Sustainable and Resilient Energy Systems: Data and Technology Issues

Roundtable on Science &Technology for Sustainability, National Academies

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The Energy System Is Under Strain

- **Surging demand**
  - **Population growth**
  - **Economic growth**
- **Aging infrastructure & workforce**
- **Archaic markets with fixed electricity rates**
- **Mismatch of demand and availability of power**
  - **Underutilized capacity: <50%**
- **Vulnerability to massive failure**

The Grid Can Fail Dramatically

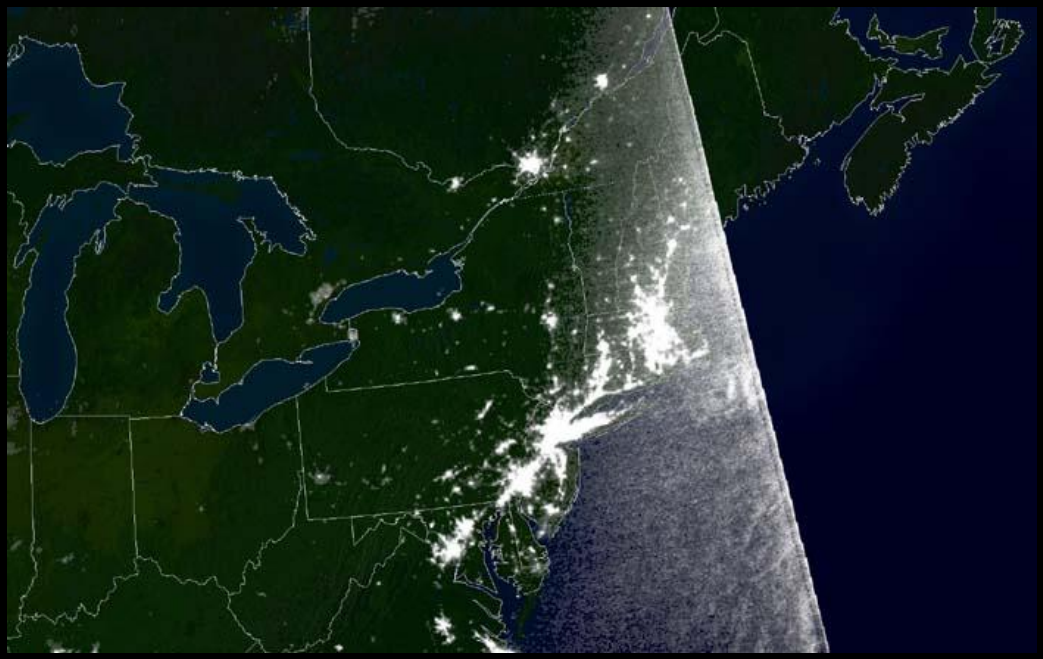
Source: Air Force Weather Agency, via NOAA

Top Picture:

8/14/03

Bottom Picture:

8/15/03



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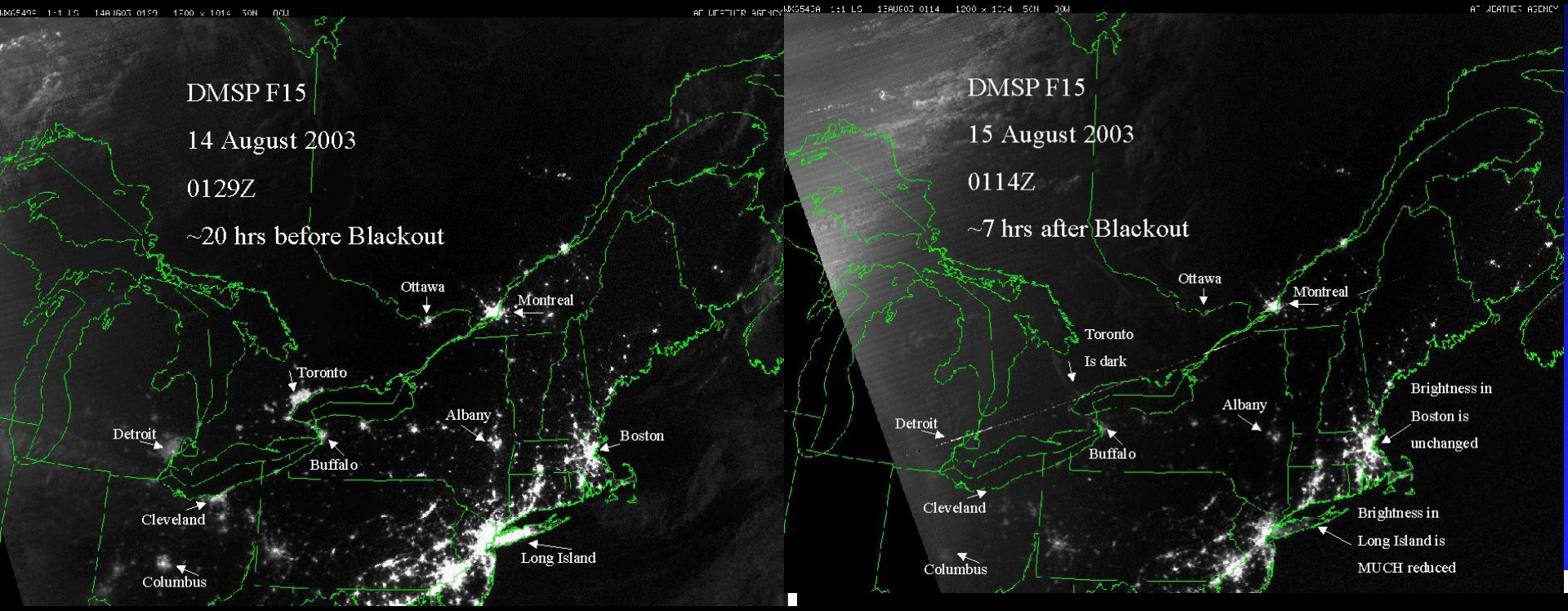


Source: Air Force Weather Agency, via NOAA

The Gasoline Supply System Can Fail, Too

Atlanta, September 2008

(Source: Atlanta Journal Constitution, Bob Andres, bandres@ajc.com)

Atlanta, September 2008

(Source: CNN.com)

The Water System Is Under Strain

- **Surging demand**
  - **Population growth**
  - **Economic growth**
- **Aging infrastructure & workforce**
- **Archaic markets with fixed water rates**
- **Mismatch of demand and availability of water**
  - **Water availability higher in Fall, Winter & Spring**
  - **Water demand is higher in the summer**

The Water System Can Fail Dramatically

New Orleans, 2005 (post Katrina)

Resiliency Planning for Energy and Water Has Different Timescales

- **Water:**
  - **Water plans are 50-100 years**
  - **Most water companies are governmental**
  - **Austin, TX debated a water plant for 40 years**

- **Energy:**
  - **Energy plans are 2-30 years**
  - **Energy companies are more likely to be publicly listed and have quarterly statements**

The Energy and Water Systems Will Change

- **Energy and water will get cleaner**
  - **Renewable energy prices will keep falling**
  - **Water standards will get stricter**
- **There Will Be More Home-fueling for Transportation**
  - **Electric cars with home-charged solar panels**
  - **NG vehicles with home filling**
- **Distributed Systems Will Become More Popular**
  - **Distributed power generation**
  - **Distributed water collection, treatment and use**

Energy and water will get smarter

- **Real-time**
- **Flexible**
- **Self-healing**
- **Data intensive**
- **Information/resource convergence:**
  - **Energy needs more information**
  - **Information needs more energy**

The Digital Energy Convergence Is Accelerating

- **Energy Will Have Higher Information Density**
  - **Ubiquitous sensing**
  - **Increasingly granular data collection**
    - **Greater spatial resolution**
    - **Greater temporal resolution**
- **Information Will Have Higher Energy Density**
  - **Greater volumes of information**
  - **Increasingly powerful servers and data centers**

Information and Energy Are Also Diverging

- **Electricity generation is moving from large, remote systems to small, distributed systems on our rooftops**
- **Computing is moving from small, distributed systems on our desktops to large, remote systems far away**

There Are Significant Data Challenges

Conventional Meters and Billing Have Shortcomings

- ***Electricity***:
  - Spinning analog dials at back of house
  - Can slow down with time
- ***Water***:
  - Rotating vane technology is a century old
  - Can slow down with time
  - Meters were illegal in Sacramento & Nevada

Conventional Meters and Billing Have Shortcomings

- **Manual readings (fences, dogs, thorn bushes)**
- **Consumption information is disaggregated**
  - **Bills delivered up to 45 days after usage**

Smart Meters Yield More Information

- **Automatic readings**
- **Immediately alerts utility to outages**
- **Might give consumer real-time usage and price info**
  - **Digital readouts with wireless to indoor displays**

Smart Meters Will Be Data Intensive

- **Conventional billing:**
  - **2 meter readings per month**
- **Smart billing:**
  - **Meter readings every 15 minutes**
    - **2700-3000 meter readings per month**
- **Case Study:**
  - **Austin Energy's budget for smart meters: ~$50M**
  - **Austin Energy's budget for billing software: ~$50M**

Not All Smart Meters Are The Same

- **AMR = Automatic Meter Reading**
  - **One-way automatic communications with the utility**
  - **Smart Grid 1.0**

- **AMI = Advanced Meter Infrastructure**
  - **Two-way communications with the utility and 3rd parties (e.g. consumers)**
  - **Smart Grid 2.0**

We Need Smarter Water Meters, Too

- **The Parable of Amy Hardberger's underground water meter**
- **Michael Webber's hot water fail**

Water Systems Will Get Smarter

- Today's meters are dumb
- Need to know:
  - Use by time of day
  - Use by function
    - Indoor vs. outdoor
    - Heated vs. unheated
    - Greywater vs. blackwater
    - Piped vs. collected

Water Meters Are Becoming More Popular

The New York Times

Replacing Water Meters to Cut Costs Across Texas

Sarah Lim for The Texas Tribune

A utility worker in Round Rock installing a new electronic water meter intended to save water and lower costs for municipalities.

By JOHN WAYNE FERGUSON
Published: August 4, 2012

>3.5M smart water meters installed in Texas by 2010

Water Data Are Sparse, Error-prone, and Inconsistent in the USA

- **USGS data-collection is infrequent**
  - **Last survey on water consumption: 1995**
  - **Last survey on water withdrawals: 2000 (2005)**

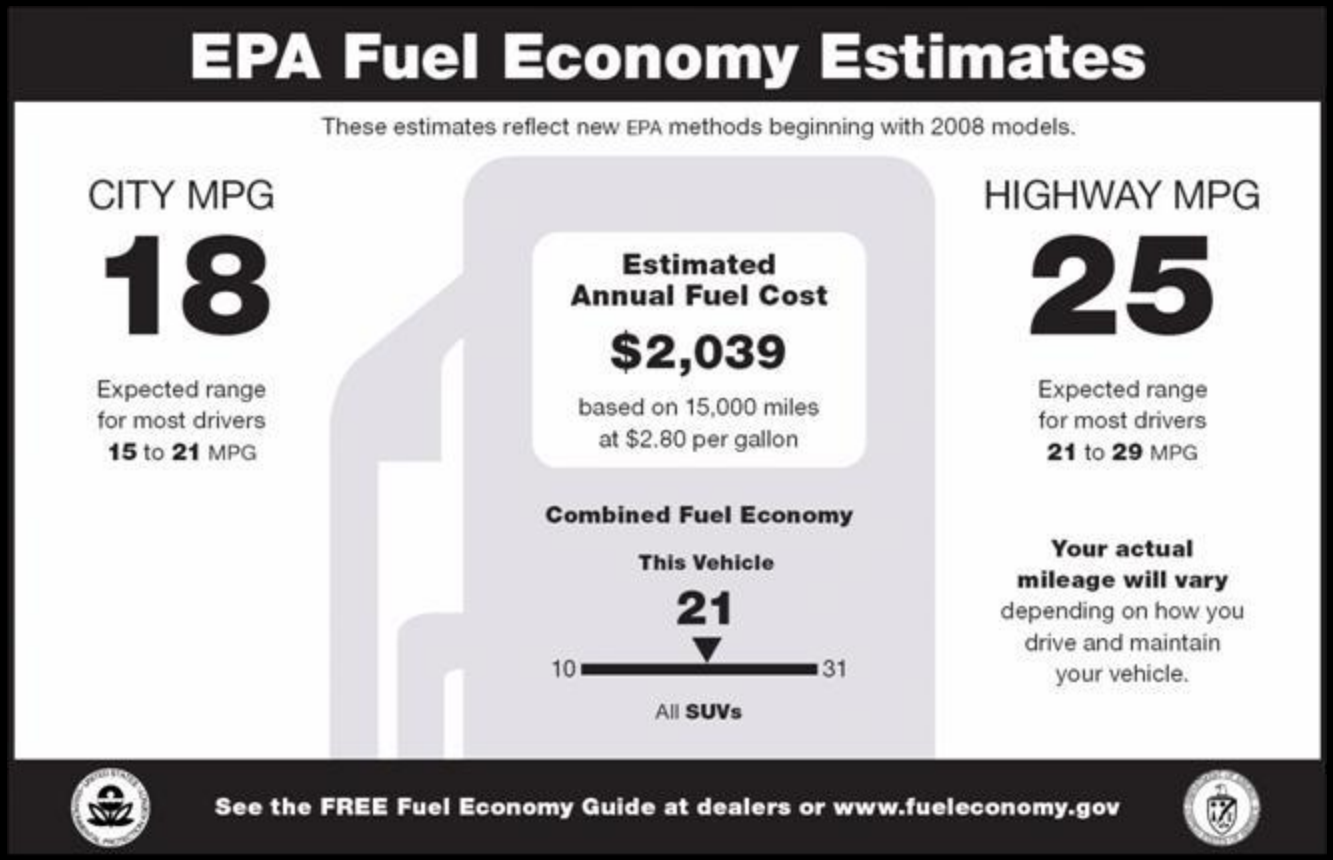
- **Errors in national databases (Egrid, etc.)**
  - **Differences between state and federal reporting**
  - **Unclear definitions:**
    - **Use vs. Withdrawal vs. Consumption vs. Diversion**
  - **Different units**
    - ***East*: gallons**
    - ***West*: acre-feet**

With More Information, Consumers Can Make Better Decisions

- **Typical energy reductions are 2-15% because of more accurate, up-to-date and accessible information**
  - **Opower is finding 2% average savings across 15 million households based on more data**

- **Analogy: real-time fuel economy readouts for the Toyota Prius make driving a contest**

But, Labels Aren't Always Enough to Encourage "Better Behavior"



People buy cars with poor fuel economy despite the label…but use the labels to buy fuel efficient cars when gasoline prices are high

But, Labels Aren't Always Enough to Encourage "Better Behavior"

Nutrition Facts

Serving Size: 16 oz	
Amount Per Serving	
Calories 200	Calories from Fat 0
	% DV
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Polyunsaturated Fat 0g	
Monounsaturated Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 52g	17%
Dietary Fiber 0g	0%
Sugars 52g	
Protein 0g	0%
Vitamin A 0% •	Vitamin C 0%
Calcium 0% •	Iron 0%

People buy sugary soda despite the label...but use the labels to buy nutritional foods when they are conscious of their diet

Good Revolutions in Consumption Combine Additional Information, Technology Improvement, Cultural Pressures, and Prices

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