Blackout Resilience: How Much Protection is Necessary?

Summary

Municipalities face challenges on several fronts in the face of power grid failure from electromagnetic events. The loss of power has cascading effects that can quickly bring about shortages in food and water and a severe reduction of services from healthcare, law enforcement, and other essential services.

This whitepaper offers a discussion of the anticipated breakdowns in household and municipal functioning during a power-loss scenario, along with an estimation of what minimum safeguards are needed to sustain a population during a crisis. These guidelines align with research performed by the Department of Homeland Security (DHS), the Federal Emergency Management Administration (FEMA), and many municipality disaster plans.

Household Vulnerabilities

A household experiencing a blackout is easy to imagine. Residents are forced to make do with less. They begin to adopt alternative practices and conserve existing resources. Houses fortunate enough to have a generator might use it only sparingly, using only a fraction of its typical electricity consumption. Faced with a cutoff of water supply or food sources, households begin to carefully ration what reserves they have on hand.

Most households will naturally transition from a normal mode to a minimal mode of consumption during periods of uncertain supply. In so doing, populations can survive weeks or months on the bare minimum. When these essentials fall to zero, however, households face dire consequences.

Humans can survive 4-7 days without food, but the timeline is much shorter for clean drinking water supply. Households can only go 3-5 days without drinking water.

Loss of electrical power constitutes not an immediate threat, but rather the first step towards an imminent breakdown in household functioning. Residents can forego lights and entertainment, but lack of refrigeration results in a sharp reduction in food stock within hours.

Core Components of Municipality Resilience

Given the vulnerabilities of their populations, municipalities face a ticking-clock situation after an electromagnetic pulse (EMP) event. The timelines which define residents' survival become the deadlines of emergency actions by the part of city leadership.

Like a household, the loss of grid power forces city departments to make do with far fewer utility resources. Emergency responders, police forces, hospitals, and water treatment facilities can remain functional — albeit with much rationing — with a small fraction of normal capacity.

Yet with zero grid power and zero backup power available (or similarly with water access) city agencies may quickly degrade towards a point of paralysis, where providers of services are helpless to respond to the needs of their residents. While emergency food, water, or medicine stockpiles might become available from other regions, without viable communications and transportation networks they may not be able to get where they are needed. Equipment failure may demobilize police, fire, and medical teams.

Therefore, it behooves municipalities to make contingency plans that will secure at least some minimal level of resilience to keep the most important institutions up and running during an emergency.

Five Critical Factors for Survival

Based on knowledge gained from discussions with the DHS, we can identify the five most important components for survival during large-scale emergencies. Maintaining some level of capacity in these areas can help municipalities avoid the most catastrophic consequences for their populations:

1. Power
2. Communication
3. Transportation
4. Food / Water Supply
5. Waste Removal

A discussion of each factor in detail will include a projection as to what fraction of capacity needs to be secured by resilience plans.

Power

As noted, the absence of electric power in a community is of the most critical importance because of the downstream effects to all other public services. Power is needed for water treatment, waste removal, hospitals, police and emergency response, as well as transportation and communications networks. Discussion on each of these categories will follow in more detail.

The immediate effects for homes and businesses are the loss of use of appliances, which can lead to various problems – most prominently, food spoilage. Loss of power could also disrupt mobile phone networks and other forms of communication. A downed grid might make it difficult to get around or evacuate a location without traffic lights or other electronic systems.

Long-term effects, particularly in the case of an electromagnetic energy event, can include damage to infrastructure such as power lines, transformers, and substations. This can take weeks or months to repair, sometimes leading to new power outages long after the initial failure has been resolved.

Overall, disruption of power generation and distribution can paralyze a local economy, with businesses closed and work suspended, leading to financial hardship for months afterward.

Because power is so influential to the fate of all other survival efforts, experts recommend strengthening or backing up a total of at least 30-50% of normal power capacity.

Communications

The ability to talk for hours on a cell phone may disappear, but at least some communications between important organizations after the emergency will have to be reestablished in order to recover from the disaster.

Mobile communications companies, most obviously, need to think about their network resilience and their response plans for recovery. Organizations that have the responsibility to respond, coordinate, and align during a disaster — such as local law enforcement and FEMA — need plans to fortify their most essential lines of communications.

In the event of a total outage of the electric grid, communication failures would have a significant impact on people's ability to stay informed and connected. The immediate aftereffects of an EMP may likely include loss of cell phone service, internet access, as well as radio and television.

Transportation

Like electrical power, transportation has a role to play in every other category of municipal service. Food and water, portable power, fire and medical services, and law enforcement will all depend on reliable vehicles after a disaster.

While grid failure alone would not stop conventional cars and trucks, an event such as a high-altitude electromagnetic pulse (HEMP) might overload the small electronic control systems onboard. Therefore, a fleet of fully fueled trucks would sit disabled until these components could be replaced.

Other modes – air, rail, and marine – would struggle to a similar degree to keep their fleets running.

Rebuilding city infrastructure greatly depends on transportation networks relieving supply shortages and bringing in the materials necessary for repair.

Water

While power outages have the most widespread impact on the functioning of a city, the most direct threat to human health is the lack of water. Residents cannot survive for much longer than three days with drinking water. Water is essential to hospital operations, which cannot continue past four hours without supply.

An electrical grid failure coupled with disabled electronic control systems can damage water infrastructure, such as pumps, pipes, and treatment plants. According to a study by the National Academies of Sciences, Engineering, and Medicine, the loss of water pressure can occur within minutes of an electrical grid failure. The loss of water treatment can occur within hours and the loss of pumping within days.

Cessation of pumping, in turn, can lead to flooding in low-lying areas which is particularly dangerous for a demobilized population. Standing water can be considered contaminated after only 24 hours and can increase its health risks as time goes on.

For the purposes of disaster planning, experts believe that water treatment, one of the most critical elements for municipality functioning, would have to run at approximately 30% of its normal capacity to keep clean, reliable water flowing to residents, avoid the spread of waterborne diseases and allow the partial functioning of important government and business entities during the crisis.

Food

In the aftermath of a blackout, the loss of refrigeration can lead to large-scale food spoilage in homes as well as the business entities that supply and distribute perishable items such as meat, dairy, and produce. These stocks on hand would be eliminated within hours.

In a prolonged crisis, interruption of food processing and distribution can lead to further shortages of food in areas, especially those in remote areas. As with grid and water equipment failure, food infrastructure, such as warehouses, processing plants, and distribution centers, may take time to repair, and food shortages may linger even after the initial failures have been resolved.

Lack of food may create a countdown to civil collapse and force municipalities into tight timelines in which to restore essential transportation and infrastructure.

Over time, people may run out of food and, without work or access to funds, the ability to obtain food. In the long term, malnutrition and foodborne illnesses could exacerbate the public health crisis and strain an overburdened healthcare system.

Waste Removal

One public service that is absolutely critical for resident survival in the days after a paralyzing event is waste removal. Perhaps the biggest public health risk would be a halt on waste removal, including both sewers and garbage pickup. Like standing water, the accumulation of trash or backups of sewage throughout a city increases the likelihood of bacterial diseases.

An epidemic of waterborne diseases could tear through a community 10 to 15 days after the precipitating incident and might be responsible for a majority of deaths. It is estimated that a continent-wide HEMP attack could result in 30% mortality at 21 days.

In the year after a disaster, it has been found that restoration of waste removal has a significant positive impact on community morale and rebuilding efforts.

Prioritizing Resilience Building Efforts

Communities with disaster plans have learned that distributing limited funding for resilience building is a matter of identifying the crucial pieces of their infrastructure that will have the most impact in the days following an adverse event. For departments that rely on transportation and communications to complete their mission, it is to select a few routes or nodes in a network that should be protected first because they will be most critical for rescue efforts.

The rule of thumb for municipal districts regarding utility service is to aim resilience efforts to protect 30-50% of electricity capacity – which may mean choosing substations and power lines that serve important government functions first – and to preserve 30% fraction of water delivery and 30% of normal water treatment. Water utilities can conduct a survey of what processes require electricity or electronic controls and similarly pick strategic channels to shield from EMP surges.

Protecting Power

Since natural or man-made pulses affect the grid and electronic equipment and because grid power and electronic controls support a full spectrum of essential city services, it makes sense to focus on power infrastructure as the entry point into disaster plan investment.

Building resilience in the grid

By understanding the vulnerabilities and consequences of power failure, municipalities and other agencies can make efforts to protect the most critical infrastructure, thereby assuring the availability of at least a portion of resources during a period of emergency response.

As we have seen in preparing for the worst, protecting 100% of normal level is not necessary, but certainly 30-50% of capacity may save a community from catastrophe.

Once prioritized activities are identified, disaster planners can then examine the remediation available. Backup power through on-site generators support continuity of operation at the time of a blackout, yet generators last only as long as their fuel supply.

To shield or fortify existing electricity sources against EMP-induced surges and overheating requires high performance filters on source lines that can divert heavy current towards the ground and away from vulnerable equipment.

Technological innovation from TSS USA Manufacturing has recently gained compliance approval for a medium-voltage (in the context of electric power lines, up to 5000V) filter that can shield larger equipment at substations and lower-voltage grid distribution points.

There are also low-voltage filters available, designed to protect near the point of delivery, say a computerized control room. These filter types are certified to meet the production requirements of MIL-STD-188-125-1A and MIL-STD-188-125-2 as well as UL1283.

City emergency planners have found a combination of remedies, from back-up power to hardening of infrastructure to installation of low and medium filters, is usually the most strategic approach to building resilience against EMP.

Conclusion

With limited funding to plan for contingencies, municipalities and emergency agencies unfortunately cannot build resilience in every aspect of critical infrastructure. The good news is that our infrastructure does not need complete protection, but enough to maintain a strategic core of essential resources.

Therefore, it is the task of every municipality to undertake an assessment of infrastructure assets and a mapping of their functions. Understanding and prioritizing the infrastructure which will be most critical to sustained functionality is the best we can do, and with this assessment, cities can then make sensible and strategic decisions.

Further Reading

Here are some additional resources that you may find helpful:

Federal Emergency Management Agency (FEMA): www.fema.gov/

Ready.gov: www.ready.gov/

The National Institute of Standards and Technology (NIST): www.nist.gov/

The American Red Cross: www.redcross.org/

The Centers for Disease Control and Prevention (CDC) website: www.cdc.gov/

Senate report on cybersecurity infrastructure: www.rpc.senate.gov/policy-papers/infrastructure-cybersecurity-the-us-electric-grid/

Strategic recommendations from the EMP Task Force: www.nerc.com/pa/Stand/Pages/EMPTask.aspx

The Potential Consequences of an EMP Attack on the US Electric Grid, by Spencer Rogers: www.Large.stanford.edu/courses/2019/ph241/rogers1/

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