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Impact Analysis of Penetration of Induction Stoves on Distribution System: A Case Study of Nitanpur Feeder

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Abstract
Massive and sudden penetration of induction stoves in feeder results in degradation of power quality such as power loss and voltage drop. So, integration of induction stoves must be encouraged only after strengthening the power distribution infrastructure in order to ensure secured, safe and reliable power quality and security of power distribution network. This study investigates the impact of integrating induction stoves in 11 kV Nitanpur feeder under 132/11 kV Parwanipur substation through using CYME distribution software. The feeder is of radial nature with 3.7 kilometer length comprising of Dog and Weasel conductor. It has 1425 number of consumers and consists of 29 private and 9 public transformers. At base case the feeder was observed to be overloaded from substation to Chattapipra Chowk and minimum voltage recorded was 10.38 kV at yearly peak of 366 A and all public transformers were overloaded at evening peak of 333 A with total loss of 208.18 kW. Mitigation to existing feeder was given by running Dog conductor parallel to existing conductor from substation to Chattapipra chowk and upgrading all residential transformers to higher capacities which reduced power loss to 110.27 kW from 208.18 kW. Load flow was done for different level of penetration and optimum penetration level was found to be 10% which means 143 number of consumers can use induction stoves contributing 7.83 kW additional loss to the feeder. Consumer of class A can make saving of NPR 491 per month and consumer from class B can make saving of NPR 298 per month if consumers shift from LPG gas to induction stoves.

Keywords
Penetration Level, CYME

1. Introduction

There is huge opportunity to switch into modern, safe and efficient cooking technologies such as induction stoves and reduce the consumption of traditional source of energy with regard to the policies and objectives set by government. Nepal has set its internal targets of increasing electricity access to 99% and reducing use of firewood to 10% in order to coordinate in achieving goal number 7 of Sustainable Development (2015-2030). Budget speech of F/Y 2022/23 has launched 'Quit Liquefied Petroleum Gas (LPG)-Connect Electricity Campaign' aiming the promotion of modern energy technologies to substitute the daily energy requirement for cooking purposes from traditional means of cooking providing access to around 100 thousand households by subsidizing electricity consumption and reducing subsidy on LPG gas [1]. Alternative Energy Promotion Centre (AEPC) has promoted the use of induction stoves through its Programme. Cooking using induction stove is cheaper, easier and safer compared to LPG cook stove if the energy consumption is less than 300 kWh [2]. Cooking by induction is both faster and more efficient than gas cooking [3]. Induction stoves for cooking is more cost-effective than using LPG burners in various circumstances [4]. The study on impact of integrating induction cooker of 1500 Watts in Nagarkot feeder has concluded that optimum penetration level up to 25% of total peak load can be given by DG integration of 5965 kVA at 0.8 power factor lagging contributing an active power loss of 530 kW. Maximum penetration can be done up to 40% of total peak load by adopting bundling technique contributing power loss of 477.7 kW [5].

2. Methodology and Methods

2.1 Methodology

The methodology of study begins with identification of problem after intense literature review. The base case load flow was done taking yearly peak loading of 366 A and evening peak loading of 333 A from substation. Two types of consumer group were observed class A: consumer group using 10 LPG cylinders and remaining maize stem, firewood for cooking purpose per year and class B: consumers group using 6 LPG cylinders and remaining maize stem, firewood for cooking purpose per year. It is considered to use 2000 W induction stove taking reference of induction stove distributed by AEPC under Clean Energy Programme.

2.2 Methods

The tool used here is CYMDIST due to its superiority on other available methods for distribution system.

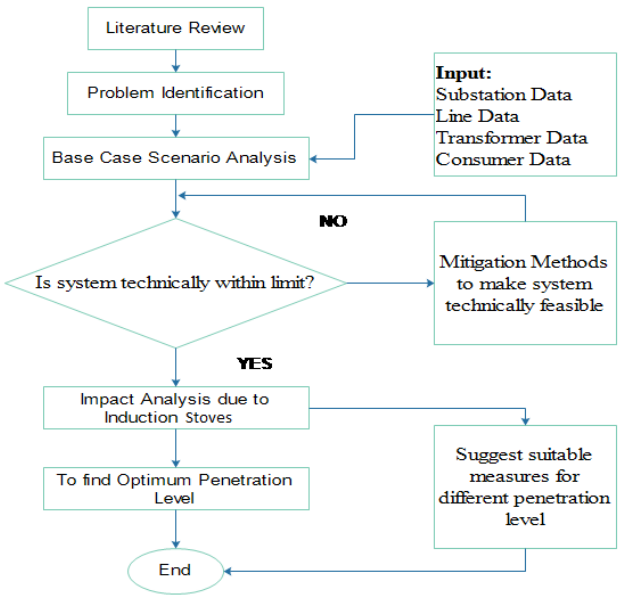

Figure 1: Flow chart

3. Results and Discussion

3.1 Base Case

Base Case load flow shows an overloading of conductor from substation to Chattapipra Chowk and overloading of all public transformers. This makes impossible for penetration of induction stoves in feeder. So, mitigation to the existing feeder was given by running Dog conductor parallel to existing conductor from Substation to Chattapipra Chowk and upgrading all public transformers to next higher sizes. The mitigation resulted in reduction of power loss to 110.27 kW from 208.18 kW and all electrical parameters within permissible limit.

3.2 Penetration of Induction Stoves

Load flow was performed in the mitigated model with different penetration level in steps of 10%. At 10% penetration no violation was observed for any electrical parameters. However, at 15% penetration 4 public transformers out of 9 transformers were found to be single phase overloaded out of 3 phases. So, optimum penetration was found to be 10% which means 143 number of consumers can use induction stoves. Additional loss contributed by induction stoves at 10% optimum penetration is 7.83 kW. The penetration of 15% can be ensured after phase balancing the same transformers. In order to ensure 20% penetration it is required to upgrade 6 public transformers out of 9 transformers whose payback period is 4.72 years for the investment made on upgradation. Above 20% penetration almost all public transformers are overloaded and required transformer capacities seem unrealizable in the existing distribution system.

4. Conclusion

Existing condition of feeder makes impossible for induction stoves penetration but after running Dog conductor parallel to the existing conductor from substation to Chattapipra Chowk and upgrading public transformers to higher sizes eliminated the overloading of conductor and transformers and reducing power loss to 110.27 kW from 208.18 kW thus providing scope for induction stoves penetration. Optimum penetration level was found to be 10% which means 143 number of consumers can use induction stoves. The payback period for recovering investment made on infrastructures to ensure 20% induction stoves penetration is 4.72 years. Consumer of class A can make saving of NPR 491 per month and consumer from class B can make saving of NPR 298 per month if consumers shift from LPG gas to induction stoves.

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