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When The Grid Goes Down

ISSUE 1

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ANTI-TECH QUARTERLY

Freedom From Technological Slavery

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Our mission is to organize coherent political action against the global techno-industrialist system. With this publication, we aim to disseminate ideas relevant to this cause in order to inspire others like us to stand in opposition to a force which we have judged to be ethically, philosophically, and practically irredeemable.

It is our view that the techno-industrialist machine is a violent, destructive, and irreparable system of subjugation, and because of this we do not support any social or political efforts to rehabilitate it. It is on these grounds that we repudiate reformist and environmentalist sentiments, which we believe serve only as distractions that do nothing to counter the true goal of techno-industrialism; that is, the total enslavement and annihilation of Wild Nature.

Thus, we are not a partisan movement, nor do we have any interest in furthering the ideologies of any movement on the left-right political spectrum. We reject the call to engage with issues such as social justice, feminism, anti-racism.
We oppose racism, nationalism, ethno-nationalism, any form of fascism or defense of the rule of law. It is our opinion that the pursuit of any one of these values will be meaningless on a dead planet.

If you identify with any of these viewpoints, this zine is not for you.

Finally, we do not advocate that anyone consider this publication an exhortation for violent or illegal action of any kind. We denounce violence as a matter of pragmatism, not a matter of principal. It would be anathema to a nascent anti-tech organization to openly incite violence, which would prompt law enforcement to hinder our ability to spread our message. We hope only to exercise our right to freedom of speech in order to present our personal views authentically and honestly.

Yours,

For Wild Nature

"GIVE ME SIX HOURS TO CHOP DOWN A TREE AND I WILL SPEND THE FIRST FOUR SHARPENING THE AXE"

- Abraham Lincoln -

It is easier to work with a sharpened blade rather than a dull one. To execute a major goal effectively takes time, effort, and planning. Many people who share our vision want to start hacking away before making the necessary preparations. We have made it our aim to provide information we deem important for those with determination to craft the essential tools before it's time to yell:

"Timber!"

When The Grid Goes Down

When the Grid Goes Down:

Part 1

Introduction

In issue 3 we identified the 9 key substations that, if brought down, could send the United States into a national blackout. A breakdown on such a mass scale would be no smooth ride as the US has only ever had to deal with short term blackouts. The complexity of our technological society requires systematic order which, if critically disrupted, would produce a ripple effect impacting multiple areas. There would be various organizations and entities deployed along with immediate measures taken in an attempt to prevent and stabilize failing infrastructure. Here we provide a detailed hypothetical analysis into what exactly such a situation would look like starting with two of the most critical systems that rely on electricity: energy infrastructure and communications. While a precise prediction can not be fully determined, taking a look at major blackouts in the past and examining the emergency plans for entities can give a realistic idea on what would be expected.

1. Energy Infrastructure

The challenge to restore the national grid after a wide-scale blackout would involve a very elaborate process, but the level of difficulty would depend on the severity of the breakdown. The majority of entities in the electric utility industry have preparations and plans in place in the case of a wide-scale grid failure. These preparations do not guarantee the resiliency of the grid, but reveal what the next steps for restoration would likely entail. The information identifies vulnerabilities in the recovery process which exposes the fragility of the grid.

Grid Restoration

Electrical Islands

The restoration process of the US electrical grid would work similar to putting together a puzzle piece. This is performed by creating so-called electrical islands, which are isolated portions of an interconnection. To energize an electrical island after a total shutdown requires using a power plant that is able to start its generator unit(s) from a completely unenergized state without the need for external electricity. This is known as black-starting.

Typically after a small-scale blackout a process called sequential restoration is used where loads and generators are incrementally added to the electrical island, enlarging the island and reducing the size of the blacked-out region. Loads are defined as the amount of electricity on the grid at any given time. In the event of a large-scale blackout a different process is used called parallel restoration where multiple geographically dispersed black start plants/units are powered up simultaneously. These islands would grow as additional generation is brought online and load is restored. When the islands are large enough, they would be connected to one another, piece by piece, to bring back an interconnected grid network.

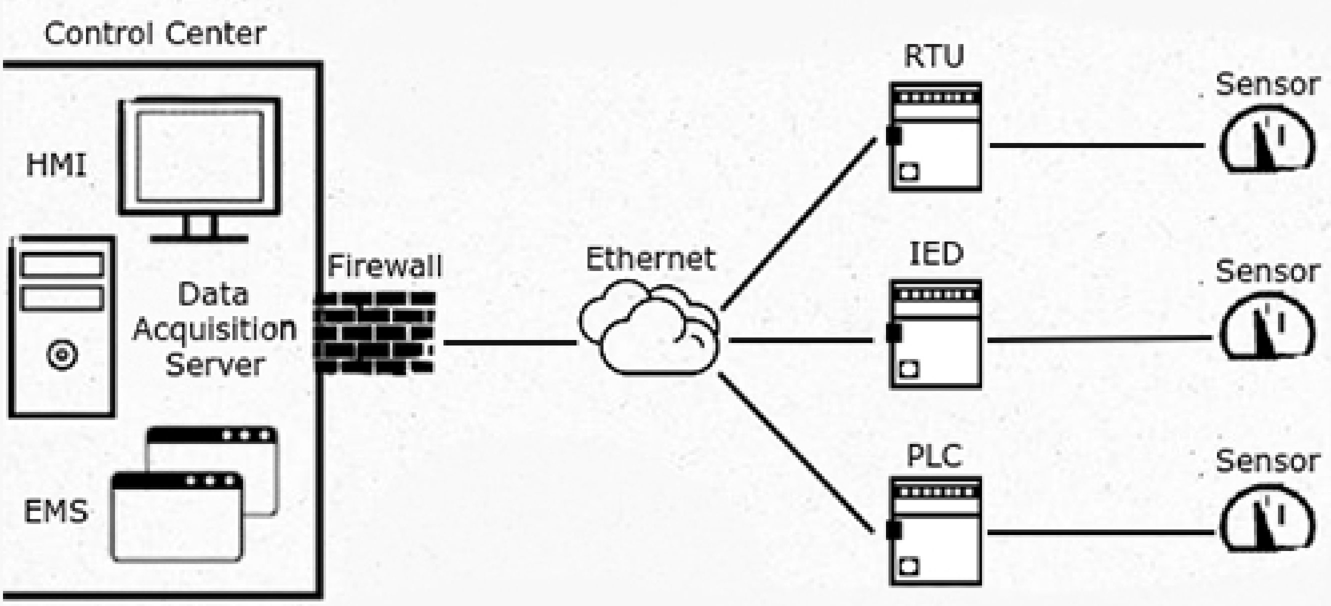
Grid Surveillance

The restoration of the grid and synchronization of electrical islands is heavily reliant on data collecting tools which can assess the disruption. A 2014 report by the Federal Energy Regulatory Commission and the North American Electric Reliability Corporation (FERC-NERC) reviewed entities' plans for restoration and recovery of the bulk electrical system following a widespread outage. This study revealed the dependency on data sources and the risk of their loss of function in a long-term outage.The primary data sources used for grid monitoring include Supervisory Control and Data Acquisition (SCADA), which gathers data in real time, operating with coded signals over communication channels to monitor and provide control of remote equipment. Combined with a larger Energy Management System (EMS) that oversees the whole grid (Federal Energy Regulatory Commission & North American Electric Reliability Corporation [FERC-NERC], 2014).

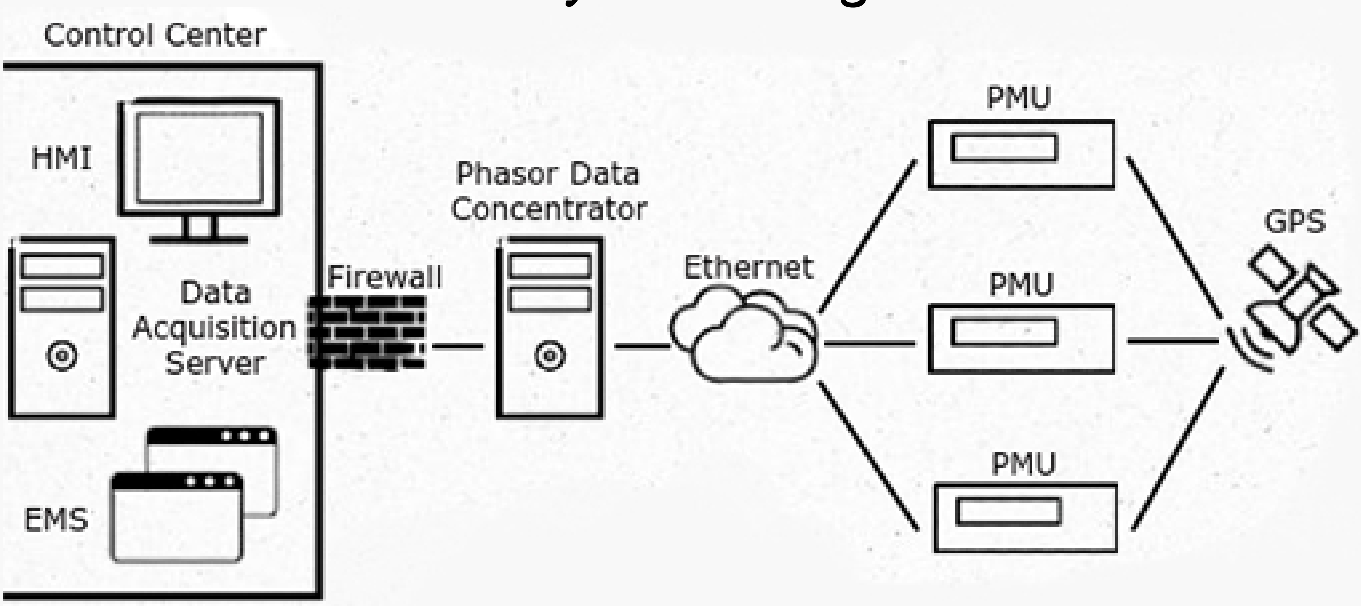
Part of SCADA are sensors at substations that serve as measuring tools on the equipment which are connected digitally or through analog to the substation processors commonly known as Remote Terminal Unit (RTU), Programmable Logic Controller (PLC) or Intelligent Electronic Device (IED). These processors receive and translate the data from the sensors at substations to be transmitted through telephone lines, microwave, or satellite to SCADA computers at a control center. There the data is displayed in a coherent picture for the supervisory operator to view and take control of certain pieces of equipment to make repairs or isolate failures.

An Inter Control-center Communication Protocol (ICCP) server is used to transfer this information from control center to control center at the state level to the regional level to the national level, each with their own SCADA system integrated in a hierarchical structure. Users can also view SCADA through web SCADA systems which use internet browsers to allow access from personal devices such as laptops, mobile phones and tablets (Kumar, 2017; Sayed & Gabbar, 2017).

SCADA system using RTU, IED, PLC



SCADA system using PMUs



RTU, PLC, and IEDs work similarly with functionality that overlaps that are sometimes used together, but offer different technical specs. To put simply, An RTU is mostly used in widely spaced geographic regions transmitting data to SCADA systems via wireless communication, whereas a PLC is better suited for local controls and is programmable. IED is a more modern microprocessor that is capable of recording huge amounts of data and providing much more information. IEDs are typically connected with a Global Positioning System (GPS) which can support Phasor Measurement Unit (PMU) devices (Ali & Swaminathan, 2022; Paessler The Monitoring Experts, 2022).

PMU's measure voltage and current and communicate to a Phasor Data Concentrator (PDC) which acquires the GPS phasor data from the multiple PMUs before reaching the control room for state estimation (Ali & Swaminathan, 2022; Bose & Overbye, 2021).

In the Ferc-Nerc 2014 report participants noted restoration of the grid would be a long, tedious process in the event SCADA/EMS and other data sources are not available. Recovery of these data tools would be of top priority during a national blackout as their loss would pose significant challenges. One of the main causes of the 2003 Northeast blackout in the US were failures in the affected EMSs. How quickly these systems would become operational again would depend on the extent of the damage (Federal Energy Regulatory Commission & North American Electric Reliability Corporation [FERC-NERC], 2014).

If subject to cyber-attack, it could mislead operators and cause them to take wrong actions eventually jeopardizing the power grid. False data attacks do not often lead to widespread blackouts though, unless they are coordinated with physical failures of critical infrastructure such as transformers, generators, or heavily loaded lines in the vicinity of large generators. Both cyber and physical attacks combined would hinder restoration operations, as damage to microprocessors within the substation or the communication links to the control center would also affect their functionality (Basumallik, 2021).

Emergency Response

In the event of an EMS or SCADA failure, operators notify EMS, Information Technology (IT), and/or telecommunications staff responsible for resolving SCADA and EMS concerns.These operators can dispatch field personnel to transmission stations to manually perform feasible restoration activities and provide field equipment status at the direction of management. Staff could encounter difficulty moving from one location to another when streetlights and public communications infrastructure are affected during a wide-scale blackout. Dedicated telephone or radio are the primary forms of communication for operators which are typically redundant and diversely routed.

LPTs can be labor intesive and expensive to transport

Without this they would have to rely on back-up voice communication; which includes additional phone lines, cell phone, satellite phone, and Government Emergency Telephone Service cards (Federal Energy Regulatory Commission & North American Electric Reliability Corporation [FERC-NERC], 2014).

Replacing a critical component to the bulk electric generation such as a Large Power Transformer (LPT) could also prove to be difficult. LPT's are very expensive and tailored to fit specifications, making them non-interchangeable. The replacement and repair of a LPT can range from one to two years, and they require transportation by large trucks or trains; as LPT's are too heavy to be transported by air (Mazumder, 2018).

Blackstart Power Plants

Hydropower

Hydroelectricity currently generates 6.3% of the total US electricity supply, with the largest dams located in the western United States. They serve a critical role when restoring the grid with the capability to act as a blackstart generator. During the northeast blackout of 1965, which affected multiple states in the northeast including parts of Canada, utilities with access to hydroelectricity were among the first to restore service. The same occurred during the 2003 Northeast blackout where the New York Power Authority (NYPA) provided hydropower for the region only after 6 hours.

Very little energy is needed to start the plant's auxiliary system. This is in comparison to other power plants which require energy-intensive processes that need to run before the generator is brought online. Hydropower plants are able to start up faster. The diesel generators required are relatively small, and do not require much fuel. The main use of water flow to fuel generating facilities is less prone to interruption and enables hydropower plants to provide several rounds of black start service (Gracia et al., 2019).

Typically during the summer months, hydro operators use stored water in reservoirs when demand for electricity, electricity prices, and fuel consumption peak (California Energy Commission, 2021). Once the dry season starts there is gradual depletion from the reservoirs. The lowest rate of replenishment is found during the late summer when it is the hottest and driest time of the year. This decreased rate continues into the late winter until the annual snowmelt adds significant potential for hydroelectric generation. A wide scale blackout during these low points could potentially put a strain on water release since reservoirs are not fully replenished yet (Wessel et al., 2021).

A hydropower plant relies on the appropriate water resources, most of which lie in suburban or rural areas. An area like New York City would need more local black start resources for the accelerated restoration of electric service (Gracia et al., 2019).

Combustion turbines

Combustion turbines are designed to meet peaks in energy demand quickly. They operate by drawing in air in the front of the unit, compressing it, mixing it with fuel and igniting it. Combustion occurs immediately allowing gasses to expand through turbine blades connected to a generator to produce electricity. These power plants are black-start capable, but they are dependent on having available fuel supply such as a pressurized natural gas pipeline in service. Gas turbines do not need fuel handling equipment, but after they exhaust any gas supplies stored on-site, their continued operation requires that natural gas lines feeding the turbines be maintained at proper pressurization, and this takes electricity. This makes combustion turbine availability dependent on the gas pipeline being unaffected by the blackout (hydro, O'Brein et al., 2022).

Other Power Generation Technologies

Nuclear Power Plants

Nuclear power plants are unable to restart without access to off-site power as the on-site generators provide only enough for the nuclear plant to shut down safely. The 2003 blackout caused nuclear plants located in New York, New Jersey, Ohio, and Michigan to experience an automatic shutdown. Offsite power was maintained for one of the nuclear power plants, while the rest of them relied on onsite backup from Diesel generators before they were able to restart (United States Nuclear Regulatory Commision [U.S NRC], 2022). In the absence of on-site fuel, it would need to be transported to the sites either by land, air, or water. If transportation was forestalled, a potential calamity would be expedited.

Within a nuclear power plant, rod assemblies located inside its reactor contain fissile material to produce heat for generating steam that turns the turbine to produce electricity. Fuel rod assemblies must be removed and replaced with new rods every 18-24 months. Spent rods are kept in giant pools of water laced with boric acid and must be kept cool through circulating the water since they are still incredibly hot and radioactive. This process takes on average 5-7 years. Without circulation, the heat from the fuel rod assemblies could boil the surrounding water, making the water levels drop, exposing them to air.

The steam released would carry radioactive containment, affecting surrounding areas. Urgent measures may be taken by bringing in river or ocean water to flood the reactor in order to cool it should all else fail, but the cooling system would be damaged (Bradley, 2017).

Coal-fired Power Plants

Coal-fired power plants produce electricity by burning coal in a boiler to produce steam. The steam produced, under tremendous pressure, flows into a turbine, which spins to create electricity. The steam is then cooled, condensed back into water and returned to the boiler to start the process over. Coal-fired power plants are large with greater inertia and have fuel onsite. Where coal-fired power plants falter is in their large cooling apparatus that must be in operation before the plant can be restarted. It takes many hours to return their boilers to temperature to produce steam to start the turbines. They also have complex fuel processing and handling, and emissions control technology that requires significant amounts of electricity (Gracia et al., 2019; O'Brein et al., 2022).

Wind and Solar Energy

Due to the unpredictability of wind and solar energy, renewables are not a viable option as blackstart resources. A totally controlled environment is required for successful grid restoration since during the initial phase the system is relatively weak. Because the wind and solar output vary, the system can undergo another blackout if uncontrolled power sources are added during the initial phase of restoration (Gracia et al., 2019).

2. Communications

Telecommunications and Information Technology are critical infrastructure for transmitting and receiving data that can not be supported without access to a power supply. Key network components and devices - including switching centers, antennas at cell sites, fiber cables , mobile phones, computers, and tablets-rely on electricity. The extent to which service would be available can depend on the backup capabilities at different cell sites, stations and infrastructures, ranging from a few hours to weeks of functioning after a blackout. In any case, all technological forms of communication would eventually become inoperable in the event of a prolonged blackout without a constant supply of fuel, which would prove difficult in a time of high demand.

Phone Service

Wire-line Phones

A landline may serve as an alternative communication source in the case of an outage. Traditional wire-line telephones, which consist of copper wires, are energized from the central exchange offices. However, if the phone company loses power then these landlines stop working. Several areas of New York City during the 2003 blackout experienced a loss of landline communications because three central offices experienced outages (Allan et al., 2004).

Another traditional standard is the Integrated Services Digital Network (ISDN) which uses digital signals sent via copper or fiber optic cables to communicate between phones. Customers with analogue or ISDN phones could only use these until the Uninterruptible Power Supply (UPS) of the relevant local switching exchange fails, which would happen after a few hours (Petermann et al., 2011).

In our digital age, these older forms of telecommunication are increasingly falling out of use. The majority of service providers have switched over to Voice Over Internet Protocol (VoIP), which uses broadband internet connection via Digital Subscriber Line (DSL) routers or cable modems that only work if the power supply is functioning. Most modern business phone systems use VoIP as the foundation for telephony, which leaves them vulnerable in the event of a prolonged blackout.

Mobile Phones

In the case of mobile phones the majority of cell towers have auxiliary backup on site, but the amount of time in which they last varies. After Hurricane Katrina in 2005 the Federal Communications Commission (FCC) released the "Katrina Panel Order" which recommended that nearly all US cell phone towers be outfitted with at least 8 hours of backup power. This order never became law, but in most cases cell phone networks remain operational for at least 6-8 hours after an outage begins (Peterson, 2017). Some cell phone towers have a Diesel generator and enough fuel to last for several days. In 2020, California mandated that all macro cell towers, which provide far-reaching coverage, be equipped with at least 72 hours of backup supply (Karish, 2020).

Mobile phones could only be used temporarily as they require battery life to work and could not recharge without accessible power. The risk of network congestion is also high during a widespread emergency when many people are trying to make calls. This was experienced during the 2015 earthquake in Nepal when service quality degraded due to network congestion and lack of electricity to charge mobile phones (Khaled & Mcheick, 2019).

Satellite Communication

Satellite phones would be less likely to immediately fail. The signal on these devices is sent and transmitted by orbiting satellites. They are primarily used by government agencies and industries such as maritime, military forces, oil, gas and mining because it is considered a more reliable method of communication between first responders during emergencies (Axess Networks, 2019). However, batteries are required for them to work. Depending on the model, it can allow for up to 8 hours of straight talk time and over 100 hours of standby before needing to be recharged (United States Department of Homeland Security [DHS], 2016). The downside of satellite phones is that they must have a direct line of sight to a satellite in order to successfully connect a call. For instance, users would be unable to receive a signal in places such as downtown New York City due to the limited view of the sky and tall buildings (Globalcom).

Radio Communication

Ham radio, also known as amateur radio, uses over-the-air radio frequencies to transmit messages for non-commercial purposes. They are able to reach great distances; However, just like satellite phones they also depend on batteries to work and require a license to operate. Being used by a limited number of people in the United States, Ham radio could not serve as an alternative for mass communication (Westchester County Emergency Services, 2022).

During emergency disasters, amateur radio organizations are likely to be utilized to assist the public with direct communication with first responders (Westchester County, 2022). Repeaters are used to operate nets to coordinate emergency aid efforts across a broad range (Amateur Radio Emergency Service [ARES], 2015). Repeaters depend on an electrical source and resort to backup generators or batteries to continue operation during an outage. During the 2003 blackout. New York Police Department officers encountered issues with repeaters, and the batteries in their two-way radios ran down more quickly than anticipated (Allan et al., 2004; Domash, 2004).

Internet

Data Centers

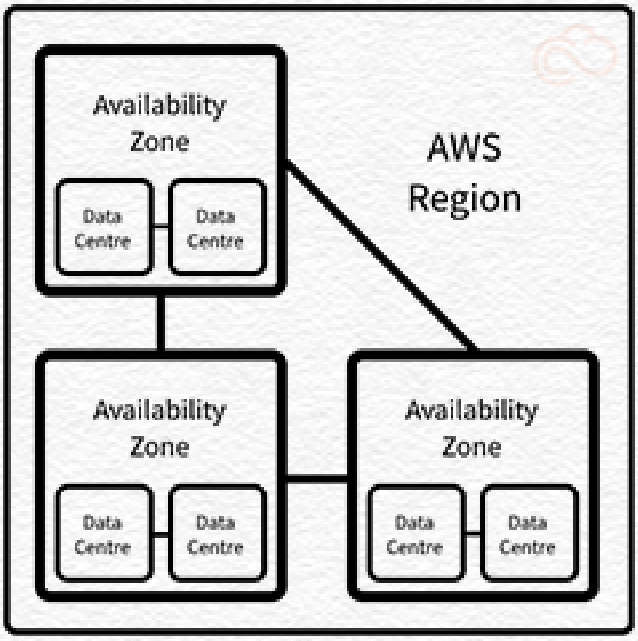
Today, the electronic exchange of data is required for nearly every business and personal interaction. This ever-growing demand for new digital information requires vast amounts of computing and networking equipment, which are kept in data centers; where information is processed, stored, and shared.

Meta data centers require extensive cooling

The amount of backup power supply provided at these facilities typically depends on their level of criticality. Larger centers used by enterprise corporations are usually equipped with a duplicate backup system providing twice the operational capacity, sometimes with an additional backup component in case failure happens while a secondary system is active. These are labeled as tier 4 data centers, which are equipped with 96 hour backup protection (Uptime Institute).

The majority of data centers use Diesel fuel for their backup generators, which are also reserved for cooling (Vreeburg, 2019). Generators may prove to be less reliable and prone to increased fuel depletion if the blackout were to happen during the hottest time of the year. In the summer when utility providers are affected by rolling blackouts and brownouts, backup systems provide emergency power. According to Uptime Institute, "If a utility grid falters amid extreme temperature and the generator needs to take the load, it may not be able to deliver full nameplate power and it may even shut down to avoid damage from overheating" (Bizo, 2022).

Cooling is one of the most crucial elements at a data center, being necessary for the reliable operation of the IT equipment, but is also one of the greatest drains on energy. Amazon Web Services (AWS) require electricity for direct evaporative cooling, which uses water pumps and fans to regulate the heat from their servers. During the summer of 2022, Amazon declared that a "thermal event" in London caused equipment failure. Around the same time, Cloud services hosted by Google and Oracle also went offline due to cooling issues, leaving customers without access to the online services for almost an entire day (News, 2022).



AWS resilience is secured through the use of separate geographical regions that house a collection of Availability Zones that map to physical data centers within the region. These regions are physically isolated from each other in terms of location, power, and water supply. Each has redundant and separate networking and connectivity to reduce the likelihood of two Availability Zones failing simultaneously. There can be multiple centers located in each zone to avoid a critical service dependency on a single facility (Amazon Web Services [AWS], 2022).

AWS has had its fair share of power disruptions within their regions. In one known incident during 2021 the US-EAST-1 region was affected by a failure from one of the availability zones, followed by an extended recovery process. A number of major companies and services were impacted. The outage prevented Amazon delivery drivers from getting routes or packages and shut down communication due to their inability to use essential company apps (Soper, 2021).

The outages AWS has faced have not been severely detrimental. The level of resilience from AWS' infrastructure would take more than a few data centers being down. Major consequences could ensue from a wide-scale blackout that reaches areas where each region is located.

Satellite Internet

Even without the failure of data centers and infrastructure, the internet would be inaccessible for customers if the devices to access it are not working. This includes satellite internet, which uses a dish that is connected to a modem that connects to the computer. Because the modem requires external power, satellite internet would become inoperable (Crist & Leavitt, 2022).

Broadcasting

News Media

During emergency events dissemination of news is considered a top priority in order to keep the public informed on the state of things. In a wide-scale blackout mass media would face challenges as the modern means for spreading information rely on technologies.

Public-law broadcasting stations are usually prepared with emergency power in case of a disruption. If they are unable to run, news networks will sometimes broadcast from stations located in other regions. This was the case during the 2003 Northeast blackout, when major US networks and cable television channels, centered in New York City, relied on out-of-state backup stations (Apt, Granger & Lave, 2006).

Information could continue to be available for a limited amount of time to those equipped to receive over-the-air TV and radio reception. Those reliant on the Internet would be disconnected from their news source for the duration of the blackout. The only exception being dial-up access from laptop computers, which would work until the batteries ran out of charge.

When it comes to newspapers, press and printing companies are major consumers of energy. Newspaper rotary printing presses alone require electricity volumes equivalent to those used by a few hundred to a thousand households. The extent to which newspaper publishing houses and major printing works could maintain emergency operations depends on the extent to which replenishments of Diesel for the emergency generators can be ensured (Petermann et al., 2011).

Alerts

The National Public Warning System (NPWS) is used to send out urgent messages during disasters, and allows the President of the United States to communicate with Americans in the event of a national emergency. There are currently 77 private sector radio broadcast stations throughout the United States equipped with backup transmitters, communications equipment, and generators in order to broadcast national emergency information to the public. These stations primarily transmit through cable, satellite, or television, as well as AM/FM and satellite radio (United States Department of Homeland Security [DHS] 2022b; United States Department of Homeland Security [DHS], 2017).

Because the use of broadcast media is becoming less common, Wireless Emergency Alerts (WEA) is often used to disseminate public warnings to mobile devices. Authorized public safety officials send the alerts to wireless providers, which are then transmitted from cell towers at the mobile carrier sites to the devices in the affected area. As stated previously, these cell towers would run on backup power which are typically equipped to sustain for up to 8 hours or more (Public Broadcasting Service [PBS], 2022).

Portable Broadcasting

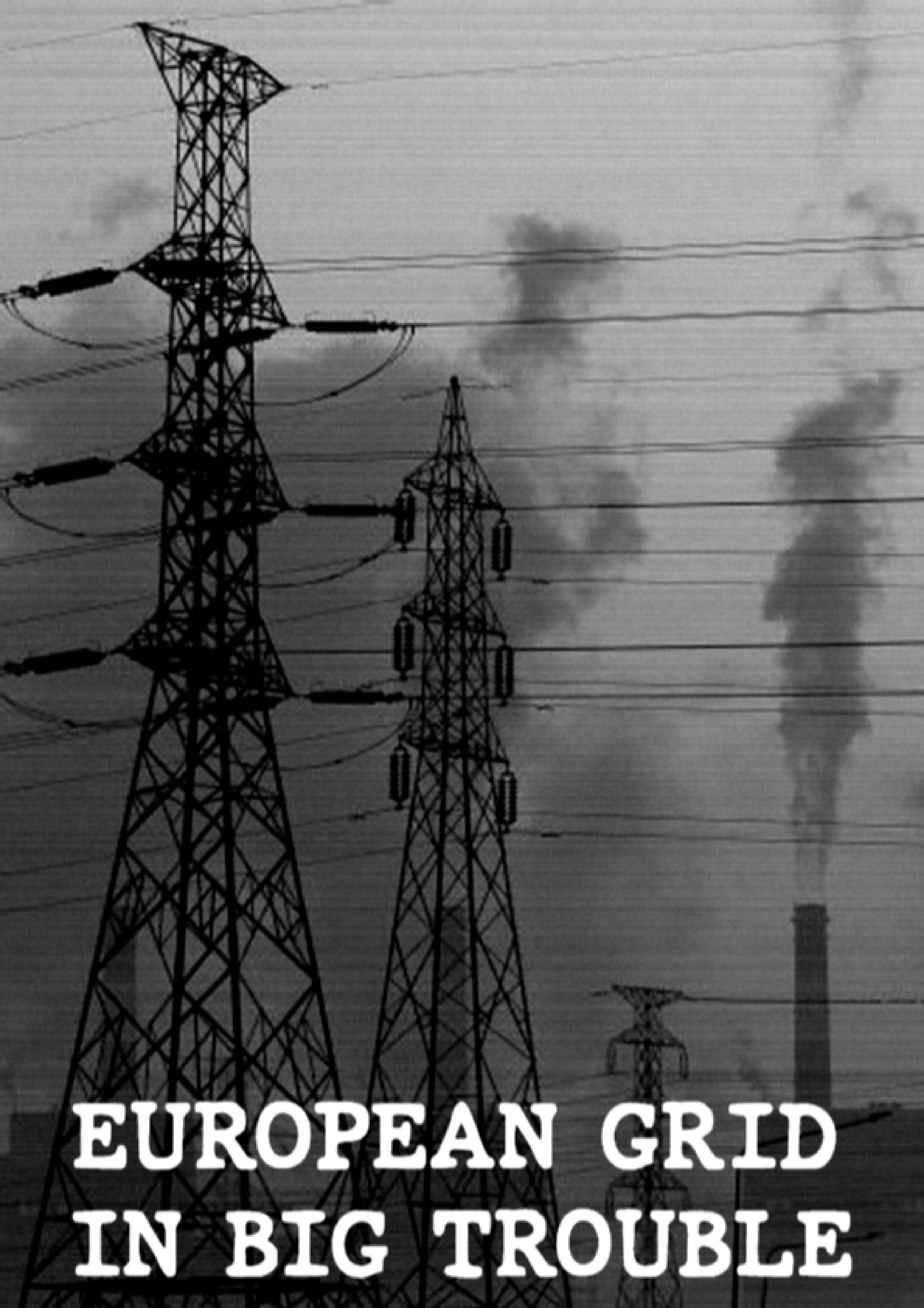
Some emergency responder and commercial communications entities would deploy Very Small Aperture Terminals (VSAT) to provide backhaul for portable communication infrastructures. These include Cell On Light Truck (COLTs), Cell On Wheels (COWs), and Tower On Wheels (TOWs). These terminals typically have an outdoor "dish" antenna and an indoor electronics box. When installed at emergency operations centers and other public safety facilities, VSATs can provide continuity of communications when terrestrial links are severed; but only as long as electrical power is available with the use of back-up (Federal Communications Commission [FCC], 2008).

Conclusion

The two most critical components of restoration and emergency operations during post-grid failure were explored in this part. If energy infrastructure and communication failed it would impede the chance of the grid network being pieced back together, potentially resulting in a "no-start". In summary, the key takeaways from this article are:

- Grid restoration would require incremental start up of isolated interconnections called Electrical Islands which would be connected together to bring back the national grid network.
- Electrical Island synchronization relies on data sources which primarily consist of SCADA/EMS systems. Damage to critical infrastructure such as, Large Power Transformers, generators, or heavily loaded lines in the vicinity of large generators would be a major hindrance to grid restoration.
- Start up of electrical islands requires a power plant that is black-start capable such as hydropower. Hydropower reservoirs are lowest during late summer and late winter when they are not yet replenished by snowmelt and rainfall in Spring.
- First Responder communication would mainly consist of Satellite phones which allow for up to 8 hours of talk time before needing to be recharged.
- Hotter weather can put a strain on Data Centers and generators.
- Back-up systems for critical infrastructures rely on Diesel fuel supply

In part 2 we will explore how other critical industries and infrastructure would be affected during a national blackout.


EUROPEAN GRID
IN BIG TROUBLE

European Grid in Big Trouble

Introduction

The United States grid has been the primary focus thus far, and while the attention is highly warranted, the European power system has not been thoroughly investigated. Given today's recent events it would be foolish to turn a blind eye to the largest synchronous electrical grid in the world.

Russia and Renewables

In February of 2022 Russia invaded Ukraine which brought about dramatic repercussions on other countries. Europe was especially affected by the invasion, as many of its countries, notably those in Central and Eastern Europe, are dependent upon Russian oil and gas. Keisuke Sadamori, the International Energy Agency's (IEA) Director of Energy Markets and Security, has been quoted by many, including the World Economic Forum, that: "Russia's invasion of Ukraine and sharp reductions in natural gas supplies to Europe are causing significant harm to consumers, businesses and entire economies - not just in Europe but also in emerging and developing economies[...]" (International Energy Agency [IEA], 2022a).

The European Union (EU) has taken immediate attempts in hopes to decrease the reliance on Russian oil and gas exports. One of these measures include a bill recently developed to spend close to 600 billion on grid infrastructure to prepare it for renewables. While Europe's low reliance on fossil fuels and hopeful future for "green energy" has been boasted about, it seems that reality has the last word (Ainger & Nardelli, 2022). The situation is likely to only become more challenging as demand for power increases. Leonhard Birnbaum, president of an electricity industry body by the name of Eurelectric, stated: "the accelerated installation of wind turbines and solar panels across the EU [while it] tries to wean itself off Russian fossil fuels was creating bottlenecks that the grid was not designed to cope with (Hancock, 2022)."

Europe may be less prepared for a wide-scale blackout with the reduction of blackstart resources. As we discussed in the previous article, "When the Grid Goes Down," wind and solar power are unreliable sources to blackstart the electrical grid making Europe's move to green energy sources a potential obstacle for restoration.

Vulnerabilities in the European power grid are apparent in the Central and Eastern region. The political upheaval following the breakdown of the Soviet Union in the late 1980s and early 1990s led to a drastic collapse of their economies, but was followed by a high rate of economic growth from the middle to late 1990s and into the 2000s.

This high rate of economic growth in the late 1990s in the region was not accompanied by significant improvements to the energy efficiency of the production processes and in most Eastern European countries power lines have been neglected for decades (University of Cambridge, 2021). This is in comparison to Western and Southern Europe where the grid is more modern.

Europe's Interconnections

Europe's grid system is made up of 5 synchronous regions. These are Nordic, Ireland, United Kingdom (UK), Continental Europe, and Baltic (European Network of Transmission System Operators [ENTSOE], 2018a). The stabilization of these synchronous links are headed by Regional Coordination Centers (RCC), and Transmission Security Operators (TSO). RCC's are responsible for preparing outage plans, network modeling, adequacy forecasts, capacity calculations, security analyses in regional cooperation and are contracted to provide a regional model of the grid. There are currently 6 RCCs in Europe; Nordic RCC based in Copenhagen,TSCNET Services based in Munich, Coreso based in Brussels, SCC based in Serbia, Baltic RCC based in the Baltics, and Selene CC based in Greece (Nordic RCC, 2022).

Despite their important role, RCCs are not equipped to take direct control of the grid; instead, this remains the responsibility of their owners, the TSOs. There are currently 39 TSOs from 35 countries across Europe that make up the European Network of Transmission System Operators (European Network of Transmission System Operators [ENTSOE], 2021). The TSOs and RCCs both operate in control rooms where engineers work facing a giant screen representing in real-time the power flows between different countries, and other information such as the quantity of wind or solar power produced in a region (European Network of Transmission System Operators [ENTSOE], 2018b).

The main role of RCCs and TSOs within their interconnected region is to maintain the synchronized frequency within that area. An example is The Continental Europe Synchronous Area (CESA), which is the largest synchronous electrical grid in the world, gathering 24 countries and supplying over 400 million customers. The synchronized frequency for CESA must be maintained at 50 Hz which means energy resources and consumption always needs to be balanced across the region (European Network of Transmission System Operators [ENTSOE], 2022).

Recent Disturbances

In recent years, there have been a couple of major power failures in Europe which showcase how vulnerable the grid system can be when a region's electrical frequency is off balance. In January 2021, the CESA grid system separated into two areas; the north-west area and the south-east area. The system separation started from failures at a substation located in Croatia resulting in the tripping of several transmission network elements. This led to a deficit in the north-west area and a surplus of power in the south-east area.

Due to the low frequency in the North-West Area, contracted interruptible services in France and Italy were disconnected in order to reduce the frequency deviation. In addition, supportive power was automatically activated from the Nordic and Great Britain synchronous areas respectively (Novak, 2021). Based on an analysis of the power disruption, some of the overall influences were found to be the warm weather during orthodox Christmas holidays in South-East-Europe as well as a cold spell with high demand in North-West Europe (Derviskadic, 2022).

In 2021, the power generation in Germany could not keep up with energy consumption. As was reported, the demand for electricity in Germany in the early evening of August 14 was around 50 gigawatts. However, the production of solar power, which was still over 30 gigawatts in the afternoon, collapsed to just 3 gigawatts. The network operators had to call up all available reserves, but the output of coal-fired and pumped storage power plants at maximum load was not sufficient. There were also not enough electricity imports available. Therefore the operators had to utilize load shedding that resulted in cutting power off several energy-intensive industrial plants and large consumers without warning (Rudling, 2021). Just like how a lizard sheds its tail when panicked in order to save its life, portions of the grid in the affected region are shut down to save the whole grid from suffering a voltage collapse in vicinal areas. This provides precious time to repair energy infrastructure before resupplying power to the general population.The shutdown lasted over an hour, but load shedding helped mitigate a wider scale blackout.

This can be a difficult process depending on the circumstance. The incident occurred on a Saturday evening, but on a normal weekday when significantly more industrial companies are consuming electricity, extreme measures would have to be taken which would involve separating private households from the grid (Rudling, 2021)

Cyber Attacks

Cyber attacks can also pose risks to grid stability during times of high demand when intentional load-shedding is necessary. This load-shedding process is called, "peak shaving." Peak Shaving allows operators to shift loads in real time when demand spikes and Demand Pricing drives the cost of electricity up (WIlson, 2022). During peak hours when the electricity prices are the highest, attackers may use Load Altering Attacks (LAA), where cyber attackers engage customers' high-wattage appliances in a manner that leads to negative and potentially catastrophic consequences to the power grid. An example we'll use for this scenario is with Electric Water Heaters (EWHs).

The load of domestic EWHs can be used for peak shaving as their ability to store energy in the form of hot water allows shifting their load away from peak-demand hours. Controlling EWHs is done either directly via commands or indirectly using energy pricing signals. During peak shaving, cyber attackers may target the utility's IoT platform, the vendor (or third party) cloud, or the end-user mobile application. One way this infiltration can be accomplished is by using malware delivered through an infected email attachment which would create a backdoor to the infected device allowing the attackers to perform reconnaissance to learn how to communicate with the EWHs participating in peak shaving. (Youssef, Labeau, & Kassouf, 2022).

Simultaneously activating numerous EWHs would create a surge in demand requiring a suitable response by operators in order to contain it and avoid possible complications. According to a 2022 risk evaluation on LAA cyber attacks, "with just 1% increase in power demand, attackers might be able to bring down the majority of a grid of roughly the same size as Canada—by attacking just a few tens of thousands of residential electric water heaters" (Youssef, Labeau, & Kassouf, 2022).

Submarine Cables

European countries depend on each other for energy exports, especially during major failures when a supply of emergency power is needed to stabilize the grid. During the first half of 2022, France, one of the top exporters of electricity, had to source significant amounts from other countries due to issues with its nuclear fleet (Power Engineering International [PEI], 2022). When power is sourced from other interconnected regions, transportation is carried out through subsea cables.

There are over hundreds of subsea cables in operation today, many crossing ocean floors, ranging in length from 50 miles to over 10,000 miles (Tarabay, 2022). These cables supply connected countries with electricity and internet access. The reliance on these undersea cables is evident. According to Datacenter Dynamics, a London-based company that tracks the data center industry, a disruption of this network could impact international financial markets and sensitive national security communications between governments (Tarabay, 2022). The impact from damaged subsea cables are alleviated by their numerosity allowing load to be temporarily carried by an alternate cable until repairment. The use of satellites can also potentially be used in place of subsea cables, but this is only realistic as a short-term solution. Satellites cost more and are generally slower, therefore not all data can be effectively rerouted via satellite (Burdette, 2021; David, 2022).

Subsea cables are not very resistant to physical damage. Cables commonly get impaired by ship anchors, ocean-floor rocks, and other periodic disturbances (David, 2022). Repairs must be made by ships specifically designated for the task. These vessels are custom-built and are limited in supply, making ship sabotage a serious threat to operations. Depending on how deep the cable is submerged, repairs can take hours to days to complete. For one to cut a subsea cable in the water though would require special equipment in order to reach it and damage it. Another vulnerable area would not be out in the ocean, but the cabels' terrestrial infrastructure.

Each subsea cable is trenched on-shore to connect to a landing station. More than one subsea cable may reach the same station, increasing the possibility of a simultaneous cut on links. Many of these facilities lack high security measures that make them susceptible to being targeted by outsiders (Burdette, 2021). Vulnerabilities include direct harm to the landing station, or its main power source. Electrical supply from the grid is necessary to operate the auxiliary equipment and power repeater systems. If shut down, on-site battery backup and generators would be used to mitigate the outage (Department of Home Security [DHS], 2004). Remote management systems within the stations are also vulnerable, and their loss could make cable faults go undetected (David, 2022).

A failure of every landing station would be an obvious near to impossible situation as there are hundreds that exist worldwide, typically built within great distance from one another. Depending upon their criticality level, injury to certain landing points and subsea links could be enough to produce serious consequences. An example is the North Sea Link, put into operation in October of 2021 with enough power to supply 1.4 million British homes.

Cable Landing stations are often not as guarded as they should be.

Some consisting of barbed wired fencing while others not secured by any enclosure

This link is one of the longest underwater cables interconnected between the UK and Norway and is the National Grid's fifth interconnector linking the UK with its European neighbors (National Grid, 2021). Nemo Link, BritNed and Zeus are other critical links to the UK's main importers; Belgium and the Netherlands (Power Engineering International, 2010; Hardy, 2022).

The connection between the UK and Norway is important because the UK uses Norway's hydroelectricity when demand is high and there is low domestic wind generation. This is also true for Germany and the Netherlands (Farmer, 2021; Lawson, 2022). Gas that needs to be burned to replace the inaccessibility of energy resources from other countries such as Norwegian hydroelectricity, reduces the amount of gas that can be stored for winter, the season when energy demand is highest (Lawson, 2022). A cut from hydroelectricity resources could also impede ability to blackstart power grids.

Natural Gas

Due to the recent energy crisis Europe has been facing, the UK planned for possible intentional rolling blackouts in order to conserve the gas and electricity of generators (Evans, 2023). As of 2022, the UK has been able to fill their natural gas storage facilities, but risk of lower gas storage could continue into the next winter as EU gas exports to Ukraine are set to rise this year (International Energy Agency [IEA], 2022b). The UK has been looking at the likes of Norway and Qatar to supply more of their natural gas (Penman, 2022).

The ability to keep up with demand during winter is largely dependent on natural gas storage levels. Natural gas is supplied similarly to subsea cables, but is instead passed through pipelines which reach a gas processing plant and storage reservoirs. These facilities are much more guarded and secured than subsea cable landing stations, but pipelines have been subject to damage before. Several attacks on pipelines directed at their aboveground shut-off valves have been reported by acts of vandalism through the use of high powered rifles (Edmonton Journal, 2014; Bismark, 2017). Some of these attacks turned out unsuccessful because they were carried out when the sites were not in operation.

Similar to hydropower in which reservoirs are filled during spring to be used during summer, natural gas is stored up over the summer to be withdrawn during the winter (Natural Gas, 2013). In the early winter a failure would not have as much of an impact on energy supply since storage is usually filled and gas pipelines are not operating. During replenishment in the early summer injury on natural gas infrastructure or the systems it depends on could produce severe consequences.

The operation of natural gas infrastructure is reliant on the detection of failures which are alerted from monitoring systems.These are designed to prevent further damage through automatically engaging the emergency shut off valves on each pipeline. Sensors run all the way along the length of the pipeline and must be constantly checked to secure safe flow rates, pressure levels and temperatures (Comtrol, 2023). Without the access to these systems, failures could go unnoticed or be harder to locate and operations would be hampered. The data is assessed within a control center that has the capability to monitor a vast network of piping reducing a need for manual assessments on foot (Next Industries, 2022). This creates a risk of cyber security attacks which can threaten the functionality of these control centers.

Other resources for energy are used as an alternative to natural gas such as Liquified Natural Gas (LNG). LNG has to be cooled to change into a liquid. Instead of being shipped through pipelines, it is transported in tankers onboard ships. The United States is one of the main exporters of LNG (Stapczynski, 2023). It goes without saying that a blackout in the United States would carry consequences onto European countries as well.

Conclusion

The European interconnection is extensive, and while this can make it intimidating it can also become one of its greatest weaknesses. The quick exchangement of resources between countries is vital to their stability. While there is more to touch on when it comes to Europe's grid system, we provide some of its most vulnerable points:

- Renewables. Europe's move to green energy to meet their "net zero" goals carries vulnerabilities to its grid infrastructure. Wind and Solar energy are inefficient means for blackstarting the power grid. Countries such as the UK, Germany, and Netherlands use Norway's hydroelectricity as a power source in times of high demand or low wind generation. Without access to hydropower, blackstart capabilities would be reduced.

- Subsea cables. The transportation of electrical power to other European regions is done through cables that run across the ocean to a landing station. Damaged cables in the ocean must be repaired by cable repair ships. Terrestrial infrastructure is also vulnerable to on-land destruction to the landing stations or exposed cables.

- Gas Storage. The storage of natural gas during the summer is essential for use in winter when electricity demand is at its peak. Natural gas is transported through pipelines connecting to a gas processing plant and storage reservoirs. An inflicted disruption to the natural gas process while pipelines are operating could pose significant consequences.

- Data systems. A cyberattack on grid control systems or high-wattage appliances can increase power demand bringing about major outages. The natural gas transportation process relies on remote monitoring systems located at control centers. Without access to that data, damages to pipelines can go undetected.

There are technologies put into practice with every passing decade which adds resilience to the electrical grid. With systems set in place to thwart the natural collapse of the grid, it would take multiple unnatural and unprecedented failures in order to bring about a full collapse of our technological society.

In shorter words, the grid will not destroy itself.

INTO THE MOUNTAINS

By FOREST ANON

"Into the Mountains"

A cold wind cut through my jacket and needled its way down to the bare ribs underneath. The foothills on either side of the lone twisting highway were straw-colored chaparral reminiscent of Hollywood westerns, and a characteristic feature in this region of the United States. Cider tones of dead cheatgrass and buckwheat, accented with silver hues of manzanita, basin sage and brittlebrush. The fragrant scent of artemesia mingled with the bitumen odor of damp asphalt swept through the chill air around me. Bare and leafless sycamores mantled the sides of the arroyos below, exposing the cliffside walling me out of the forest beyond.

I'd been walking along the canyon roads since sunrise making sure to pace myself so I wouldn't sweat through my layers, when something caught my attention. I scrambled off the asphalt, down the dirt embankment in its direction and hit the bottom of a willow-choked ravine below the highway. After some bushwhacking I encountered the thing I had spotted. It was a deep fissure in the rock about four feet wide, veiled behind tall thickets of brush. I could see it fractured the cliff in two, in turn offering a possible entrance up into the forest. I plowed through the sagebrush and crawled my way underneath tangled masses of scrub-oak. Upon reaching the narrow crevice I began a slow ascent.

Once on top of the divide I was greeted by a wilderness vista. The view on the other side was a network of pine-stubbled canyons and gullies that formed a lattice of wrinkles in the mountainsides, sloping their way up to the gray sky like crow's feet before tapering off below the foggy peaks. I picked a shady gorge and descended across a little valley to a larger canyon that opened up as I got closer, where a trickle of stream water gurgled out and percolated back into the mud. The smell of the wet soil and reedy banks settled my nerves for a moment and I continued up stream into the gorge, letting my eyes adjust to the shadows. The sun would set in a couple of hours but darkness would fall much sooner inside here.

It had been a full day of rambling along the highway. I planned to pitch my tent once I created some distance between myself and the mouth of the gorge, and could afford settling down for the night. After a couple of miles and veering off into a series of smaller gullies and channels I found a grassy shelf on a hillside above another creek, where I dug a hole for one of my food supply caches and set camp. The cache was a two-gallon pickle jar filled with smoked sausage, pasta, canned ham, rice, matchbooks, lighters, crank chargers, a flashlight and a few pairs of socks and underwear. I had three other caches tied to my pack that I would be burying along the route, but first I'd eat and get a good night's rest.

The woods grew dark. I ate my meal cold, climbed out of my boots and crawled in to the tent. The goal: bare simple minimalism, and to feel closer to the wildlife. The plan: hike as far back into the mountains as I could reasonably go in order to avoid detection, find the perfect spot (ideally atop a spur with a view of the desert below, and above water to stay clear of any sudden flash floods), build a tiny one-room trapper's tilt and scatter as many caches of food around the mountains as I could beforehand so that I would have a decent supply to get me through winter. When spring came I'd get some gardens going and forage around the woods, canning anything I could find. After harvesting the gardens I'd hike out to the highway for a week, and maybe try to offer temporary work on some of the ranches and orchards that lay a good fifteen miles near the outskirts of a few little farming communities. A pretty straightforward and realistic blueprint, in my eyes at least.

People dream differently. And there isn't a reason in the world reasonable enough to ignore something that's calling you. Sure we can be easily mislead by our dreams. But if it makes sense, if it builds you into something better, if it's not hurting anybody, if it polishes your character and satisfies some kind of lifelong itch in the sole of your foot and the sole of your soul then why not go for it. So far dreaming's not against the law yet. As long as your dreams don't interfere with somebody else's you should get up and go.

Who cares if they get crushed and mangled and broken. Gather up the peices and see what you can make out of every splintered fragment and particle you've got left. I always felt the point of our existence is to find what drives us, and let it drive us all the way, until we learn to love the road so much we ditch the car altogether and start walking just to feel closer to it. That's what it means to me at least. I can't speak for others. Wouldn't want to.

I was so exhausted with the days of traveling and searching around for an area to permanently call home that I fell asleep on top of my sleeping bag, only to wake up a few hours later when an icy gust of wind leaked through the tent's zipper and brushed the open blisters on my bare feet. I groaned and crawled into the bag, falling back asleep fast. Just before dawn I awoke — clenched my toes and limped down to the creek for a drink. This wasn't the first canyon-system I tried. I had done an exploratory on two others when I arrived the day before; the first one had many trees but no water, the second had plenty of water but little tree cover. This canyon with its mix of Douglas firs, gray pines and canyon oak, and the way it shed tears of fresh water in all directions made it the most favorable attempt yet.

I rested the first day and let my blisters dry. The second day I meandered up the canyon and deeper into the mountains looking for areas to bury the other three caches, while at the same time keeping an eye out for promising hills to explore. On the third day I began hiking up the fir covered slopes in search of a good spur to live on. My neck was stiff from constantly looking up at the mountain sides, and not only from scanning them for a spot, but because there was something to see in every direction. Bright green lichen hung suspended in snarled bunches that poured from the branches overhead, woodpeckers hammered away and dark-eyed juncos kicked around frantically in the duff. It was a religious experience. And that initial search for a place to pick, knowing you have whole entire mountain ranges to carve your own little place in the universe out of — that's the feeling of a different kind of freedom, of square one, of the new beginning I had always dreamed of.

I spent a week probing the mountains looking for a spot. I found a few promising clearings high up the canyonsides but they were to steep to confidently build anything on. One of them I named "Stump Overlook", and had journaled the moment I found it:

December 8th, 2018

"Found a new favorite spot today! I'm sitting on a steep hillside overlooking a ravine full of pines. Beautiful grasses and huge pines. Naming it 'Stump Overlook' after a large mossy Douglas fir stump that marks the clearing. Would be perfect to live on if it was more level. Still thinking of breaking ground here."

(Later in 2020 the wildfire would rip through the forest and turn Stump Overlook into a heap of ash. The mossy stump I named it after no longer exists.)

Five days after the initial discovery of Stump Overlook I found the place I would call home indefinitely:

December 13th, 2018

"Higher up from Stump Overlook you start to get beautiful panoramas of the desert beyond the forest. Clouds are dark and heavy today. The wind whips the mist past the ridges up here. Found a perfect spot that levels out enough to build. Dug the foundation."

It's one of the only places on this hillside that briefly flattens out into a twenty square foot shelf of livable space. The area is shaded by an overhang of oaks, whiskered with gray pines and Douglas firs that open into two small clearings on either side giving you a view of the desert and forest below. From the moment I discovered it I began digging a level spot for my tent, and immediately got to work. Each morning was spent hiking the hillside in search of the large lower limbs these firs shed as a way to defend themselves from wildfire climbing up into their crowns.

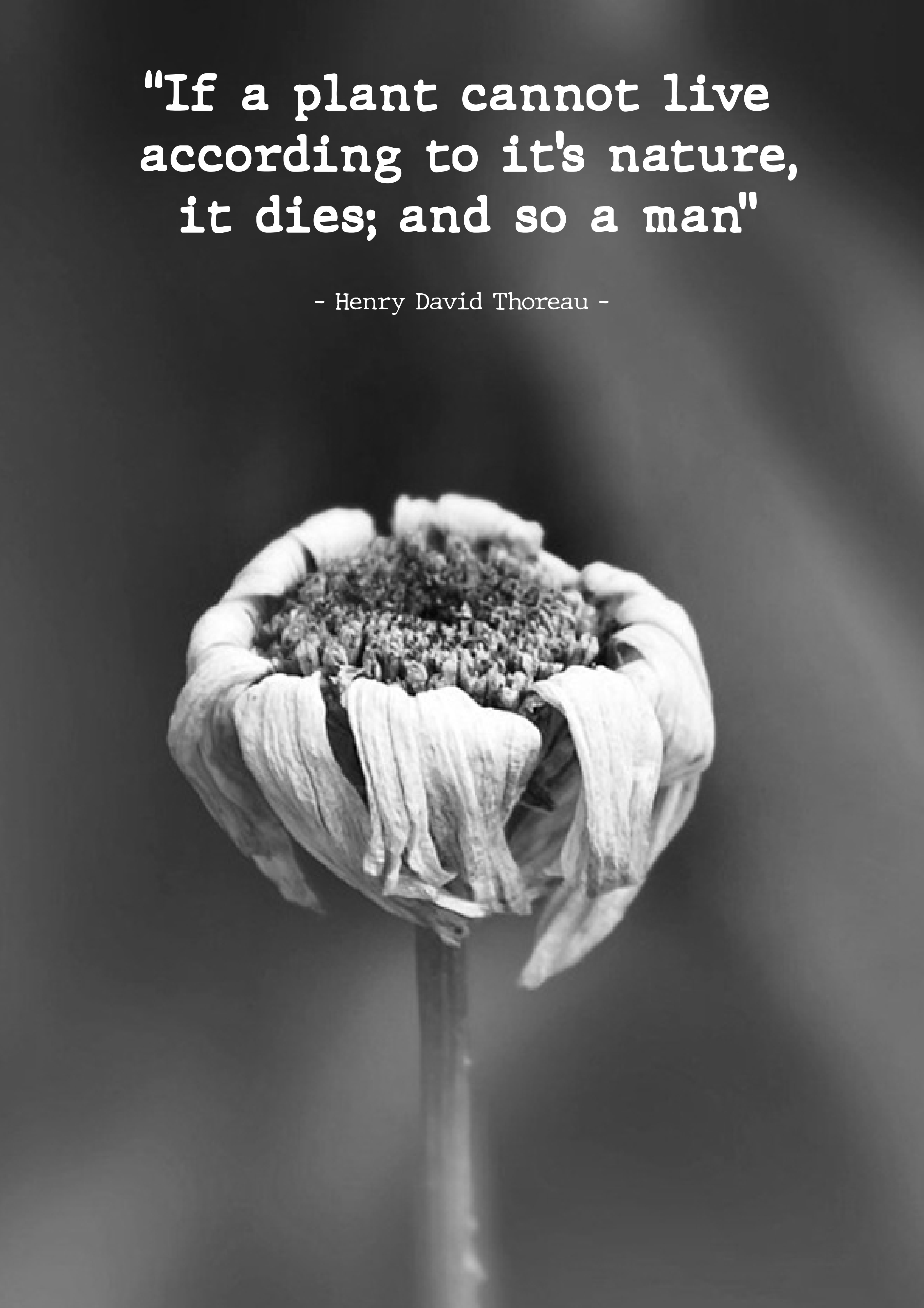
Each day was spent tying them into bundles and bringing them back to the area where I would saw them into their appropriate sizes. I found two large Douglas firs that had been felled by the high winds up here and I called them my "lumberyards". The shack's walls were made by sinking four posts for each one — two on either side — and then stacking the shoulder-thick chunks of wood between them, letting them cinch together underneath their own weight.

The storms began to roll in and I'll never forget when I saw the first rainfall from up here. You can walk out to the meadow on the side of the mountain and watch veils of downpour traveling over the top of the forest in large slow-moving curtains. I strung up a tarp for a workstation and had a fire each night to dry my clothes, but remained constantly wet as long as I wasn't in my tent or sleeping bag.

With the walls up I used large branches for cross beams, to serve as poor-man's rafters. I stretched a tarpaulin for the roof and one for the door, finally keeping the rain out and allowing the dirt floor to eventually dry. A mouse came in seeking shelter and I would catch glimpses of it darting its way around the structure. After installing some shelves I hung my hammock inside, then I finally broke the tent down and moved in. A few nights went by of sleeping in the hammock, I built a comfortable enough cot by smoothing out five boughs and tying them together, then securing them across two microwave-sized stones I had carried over from one of the meadows. From an abandoned camper in the foothills that now served as a shooting target for bored off-roaders and tourists I salvaged a rusty cast-iron pot that became my stove and fire pit. I had hiked out and gone back to the junk heap to acquire a five gallon water jug, extra rope and an assortment of other containers from there as well. I calculated the trip there and back as taking a total of two days so I didn't want to do that very often. Once back at the shack I added a stone floor, and my feet finally thawed enough to feel completely comfortable for the first time in over a month and a half.

It was a pearl-gray January morning when I noticed the clouds sweeping across the peaks had a strange look to them. They were frost-colored boiling masses that cast dark shadows over the entire forest, and morphed in lumbering psychedelic movements that took on new shapes and came in faster than I had ever seen clouds travel. I hadn't experienced a snowstorm before, but for the first time in my life, alone in a rugged little shack I was about to.

First it rained — then it rained harder. The wind picked up and grew violent, freezing the raindrops into ice crystals and blasting them against the door like buckshot. When the snow began to fall I hurried outside and fell to my knees, digging up three food supply caches I had buried underneath the shack. I retreated back inside, secured the door flap tight, lit a few candles and waited in my sleeping bag for what was about to come. Terrified and unsure in the dark windowless hut I began recalling the whole entire journey that had led me to this very moment.


"If a plant cannot live according to it's nature, it dies; and so a man"
- Henry David Thoreau -

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