ENERGY SAVING POTENTIAL OF
CEILING FAN-ASSISTED AIR CONDITIONING
IN TROPICAL CLIMATES

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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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ABSTRACT

The cost of air conditioning in tropical climates makes the biggest contribution to the energy bill in most domestic, commercial, and industrial settings. Improving the air circulation and thereby enhancing the thermal comfort of occupants pave the way to running the air conditioners (AC) at a higher temperature setting, which leads to lower power consumption. Accordingly, this research examines whether ceiling fan-assisted air conditioning systems can reduce the energy required for cooling in tropical environments.

The research is primarily based on field studies and was conducted in a typical office space in Kankesanturei, Sri Lanka, which has a year-round tropical climate with high temperatures and high levels of humidity. The office room is air-conditioned with a window-type AC, and air circulation is provided by a ceiling fan. 50 participants with almost identical clothing were selected. Testing was conducted for different AC temperature settings and different speed settings of the ceiling fan. Wind speed, temperature profiles within the room, and corresponding energy consumptions were recorded. Thermal sensation feedback from participants was also obtained via a questionnaire for each operating condition. Measurements and participant feedback were analyzed, using established ASHRAE standards to rate the thermal comfort level.

According to the findings, utilizing ceiling fan-assisted AC can result in a reduction in energy usage of up to 40% (depending on the AC type, temperature setting, and the nature of the occupants). As a result of the improved airflow generated by the ceiling fans, the hybrid system provides superior thermal comfort at moderate fan speeds. This is because the increased air movement improves air circulation and reduces temperature stratification within the room. Accordingly, this research highlights the potential benefits of adding this combined system to building design and HVAC system selection, providing significant information for building designers.

Keywords: Fan assisted AC, Thermal Comfort, Air Conditioner, Ceiling Fan, Office buildings.

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I.E. Tennakoon

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LIST OF ABBREVIATIONS

Abbreviation	Description
AC	Air conditioner
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
HVAC	Heating and Ventilation Air Conditioner
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
CAPEX	Total cost of a building for financing and constructing
OPEX	Total cost of a building for financing and constructing
FS	Fan speed
NF	No fan operating
TEMP	Temperature
MRT	Mean radiant temperature
EER	Energy Efficiency Ratio
SEER	Seasonal energy efficiency ratio
COP	Coefficient of performance
TOE	Ton of oil equivalent
NZEB	Net Zero Energy Building
AM	Tropical monsoonal
POE	Post-occupation evaluation
RETs	Renewable energy technologies
GHG	Greenhouse gases
BMS	Building management systems
IAQ	Indoor air quality
BIPV	Building-integrated photovoltaics
TPES	Total primary energy supply
ODSM	Operation Demand Side Management

Nomenclature

C_p	-	Specific heat of air, J/ (kgK)
f_{cl}	-	Ratio of clothed surface area to nude surface area of human body
h_c	-	Convective heat transfer coefficient, W/(m^2K)
I_{cl}	-	Thermal resistance of clothing, m^2K/W
K	-	Thermal conductivity of air, W/(mK)
M	-	Heat generation rate -Metabolic, W/m^2 of area of the body
m	-	Water vapor Concentration, kg/kg of mixed air
p	-	Pressure, Pa
p_w	-	Water vapor Partial pressure in moist air, Pa
p_{ws}	-	Saturated water vapor Pressure, Pa
RH	-	Relative humidity
T	-	Temperature, °C
T_a	-	Mean air temperature, °C
T_r	-	Mean radiant temperature, °C
R_{cl}	-	Thermal resistance of clothing, m^2K/W
R_{cl}	-	Thermal resistance of clothing, m^2K/W
v	-	Mean speed of air relative to the body, m/s
V	-	Air speed, m/s
W	-	External work, W/m^2 of naked body area
ρ	-	Density of air, kg/m^3