All the measures discussed in the previous chapter would reduce the vulnerability of the electric power system. Some are already being implemented by the power industry, as utilities become more aware of the potential for major disasters. However, the level of implementation of these steps could be increased, and other effective measures are available which the industry is less likely to implement on its own initiative.

Some steps, such as planning, analysis, and legal arrangements, need not cost much, but could significantly increase preparedness in case of disaster. Others, such as stockpiling, would require considerable investment. The following analysis groups the specific measures according to whether they are likely to be implemented under present trends; or if they would require small expenditures; or whether they would be moderately to quite expensive. These groups are shown in table 7. Some of the measures are shown in more than one group, representing differing levels of implementation, or analysis in one and implementation in another.

The desirability of further government involvement in a largely private enterprise is a matter of opinion. There is a clear government role in handling emergencies and protecting the public health and safety (e.g., minimum standards for nuclear reactor safety, and direct implementation of airport security). It is less clear how far the government should go in preventing emergencies that have major indirect but little direct impact on the public. If, in the judgment of policymakers, the threat is greater than is being recognized by industry, and the consequences have grave ramifications for the public, then policy action may be justified. However, it should be noted that some of the initiatives discussed here will be controversial on ideological as well as practical grounds.

PRESENT TRENDS

Utilities are moving to reduce vulnerability through improved security and planning. The National Electric Security Committee of the North American Electric Reliability Council (NERC) has made a series of recommendations intended to reduce the risk of major damage occurring and to expedite restoration of service afterwards. The Edison Electric Institute has a security committee that coordinates information for physical protection for its member utilities. In addition, there are several government programs that analyze vulnerability and address weaknesses. These activities are described in chapter 5.

Collectively, these steps are reducing vulnerability, and should lead to further improvements. However, the improvements are unlikely to be as great as could be realized if Congress takes a more activist role. Furthermore, the generating and transmission overcapacity of the last 15 years is diminishing. This overcapacity was expensive, but it had the unintended effect of providing reserves that would have been highly beneficial if a major disaster had occurred. It is likely that the increase in vulnerability due to decreasing reserve margins outweighs the improvements in security underway. The advantages and disadvantages of leaving the decisions in the industry's hands follow.

Advantages

If decisionmakers see the threat of massive destruction as quite low, the measures already underway may be adequate. The design and operation of U.S. electric power systems are quite adequate for all emergencies except the loss of several key facilities at one time. Considerable damage can be accommodated without greatly affecting customers. Only extraordinary disasters would cause more than short-term, localized blackouts. The actions utilities are taking will further reduce the range of disasters that can have devastating consequences. With the additional attention being paid to earthquakes and hurricanes, preparation for natural disasters may be sufficient to handle all but very unlikely events.

Under most plausible sabotage or natural disaster scenarios, the utilities themselves would be big losers, from lost sales and damaged equipment. Therefore they also have incentive to achieve a reasonable level of defense. Leaving the decisionmaking to the utilities on investments to protect against disasters minimizes the risk of a commitment to expensive measures that prove ineffective.

Table 7—Policy Package Components

	Present trends	Low cost	Moderate to major investment
A. Preventing damage			X
1. Harden key substations.			
2. Surveillance			X
3. Guards			X
4. Improve coordination	X		
B. Limiting consequences			
1. Improve emergency plan/ procedure	X	X	
2. Modify the physical system. .			X
3. Spinning reserves		X	X
C. Speeding recovery			
1. Contingency planning	X	X	
2. Clarify legal framework	X		
3. Stockpile critical equipment. .			X
4. Assure adequate transportation	X	X	
5. Monitor domestic manufacturing		X	
D. General reduction of vulnerability			
1. Less vulnerable technologies.		X	
2. Decentralized generation . . .	X	X	

SOURCE: Office of Technology Assessment, 1990.

Disadvantages

Terrorist attacks are largely unpredictable. The lack of such attacks in recent years is no guarantee that there won't be an upsurge in the near future. Several international situations, including the Colombian drug wars, separatism in Puerto Rico, tensions in Central America and the Middle East, and even the shifting political climate in Eastern Europe could lead to efforts to cause harm to the United States by surreptitious means. Electric power systems could be a prime target for such attacks.

Even though some utilities are taking steps for protection, it is unlikely that all will implement even minimal measures. Some managers are bound to ignore low-risk, high-consequence events until they materialize, but by then it would be too late. Some areas could suffer extensive blackouts, at great economic and social cost, that might be averted or at least minimized if the government assures that the national interest is given due consideration.

LOW-COST GOVERNMENT INITIATIVES

Most of the measures in this package are already being addressed to some extent, and were included in the preceding section. The purpose of this package is to assure that these efforts are adequate, especially those that are voluntary for utilities. In addition, initiatives with potentially important long-term implications but which would not require large expenditures of government or private funds are included. This group of options is intended for those who conclude that electric power system vulnerability is a problem that requires greater attention, but does not justify major financial commitments.

Several of the steps discussed below suggest an approximate budget level for implementation by the Department of Energy (DOE) or other agency. This study has not analyzed the effectiveness or efficiency of any of the government agencies mentioned. Therefore it intends no suggestion as to whether the activity could be absorbed within the existing budget by simply increasing efficiency, or if less important activities could be cut back, or whether the overall budget would have to be increased.

Specific Initiatives

Planning for **Emergencies**

Most utilities with vital facilities appear to have established contact with the Federal Bureau of Investigation (FBI) to facilitate warnings that sabotage efforts are likely. DOE could perform a survey to confirm this coordination (which in itself would encourage utilities to establish and maintain these contacts) and perhaps sponsor regular meetings among utilities with critical facilities and the appropriate law enforcement agencies. This activity would require perhaps $100,000 in DOE's budget for the Office of Energy Emergencies (OEE).

DOE could also play an important *role in* coordinating utility emergency plans. Many of OEE's activities have been concerned with national security issues—assuring that vital military and industrial facilities will not be crippled by power shortages during an international crisis. Less attention has been paid to the economic damage that could be inflicted on the civilian economy. For instance, the Department of Defense (DoD) has a list of transmission substations that are vital to militarily important facilities, but DOE has no equivalent list for facilities vital to major civilian load centers. OEE could expand its cooperation with NERC, individual utilities, and State and local governments to analyze a wide range of disasters. OEE could then help the utilities and local police (or other agencies) plan

emergency responses. These same exercises could include emergency planning to limit the consequences of damage and speed recovery (e.g., contingency planning for locating and transporting spares). All these activities could require OEE expenditures of several hundred thousand dollars annually, depending on how rapidly the analyses and planning exercises are to be completed and how often they would have to be updated. The Federal Emergency Management Agency (FEMA) and other government agencies should also have a role in this emergency planning.

Increased Spinning Reserves

Increasing spinning reserves beyond present levels would have to be either mandated or paid for by the government. Additional equipment would have to be kept operating, which incurs manpower, fuel, and maintenance costs. In some cases, low-cost units would have to be operated at less than full load to supply spinning reserves because other units couldn't be operated at the necessary levels. Construction of new generating equipment would also be required if the installed capacity was inadequate to support higher reserves, as is becoming true in many parts of the country. Both the costs and the value of increased reserves are uncertain. Utilities have not yet determined the cost of spinning reserve as a separate, unbundled service to be purchased under competitive generation. A DOE study, possibly done in cooperation with NERC, could be of value to determine the costs of increased spinning reserve and the value if widespread damage does occur.

Increased Sharing of Spares

Congress can consider legislation to encourage the sharing of backup equipment, which utilities would otherwise consider necessary for their own system. This legislation would establish a forum for determining priorities in a national emergency and relieve lending utilities of liability for power outages in their own territory stemming from the absence of this equipment. The purpose would be to improve the chances that spare transformers and other key equipment are available where most critically needed. The first step would be to request a legal analysis, perhaps from the Congressional Research Service, to determine the applicability of existing legislation to a situation of a major, long-term power crisis that does not have great national security implications. It also could be beneficial to have DOE analyze how to include such sharing of otherwise unavailable equipment in the emergency planning discussed above.

Assuring Adequate Equipment Supply

The future of the electric equipment supply industry is of concern to both DOE and the Department of Commerce (DOC). A joint study of both its competitiveness and its role during emergencies would establish whether there is a government interest in maintaining particular capabilities. This study would not have to be very large. DOC already has studied the competitiveness of the industry. Utilities and the supply industry, both here and abroad, should cooperate in determining how equipment would be handled during an emergency.

Analyze Vulnerability Implications of Future Growth

DOE could also consider how the long-term evolution of the industry could be guided toward reduced vulnerability. Analysis of different technologies (e.g., underground cables) and configurations (e.g., small, dispersed generation) could determine the relative vulnerability, costs, operability, etc. In addition, the study would consider how to get the industry to give low-vulnerability options proper consideration. This would be a complex, demanding study with many different lines of analysis.

Advantages

This package of options would raise the visibility among utilities of the necessity of preparing for major attacks. Advance emergency planning should improve the handling of a disaster and the recovery afterwards, at least if the disaster conforms to anticipations. Few attacks would be deterred by this package, but the impact of some could be reduced. This package would also raise the priority given to such preparation by government agencies and provide the analytical basis for further steps. These options should lead to a useful reduction in vulnerability without requiring much investment by either government or industry.

Disadvantages

There are no real disadvantages to this package. The main question is whether the modest gains justify the modest costs. It is impossible to quantify the benefits of this package relative to present trends, but they are unlikely to be major, at least in regard

to terrorist attacks. There are too many different ways in which the system can be attacked to anticipate all of them. Advance planning by utilities has obvious value, but it would still be easy to overwhelm these preparations with a large-scale attack. Even routine vandalism, including shooting at transmission lines and substations, would not be greatly deterred. The studies proposed could be useful, but unless the results are implemented, they would provide no significant benefits.

MODERATE AND MAJOR INVESTMENTS TO REDUCE RISKS

If the initiatives discussed above are seen as inadequate, the next step is to ask what could be accomplished at higher cost. There are several options outlined in the previous chapter that entail considerable cost but promise significant reduction in vulnerability, at least under some conditions. Utilities are not likely to undertake these measures on their own. The measures are intended to address low-probability, high-consequence events that utilities do not consider sufficiently probable to include in their reliability considerations. If policymakers find that national interest considerations require that these investments be made, it is likely that the government will have to at least share expenses or coerce utilities. Sharing expenses will call for significant government expenditures at a time of considerable budget difficulty. One possibility would be a kind of users fee: a small, temporary tax on power sales. For instance, a tax of 0.01 cent per kilowatt-hour (raising an 8 cent/kilowatt-hour charge to 8.01 cents) would produce almost $300 million per year while remaining virtually invisible to all but the largest users. If imposed for a year or two, this tax would pay for most of the proposals discussed here. This approach is already used by some States to fired energy studies, for example. However, the fact **that** such a tax would not be obvious does not justify it if the need for government involvement is seen as very small.

Specific Initiatives

Protect Facilities

Protecting key facilities, particularly substations, would significantly reduce the risks of long-term damage, especially from low-level threats (unsophisticated saboteurs and vandals). The problem is to determine which facilities are worth protecting, what measures to take, and how to pay for them. DOE presumably would identify the most important facilities if the analyses of the previous section are performed. Depending on the decrease in vulnerability desired (i.e., how many areas are of concern, the acceptable duration of blackouts, and the level of reliability required after a disaster) there could be as few as 30 or as many as 150 facilities that would require protection to significantly limit the long-term disruption following a multi-site attack. The exact protection measures-hardening, surveillance, guards—for each facility would depend on its importance, physical characteristics and location as well as on the nature of the anticipated threat. Both DoD and DOE have extensive experience in protection design though they may not have applied it to many substations. These agencies could expand on DoD's Key Assets Protection Program to include designs for physical protection. The utility owner should also be involved in this exercise to ensure that the physical protection and its implementation would not interfere with the operability of the facility.

The cost of physical protection such as remote surveillance equipment and walls around the transformers would be highly variable, but the one-time total might be on the order of several hundred thousand dollars for each substation. This is only a few percentage of the cost of the facility, but it is still significant. Stationing a guard during off-hours (about 130 hours per week) would entail an annual cost that might be on the order of $50,000 to $100,000. It is likely that some utilities would be reluctant to make these changes voluntarily. The benefits (e.g., reduced threat of a major blackout) considered in arriving at the level of protection specified, accrue largely to the users of the power, not to the utility. Therefore it is likely that the government would have to mandate these improvements or pay for at least part.

Make Power Systems More Resilient

The analysis that identified key facilities presumably would also suggest opportunities for modifications (e.g., upgraded control centers, improved communications) to the physical system that would help maintain reliability following major damage to the system. However, getting these modifications implemented is likely to be difficult because no appropriate policy tools exist. Utilities build their

bulk power systems according to industry standards for reliability. Other than certain licensing procedures and interstate economic regulation, the Federal Government has little direct influence on how transmission systems are built and operated. The Federal Government does not tell utilities when to build more lines, how to operate them, or how to assure reliability. Unlike upgraded physical protection, which involves decisions on relatively few key facilities, system improvements are likely to entail many small modifications. Voluntary cooperation on the part of utilities would be essential.

One way would be for DOE to establish a program to help utilities identify weak points that would hamper recovery from a widespread attack, and at least share the costs of corrective action. Utilities would be particularly uninterested in extremely expensive physical modifications, such as increased generating and transmission reserves. Utilities are concerned with building new capacity to meet growing demand, but not to increase reserve margins above the levels they find prudent. Any estimate of the level of funding that would be required is highly speculative at this time because analyses showing what would be needed have not been conducted.

Stockpile Transformers

Stockpiling of transformers beyond the spares kept for customary reliability purposes is also of little interest to utilities, though there has been at least one case of the lack of a spare keeping a low-operating cost, nuclear powerplant inoperable for a considerable period. The total cost of establishing a stockpile would be large, perhaps $100 to $200 million. Requiring utilities to backup each important transformer would cost several times as much. However, the cost of either approach would be small compared to the benefits if several substations are destroyed simultaneously. A transformer stockpile would be needed only to counter terrorist threats since natural disasters (or even casual attacks) are very unlikely to damage more than one or two substations. The likelihood of a major assault is outside the scope of this analysis. If policymakers and the industry are convinced that the threat is sufficient, a government-industry cooperative venture might be possible. In addition to establishing the stockpile, decisions must be made on where to locate it, how to maintain it, how to allocate the transformers in case of a major emergency, and how to expedite their transport. Considerable advance planning and analysis must be conducted before implementation. DOE and FEMA might cooperate with the industry on these studies.

Advantages

Collectively, these steps would greatly reduce the vulnerability of the U.S. electric system to the kinds of attacks (see ch. 2) that have been experienced in the United States. The risk of major disruption from small-scale terrorist attacks would be virtually eliminated. In addition, normal operation should be more reliable because of greater reserve margins.

Disadvantages

Several of these steps could be very expensive (e.g., greater reserve margins, stockpiling). Apportioning these costs among utilities, rate-payers, and government will be difficult unless a general kilowatt-hour tax, as discussed above, is imposed. Furthermore, power systems would still be vulnerable to sophisticated saboteurs, including sophisticated terrorist groups as well as national commandos. These measures would make destruction more difficult and perhaps reduce the damage, but they won't eliminate the greatest concerns. Furthermore, even greatly enhanced resistance to sabotage is likely to simply move the problem somewhere else. For instance, small groups deterred from attacking substations could simply shoot transmission lines out. While the impact of a single incident would be much less dramatic and lasting than that of blowing up several substations, it could be repeated frequently over a wide geographic area, achieving much of the same disruption. Alternatively, the saboteurs could turn to telecommunications, water supplies, or other infrastructure elements. Thus, it is questionable how much protection would be purchased by these options for society as a whole.