

**CONSUMER'S PURCHASE DECISION OF
ELECTRICALLY EFFICIENT CEILING FANS USABLE
WITH BIODIESEL GENERATOR**



By

S. FARHAD HASSAN

IJAZ AHMAD

UMARA AJAZ

Department of Earth and Environmental Sciences

Bahria University, Islamabad

2015

ABSTRACT

Globally, the inevitable issue of energy crisis is increasing day by day, adversely affecting the environment and its inhabitants. As a result of industrial revolution and population growth, there has been a colossal rise in the worldwide demand for energy in recent years. In such circumstances where the demand of energy is high but resources are meager, the need of hour is to explore and utilize such renewable energy resources which will not impose a negative impact on the environment as well as on energy sources upon its conversion. The main impetus of this research study is to emphasize the significance of energy-efficient ceiling fans operated with renewable energy source such as biodiesel. In order to support the research study, perception of both household consumers and commercial area retailers were collected. This study assisted to attain a broader view of people's awareness on the benefits of using such fans and whether they are willing to purchase such products functioning on biodiesel if knowing its cost-effectiveness and positive influence on the environment. Interview sessions were held with retailers and NGO's to gather views on energy-efficient fans and consumer buying behavior. Also lab work was conducted in order to extract biodiesel from waste animal fats and plant oil for use in biodiesel generator to operate ceiling fans during load shedding. The results achieved illustrated a diverse response from both respondents; household consumers were observed to be grey consumers as their purchasing decision was more associated with their own economic feasibility as compared to environmental stability, whereas commercial area retailers proved to be green consumers as environmental aspects had more significance to them than self-benefits received from such fans. Similarly animal fat and plant oil both have great potential to produce biodiesel but according to the results achieved from lab work, it has been observed that only chicken oil displayed a positive result by producing 75% biodiesel. On the contrary, both animal fat and plant oil showed negative results in yielding biodiesel due to lack of equipment facilities to properly carry out the experiment.

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent, the Most Merciful. All praises to Him for the strength and blessings endowed upon us in completing this thesis.

We are indebted to our supervisor Dr. Humera Farah, Associate Professor, Department of Earth and Environmental Sciences, Bahria University Islamabad, for her supervision and constant support. Her invaluable help of constructive comments and suggestions throughout the research works have contributed to the successful and timely completion of this research study. We would like to thank Dr. Muhammad Zafar, Head of Department Earth and Environmental Sciences, Bahria University, Islamabad for his kind attention and guidance.

Last but not least, our deepest gratitude goes to our beloved parents, and siblings for their constant support, prayers and encouragement.

ABBREVIATIONS

ENERCON National Energy Conservation center

BRESL Barrier Removal to the Cost-Effective Development and Implementation of Energy Efficient Standards and Regime

UNDP United Nation Development Program

PSQCA Pakistan Standards and Quality Control Authority

NGOs Non-Governmental Organizations

MW Mega watts

EPA Environmental Protection Agency

CI Compression-ignition

EPAct Energy Policy Act

ECRA Energy Conservation and Reauthorization Act

GHGs Green House Gases

ASTM American Society for Testing and Materials

NaOH Sodium hydroxide

KOH Potassium hydroxide

CO₂ Carbon dioxide

kVA Kilo-volt-ampere

AEDB Alternative Energy Development Board

PSO Pakistan State Oil

PMY Pipri Marshalling Yard

NUST National University of Science and Technology

MeOH Sodium methoxide solution

FAME Fatty acid methyl ester

rpm Revolution per minute

CONTENTS

ABSTRACT.....	i
ACKNOWLEDGEMENT	ii
ABBREVIATIONS	iii
CONTENTS.....	v
FIGURES	viii
TABLES	x

CHAPTER 1 INTRODUCTION

1.1 Energy issues in the World	1
1.1.1 Energy efficient fans in the World.....	1
(a) Energy labeling and its criteria.....	1
(b) Biodiesel generator to run these fans in World.....	1
(c) What is biodiesel	2
(d) Properties of biodiesel.....	2
(e) Sources of biodiesel	3
(f) Formation of biodiesel.....	3
(g) Variables affecting the transesterification reaction.....	4
(h) Advantages of biodiesel over petro-diesel	4
(i) Consumer awareness and decision making.....	4
1.2 Pakistan energy crisis.....	6
1.2.1 Power shortage and load shedding.....	6
1.2.2 Current usage of fans in Pakistan.....	7
1.2.3 Current diesel generator usage in Pakistan	7
1.3 Energy efficient fans concept in Pakistan.....	8
1.3.1 ENERCON and its activities.....	8
1.3.2 BRESL and its activities	8
(a) Energy efficient standards/Eco-labels	9
1.3.3 Manufacturing of energy efficient fans.....	10
(a) Availability of materials	11
1.4 Biodiesel generation in Pakistan.....	11

1.4.1 Current status of biodiesel generation in Pakistan	11
(a) Pakistan State Oil company limited	11
(b) Private sectors involved in production of biodiesel	12
(c) Various feedstock's availability for biodiesel production in Pakistan	12
(d) Difficulties in commercializing of biodiesel.....	12
1.5 Biodiesel generators options for various sectors	12
1.6 Objectives of study	13

**CHAPTER2
DATA COLECTION**

A. Primary data	14
2.1 Energy efficient and labeled fans.....	14
2.1.1 Consumer awareness and purchasing of such fans	15
2.1.2 Questionnaires	15
(a) Sample size	16
(b) Participants of survey	16
I Consumers	16
2.1.3 Interviews.....	16
(a) Sample size.....	16
(b) Interview guide	16
(c) Participants of interviews	16
i Retailers	16
ii Government organization (ENERCON).....	16
iii NGO (the consumer network)	17
2.2 Assessing mixtures of various feedstock's for biodiesel production	18
2.3 Cost analysis of biodiesel production	20
B Secondary data.....	21

**CHAPTER 3
RESULTS AND DISCUSSION**

3.1 Energy efficient and labeled ceiling fans as option for Pakistan: Stakeholders view .	22
3.1.1 Household Consumers view	25

3.1.2 Consumer area analysis	45
3.1.3 Retailers (Hamdan Electronics) interview's result	53
3.1.4 Government organizations	56
(a) ENERCON (BRESL project)	56
(b) Alternative Energy Development Board (AEDB)	59
3.1.5 The consumer networking.....	60
3.1.6 Fan manufacturers.....	63
3.2 Assessment of biodiesel from various feedstock's	63
3.2.1 Biodiesel production from animal fats.....	63
(a) Single animal fats	64
(b) Mixtures animal fats.....	68
3.2.2 Biodiesel production from non-edible plant feedstock's	71
3.2.3 Cost analysis of biodiesel for animal and plant feedstock's	73
3.2.4 Cost analysis of biodiesel for chicken fats.....	74
3.2.5 Environmental benefits of biodiesel production	77
(a) Carbon dioxide emission reduction	77
(b) Negative environmental effects.....	77
3.2.6 Comparison of study results with previous work	77
3.2.7 Research limitations.....	78

CHAPTER 4

COCLUSIONS &RECOMMENDATIONS

4.1 CONCLUSIONS.....	80
4.2 RECOMMENDATIONS	82
REFERENCES	84
Appendix 1	87
Appendix 2	92

FIGURES

Fig. 1.1: Chemical reaction of methyl ester.....	3
Fig. 1.2: Consumer awareness and decision making.....	5
Fig. 1.3: Pakistan energy label.....	10
Fig. 2.1: Data collection flow chart.....	14
Fig. 2.2: Biodiesel formation.....	17
Fig. 2.3: Biodiesel transesterification.....	17
Fig. 3.1: Frequency of purchasing ceiling fan.....	25
Fig. 3.2 Purchasing motive.....	26
Fig. 3.3: Product characteristics influencing purchasing decision.....	27
Fig. 3.4: Pre-purchase preferences.....	28
Fig. 3.5: Product guidebook.....	29
Fig. 3.6 Impact of brand name.....	30
Fig. 3.7: Influence of product advertisement on purchase decision.....	31
Fig. 3.8: High voltage consumption by removed brand.....	32
Fig. 3.9: Copper wiring in fan energy consumption to silver wiring.....	32
Fig. 3.10: Reliability of energy labeling.....	33
Fig. 3.11: Environmental impacts of energy efficient fans.....	34
Fig. 3.12: Willingness to purchase energy-efficient fans.....	35
Fig. 3.13: Willingness towards biodiesel conversion to reduce environmental impacts generated from petro-diesel.....	36
Fig. 3.14: Willingness to spend on biodiesel.....	37
Fig. 3.15: Factors preventing biodiesel adoption.....	38
Fig. 3.16: Preference for biodiesel adoption over petro diesel despite its high cost.....	39
Fig. 3.17: Quality of ceiling fan material.....	40
Fig. 3.18: Willingness to buy energy-efficient fans despite high cost.....	41
Fig. 3.19: Ceiling fan durability.....	43
Fig. 3.20: Frequency of generator usage.....	44
Fig. 3.21: Daily average diesel fuel consumption.....	45
Fig. 3.22: Pre-purchase preferences.....	46

Fig. 3.23: Product guidebook.....	47
Fig. 3.24: Influence of product advertisements on purchasing decision.....	48
Fig. 3.25: Copper wiring fan energy consumption in comparison to silver wiring.....	49
Fig. 3.26: Reliability of energy labeling.....	50
Fig. 3.27: Willingness to spend on biodiesel.....	51
Fig. 3.28: Factors preventing biodiesel adoption.....	51
Fig. 3.29: Frequency of generator usage.....	52
Fig. 3.30: Daily average consumption of diesel fuel.....	53
Fig. 3.31: Separation of layers.....	66
Fig. 3.32: Biodiesel.....	66
Fig. 3.33: Formation of soap and glycerin.....	67
Fig. 3.35: Biodiesel from mixtures of feedstock's.....	70

TABLES

Table 1.1: Properties of biodiesel and petro-diesel.....	2
Table 1.2: Production and voltage variation in various types of fans.....	7
Table 1.3: Purchase cost of diesel generator.....	8
Table 2.1: Biodiesel blend with petro-diesel.....	21
Table 3.1: Demographic profile of respondents.....	22
Table 3.2: voltage variation in various types of fans.....	54
Table 3.3: Melting temperature, time and yield of oil from different types of animal fats.....	63
Table 3.4: Formation of sodium methoxide solution for various animal fats.....	64
Table 3.5: Transesterification of various animal samples.....	65
Table 3.6: Ester yield from various animal fat samples.....	65
Table 3.7: Formation of sodium methoxide solution for mixture of animal fat.....	68
Table 3.8: Transesterification of mixture of animal fat samples.....	69
Table 3.9: Ester yield from mixture of chicken and sheep fat samples.....	70
Table 3.10: Formation of sodium methoxide solution for non-edible plant oil.....	72
Table 3.11: Transesterification of various plant samples.....	72
Table 3.12: Quantity and cost of selected animal waste fats.....	73
Table 3.13: Quantity and cost of selected non-edible plant oils.....	74
Table 3.14: Quantity and cost of chemicals.....	74
Table 3.15: Yield of oil from chicken fats.....	74
Table 3.16: Quantity and cost of chicken waste fats.....	74
Table 3.17: Quantity and cost of NaOH.....	74
Table 3.18: Quantity and cost of methanol.....	75
Table 3.19: Production of biodiesel.....	75
Table 3.20: Total initial cost per liter of biodiesel.....	75