SUSTAINABLE HAMMAMS

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01

BACKGROUND

Climate change is no longer some far-off problem; it is happening here, it is happening now

- Barack Obama

What is a Hammam?

The Hammam is Morocco's traditional public bathhouse. It serves as a cultural cornerstone, providing services not only for the physical act of cleaning, but also for social interactions and religious purposes. It used to be that homes in Morocco had no access to running water, so families would have to visit the Hammam for sanitary purposes, but even today many Moroccans visit the Hammam at least once of week, especially on Thursdays or Friday mornings, to cleanse themselves before prayer.

THE PROBLEM

DEFORESTATION

The Hammam industry is a leading cause of deforestation in Morocco.

POLLUTION

Burning wood releases CO_2 into the atmosphere, which diminishes the ozone layer.

WATER SCARCITY

Morocco is considered a water scarce country, regularly experiencing severe droughts.

DESERTIFICATION

Mass clearing of vegetation mixed with Morocco's dry climate increases the risk of soil degradation resulting in an arid landscape.

HEALTH RISKS

The combustion of wood emits harmful toxins into the air, threatening surrounding communities.

ENERGY EFFICIENCY

Inefficient lighting methods contribute unnecessarily towards operation costs.

OUR SPONSOR: RIBAT AL-FATH

Association Ribat Al-Fath is a Moroccan NGO focused on promoting sustainable living while fostering Moroccan culture and heritage.

02 METHODOLOGY

PROJECT GOAL

To make recommendations to Association Ribat Al-Fath to aid in the creation of more sustainable management methods for Hammams in Morocco

OBJECTIVES

GATHER

Understand the financials and resource management of Hammams throughout Morocco

01

SYNTHESIZE

Model and quantify the sustainability of the heating systems in Hammams

02

DELIVER

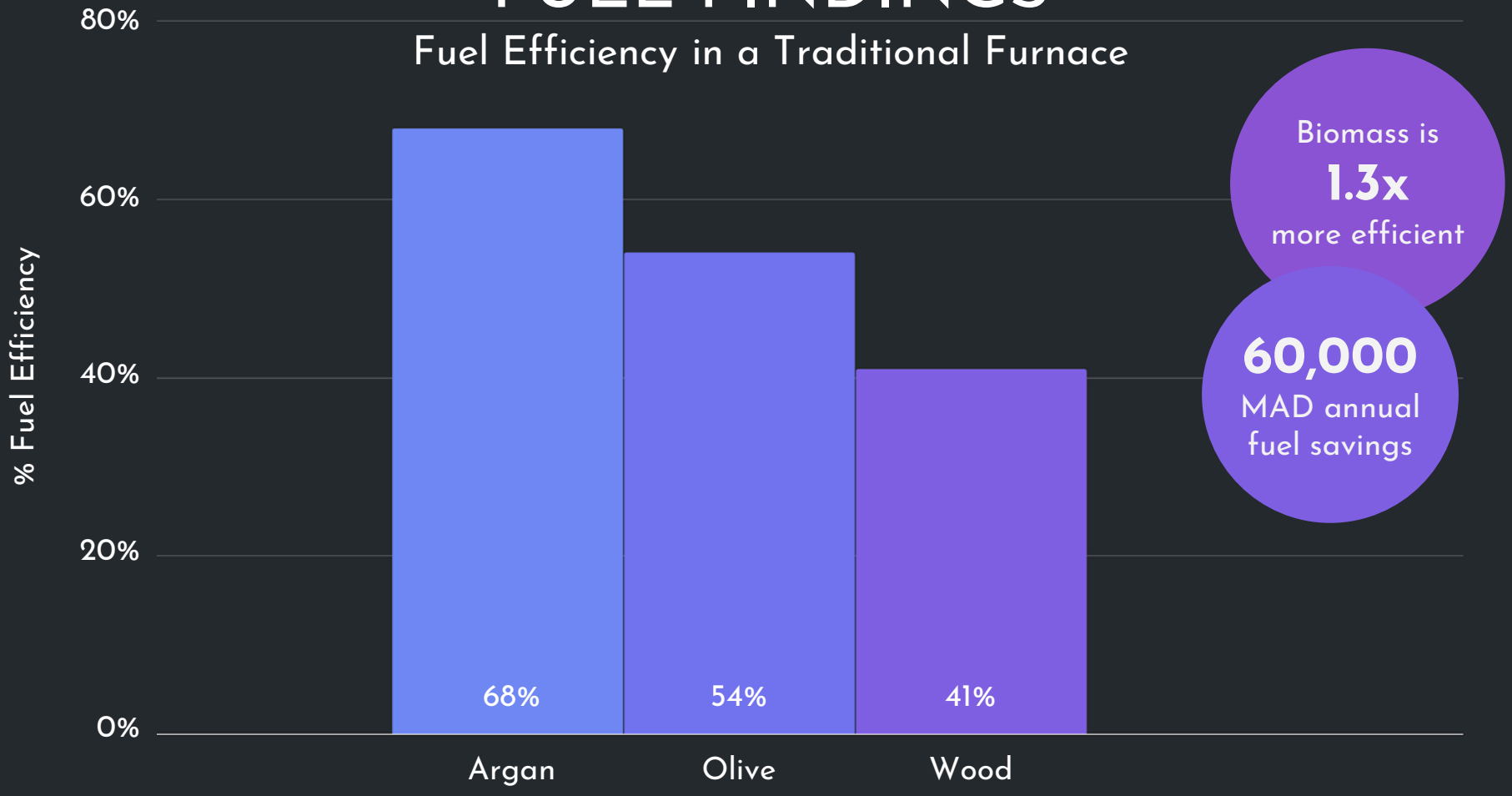
Prepare recommendations for guiding Hammams towards more sustainable operations

03

03

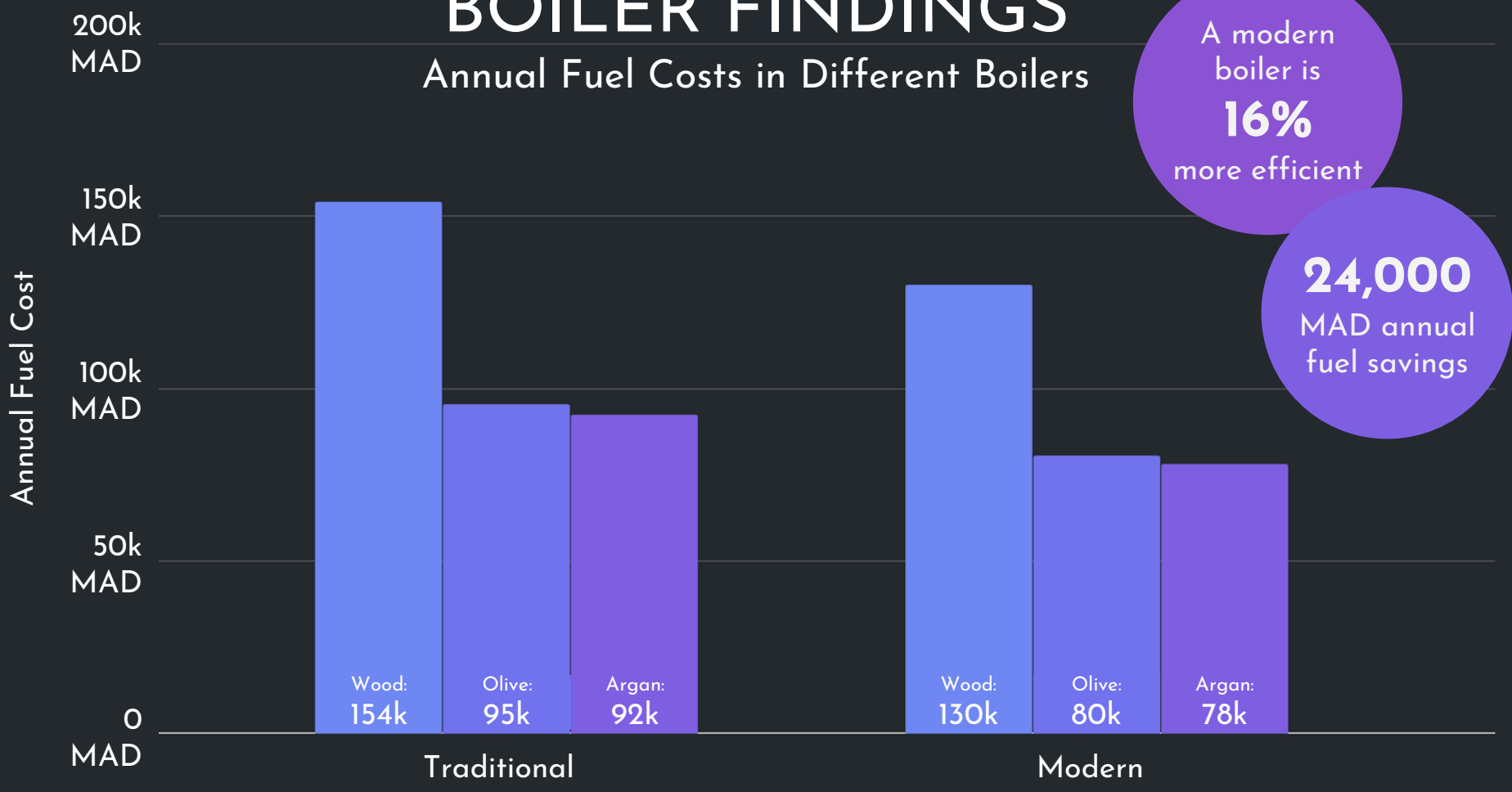
FINDINGS & ANALYSIS

FUEL FINDINGS



BOILER FINDINGS

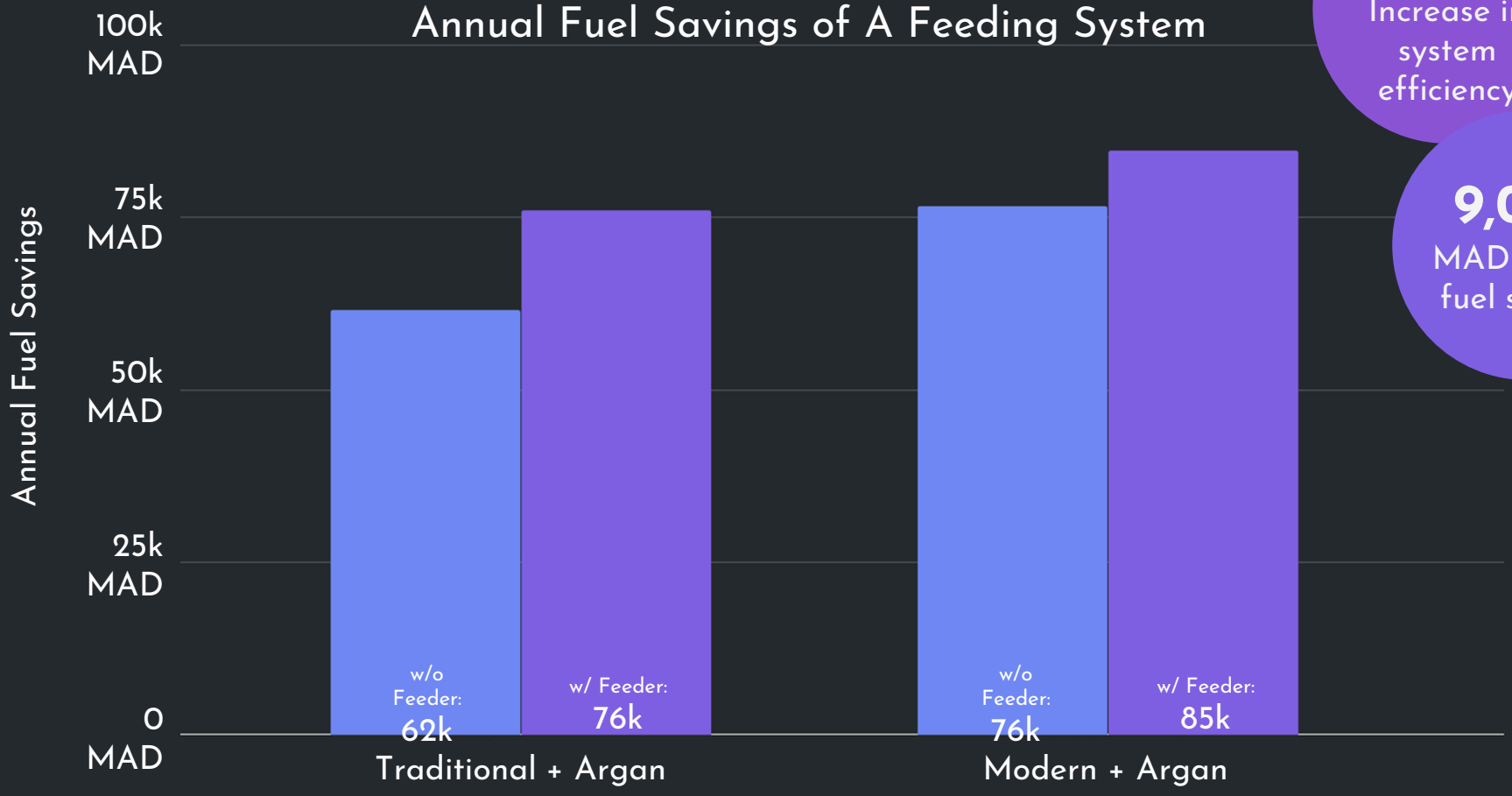
Annual Fuel Costs in Different Boilers



A modern boiler is **16%** more efficient

24,000 MAD annual fuel savings

FEEDER FINDINGS



10%
Increase in system efficiency

9,000
MAD annual fuel savings

04 RECOMMENDATIONS

#1 Switch to a Biomass fuel in place of wood

Biomasses are organic byproducts repurposed as fuel. Pictured we have a bucket of argan shells but other options such as olive pomace exist. Regardless of which biomass is used, biomasses prove to be a cheaper and more efficient fuel, while also diminishing smoke and ash production.

#2 Upgrade from a traditional furnace to a modern boiler

Boilers use significantly less fuel to produce the same amount of energy, making for a more efficient system. The investment of 100,000 MAD ($10,000 USD), has a return rate of only 3-5 years. Solar water heating is another good option, and is extremely cost efficient. This can be done by distributing the water supply throughout an array of glass pipes exposed to the sun.

#3 Implement an automatic feeding system

Based on our data, the implementation of an automatic feeding system, like the one pictured, improves boiler efficiency by 50% and system efficiency by 10%. It also creates a much safer environment for employees, because it removes the need the open the door of the boiler and fuel the fire directly.

Implementing biomass, a modern boiler, and a feeder all together will double the overall system efficiency.

#4 Use proper storage methods for fuel to increase efficiency

Proper fuel storage assures that moisture and other unwanted substances do not contaminate the fuel, which is crucial because contaminated fuel will burn less efficiently and produce more ash and smoke. Fuel should be stored in waterproof bags or containers in a separate, dry, ventilated area away from the boiler.

#5 Install a water mixing system to reduce clientele water waste

Typically water has to be mixed manually by customers to reach the right temperature, which is often a very wasteful method. By using a system that mixes hot and cold water from the system before it reaches the faucets, water can instead be dispensed at the ideal bathing temperature. This could also be accomplished by adding a control system for the boiler which stops heating the water as soon as it has reached the desired temperature.

#6 Utilize light diffusion domes to improve natural daylighting, and switch to LED bulbs

Hammam owners could replace skylights with glass light diffusion domes, which provide more light into the hammam and reduce the need for electric lighting. A solar panel system could also be used to power LED light bulbs at night when natural light is no longer available. These actions together could effectively eliminate lighting electricity costs.

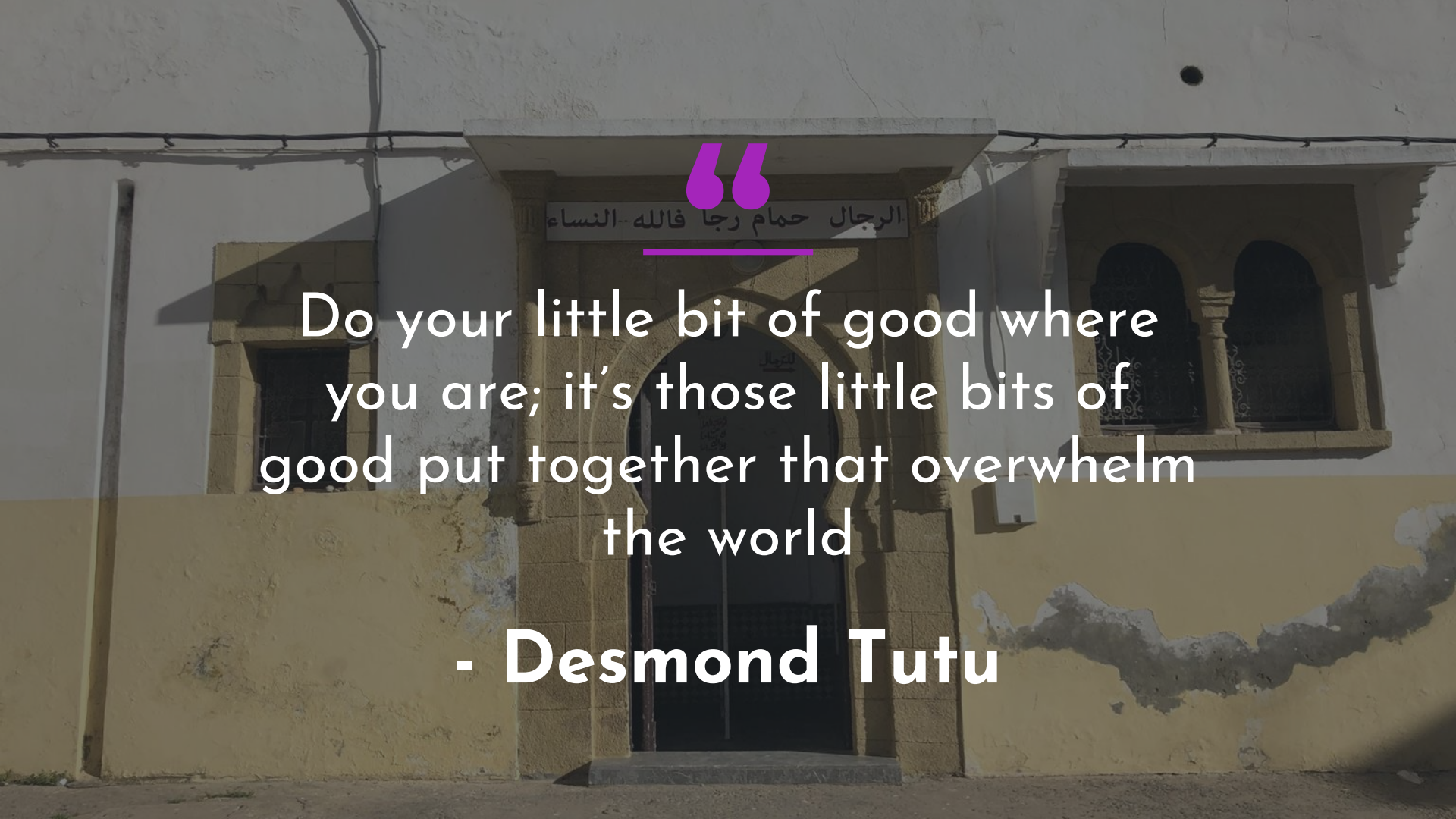
#7 Modernize Hammam management methods

1. Implement tracking systems to provide Hammam owners with accurate economic and utility usage data.
2. Provide safety equipment for Hammam employees.
3. Implement educational programs in local vocational schools to train professionals to provide system maintenance to specialized Hammam equipment.
4. Promote environmental awareness amongst Hammam owners and advocate for improvements with an informational video.

05 CONCLUSION

The Intersection of Science and Society

Climate change is not an issue any individual person, corporation, or nation can solve. However, here in Morocco, we have an instance where small, directed actions in the Hammam industry create a real environmental impact while also meaningfully benefiting the economy, on both a micro and macro scale.



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Do your little bit of good where you are; it’s those little bits of good put together that overwhelm the world

- Desmond Tutu

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ENERGY BALANCE SHEET

Boiler Type	Traditional	Modern	Fuel type	Wood	Argan Shells	Olive Pomace
% Energy Captured	0.675	0.8	Caloric Value (kJ/Kg)	23012	20630	22500
% Energy lost	0.325	0.2	% Energy Potential	0.6	1	0.8
			% Energy Lost	0.4	0	0.2

Boiler Type	Traditional			Modern		
Fuel	Wood	Argan Shells	Olive Pomace	Wood	Argan Shells	Olive Pomace
Usuable energy from fuel (kJ/Kg)	13807.2	20630	18000	13807.2	20630	18000
Energy lost from fuel (kJ/Kg)	9204.8	0	4500	9204.8	0	4500
Energy lost by boiler (kJ/Kg)	4487.34	6704.75	5850	2761.44	4126	3600
System Energy Output (kJ/Kg)	**9319.86**	**13925.25**	**12150**	**11045.76**	**16504**	**14400**
System Efficiency %	**0.405**	**0.675**	**0.54**	**0.48**	**0.8**	**0.64**
System Efficiency with feeding system %		**0.805**	**0.67**		**0.9**	**0.74**
System Energy Output with feeding system (kJ/Kg)		**16607.15**	**15075**		**18567**	**16650**

Hammam Energy Requirement (kJ)	9319860

Boiler Type	Traditional			Modern		
Fuel	Wood	Argan Shells	Olive Pomace	Wood	Argan Shells	Olive Pomace
Weight of fuel to supply energy (Kg)	1000.0000	669.2778	767.0667	843.7500	564.7031	647.2125
Weight of fuel to supply energy with feeder (Kg)		561.1956	618.2328		501.9583	559.7513514

Boiler Type	Traditional			Modern		
Fuel	Wood	Argan Shells	Olive Pomace	Wood	Argan Shells	Olive Pomace
Weight for 1000 kJ (Kg)	0.1073	0.0718	0.08230452675	0.0905	0.0606	0.0694
Weight for 1000 kJ with feeder (Kg)		0.0602	0.0663		0.0539	0.0601

Boiler Type	Traditional			Modern		
Fuel Type	Wood	Argan Shells	Olive Pomace	Wood	Argan Shells	Olive Pomace
efficiency vs Traditional wood no feeder		1.494147981	1.303667652	1.185185185	1.770842051	1.545087587
efficiency with a feedrer vs Traditional wood no feeder		1.781909814	1.617513568		1.992197308	1.786507523

ECONOMIC BALANCE SHEET

Clientelle Per Year
30,000

Cost of Wood + Traditional Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	41%	527.6509386	MAD	422.12	MAD	12,663.62	MAD	154,074.07		

Cost of Argan + Traditional Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	68%	316.5905632	MAD	253.27	MAD	7,598.17	MAD	92,444.44	MAD	61,629.63

Cost of Argan + Traditional Boiler + FS (MAD/Kg		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	81%	265.4641368	MAD	212.37	MAD	6,371.14	MAD	77,515.53	MAD	76,558.55

Cost of Olive + Traditional Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.66	54%	395.738204	MAD	261.19	MAD	7,835.62	MAD	95,333.33	MAD	58,740.74

Cost of Olive + Traditional Boiler + FS (MAD/Kg		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.66	67%	318.9531793	MAD	210.51	MAD	6,315.27	MAD	76,835.82	MAD	77,238.25

Cost of Wood + Modern Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	48%	445.2054795	MAD	356.16	MAD	10,684.93	MAD	130,000.00	MAD	24,074.07

Cost of Argan + Modern Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	80%	267.1232877	MAD	213.70	MAD	6,410.96	MAD	78,000.00	MAD	76,074.07

Cost of Argan + Modern Boiler + FS (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.80	90%	237.4429224	MAD	189.95	MAD	5,698.63	MAD	69,333.33	MAD	84,740.74

Cost of Olive + Modern Boiler (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.66	64%	333.9041096	MAD	220.38	MAD	6,611.30	MAD	80,437.50	MAD	73,636.57

Cost of Olive + Modern Boiler + FS (MAD/Kg)		Source Efficiency	Daily Energy Use	Daily Energy Cost		Monthly Energy Cost		Yearly Energy Cost		Yearly fuel cost savings	
MAD	0.66	74%	288.7819326	MAD	190.60	MAD	5,717.88	MAD	69,567.57	MAD	84,506.51