U.S. Energy Consumption

Source: Energy Information Administration, 2009
73 MW solar farm in Thailand

Source: 12/3/10 Wall Street Journal, Sharp Corporation
Change in Our Energy Future

Energy consumer to producer/exporter. Value-added??
Emerging Trends

- NG for power generation increased 3% -2/yrs
- Most gained from coal-fired plants
  -- permitting?
  -- New EPA rules?
- Estimates of 35% by 2030 vs. 22% in 2010
- GHG emission reduction of 44% by 2030
- Climate legislation??
- Political implications – alternatives %??
- Possible nuclear policy changes

Source: Deutsche Bank
Utilization—A New Future??

- Public policy for energy?
  -- Public initiatives
  -- Private efforts
  -- New funding?

- Power generation
  - conv. vs. fuel cell

- Feedstock
  -- industrial use
  -- plastics, paper, steel, glass all seeking options
  -- new employment opportunities
Transportation

Transportation fuels

- $8M in new alternative fuel usage
- 21 new projects in PA
- CNG for private/public use — ex. Towanda
- Refueling corridors East/West, North/South

Gas To Liquids technologies

- Diesel
- Other more efficient fuel chemistry
- Engine modification and/or redesign
- Research initiatives -- Commercialize?
Marcellus Shale Economic Impact

~60+ companies looking at Marcellus
--est. $8 B+ spent in ‘10
--est. value of Marcellus - $1.5T
--Royalties to PA landowners – $250 billion?
-- 1.2 bcf/d in Aug ‘10 to 5 bcf/d+ (est) in 2015
--International interest.
--Lowest cost shale?? Other shales??
--New trend?? --movement towards NG liquids
Marcellus Production Data

Pennsylvania Counties Reported Marcellus Production Totals from 7-1-2009 to 12-31-2010
Total Gas Reported: 466,295,625 MCF
Total Oil Reported: 1,232,051 Barrels

Source: Powell Shale Digest 3/18/11
Other Shale Targets

Key Gas-Producing Formations in Pennsylvania

- Catskill & Lock Haven Sandstone
- Huron Shale
- Rhinestreet Shale
- Genesee Shale
- Marcellus Shale
- Onondaga Limestone
- Oriskany Sandstone
- Tuscarora Sandstone
- Utica Shale
- Trenton-Black River Limestone

Generalized Geologic Cross Section Showing Marcellus Shale in Western Pennsylvania

Marcellus Center for Outreach and Research, Penn State
www.marcellus.psu.edu
6000’ lateral
8 wells: 800’ spacing
925 acre drainage area
1.5 sq. miles / well pad
Bradford Co Pipeline Development
Impacts

Land Use

Pad drilling
  Fewer trees cut
  Fewer roads built
  Less aesthetic change
  Less land disturbed (2%)

Pipelines

Eminent domain – no
  Public utility
Terminal use of property
ROW locations and agreements
Restoration
24" conductor casing (brown) is installed up to 50 feet deep and cemented (grey) to the surface.

20" casing is installed through the 24" casing and continuing up to 500 feet deep. This casing is cemented to surface to isolate and protect near-surface groundwater.

13 3/8" casing is installed through the 20" casing and continuing up to 1000 feet deep. This casing is also cemented to the surface to protect the groundwater aquifer from the gas well.

5 1/2" casing continues down and is turned laterally into the Marcellus formation at a depth of 5000 to 9000+ feet below the surface.

Horizontal, “lateral” portion of well extends from 3,000 to over 10,000 feet within Marcellus formation.
"Frac Barriers" of Onondaga Ls. below & Tully Ls. above. Marcellus Sh. thousands of feet below fresh water aquifers. Induced fractures cannot extend upwards because of overburden stress and horsepower limitations.
Fractures and Seals

T. Engelder, PSU

Limestone
Layer Frac.
Barrier?
Groundwater/Pad Protections
Water Use Data in Susquehanna Basin

- Total water use: 1.605 billion gallons on 553 wells (6/08 to 3/11)
  - 562 mgal from public water supply (35%)
    - 41 public sources permitted
  - 1.043 bgal from surface water sites (65%)
    - >130 surface water sources permitted
- Average total volume of fluid used per well: 4.2 million gallons per well
  - 3.8 million gallons of fresh water (90%)
  - 0.4 million gallons of reused flowback (10%)
- 30-day avg. recovery of flowback: 8%
- Total amount of flowback: 117 million gallons (6/08 to 3/11)
  - Reuse 75 million gallons
  - Disposal 42 million gallons
  - 64% flowback reuse
Water Transport
Flowback Water Management Options

- Direct reuse (blending)
- On-site treatment w/reuse
- Off-site treatment w/reuse
- Off-site treatment and disposal

Approx. 65% flowback reuse

New treatment standards for new or expanding treatment facilities
- TDS-500 mg/L
- Chlorides-250 mg/L
- Strontium-10 mg/L
- Barium-10 mg/L

In PA there are 14 treatment facilities with 2.6 mgd capacity
- 8 Industrial Treatment Plants
- 6 Municipal Plants

3 recycling plants with 2 mgd capacity
Currently 7 injection wells in PA (only 1 commercial facility)

Limited injection capacity (est. 3600 bpd/150,000 gpd)

Difficult to permit

Difficult to find target injection reservoirs

Prone to plugging

EPA has primacy for UIC permit
State Environmental Initiatives

New regulations

- 150’ buffer for well pads near high quality streams
- Total dissolved solids treatment standards for flowback
- Flowback water quality testing
- Well construction, cementing, and testing
- Production reporting (Act 15)

- Environmental monitoring
  - River water quality monitoring
  - Air quality monitoring
  - Enforcement (>2000 NOVs)
  - Increase in PaDEP O&G regulatory staff from 88 to 202
Web Resources:

www.marcellus.psu.edu
www.msetc.org
www.naturalgas.psu.edu