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# Novel Evasion Attacks against Adversarial Training Defense for Smart Grid Federated Learning

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**ABSTRACT** In the advanced metering infrastructure (AMI) of the smart grid, smart meters (SMs) are deployed to collect fine-grained electricity consumption data, enabling billing, load monitoring, and efficient energy management. However, some consumers engage in fraudulent behavior by hacking their meters, leading to either traditional electricity theft or more sophisticated evasion attacks (EAs). EAs aim to illegally reduce electricity bills while deceiving theft detection mechanisms. The current methods for identifying such attacks raise privacy concerns due to the need for access to consumers' detailed consumption data to train detection mechanisms. To address privacy concerns, federated learning (FL) is proposed as a collaborative training approach across multiple consumers. Adversarial training (AT) has shown promise in countering evasion threats on machine learning models. This paper, first, investigates the susceptibility of traditional electricity theft classifiers trained by FL to EAs for both independent and identically distributed (IID) and Non-IID consumption data. Then, it investigates the effectiveness of AT in securing the global electricity theft detector against EAs, assuming no misbehavior from the participant consumers in the FL process. After that, we introduce three novel attacks, namely *Distillation*, *No-Adversarial-Sample-Training*, and *False-Labeling*, which can be launched during the AT process to make the global model susceptible to evasion at inference time. Finally, extensive experiments are conducted to validate the severity of these proposed attacks. Our findings reveal that the AT can counter EAs effectively when the FL participants are honest, but it fails when they act maliciously and launch our attacks. This work lays the foundation for future endeavors in exploring additional countermeasures, in conjunction with AT, to bolster the security and resilience of FL machine learning models against adversarial attacks in the context of electricity theft detection.

**INDEX TERMS** Security, Evasion attacks, Federated learning, and Smart power grid.

## I. INTRODUCTION

The integration of communication and computing resources in the smart grid has brought about a significant transformation in traditional power delivery methods [1]. By employing various techniques to gather, process, and manage information, the smart grid has greatly improved the intelligence of power systems, leading to enhanced efficiency, reliability, sustainability, and cost-effectiveness [2]. A crucial element of the smart grid is the Advanced Metering Infrastructure

(AMI), which enables real-time monitoring of electricity consumption through communication between the electric utility (EU) and smart meters (SMs) installed at consumers' houses. This functionality enables dynamic billing, load monitoring, and grid management, granting greater control and optimization of the power systems [3].

Despite the numerous benefits associated with smart grids, they encounter various challenges, one of which revolves around the problem of electricity theft. This occurs when

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