Non-technical loss detection at unregistered points in power distribution systems

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Non-technical loss(NTL) is the result of illegal human activity i.e. theft of electricity. It can lead to hazardous operation and unnecessary financial losses. Through advanced metering infrastructure(AMI), customers registered by the utility equipped with smart meters provide measurement data in 15 minute periods. This can be then used for NTL diagnostic purposes utilizing machine learning, hardware development or model based methods. [1] However illegal activity can happen between registered points, where no direct measurement data is available. Model based methods are as good as the developed model, however AMI enables to obtain a higher fidelity model regarding line parameters. [2] In this paper a model based method is presented for the detection of NTL between unregistered points. Taking the graph representation of the distribution system, there are feeder buses, distribution line edges and registered consumer buses. If the power balance equation doesn't hold, it can be concluded that there is unaccounted power loss in the network. By taking the power measurements, conducting load flow analysis and comparing the measured and calculated voltage levels, the fault can be isolated. [3] Unregistered NTLs are characterized by having two registered neighbouring buses. The NTL lies on the connecting edge between these two buses, however the location and the fault magnitude is unknown. An extended network model is introduced by cutting up distribution line edges according to a division point, and inserting hypothetical illegal consumers. The task is to determine the set of division points and faulty consumptions, which reproduce the measured voltage levels at the registered points. This is formulated as a non-linear optimization problem. Solution is achieved through a novel two stage genetic algorithm(GA), where in the first part the NTL currents, then the division points are taken as fixed values. However, by extending the whole distribution network, the search space becomes enormous. Therefore, a search space reduction technique is proposed based on the idea of discrete convolution. A subset of the power flow equations is derived, which evaluates a local neighbourhood for unregistered NTL. This local evaluation is then shifted through the whole network, taking locations out of the picture which contain no fault. Finally, the GA based non-linear optimisation method is used for finding the appropriate division points and fault magnitudes. At least the method is illustrated through a simulation case study using the IEEE European Low Voltage Test Feeder network.

References

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