Energy Infrastructure and Security

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Introduction

- *Annual Review of Energy and Resources* (vol 29)
- Co-authors: Hisham Zerriffi and Hadi Dowlatabadi
- 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.

- EO 13010 (1996), PCCIP (1997), PDD-63 (1998), EO 13228 (2001), various *National Strategies* (2000, 2002, 2003)

- 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

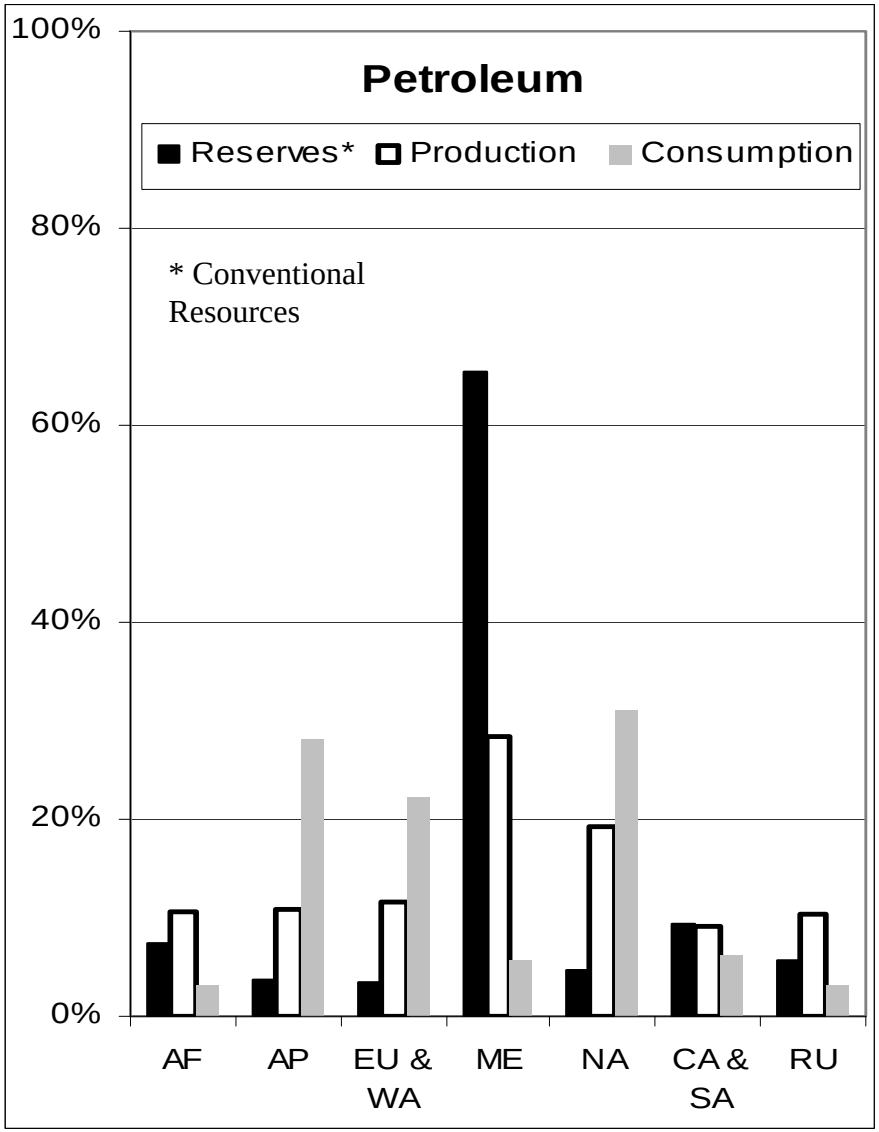
- Private ownership
  - Cost recovery in regulated industries?
  - Standards, incentives, or voluntary for competitive industries?
- Prioritization
- Who pays? Consumers or taxpayers? And which ones?
- Effect on competitiveness
- Information sharing with government
  - FERC rule on Critical Energy Infrastructure Information (CEII)
- Freedom Of Information Act and open government

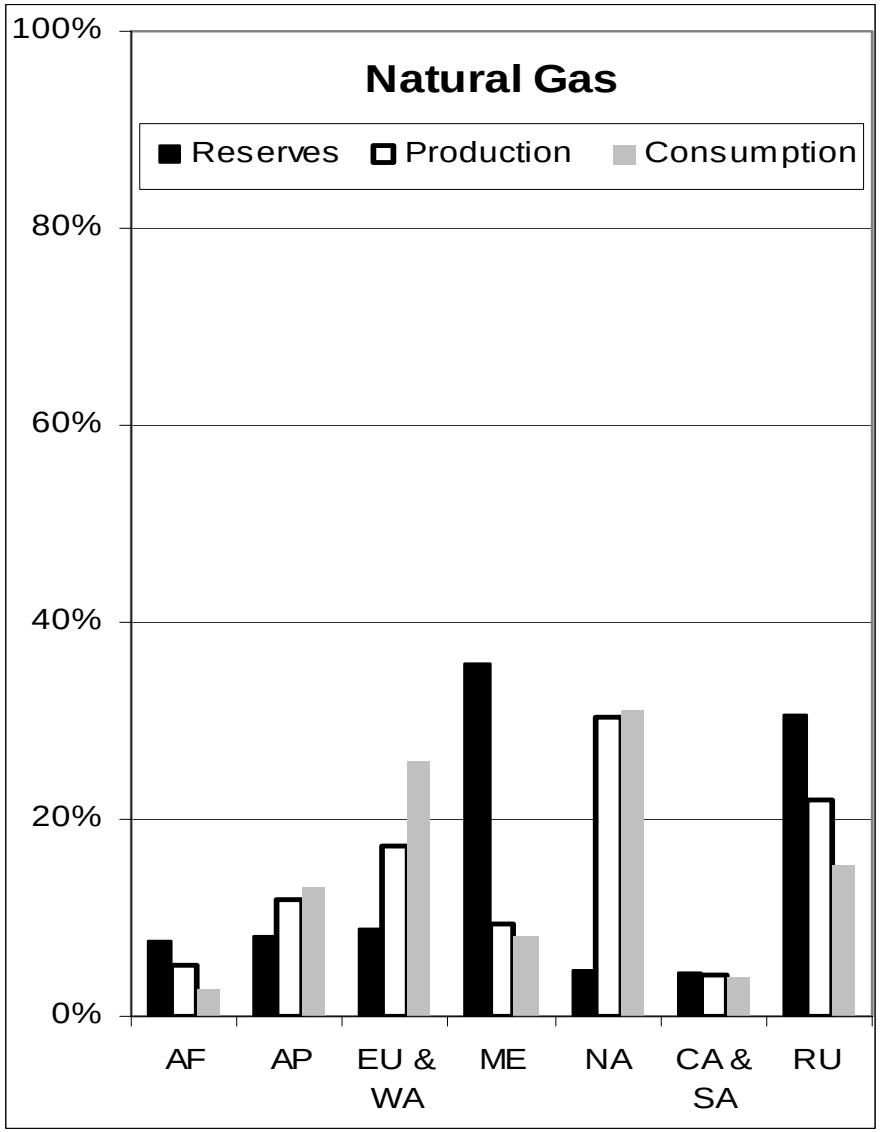
CIP R&D Issues

- *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





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 is 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

Importer	% World Oil Imports	% Generation From Imported Oil
Singapore	3%	65%
Italy and San Marino	5%	32%
Philippines	0.9%	28%
Portugal	0.7%	25%
Greece	1%	16%
Japan	11%	16%
Thailand	2%	16%
Belarus	0.5%	8%
Korea, Republic of	6%	7%
Spain	3%	7%
Netherlands	3%	7%

Electricity Generation from Imported Gas

		% Electricity Generation from Imported natural gas (by supply region)			
Importer	**% World Gas Imports**	**Russia**	**Algeria**	**Europe**	**Asia (incl. Mid-East)**
Belarus	3%	87%			
Turkey	2%	19%	8%		2%
Italy	8%	9%	12%	2%	
Belgium	3%		7%	15%	
Japan	13%				16%
Kazakhstan	0.6%	14%			2%
Finland	0.7%	14%			
Ukraine	10%	13%			
Hungary	2%	13%			
N. Korea	3%				11%

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
- Institional 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 it 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?