Smart Grid Security—Attack and Defense Strategems

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# Introduction (*Heading 1*)

# Smart Grid Attacks

## False Data Injection

In our first attack, we look both conceptual research and current impacts in violations of integrity. Integrity is defined as the manipulation of data either by a malicious adversary or an error-producing source that compromises the authenticity of information that can be gained from the data. In networks protocol design, some protocols use checksums or error correction codes in order to prevent or fix integrity violations. Unfortunately, only one power substation protocol, DNP3, gives any kind of integrity checking with checksums [DNP3 Primer], but DNP3 is not as widespread as other, more insecure protocols like BACnet or Modbus. Today, most power substation setups utilize these insecure protocols as minimal as possible and only in machine-to-machine networks.

However, the Smart Grid aims to ubiquitous and secure across its realms. Therefore, new problems arise while implementing past-day solutions. An adversary might not have access to all parts of the Smart Grid, he or she can attack either at the top at the power generation realm or at the bottom at the distribution, end user, or service provider. Therefore, making use of either the top or bottom might compromise the other. By injecting integrity violations, the adversary can push incorrect data that will affect operations and lead to issues in power delivery service.

### Integrity violation via calculations

With respect to integrity violations, Mrabet et al. [Mrabet] describe the *false data injection attack*. In the scope of the Smart Grid, false data injection is typically implemented at the bottom realms of power distribution, end user networks, and the service provider. By influencing the calculations on the metrics of power consumption, an adversary violates the integrity of the data and ensures a false result once the metrics reach to the SCADA core. Specifically, Liu et al. [Liu et al.] give the calculation of state estimation as describe by the linear regression model:

By impacting values in z to find an attack vector, the estimation function H can be altered and produce a false result of the estimate. Liu et al. also debunk previously stated beliefs that an attacker would need a substantial probability to find an attack vector to compromise the network. In the experimental evaluation, the attacker only needs a 20 percent chance of random false data injections before the attack vector is found. A sample setup of this attack can be modeled by an attacker having access to a variety of RTUs or parts of the AMI such as a smart meter for a house. The formation of the state estimation for Smart Grids is primarily used as the basis for modeling an Intrusion-Based Detection System (IDS).

### Integrity violation via hardware

Along with the manipulation of data via software inferred calculation, an integrity violation with easy accessibility to the attacker is found in the smart meter devices themselves as a part of the Smart Grid. An article written by reporter Brian Krebs informs of widespread hacking of smart meter devices in Puerto Rico [Krebs]. Puerto Rico is among one of many locations around the world that have implemented smart meter infrastructure due to natural disasters destroying the infrastructure. In Puerto Rico, some citizens have modified their smart meters to cut off metrics being sent back to the public power utility, PREPA. As a result, the FBI claims 400 million US dollars will be lost in the long term.

Halim et al. [Halim] give a review of various hardware hacks that can implemented on smart meters [Halim]. Smart meter infrastructure, just like the rest of Smart Grid components, are still early in their development and deployment, but still ship with hardware vulnerabilities. First off, smart meters come without any encrypted or obfuscation of memory locations. Therefore, it is easy to get memory readouts via the pins connecting the devices and inject data to cause integrity violations. Another method is simply unplugging the meter’s metric connection or placing a strong magnet on the meter—the technique used in Puerto Rico. No data at all still means disruptions of power consumption. Whole communities within the end user realm could use these techniques which are highly incentivized by the financial gain and highly accessible due to rise of a technology-savvy generation.

### Preventing false data injections

By the Smart Grid’s own interconnectedness, false data injection can cause widespread disruption in the network. As mentioned before, the calculation for state estimation is typically used for modeling an IDS. The solution proposed by current research involves various algorithms that try to decrease the number of false positives while maintaining true negative accuracy. Chen et al. [Chen et al.] tries a machine learning approach that differs in the traditional statistical-based IDS. The authors formulate a consistent-inconsistent region to measure how much of a grid is reliable or not. Then, each state and its neighbor in a set is compared by trust-based voting to see if their state estimations are reliable. Finally, elements are targeted as “Good”, “Abnormal”, and “Unknown” if they fall into the consistency region or not.

In experimental evaluation, this method proved to produce false-positive rates two-thirds lower than the next best algorithm. It also provides configurable regions to let end users decide on­ how reliable they want the algorithm to perform. Various improvements can be made by strictly checking the “Unknown” components. According to the solution, “Unknown” components are caused when there is not enough data on state estimations to say a neighbor is reliable or not. Data-sparse regions in the Smart Grid are plentiful in more rural areas or places with poor data connection. If the solution is to be made for real-time correlation, some development in data-sparse areas should be considered, perhaps even utilizing data from the previous statistical-based models if applicable.

For the issue of hardware violations, it is representative of the more “security through obscurity” problem largely present in the current power generation grid. Mandatory requirement for future standard IEC 62056-21 should be implemented across the Smart Grid which includes simple passwords, encrypted passwords, and handshaking to smart meters. Future specifications of the standard should include higher cryptographic protocols. The meters themselves should be secured based on a minimal set of requirements to delay tampering or notifying the end user or power company.

## Popping the HMI

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*a**b* 

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* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

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1. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
2. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
3. K. Elissa, “Title of paper if known,” unpublished.
4. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
5. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
6. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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