Synapse
Energy Economics, Inc.

Consumers at the Water / Energy Nexus

Protecting Electricity and Water Consumers in a Water-Constrained World

November 16, 2010

Jeremy Fisher, PhD. Synapse Energy Economics

 |

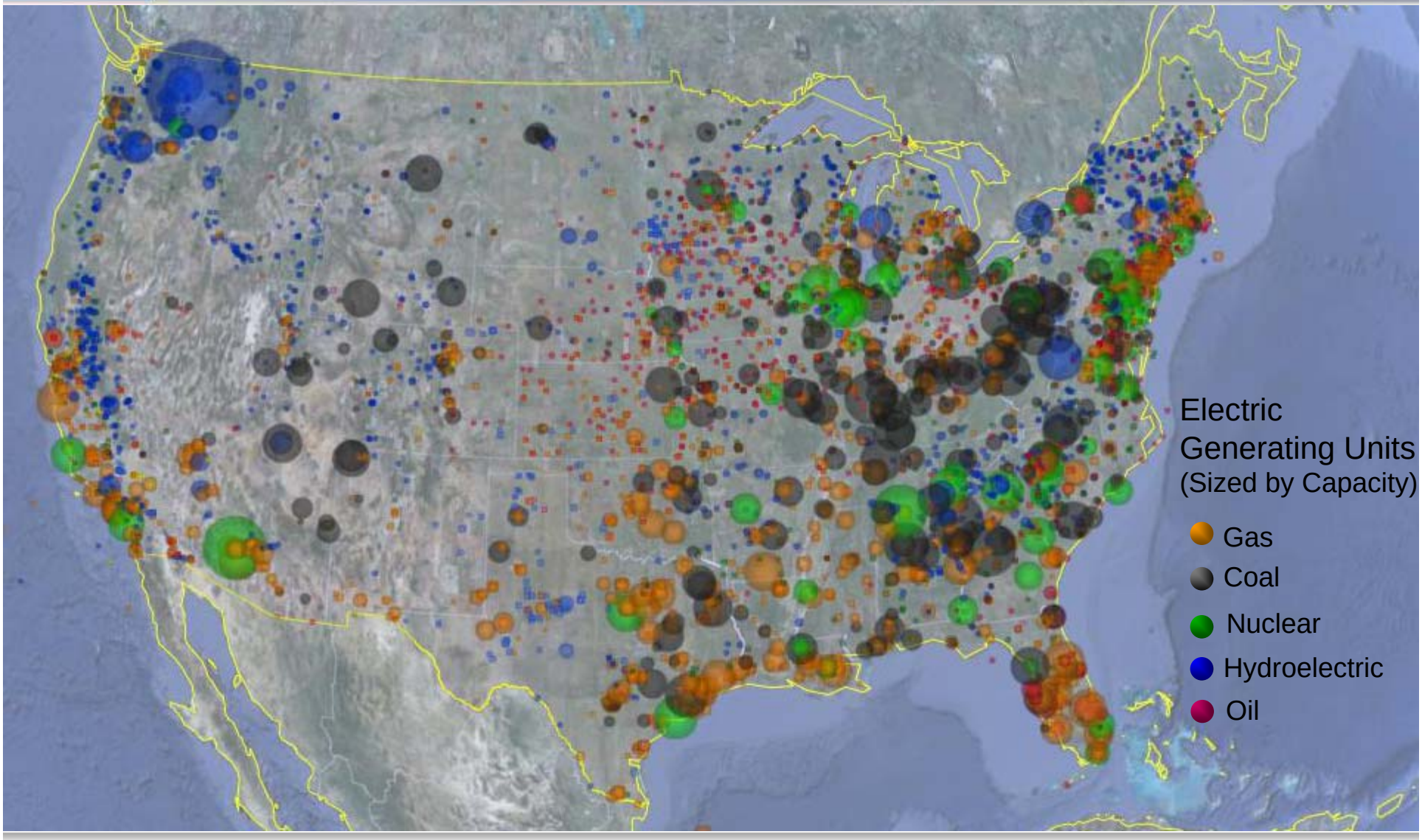
- Generating stations along the banks of the Ohio River withdraw about 5 trillion gallons of water each year
- For each gallon of river water…
  - …one cup passes through a thermal power plant
  - …one tablespoon has already disappeared through a cooling tower
- Electric production accounts for 50% of water withdrawals (200 billion gallons annually)
- Coal fleet alone cycles through 42 trillion gallons annually (125 million acre-feet), and consumes 2.5 million acre-feet

Water Use for Electric Generation

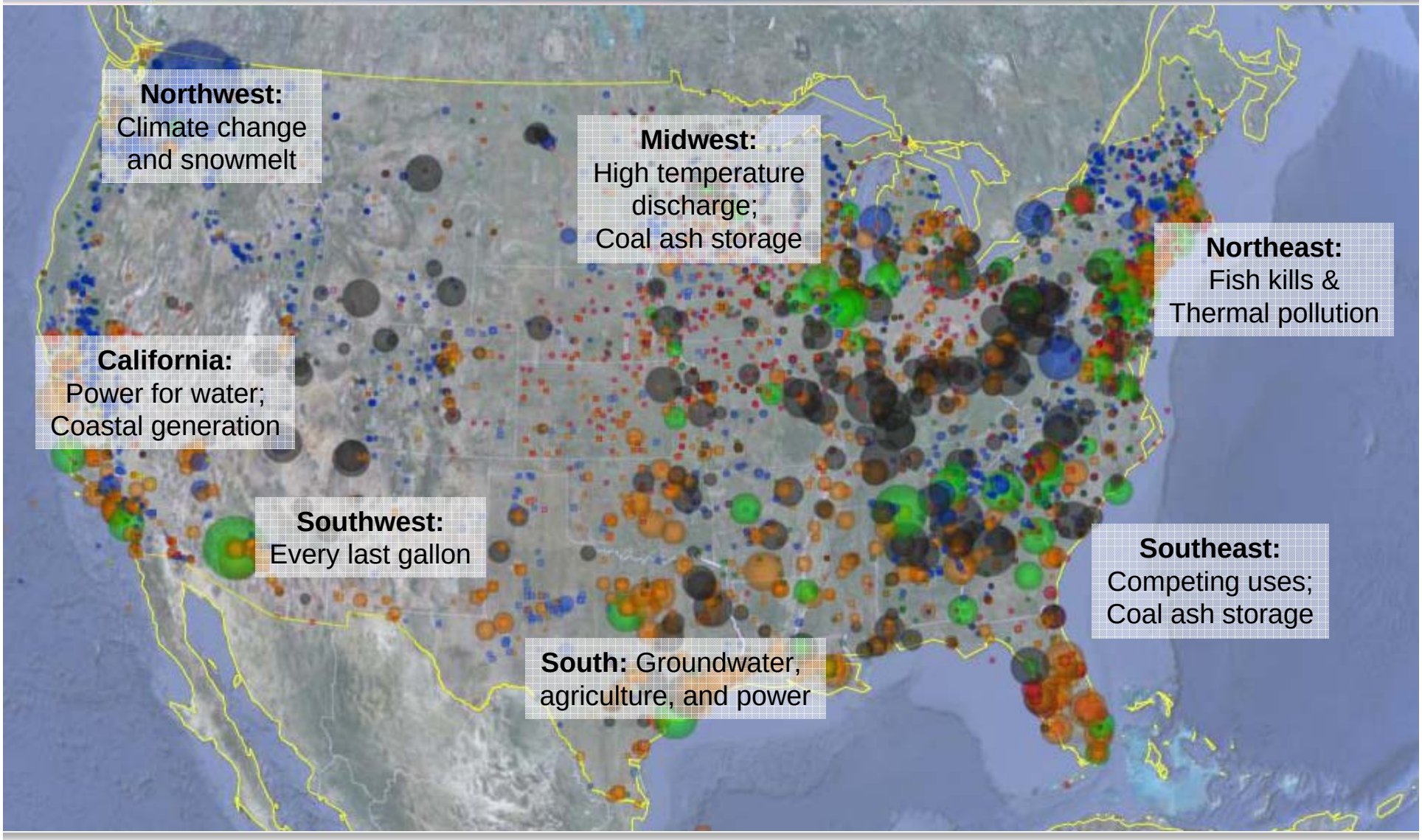
- Water withdrawals for thermal electric generation
  - Fuel extraction and processing
    - Coal processing (10-50 gal / MWh)
    - Gas separation (IGCC technology) (30-60 gal / MWh)
    - Oil shale (100-250 gal / MWh)
  - Boiler efficiency
  - **Cooling (condensation)**
    - **Open-loop (13,000-42,000 gal / MWh)**
    - **Closed-loop (230-950 gal / MWh)**
  - Pollution control
    - SO_2 (FGD)
    - NO_x (SCR / SNCR)
  - Carbon capture and sequestration
    - May double water consumption
    - Additional cooling, amine or ammonia spray, flue spray-down
  - Dry cooling requires less water (10% of closed-loop) but exacts energy penalty, particularly on hottest (i.e. peak) days

Number of gal / MWh represent withdrawals of water, as opposed to consumption.

Geography of the Water/Energy Nexus



Geography of the Water/Energy Nexus



Consumer Impacts at the Energy/Water Nexus Today, Tomorrow, and the Future

- Today:
  - Shutdowns in thermal fleet (coal and nuclear) due to temperature violations: direct impact on electric ratepayers
  - Emergency provision of water in shortages
  - Competition between consumption, agriculture, and electricity production
  - Rising costs of power increases costs for water and sewage
- Tomorrow
  - High cost retrofits to meet water standards (CWA 316(b))
  - Increasing severity of heat waves and extended regional drought
  - Implicit requirement for dry cooling in the arid SW?
  - Forward costs for water?
- Planning for the next decades
  - Comprehensive energy and water planning (not just retrofits)
  - Water as a top consideration for new thermal plants (coal, nuclear, geothermal, and solar thermal)
    - Reduce risk of shortage
    - *consumer protection* standpoint
  - Improved efficiency eases water *and* electric demand?

Today
Shutdowns

- July 2010: Water temperature discharge violation forced a 45% derate
- TVA charged ratepayers $40 million to purchase wholesale power during Browns Ferry shutdown in July 2010
- Has had to cut production in two of the past five years because of permit violations

Browns Ferry, AL
3,274 MW

Today
Emergency provision of water

- In mid-2008, Grayrocks reservoir dropped to 10% capacity
- The power plant was forced to purchase 80% of its cooling water from agricultural groundwater users
- Plant drew 26 billion gallons from the High Plains Aquifer from late 2004 through 2010.

Laramie River Station, WY
1,710 MW

Today
Inter-Sector Competition

- Mohave previously pumped liquid coal slurry 273 miles from Arizona, using 1.3 billion gallons per year
- Mohave itself withdrew 3.6 billion gallons annually for cooling
- Water use disputes with Navajo and Hopi, as well as air emissions concerns, resulted in the plant's closure in 2005

Mohave Generating Station, NV
1,580 MW

Tomorrow
Retrofits for 316(b)

Brayton Point, MA
Construction of new cooling tower

- CWA 316(b) requires reduction in intake velocity
  - EPA rule expected in 2011 / 2012
    - Require change from OTC to recirculating
    - Wildlife kills (aquatic eggs, larval fish, and small marine organisms)
  - Approximately 50% of US thermal generation uses some form of once-through cooling
  - Cost analogs today:
    - Brayton Point (2000 MW) in MA being retrofit for $600 million (~0.5 ¢/kWh)
    - Indian Point (2000 MW, nuclear) in NY water use in dispute ($1.5 billion - ~1 ¢/kWh)
  - Total expected cost:
    - ~$30 billion to retrofit coal fleet alone

Tomorrow
Dry Cooling

ANP Blackstone
580 MW

- American National Power (ANP) constructed two 580 MW CCs in MA's Blackstone River Valley in 1997
- Company was persuaded to install dry cooling for both plants, reducing water demand by 70%, saving 30,000 to 580,000 gallons per day at each plant
- In 1998, the plant proposed and built a third plant using dry cooling in Connecticut

Tomorrow
Dry cooling in the West

Apex Power Station, NV
600 MW

- Water shortages require choices about future water use
  - SW is currently using nearly all allocated water,
  - Conflicts in use of existing resources
    - e.g. Utah proposed Lake Powell pipeline
  - Future probably requires comprehensive dry-cooling
    - Dry cooling energy penalty
    - Cost to consumers

Water Resource Planning in Electricity & Consumer Protections

- Comprehensive multipollutant planning should include water, along with SO_2, NO_X, mercury, and CO_2
  - Plan across sector, not just retrofits and bandaids
- Price water by its social value for planning purposes
  - Not by the utility's contractual cost, and
  - *Not* a price of $0
  - Scarcity price / marginal price / forward cost?
- Require a long-term water resource planning
  - Competing demands for the resource
  - Full watershed considerations
- Stress-test cross-sectoral plans by investigating how operations and consumer welfare will be affected under low-water, high temperature conditions
- Think efficiency: energy savings and water savings in appliances

