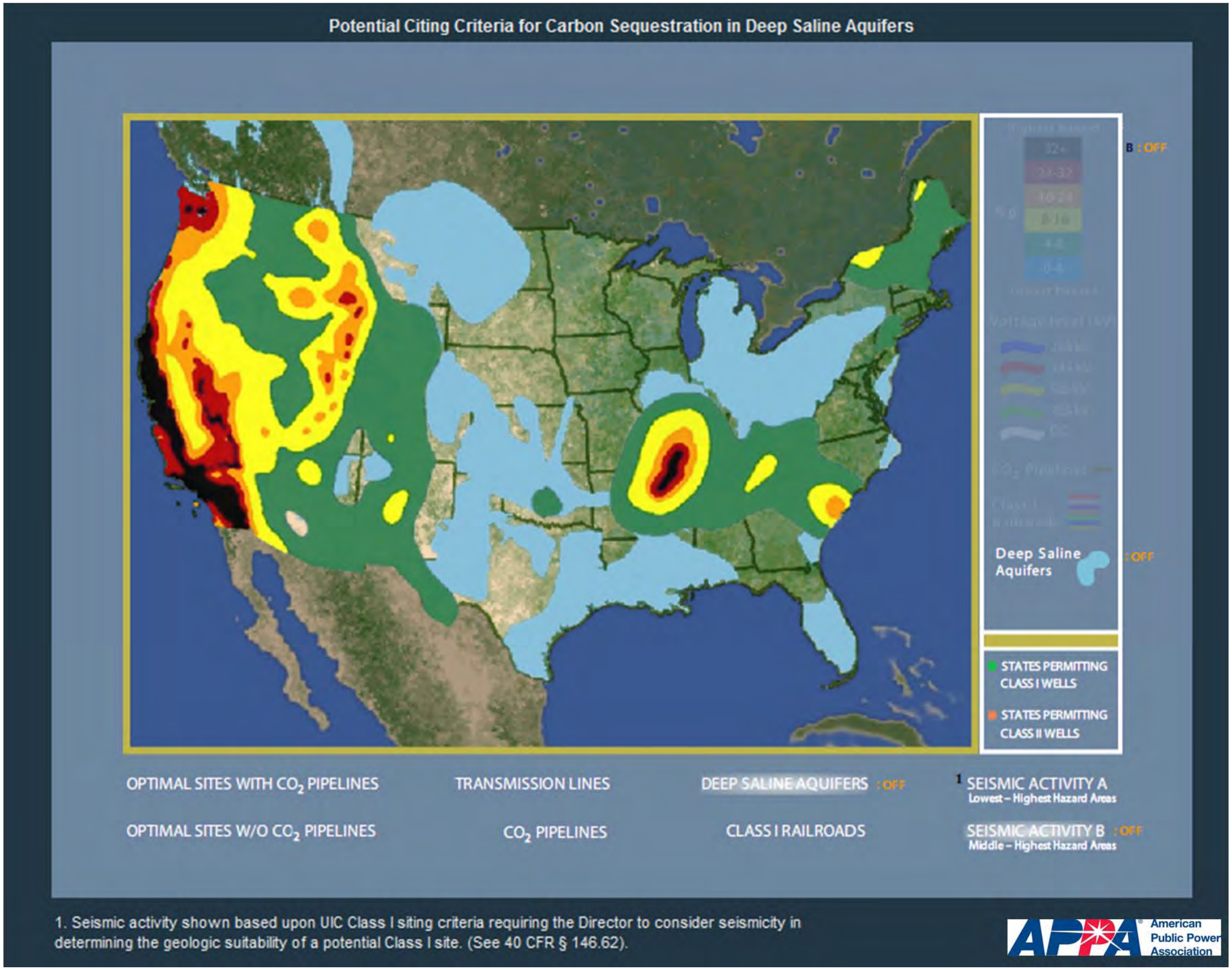
Aspen Environmental Group

APPA American Public Power Association

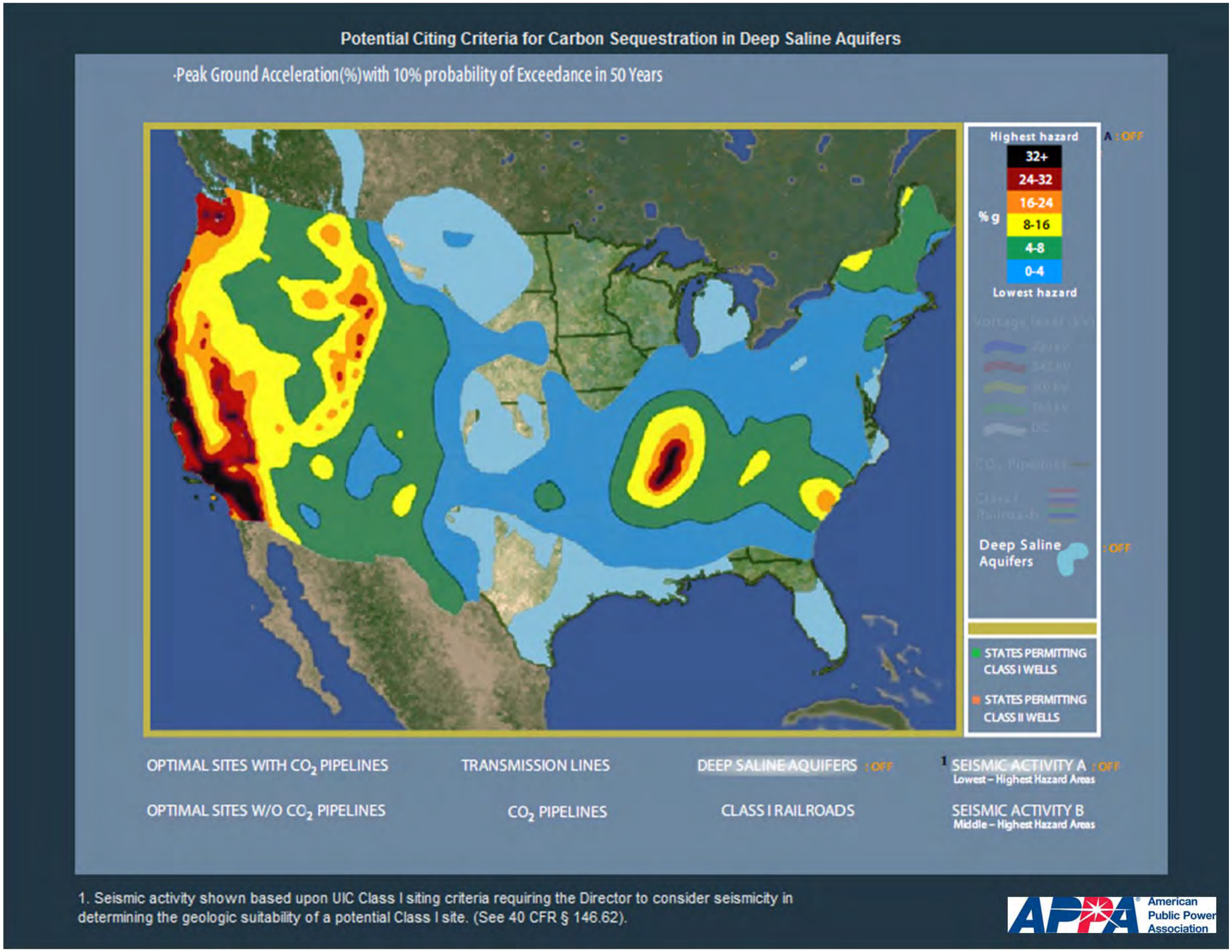
Deep Saline Aquifer Locations



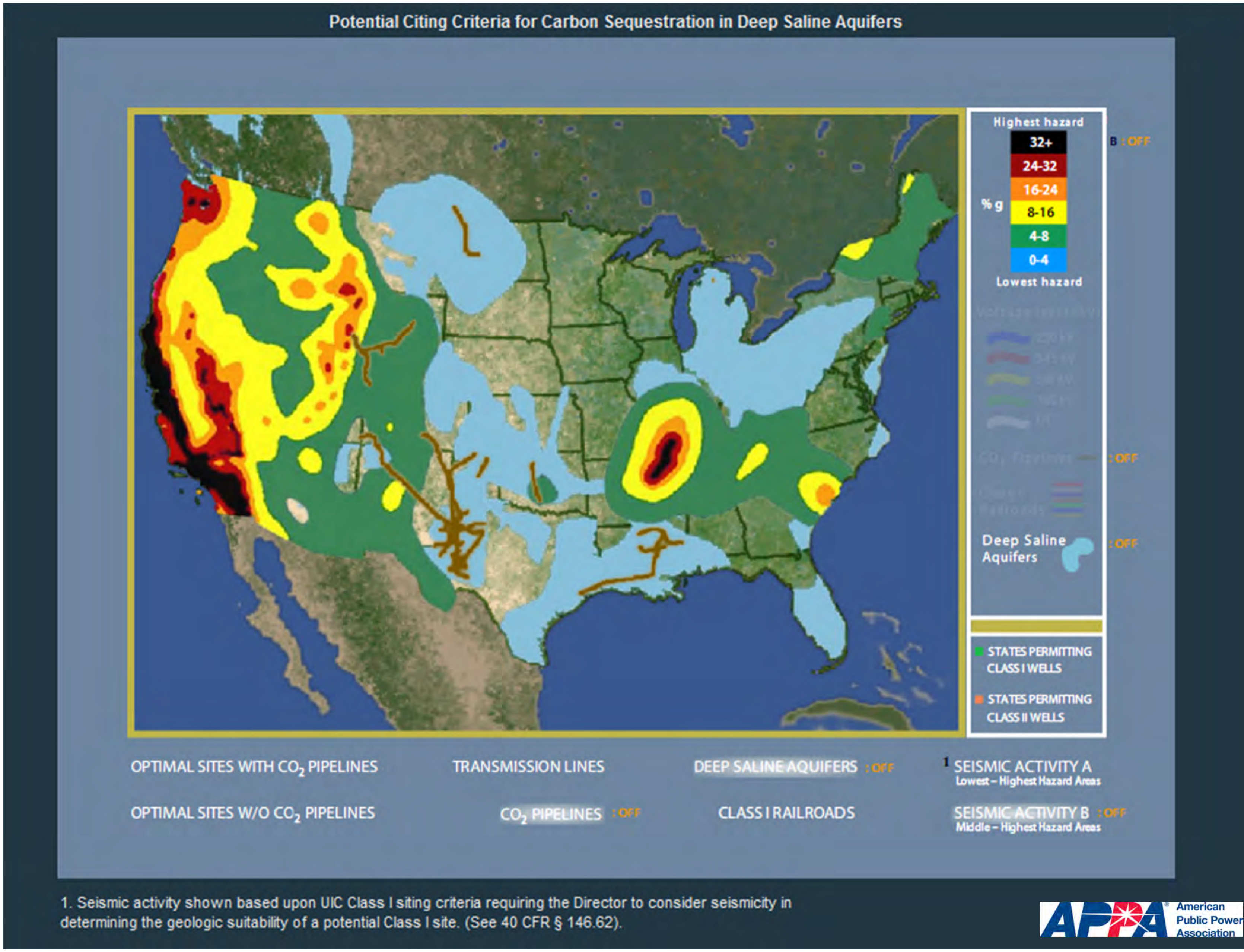
Deep Saline Aquifer Locations & ‘Lenient’ Seismic



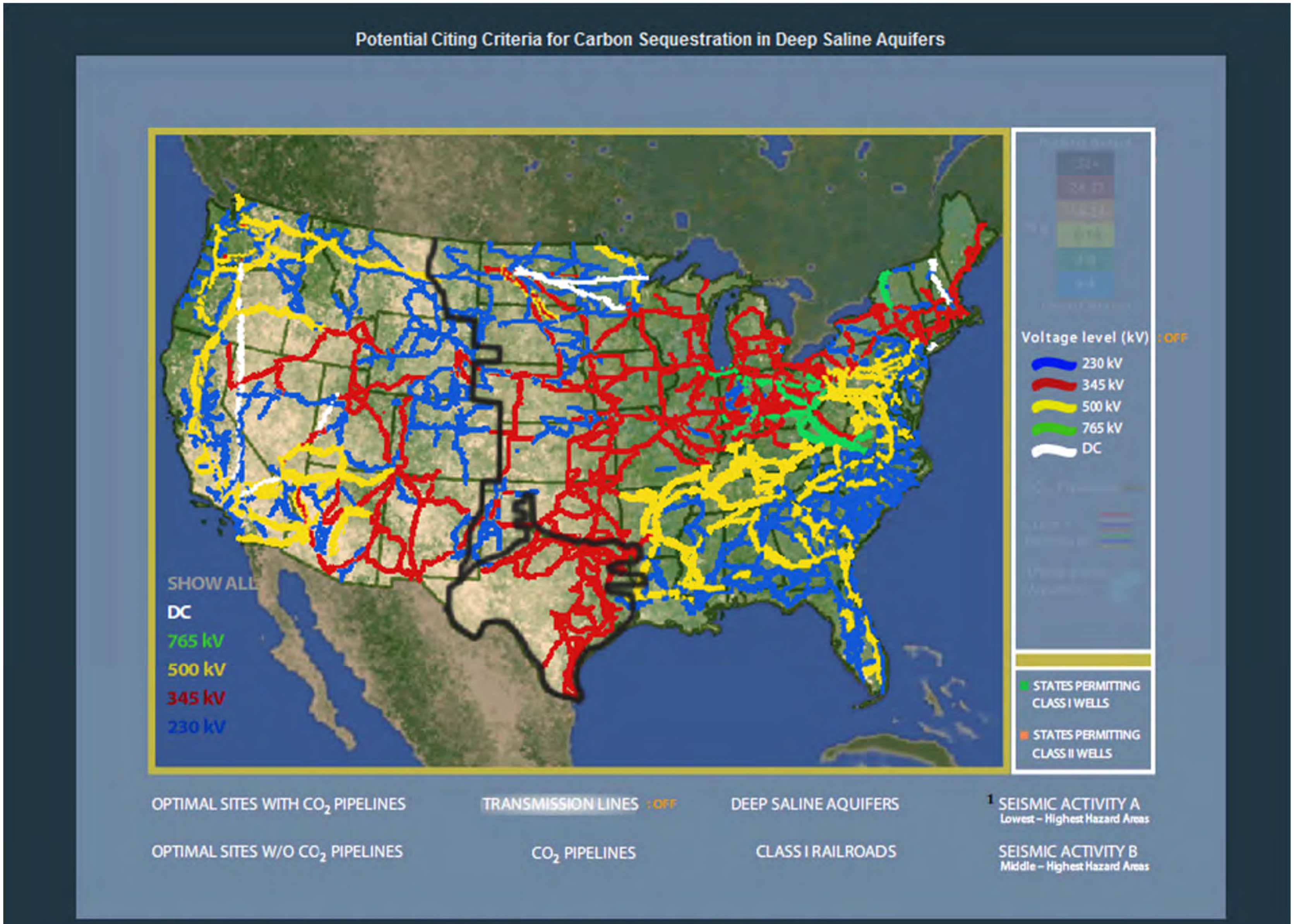
Deep Saline Aquifer Locations & 'Stringent' Seismic



Saline Aquifers, CO_2 Pipelines, & 'Lenient' Seismic

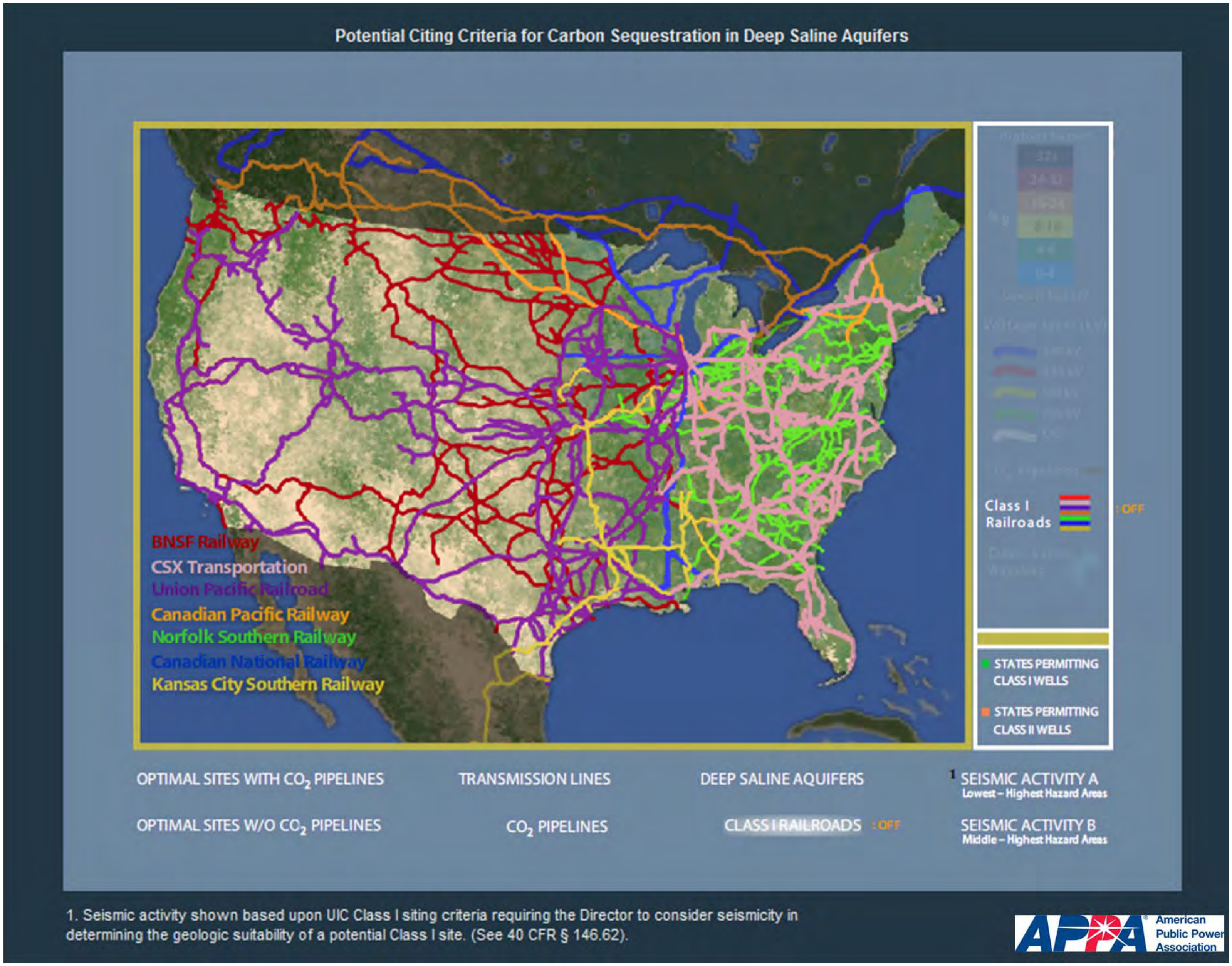


Other Considerations – Transmission Lines

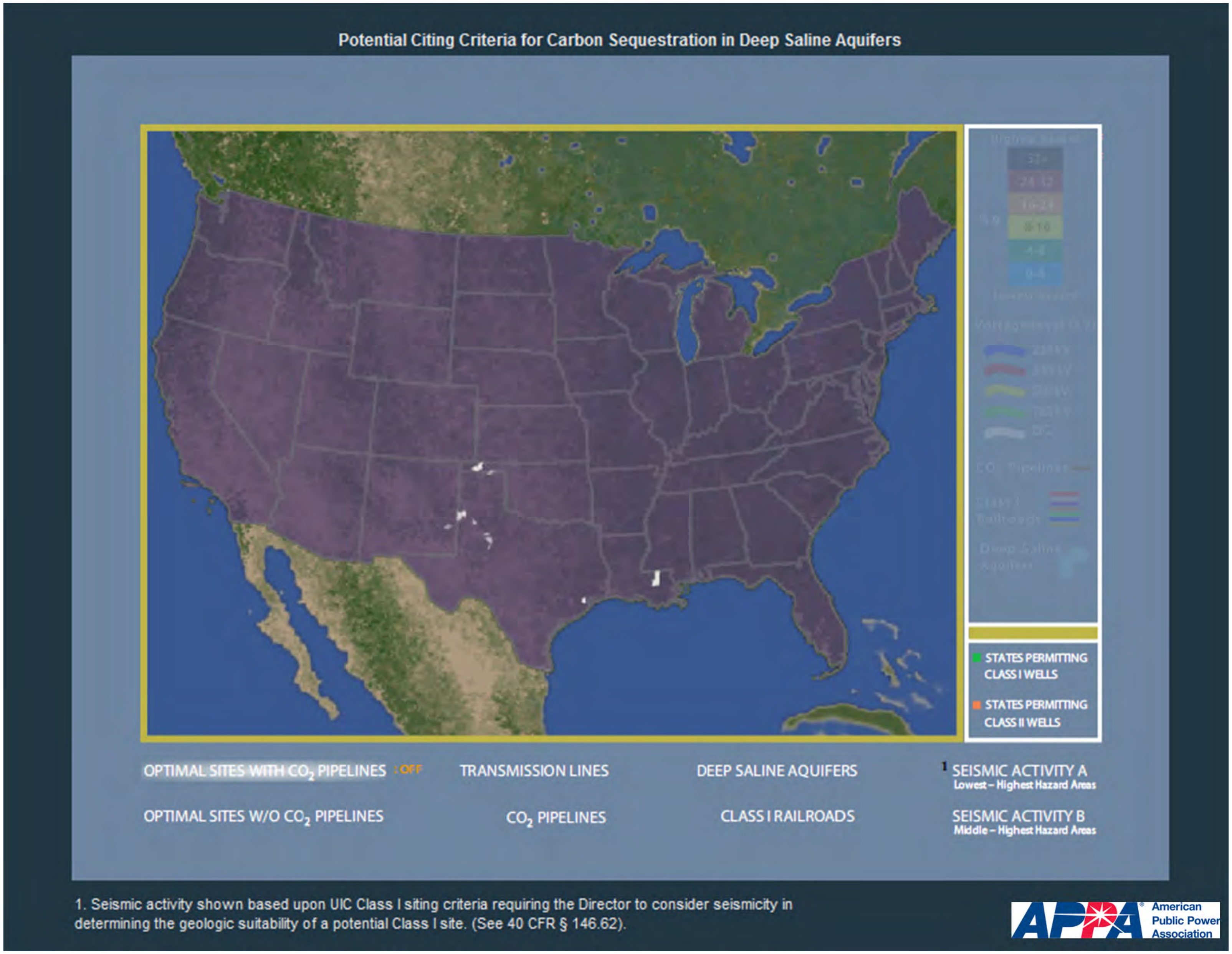


1. Seismic activity shown based upon UIC Class I siting criteria requiring the Director to consider seismicity in determining the geologic suitability of a potential Class I site. (See 40 CFR § 146.62).

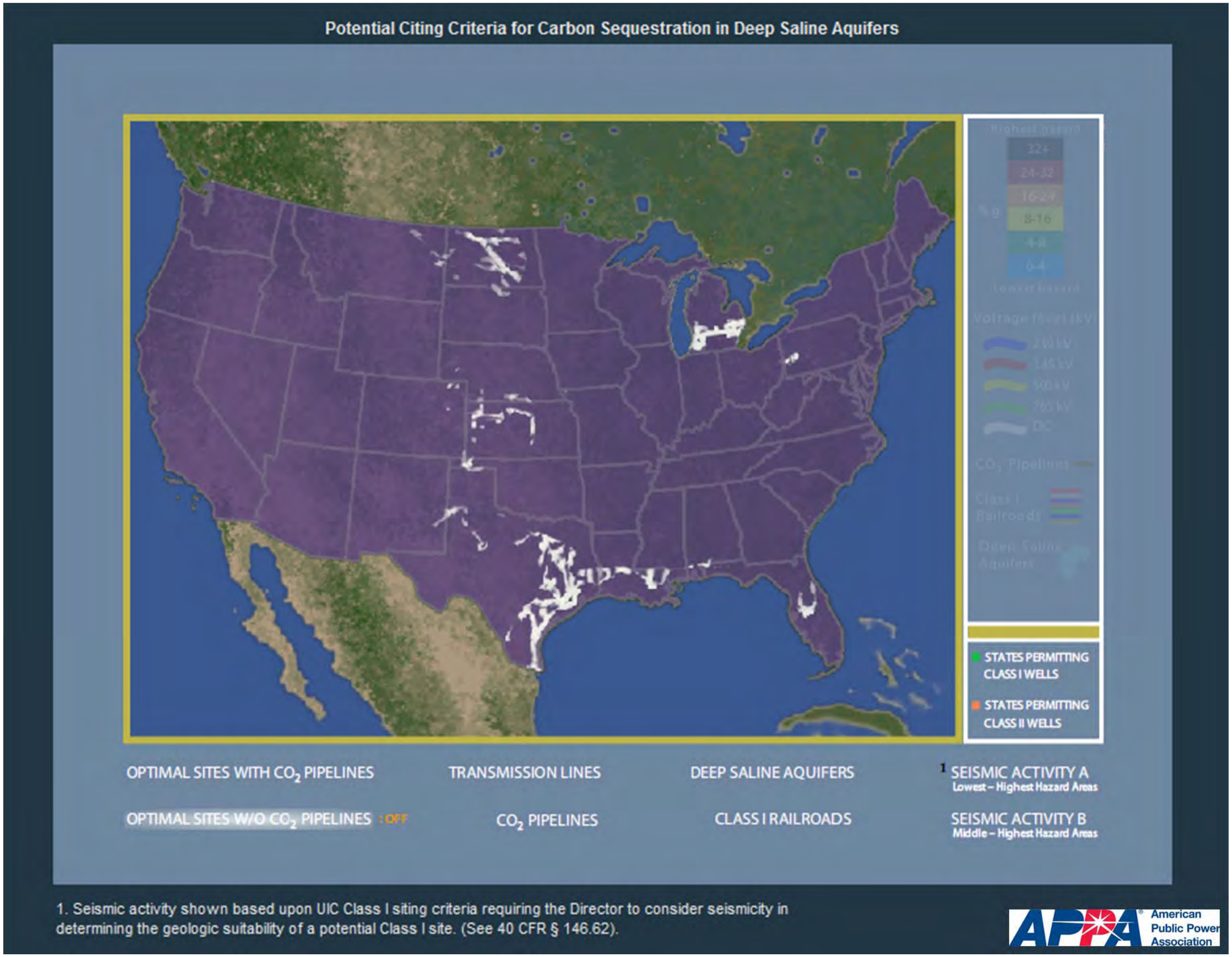
Other Considerations – Railroads



Optimal Sites – Using Existing CO_2 Pipelines



Optimal Sites – Not Requiring Proximity to CO_2 Pipelines



"Best Guess" Timeline for Baseload CCS Plant in Non-EOR/EGR States

2011

UIC Rule Finalized

2012-2015

States Finalize UIC Rules for Class VI and II Injection

States in non-oil & gas locations pass laws dealing with property, ownership, trespass, state liability, drinking water, pore space ownership, and subsurface non-mineral injection & storage of commodities or waste

- A tabulation of all wells within the area of review which penetrate the injection or confining zone(s)
- Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all USDW's, water wells and springs within the AOR
- Baseline Geochemical data on subsurface formations including all USDW's in the AOR

OR

2015-2018

Reports from pilot and pioneer CCS projects in U.S., Australia, & South Africa for parasitic improvement and sequestration

Non-Extractive industry states look at subsurface for orphan wells, abandoned wells, and other "leak" pathways (State Geologist Dept.) (5 years)

2018

Permit applications begin. Expected 5-10 year process to review all subsurface reports, studies given before final permit issued.

Plume Management 5 yr. modeling results used for permit applications

2018-2020

- Proposed testing & Monitoring Plan
- Proposed Injection Well Plugging Plan
- Proposed Post-injection Site Care and Site Closure Plan
- Proposed Emergency and Remedial Response Plan
- Any other info requested by State Director

Pipeline Construction for Chemical Delivery ?

- Proposed procedure to outline steps necessary to conduct injection operations
- Schematic or other appropriate drawings of the surface and subsurface construction details of the wells
- Injection well construction procedures that meet the requirements regulation
- Proposed Area of Review and corrective action plan
- Status of corrective action on wells in the Area of Review
- All available logging and testing program data on the well
- Demonstration of Mechanical Integrity & Financial Responsibility

2018-2025

Based on results of pilots, more non-EOR sites submit permit applications. But, none based on 5+ years of data on subsurface and plume

2022

UIC Permit Granted (every 5 years)

Air Permit Approval

2028-2030

Construction of:
- Exploratory wells ($1 million each)
- Observation wells ($1 million each)

Construction of Power Plant (3 years?)

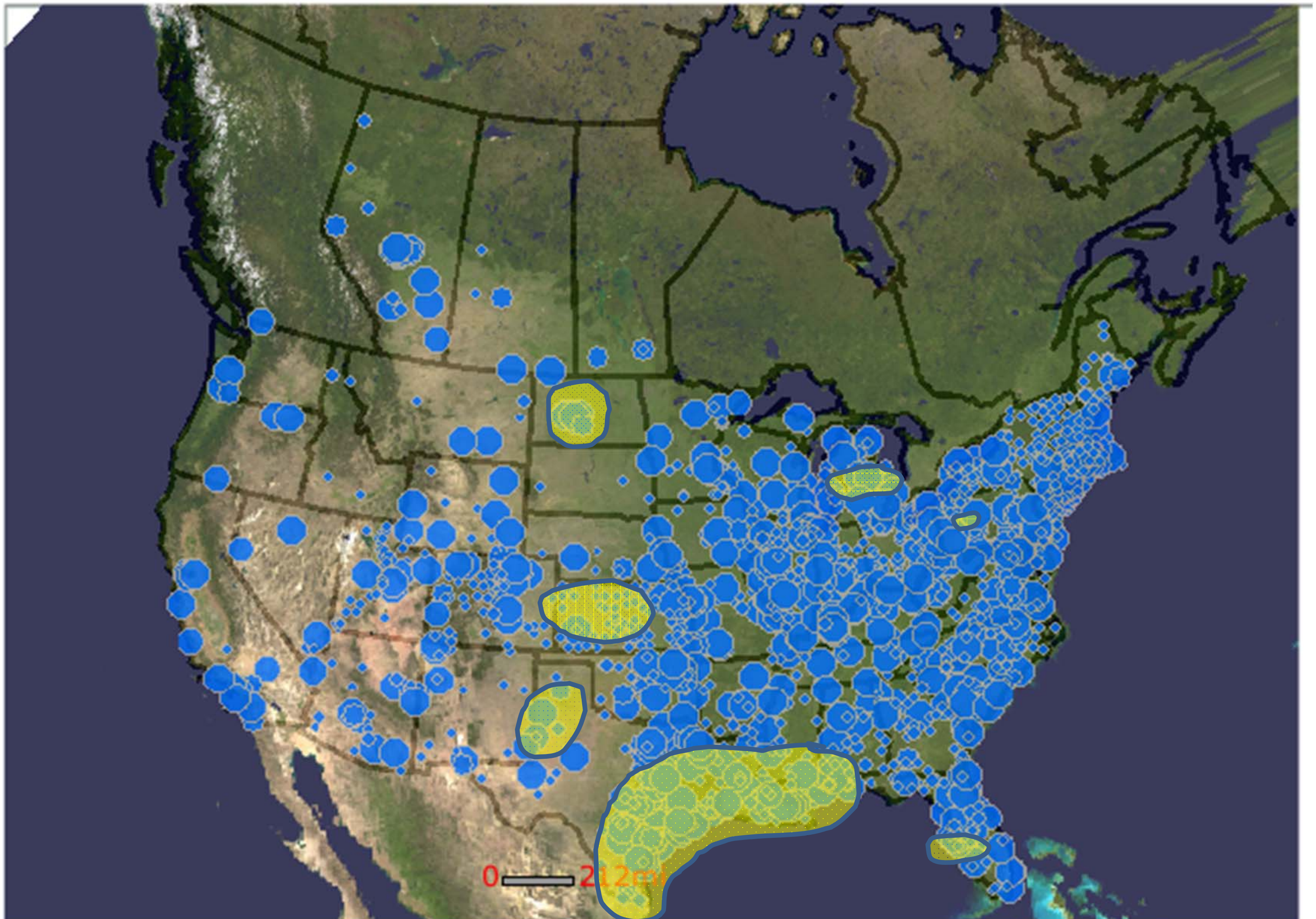
2030-203?

Other Issues:

Which comes first? The pipeline or the plant?

Backup for on-site storage of CO_2
- Tank, Pipelines, Wells??

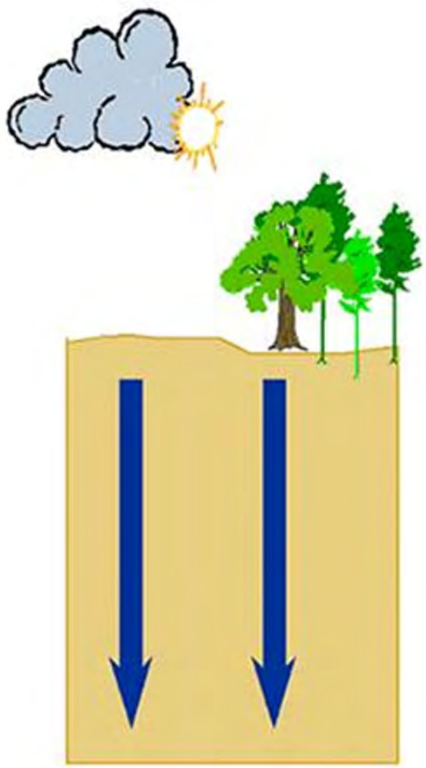
Existing Fossil Generation & Optimal CCS Locations Without Any Drinking Water Resource Location Analysis



Source of Map: NatCarb Atlas; Overlay: APPA Optimal Location Criteria Maps without CO_2 pipelines
Note: Optimal Locations are for new plants, not retrofit of existing power plants

APPA American Public Power Association

Subsurface Space Required to Sequester the Carbon Dioxide from Approximately Eight 500 MW GAS Plants Over Their 40-year Lifetime:



2,580 square miles

Roughly 1.5 times the size of Rhode Island

Roughly half the size of Connecticut

Key APPA Materials

- Link to free download of the **Aspen (APPA) Natural Gas Study**: http://www.appanet.org/files/PDFs/ImplicationsOfGreaterRelianceOnNGforElectricityGeneration.pdf
- **Links to Series of Three Webinars on Switching Coal to Natural Gas**: https://www.appanet.org/applications/registration/register.cfm?ItemNumber=28633&sn.ItemNumber=0
  - September 21, 2010, 2-3:30 pm EDT, Webinar 1: ***The Basics of Natural Gas for Base Load Energy Production***
  - October 7, 2010, 2-3:30 pm EDT, Webinar 2: ***Switching from Coal to Natural Gas: Buying Natural Gas, Nominations, and Balancing***
  - October 21, 2010, 2-3:30 pm EDT, Webinar 3: ***Switching from Coal to Natural Gas: Storage, Curtailment, Risk and Hedging***
- To purchase printed version of Aspen Natural Gas Study, please contact Jeff Haas, JHaas@APPAnet.org or 202/467-2953
- Link to availability of six APPA white papers on permitting, operating, and costs of geologic CCS for coal or natural gas: http://www.appanet.org/files/htm/ccs.html

American Public Power Association

APPA Contacts

CO_2, EPA liaison, CAA, & new generation (including renewables)
Theresa Pugh
Director, Environmental Services
202-467-2943
TPugh@APPAnet.org

GHG Reporting, 316(b), biomass and effluent guidelines
J.P. Blackford
Environmental Services Engineer
202-467-2956
JPBlackford@APPAnet.org

APPA® American Public Power Association