Introduction

• *Annual Review of Energy and Resources* (vol 29)

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• What is ‘Energy Security’?
  
  - A technical term in power engineering
  
  - Certainty of supply
    
    - A very old concept – sieges of ancient cities.
    
    - No repeats of the 1970’s oil crises

  - Preventing or coping with malicious attack (terrorism)

  - A sexy term to promote prior interests
Early Interest In Energy Security

• 19th century: Security of coaling stations for the Royal Navy

• 1865: *The Coal Question* (Jevons)

• 1911: The obsession with oil begins as Churchill shifts the Royal Navy to oil in the pursuit of higher speed and more capability

• 1940-45: Energy emerges as a key part of military strategy
  – Threats to Imperial Japan’s oil supplies provide rationale for war.
  – Submarine campaigns against tankers are highly effective
  – Nazi Germany’s need for petroleum forces desperate actions
  – Some battles hinge on fuel: N. Africa, Kursk, post-Bulge breakout
  – Allied air campaigns against electric power systems oddly ineffective
  – Size and future importance of Middle Eastern fields are recognized
Energy Security in the Cold War

• Focus on nuclear warfare and Soviet-sponsored terrorism

• 1958 “Emergency Plans Book”
  - Most energy infrastructure is destroyed, but, then, so is most demand.
  - “With strict rationing of petroleum products and allocation of coal, the surviving fuel production … is sufficient to meet properly time-phased military requirements and minimum essential civilian needs.”

• 1979 OTA Report, “The Effects of Nuclear War”
  - One scenario: 10 (multi-warhead) missiles each targeted at U.S. and U.S.S.R. refining capacity destroys most of it
  - Devastating socio-economic changes
  - Suggest decentralization and redundancy as strategic responses.
Energy, Vulnerability and War (1981)

- DoD (later FEMA) study published in 1981
- Detailed examination of energy infrastructure and vulnerability to nuclear war
- Main options: efficiency, storage (i.e. superconducting magnets and hydrogen), fuel cells, renewables, and decentralized systems
- 250 Libyan- and Soviet-sponsored terrorist attacks on energy infra.
- Suggested institutional response: Defense Energy Districts, “which would be administratively responsible for categorizing, inventorying, and coordinating the implementation of dispersed, decentralized, and renewable energy technologies.”
Brittle Power (1982)

- DoD (later FEMA) study

- Existing energy infrastructures are “Disasters Waiting To Happen”

- **Centralization** is the “root of the problem”

- Main options are efficiency and small-scale renewable energy

- Key concept is “**resilience**”, which is borrowed from ecology (e.g. Holling) and is remarkably similar to “survivability”

- Minimize the need for **social control** to operate and protect the energy system

- Raise **understandability** of energy technologies to increase social acceptance

- “Ultimately, high national levels of end-use efficiency could … allow the entire grid to depend on inherently resilient, largely local energy sources.”
Common features

- Lopsided technological optimism with little or no technical detail
- Inextricable linkage between security, decentralization, renewability, and efficiency
- No conceptual space for decentralized, fossil-based systems
- Not much discussion of institutions (e.g. firms)
- Hard to imagine how then-current Pittsburgh, or then-current Berkeley, would function with wholly-local energy supplies, yet denial that this is a recipe for “social decentralization”.
Critical Infrastructure Protection (CIP)

• Emerges in 1990s
  - 1993 World Trade Center truck bombing
  - 1996 Western states power outage
  - Y2K
  - Cyber security

• Critical Infrastructure:
  - “[S]ystems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of these matters” – USA Patriot Act
  - “…provide the foundation for our national security, governance, economic vitality, and way of life … create a sense of confidence and form an important part of our national identity and purpose.” – National Strategy for Physical Protection of CIP and Key Assets
CIP in the U.S.


- **Coordination, advocacy, R&D, cybersecurity, and ‘guards, gates, and guns’**

- 2003: Over 60 CIP bureaucracies in the federal government
  - Department of Homeland Security
  - National Infrastructure Protection Center (FBI)
  - Critical Infrastructure Assurance Office
  - National Infrastructure Simulation and Analysis Center (NISAC)
  - Office of Energy Assurance (DoE)
  - Information Sharing and Analysis Centers (ISAC)
    - Electricity: NERC www.esisac.com
    - Oil and Gas: API www.energyisac.com
CIP concerns

• Private ownership
  – Cost recovery in regulated industries?
  – Standards, incentives, or voluntary for competitive industries?

• Prioritization

• Who pays? Consumers or taxpayers? And which ones?

• Effect on competitiveness

• Information sharing with government
  – FERC rule on Critical Energy Infrastructure Information (CEII)

• Freedom Of Information Act and open government
CIP R&D Issues

• *Making the Nation Safer* (NRC 2002)

• Specific infrastructure vulnerabilities and interdependencies

• Robustness, resilience, and survivable systems
  – The ‘intelligent grid’
  – The ‘self-healing grid’

• Simulation and analysis of large, interdependent networks

• Wargaming
  – Blue Cascades
  – Silent Vector
Oil & Gas

- Supply interruption
  - State (OPEC, Russia) action and terrorism

### Petroleum

<table>
<thead>
<tr>
<th>Region</th>
<th>Reserves*</th>
<th>Production</th>
<th>Consumption</th>
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<td>AF</td>
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* Conventional Resources

### Natural Gas

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<tr>
<th>Region</th>
<th>Reserves</th>
<th>Production</th>
<th>Consumption</th>
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<td>RU</td>
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Supply Shocks

• Common wisdom: Oil supply shocks cause recessions and can change governments (ORNL 1997)
  - 24 shocks 1950-2003, average 8 mo. and 3.4% world supply
  - Two types of costs: import expenses, macroeconomic adjustment
  - Asymmetrical and non-linear response
  - “Best” linear estimate: doubling oil prices for one year lowers GDP by 6.5% for two years.
  - Strategic Petroleum Reserves (SPR) can be effective in the short run if used properly.

• But is this effect really there?
  - U.S. domestic oil policies in the 1970s?
  - U.S. price controls and monetary policy in the 1970s?
  - Japan in the late 1970s?
Oil & Gas Infrastructure

- Concentrated assets
  - Production and gathering
  - Transport
  - Refining

- Little spare capacity

- Long, exposed systems with some long lead-time components

- Some contingency planning

- LNG is controversial:
  - *Brittle Power*: “as much energy as a small nuclear weapon”
  - CRS: “hazardous fuel...highly visible...can be vulnerable...exemplary safety record...not as [risky] as popularly believed”
Electric Power

- Still targeted by war planners
- Long history of attacks by various groups, but these groups are usually not as powerful as Mother Nature
- Non-nuclear Electro-Magnetic Pulse weapons
- 6 large blackouts in 6 weeks U.S. and Europe (2003)
  - $1Billion + each, but no real agreement on measuring costs
- Modeling at Sandia (NISAC) suggests that ongoing attacks, even if smaller, might have a larger economic effect than a single large outage, which would be (and is) considered an anomaly
- Is turning out the lights attractive to terrorists?
  - Coordination, long time to repair/replace
- Fuel supply risk – coal seems secure
## Electricity Generation From Imported Oil

<table>
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<tr>
<th>Importer</th>
<th>% World Oil Imports</th>
<th>% Generation From Imported Oil</th>
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<tbody>
<tr>
<td>Singapore</td>
<td>3%</td>
<td>65%</td>
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<tr>
<td>Italy and San Marino</td>
<td>5%</td>
<td>32%</td>
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<tr>
<td>Philippines</td>
<td>0.9%</td>
<td>28%</td>
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<tr>
<td>Portugal</td>
<td>0.7%</td>
<td>25%</td>
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<tr>
<td>Greece</td>
<td>1%</td>
<td>16%</td>
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<tr>
<td>Japan</td>
<td>11%</td>
<td>16%</td>
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<tr>
<td>Thailand</td>
<td>2%</td>
<td>16%</td>
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<tr>
<td>Belarus</td>
<td>0.5%</td>
<td>8%</td>
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<tr>
<td>Korea, Republic of</td>
<td>6%</td>
<td>7%</td>
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<tr>
<td>Spain</td>
<td>3%</td>
<td>7%</td>
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<tr>
<td>Netherlands</td>
<td>3%</td>
<td>7%</td>
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# Electricity Generation from Imported Gas

<table>
<thead>
<tr>
<th>Importer</th>
<th>% World Gas Imports</th>
<th>Russia</th>
<th>Algeria</th>
<th>Europe</th>
<th>Asia (incl. Mid-East)</th>
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</thead>
<tbody>
<tr>
<td>Belarus</td>
<td>8%</td>
<td>87%</td>
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<tr>
<td>Turkey</td>
<td>2%</td>
<td>19%</td>
<td>8%</td>
<td>2%</td>
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<tr>
<td>Italy</td>
<td>8%</td>
<td>9%</td>
<td>12%</td>
<td>2%</td>
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<tr>
<td>Belgium</td>
<td>3%</td>
<td>7%</td>
<td>15%</td>
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<tr>
<td>Japan</td>
<td>13%</td>
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<td>16%</td>
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<tr>
<td>Kazakhstan</td>
<td>0.6%</td>
<td>14%</td>
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<td>Finland</td>
<td>0.7%</td>
<td>14%</td>
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<tr>
<td>Ukraine</td>
<td>10%</td>
<td>13%</td>
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<td>Hungary</td>
<td>2%</td>
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<tr>
<td>N. Korea</td>
<td>3%</td>
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<td>11%</td>
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Nuclear Power

• Attacks on facilities
  – Power plants
  – Waste storage
  – Reprocessing

• Concerns
  – Proliferation on nuclear arms
  – Release or radionuclides (attack or dirty bomb)
  – Common-mode failures
  – Panic

• Separate treatment: IAEA, NRC, National Guard
Strategic Responses

- Guards, gates, and guns
- Emergency preparedness
- Changes in energy infrastructure
- Institutional change
  - Who’s responsible?
  - Who pays?
  - How does this work in a competitive market?
- Decentralization
- Renewables
- Efficiency
- Intelligent grids and loads
Conclusion

- “Energy security” is an old concept with competing meanings.

- Energy security is a public good.
  - Dramatic events occasionally highlight energy security, but the public and policymakers lose interest in it.
  - Little evidence of any commitment to invest in security
  - Little discussion and no resolution of ‘Who Pays?’

- Centralization, organization and size of energy infrastructures emerge as key factors. Possibly renewability.

- Current CIP proposes to defend whatever energy infrastructure exists, with little to no thought about modifying it

- Emergence of non-state actors is new

- Will security concerns influence the future energy infrastructure?