Quantifying residential hot water production savings by retrofitting geysers with air source heat pumps

University of Fort Hare

Institute of Technology

Presenter: Stephen L. Tangwe

Co-author: Michael Simon

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MOTIVATION

❖ Inefficient geysers remain South Africans' most popular and conventional modes of hot water production, and hence an urgent need of alternative technologies.

❖Today, the air source heat pump (ASHP) water heater is used in the residential sector as a renewable and energy efficiency technology for sanitary hot water production.

❖In a bid to avoid constraint on the national grid during peak hours, Eskom targeted rolling out more than 65 580 ASHP up to March 2013 under a residential rebate scheme.

❖Need of real time data of the COP of an ASHP water heater, as any reliable simulation application to compute savings will depend on accuracy of measured data employed in the algorithm.

INTRODUCTION

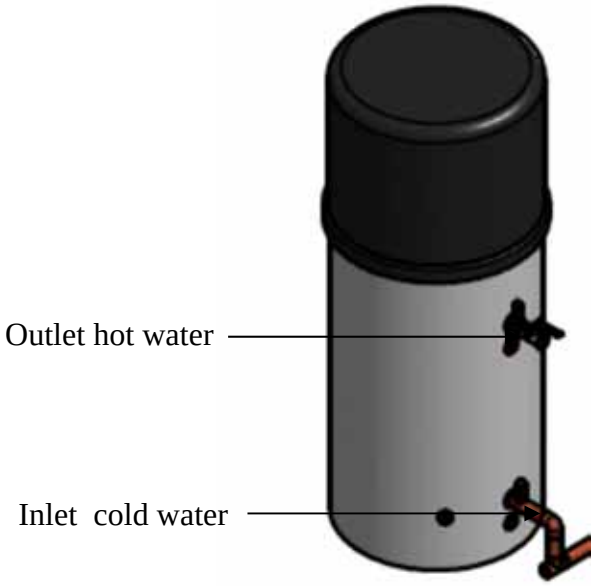
❖ Eskom is the sole supplier of electricity in South Africa; more than 90% is generated from coal.

❖ The global warming potential because of greenhouse gasses, primarily carbon dioxide, is 510 million tons of which 45% emanates from the generation of electricity from coal.

❖Sanitary, water heating in SA is the largest residential use of electrical energy with up to 50% of monthly consumption used for this purpose.

❖It is worth mentioning most hot water devices are traditionally convectional heater (electric geysers) with an average energy factor of 0.92

INTRODUCTION



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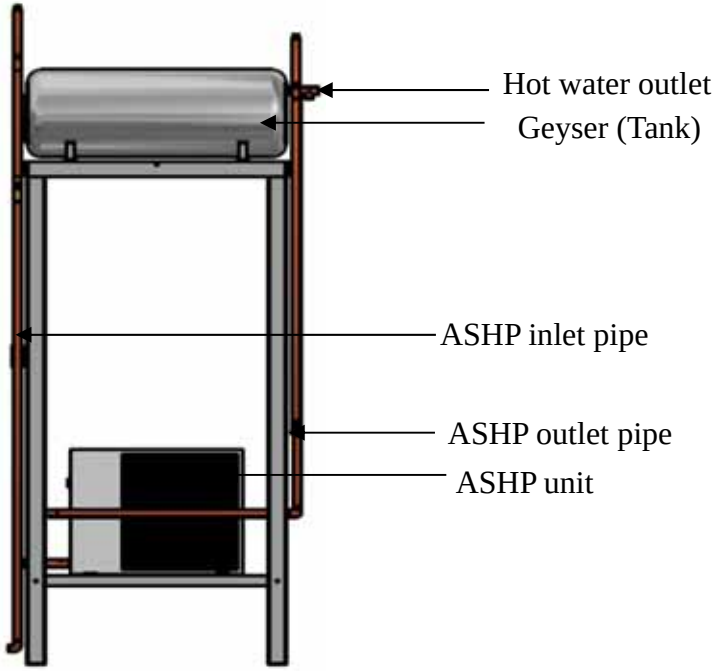

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OBJECTIVES

- To designed and built a data acquisition system for the study.
- To determine the coefficient of performance and the power factor of the ASHP water heater using empirical formulation.
- To show that by retrofitting geyser with ASHP, electrical energy consumption from sanitary hot water production can decreased by more than 50%.
- To determine the amount of aero-thermal energy extracted based on the temperature difference between the warm air in the vicinity of the evaporator and the cold, dehumidified air expelled from the duct space.

METHODOLOGY

The method is broken down into three sections:

- The experimental setup of the data acquisition system.
- The empirical calculations of the coefficient of performance and the power factor.
- The potential electrical energy savings due to the implementation of the ASHP as a retrofits to the geyser.

Technologies in use and the DAS

Power track analyzer

T-VER-E50B2 meter

U30-NRC datalogger

Input pulseadapter

Designed and built DAS

RESULTS AND DISCUSSION

❖ Average week performance for the technologies

Table: Maximum demand and load factor

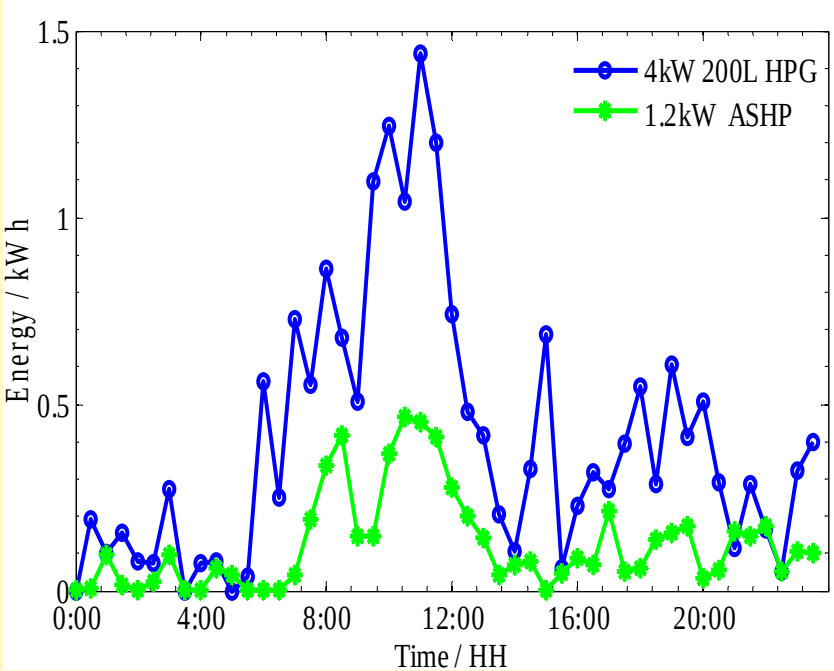
Day	High pressure geyser		ASHP water heater	
	Max p /kW	LF	Max p /kW	LF
Mon	4.00	0.19	1.63	0.12
Tue	3.93	0.18	1.50	0.12
Wed	3.86	0.18	1.45	0.15
Thur	3.93	0.19	1.49	0.19
Fri	3.96	0.22	1.43	0.23
Sat	3.89	0.25	1.44	0.18
Sun	4.00	0.22	1.45	0.20
AW	3.94	0.20	1.48	0.17

Table : Consumption for system/building

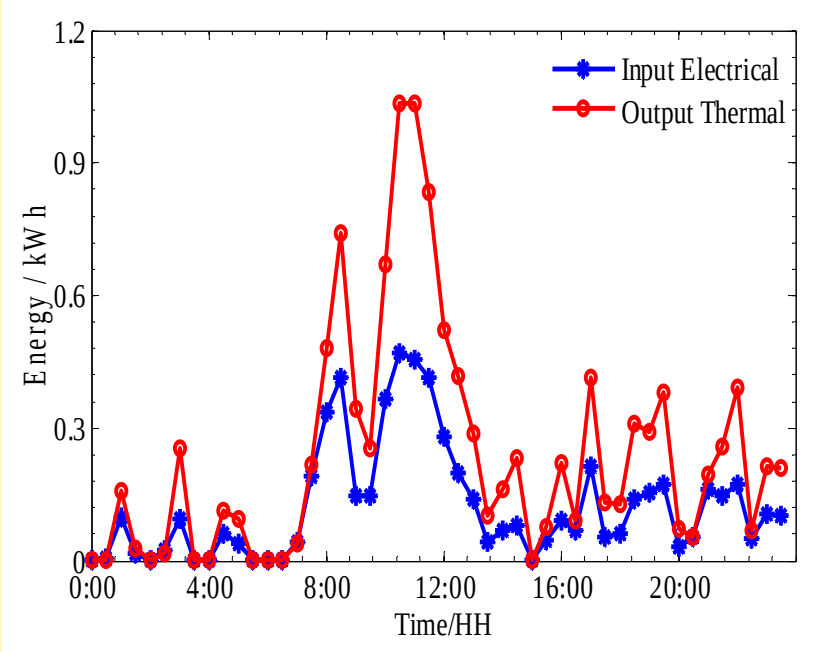
Day	System	Vd L	Es kWh	Eb kWh
Mon	HP geyser	257	18.8	30.5
	ASHP water heater	216	04.4	16.9
Tue	HP geyser	306	17.0	28.4
	ASHP water heater	204	04.3	15.3
Wed	HP geyser	269	16.7	27.7
	ASHP water heater	264	05.1	20.7
Thur	HP geyser	288	18.3	29.5
	ASHP water heater	348	06.9	18.3
Fri	HP geyser	344	21.3	35.9
	ASHP water heater	390	07.9	20.7
Sat	HP geyser	378	23.2	39.4
	ASHP water heater	363	06.4	21.2
Sun	HP geyser	375	21.6	34.5
	ASHP water heater	276	07.0	22.5
AW	HP geyser	316	19.6	32.2
	ASHP water heater	290	06.0	19.4

RESULTS AND DISCUSSION

- Average week consumption by systems and entire building



- System average week electrical and thermal energies



RESULTS AND DISCUSSION

❖ Determination of COP of the ASHP water heater and energy factor

Day	Es kWh	TE kWh	Ec kWh	Vd L
Mon	4.5	9.8	0.05	215
Tue	4.3	9.5	0.05	204
Wed	5.1	10.3	0.05	264
Thur	6.9	14.6	0.04	348
Fri	7.9	15.1	0.05	390
Sat	6.4	13.1	0.04	363
Sun	7.0	14.1	0.03	276
AW	6.01	12.46	0.04	290

❖Determination of extracted aero-thermal energy by the system

Day	Pa kW	Es kWh	TE kWh	AT °C	RH %	Tw °C	Tc °C	Qa kWh	COP
Mon	1.40	3.96	9.60	19.5	51.3	18.3	14.6	5.64	2.34
Tue	1.41	3.84	10.0	19.7	70.0	19.0	15.5	6.16	2.36
Wed	1.39	4.64	10.0	18.9	73.6	18.2	14.8	5.36	2.27
Thur	1.38	6.35	14.0	17.0	67.9	16.7	13.4	7.75	2.17
Fri	1.38	7.20	14.4	15.0	76.0	14.7	11.9	7.20	2.11
Sat	1.36	6.00	12.9	17.5	73.5	16.7	13.6	6.90	2.11
Sun	1.38	7.56	15.8	21.4	39.3	20.1	16.2	8.24	2.17
AW	1.39	5.65	12.4	18.4	64.5	17.6	14.3	6.75	2.20

❖ If conserved annually, would result in total energy saving of 2457.0 kWh, CO_2 pollution reduction of 2360000 kg and water saved of 3440 L.

CONCLUSIONS

From this study's results one could affirm that an ASHP water heater was an energy efficient technology for sanitary hot water production compared to a convectional high pressure geyser.

ASHP water heater excellent performance credits is attributable to a small load factor and low energy consumption of the system during the heating cycles.

COP was also impacted by the ambient temperature and relative humidity and in spite of the lower ambient temperatures during the VCRC, the system COP were more than 2.

Based on the energy saving, it is worth retrofitting geysers with ASHP in homes where usage of daily sanitary hot water exceeded 200 L.

THANK YOU

For your kind attention!!!