Electric Network Reliability as a Public Good

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The Public Good Nature of Grid Reliability

"In the present movement towards competitive electricity markets, it is important to remember that **electric system reliability is, in many respects, a classic public good**. By the laws of physics, the essential attributes of adequacy, voltage, and frequency are available to all interconnected users simultaneously."

- Richard Cowart, et al., "Efficient Reliability: The Critical Role Of Demand-Side Resources In Power Systems And Markets," Regulatory Assistance Project, June 2001

The Public Good Nature of Grid Reliability

"A free flowing AC network is an integrated physical machine ... When a generator turns on and off, it affects system conditions throughout the interconnected network."

"The primary economic rationale for vertical integration between generation and transmission is that it internalizes within an organization the operating and investment complementarities between these supply functions, with their associated **public goods and externality** problems."

- Paul Joskow, "Restructuring, Competition and Regulatory Reform in the US Electricity Sector", *Journal of Economic Perspectives*, (Summer, 1997).

The Public Good Nature of Grid Reliability

"First, note that the **possibility of system collapses make operating reserves a public good**. Network users take its reliability as exogenous to their own policy and thus are unwilling to voluntarily contribute to reserves. … Thus, the market solution leads to an insufficient level of reliability. In order to obtain a proper level of reliability, the system operator must force consumers (or their LSE) to purchase a fraction of reserves for each unit of load."

- Paul Joskow and Jean Tirole, "Reliability and Competitive Electricity Markets," (April 2004)

A Distinction Between Security and Adequacy?

NERC divides reliability into two separate concerns –

- Security - “the ability of the system to withstand sudden disturbances”
- Adequacy - “the ability of the system to supply the aggregate electric power and energy requirements of the consumers at all times”

“From an economic point of view security and adequacy are quite distinct in the sense that the former is a public good while the latter can potentially be treated as a private good.”

– Shmuel S. Oren, "Ensuring Generation Adequacy in Competitive Electricity Markets" (June 3, 2003). University of California Energy Institute. Policy & Economics. Paper EPE-007

Summary of Our Argument: I

- Reliability is a name for a collection of attributes of electric power as delivered to consumers. Some of these attributes are public goods and others are private goods
- Public good characteristics often arise from institutional design choices
  - Examples: use of load profiles instead of interval meters, inability to prevent free riding from investments in resource adequacy, socialization of costs of ancillary services

If public good problems are creating significant inefficiencies, the solution may require rethinking of the prior institutional choice creating the public good

Summary of Our Argument: II

- Simple cost sharing methods may not improve overall efficiency in the provision of public goods in network reliability; agent heterogeneity and private good characteristics of reliability must be accounted for

- "Internalize the externalities" is not a sufficient guide for policy. Inframarginal externalities are not policy relevant

- Agent heterogeneity, network and agent changes over time, and the private good characteristics of reliability should be considered

Public Goods and Externalities

- Public Good
  - Non-excludable in production/distribution
  - Non-rival in consumption
- Externalities
  - One agent's action affects another agent's value, positively or negatively
- Problems?
  - Free riding
  - Inefficient levels of production

Buchanan & Stubblebine (1962)

- Provides a general framework for analyzing externality issues
- Taxonomy of externalities
  - Marginal/inframarginal
  - Potentially relevant/potentially irrelevant
  - Pareto-relevant/Pareto-irrelevant
- The policy-relevant externalities should ***only*** be the Pareto-relevant ones

Policy Relevant Externalities

Private Environmental Amenity

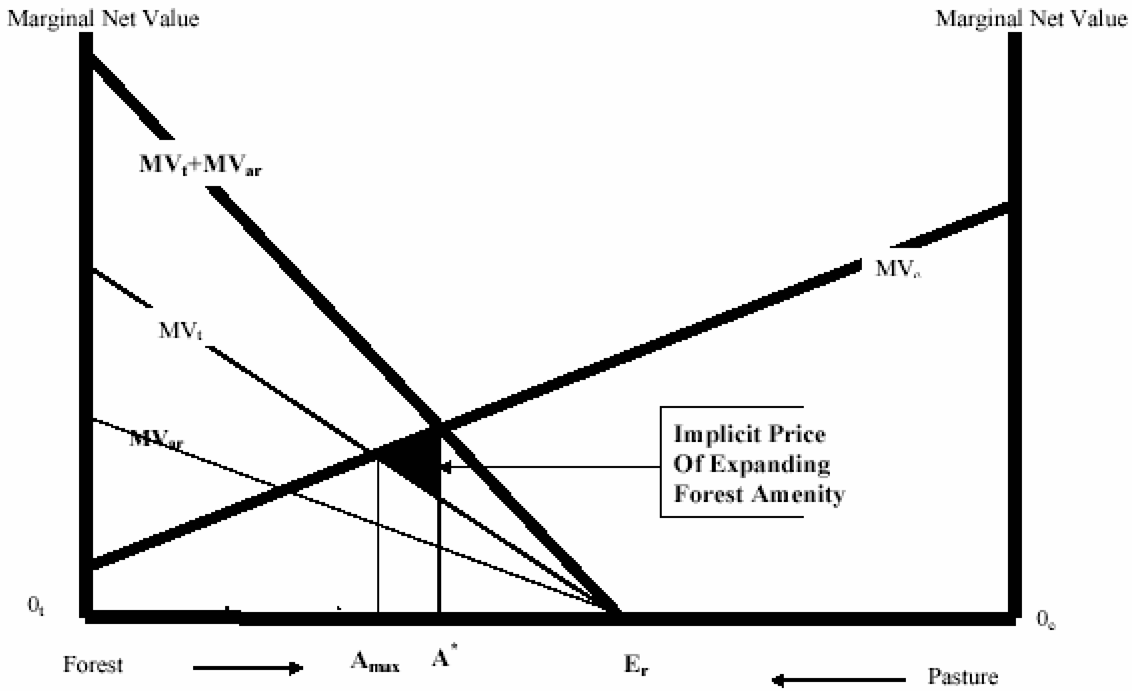

Figure 2

Source: Haddock (2004)

Inframarginal Externality not Policy Relevant

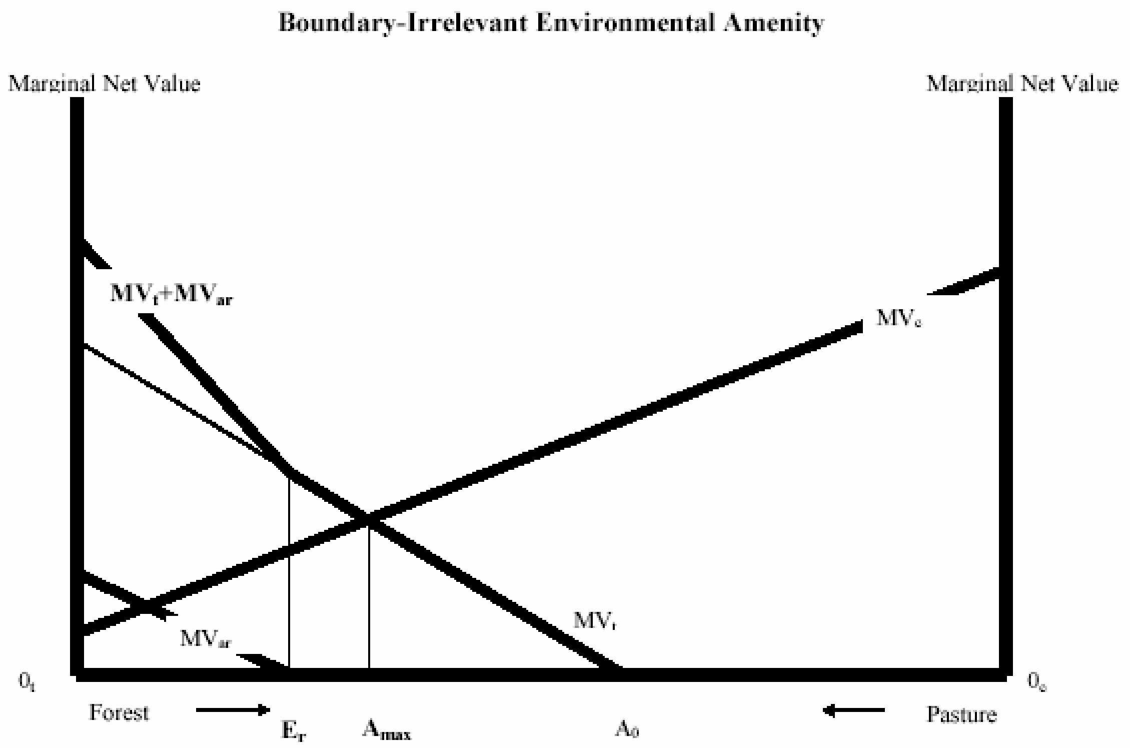

Figure 3

Source: Haddock (2004)

Implications From B&S

- Only marginal externalities are potentially relevant or Pareto-relevant
- Inframarginal externalities can occur where one agent is satiated as a result of the actions of another/others
- Only Pareto-relevant externalities can affect whether the optimal amount of the public good is provided
- Only Pareto-relevant externalities should be policy relevant

Heterogeneity

- The Pigouvian/Samuelsonian models (and policies based on them) often assume homogeneous agents
- Heterogeneity of preferences over reliability opens up the opportunity to see the private good aspects of reliability
- Suppose we rank the n agents according to value of reliability: V_H to V_L
- If I have V_H and you don't and you free ride on me and are satiated, so what? If it doesn't change my behavior, it's an irrelevant externality
- Agents in a bulk power electric network are primarily LSEs, but they are heterogeneous in costs, technologies, and consumers (derived demand)

Managerial Control

- Free riders get no say in the management & strategy of the network
- That control has a benefit and a cost, as does free riding
- "If you don't pay, you can't play" as a policy approach that enables excludability and reduces the public good characteristics
- Property rule: if you don't invest in the stock, you are a low priority flow user of the network
  - Example: To some extent this kind of rule is reflected in the practice of selling firm and non-firm transmission service

Regulation by Networks – Aviram (2004)

"Network effects facilitate mechanisms that may be very effective in mitigating opportunism. Therefore, in certain industries, networks mitigate opportunism, largely displacing in that role the parties to the transaction and the government."

- Opportunistic behavior
  - Breach of contract
  - Degradation of service
- Mitigating opportunistic behavior in networks
  - Switching mechanism
  - Exclusion mechanism
  - Control mechanism
  - Information mechanism

Policy Recommendations

- Think critically about the extent to which reliability is treated as a public good by choice instead of necessity
- Don't approach the grid as more of a commons than is technically necessary
- Focus policy on reducing transaction costs that prevent agents from internalizing contractually
- Create institutions/rules that leverage the private aspects of reliability and diversity among network users

How To Enable This?

- Priority insurance (Chao & Wilson, 1987)
- Forward contracts and options
  - Agents choose level of price risk based on their own value
- Enable large customers to participate in wholesale markets if they choose
- Treat demand reduction as an asset
  - Contract over trigger prices for interruption
  - Contract over package, then procure remainder in spot markets

Is Network Reliability A Public Good?

- Yes, but it's also a private good
  - Valued differently by agents with heterogeneous preferences
  - The benefits of managerial control reinforce the private good characteristics
- Yes, but that does not axiomatically imply that it will be underprovided in the absence of central coordination
- Networks have several mechanisms which can help mitigate opportunistic behavior – the network may be better than either the parties to a transaction or third parties (like the government) in regulating opportunism.

Conclusion

- The "who, what, where" of how we manage reliability should be open questions.
- We are using the externality & public good literature to open these questions
- The networked nature of the grid is often seen as the source of the problem. Let's not overlook how it can contribute to the solution.

Directions For Future Research

Developing theoretical treatment of our transactional approach to understanding network reliability by working through examples in an optimal power flow model.

Exploring the theory further through simulations and economic experiments conducted in networked systems.

Complementing the theoretical and experimental work through empirical studies of power systems reliability that focus on the underlying economic incentives governing contributions to system reliability.

Recommended Readings

- James Buchanan and Craig Stubblebine, "Externality" *Economica* (1962).
- Ronald Coase, The Problem of Social Cost, *Journal of Law and Economics,* (1960).
- Hung-Po Chao and Robert Wilson, "Priority Service: Pricing, Investment, and Market Organization," *American Economic Review*, (Dec. 1987).
- David Haddock, "Irrelevant Internalities, Irrelevant Externalities, and Irrelevant Anxieties," (Working paper available via SSRN).
- Amitai Aviram, "Regulation by Networks," *BYU Law Journal*, (2004).
- Kiesling & Giberson, "Is Network Reliability a Public Good?" (forthcoming… eventually).