Energy theft is a notorious problem in electric power systems, which causes great economic losses and threatens the reliability of the power grid. Recently, the Smart Grid has been proposed as the next-generation power system to modernize the current grid and improve its efficiency, sustainability, and security. Key technologies of the Smart Grid include smart meters, which allow system operators to collect real-time power consumption data from users, and microgrids, which allow users to own and control renewable resources. However, the Smart Grid is vulnerable to cyber attacks, thus making stealing energy much easier in it. Most existing energy theft detection schemes require the collection of real-time power consumption data from users, i.e., users' load profiles, which violates their privacy. In this paper, we first propose a centralized energy theft detection algorithm utilizing the Kalman filter, called SEK. It can efficiently identify the energy thieves but cannot protect users' privacy. Then, based on SEK, we develop a privacy-preserving energy theft detection algorithm called PPBE, which privately finds the energy thieves by decomposing the Kalman filter into two parallel and loosely coupled filters. Finally, we conduct thorough privacy analysis and extensive simulations to validate our proposed algorithms.