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Solar cooker on urban environment as a complement for Liquefied Petroleum Gas cooking – Case study on Las Tunas neighborhood, Buenos Aires

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Hypothesis

If the social, cultural and practical aspects of the act of cooking are taken into consideration, a solar cooker can be a complement of LGP use in urban areas.

Objectives

- Identify the habits and practices of cooking on Las Tunas neighborhood.
- Determine the viability of use of a solar cooker as complement to LPG on urban environment.

Specific Objectives

- Identify the annual expenditures in LPG for cooking ends.

  Determine the dynamics and food habits of families on Las Tunas neighborhood: cooking schedules and habits (equipment, cooking method, cooking techniques).

- Investigate the needs of the possible final users of the solar cooker and define the design/type of cooker that best suits such needs.

  Develop a solar cooker, starting from existing bibliography, adapted to the families' necessities.

  Assess the application potential of these cookers on urban areas with favorable physical and climatic conditions to solar cooking.

Adoption factors of solar cookers

Economic factors:

- Price

Social factors:

- Motivation
- Promoters use
- Gender and power relations
- Provider characteristics

Cultural factors:

- Cooked food characteristics
- Traditional cooking habits
- Cooking schedules

Political factors:

- Investment and support politics

Environmental factors:

- Availability and price of alternative fuels
- Solar radiation levels
- Available space
- Infrastructure level

Technical factors:

- Performance
- Easiness of use
- Security
- Durability
- Local construction
- Dimensions
- Accessories

Cooking as practice

Rogers (2003) innovation-decision process stages:

- Knowledge stage
- Persuasion stage
- Decision stage
- Implementation stage
- Confirmation stage

Solar cooking is a dynamic and continuous learning process that integrates the relations between user, solar cooker and the social and ecological environment.

Reckwitz (2002) defines practice as a routine behavior which consists on diverse elements, interconnected between them.

We end up cooking what makes sense to us, revealing our understandings of the practice, as well as the rules and procedures.

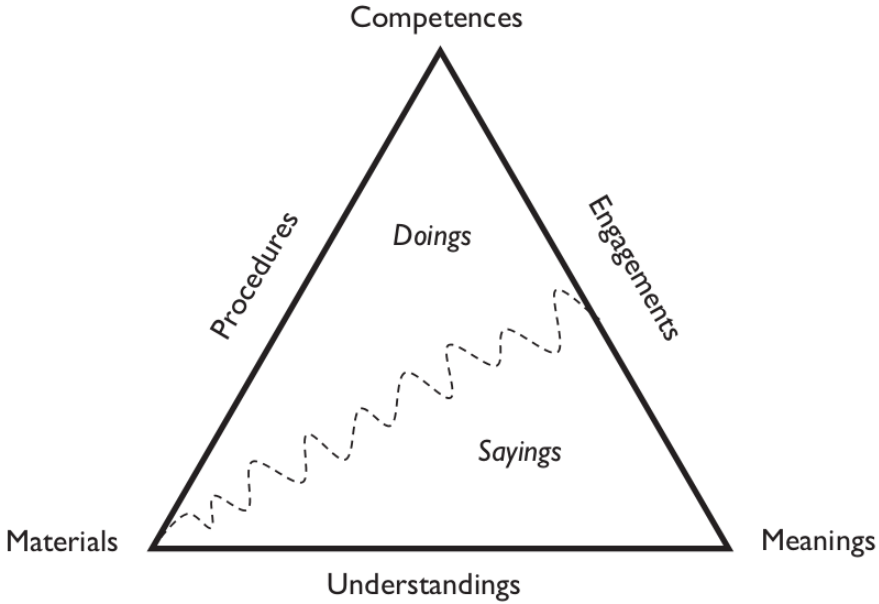


Figure 1: The triangle of elements of practice and their manifestations as doings and sayings in cooking (Torkkeli, Mäkelä & Niva, 2018).

Interviews

	Fecha	Sector del barrio	Hora	Duración entrevista	Energía para cocinar	Nº personas que comen
Entrevista 1	12-05-2018	adelante	13:50	27min 41s	GLP	3
Entrevista 2	12-05-2018	adelante	14:32	31min 39s	Gas natural	4
Entrevista 3	12-05-2018	adelante	15:17	14min 51s	GLP	1
Entrevista 4	02-06-2018	fondo	11:51	49min 49s	GLP	7
Entrevista 5	08-08-2018	adelante	11:38	32min 42s	GLP	3
Entrevista 6	08-08-2018	adelante	12:22	54min 06s	Leña	13
Entrevista 7	15-08-2018	fondo	14:39	17min 47s	GLP	6
Entrevista 8	22-08-2018	adelante	11:56	36min 34s	GLP	5
Entrevista 9	22-08-2018	adelante	12:58	34min 10s	GLP	4

Interviews

Interviews to families – Eating habits, cooking dynamics and use of GLP
Location: Las Tunas neighbourhood, Tigre, Buenos Aires

Data to retrieve

Number of inhabitants:_____ Monthly income (total):_____
Annual GLP consumption:_____ Annual GLP expenses:_____
The house has space for a solar cooker (north façade, free space with sun):_____

Questions

What type of food is more frequently consumed in your house?
How many food do you cook per day, and at what time?
Who is the person responsible for cooking?
How do you normally cook the food?
How long does it take to cook for the whole family?
What are the daily work/study routines?
Do you identify any type of problem with the use of GLP bottle?
How do you use GLP at your place?
How do you obtain the GLP bottles?
Do you use any other fuel to replace or complement GLP?
(after a brief explanation of solar cooking, the inherent changes, the sun dependence)
Do you have any interest in using solar cooking as a complement to GLP bottle?
How much money would you be willing to spend on such a cooker?

Data analysis

Energy:
- Uses of energy
- Types of energy

LPG use:
- Supply
- Bottle brand
- Perceived problems

Act of cooking:
- Number of pots
- Number of persons
- Food
- Equipment for cooking
- Space for solar cooker
- Kitchen functions
- Cooking schedule
- Reasons of interest
- Occupation
- Responsible for cooking
- Cooking times
- Types of cooking

Design parameters defined by the data obtained from the interviews

Ability to cook at lunch and dinner time, during the whole year;

Have enough space to use two cooking devices;

Aesthetically attractive, modern, with low maintenance required and autonomous functioning;

Able to reach high temperatures to boil water fast;

To be used as an oven;

That allows indoor cooking;

Ability to adapt its own dimensions to the routines and realities of each family, to use more or less pots, to have more or less power and to adapt the TSU.

Selected solar cooker

Scheffler disc

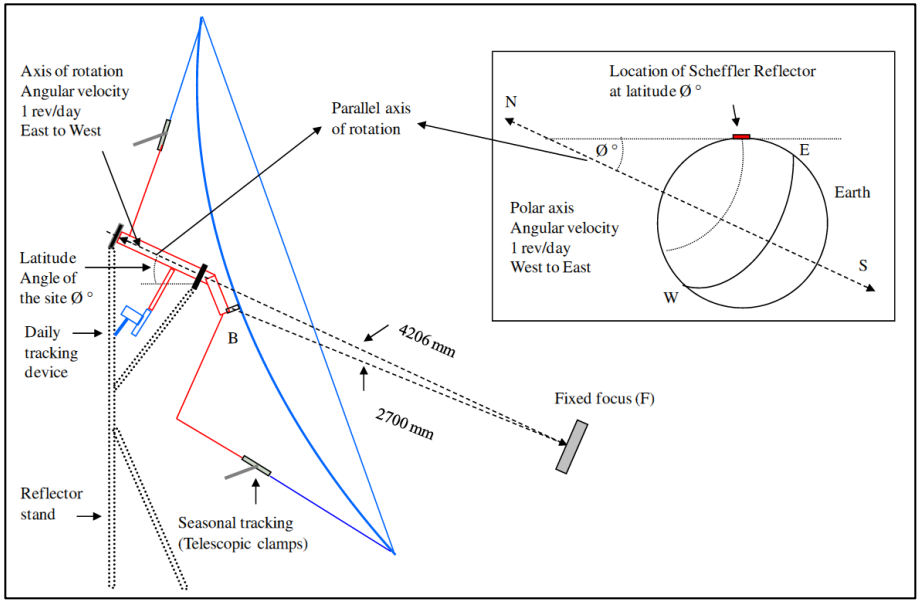


Figure 2: Installation scheme of Scheffler disc. (Scheffler, Munir, & Hensel, 2010)

Thermal Storage Unit

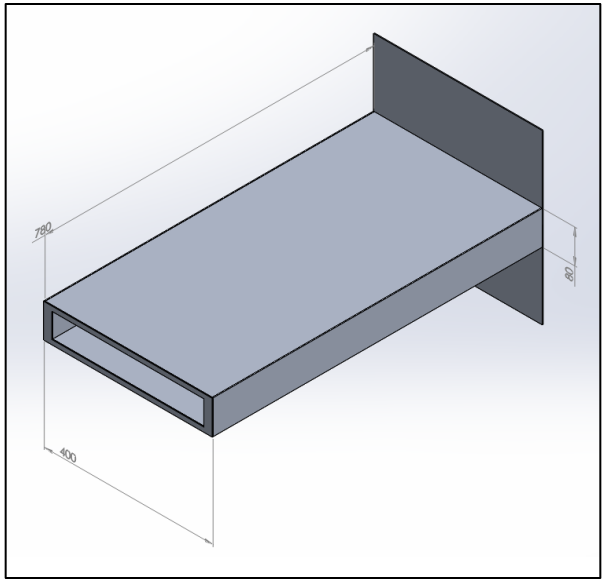


Figure 2: Scheme for the TSU, in mm.

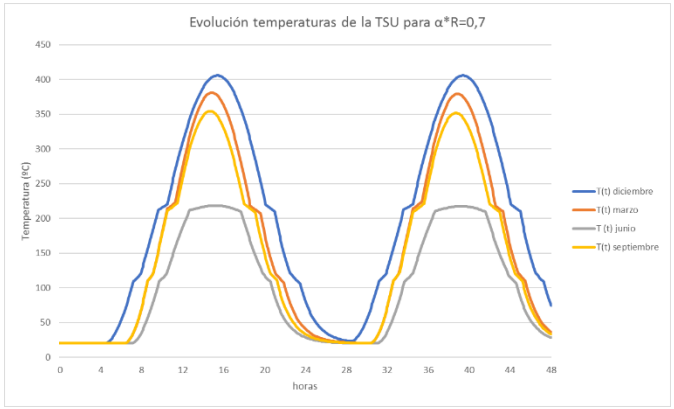
Thermal study

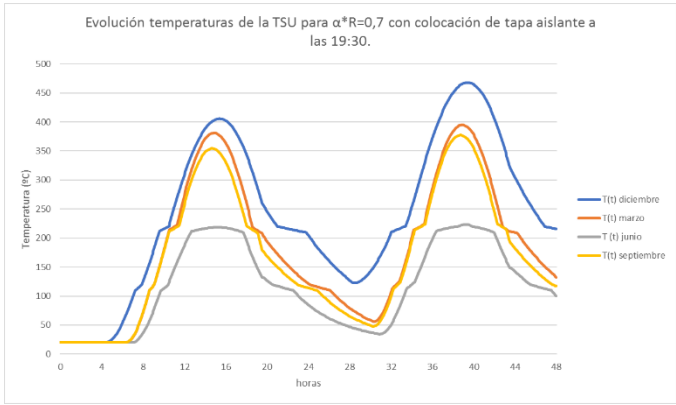
Qsol		
q (flujo solar)	kWh/m^2	q(t)
A	m^2	4
α	-	0.95
R	-	0.94
Qsales		
msales	kg	16.077
Cpsales	kJ/kg.K	0.75 (T<110ºC)
		4.1 (110ºC<T<120ºC)
		1.4 (120ºC<T<210ºC)
		12 (210ºC<T<220ºC)
		1.6 (T>220ºC)
T∞	ºC	20
Qmetal		
mmetal	kg	5.862
Cpmetal	kJ/kg.K	0.903
Qaislación		
kais	kW/m.K	0.00009
e	m	0.08
A	m^2	0.837
Qconvección		
haire	kW/m^2.K	0.025
Afocal	m^2	0.09
Qagua		
magua	kg	5
Cpagua	kJ/kg.K	4.181
T	ºC	95
Qrecip		
mrecip	kg	1.632
Cprecip	kJ/kg.K	0.903
T	ºC	105

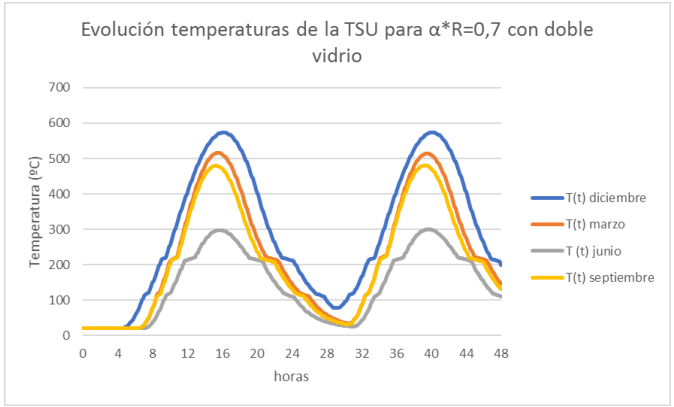
Enero	$y = 0.00000437x^5 - 0.00018632x^4 + 0.00167567x^3 + 0.00924872x^2 - 0.06104587x$
Febrero	$y = 0.00000444x^5 - 0.00019891x^4 + 0.00216669x^3 + 0.00300444x^2 - 0.04432018x$
Marzo	$y = -0.00000108x^6 + 0.00008105x^5 - 0.00223999x^4 + 0.02729285x^3 - 0.13691725x^2 + 0.22240814x$
Abril	$y = -0.00000102x^6 + 0.00007630x^5 - 0.00209735x^4 + 0.02556563x^3 - 0.12996672x^2 + 0.21548753x$
Mayo	$y = -0.00000090x^6 + 0.00006690x^5 - 0.00183698x^4 + 0.02244784x^3 - 0.11526824x^2 + 0.19364649x$
Junio	$y = -0.00000076x^6 + 0.00005677x^5 - 0.00156473x^4 + 0.01923436x^3 - 0.09971310x^2 + 0.16931034x$
Julio	$y = -0.00000080x^6 + 0.00006016x^5 - 0.00166298x^4 + 0.02049169x^3 - 0.10636769x^2 + 0.18070231x$
Agosto	$y = -0.00000098x^6 + 0.00007351x^5 - 0.00202801x^4 + 0.02487196x^3 - 0.12782769x^2 + 0.21463012x$
Setiembre	$y = -0.00000115x^6 + 0.00008522x^5 - 0.00232595x^4 + 0.02801558x^3 - 0.13938848x^2 + 0.22517184x$
Octubre	$y = -0.00000111x^6 + 0.00008232x^5 - 0.00222548x^4 + 0.02630426x^3 - 0.12598381x^2 + 0.19506379x$
Noviembre	$y = -0.00000109x^6 + 0.00008124x^5 - 0.00219710x^4 + 0.02577983x^3 - 0.12052255x^2 + 0.18206326x$
Diciembre	$y = 0.00000328x^5 - 0.00012085x^4 + 0.00034556x^3 + 0.01943370x^2 - 0.08257301x$

Polinomial expressions for solar flux during the day - y=q(t) – data obtained from NASA Langley Reseacrh Center (LaRC) POWER Project

Thermal study

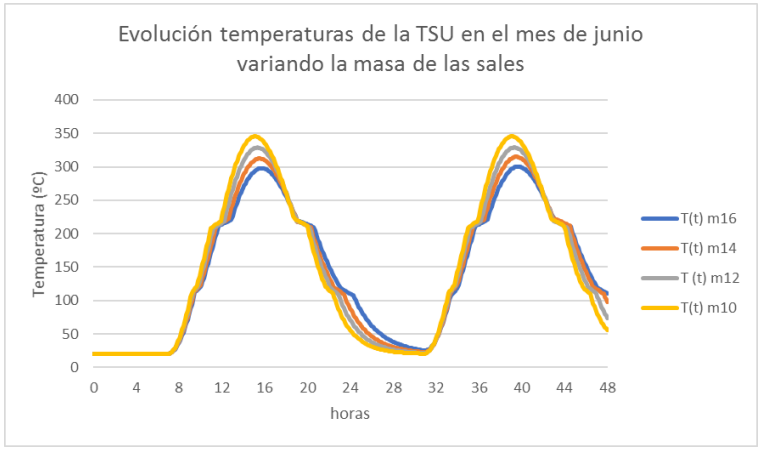


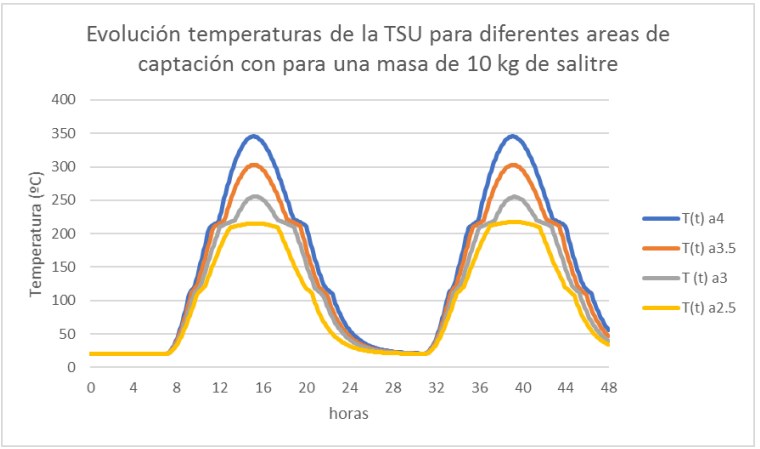




Temperaturas máximas registradas			
	Sin tapa	Con tapa	Doble vidrio
Diciembre	405.6	467.8	573.4
Marzo	380.9	394.8	515.6
Junio	218.3	223.5	300.3
Septiembre	354.2	377.1	480.7

Thermal study





Scheffler disc final dimensions
- Disc useful area: 3m^2

TSU final dimensions
- Saltpetre mass: 10kg
- Dimensions: 780x400x80 mm

Construction method and support and tracking mechanism

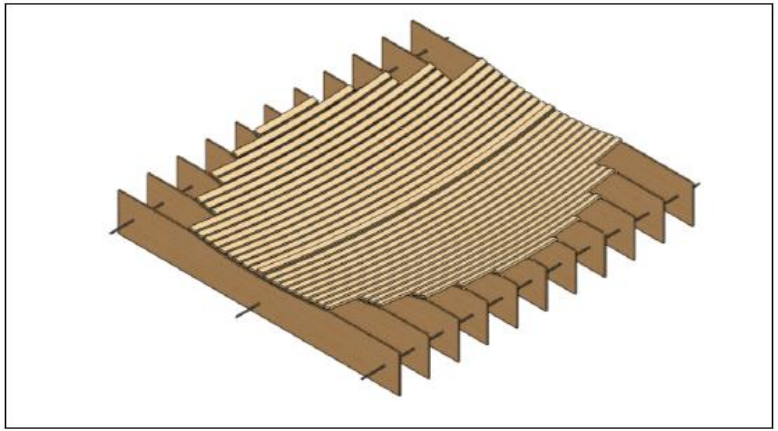
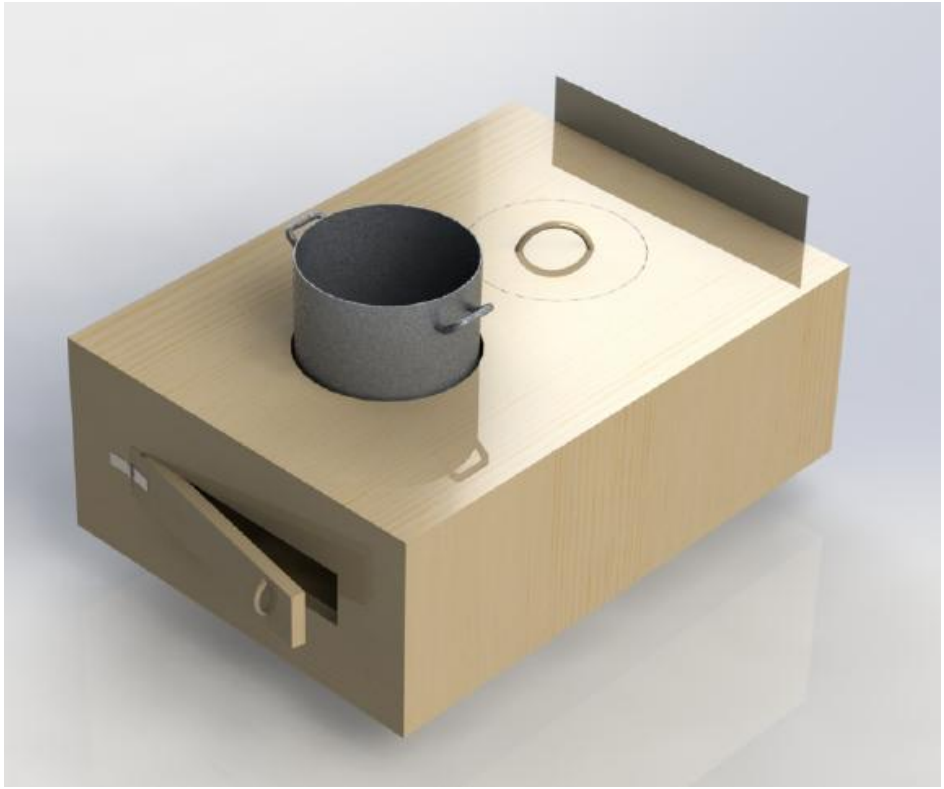


Figure 4: Scheffler disc construction method. (Sholes, Morgan, & Fuller, 2013)

Profundidad (m)		Radio (m)		Largo barras (m)	
d1	0.0333	R1	6.262406	L1	1.292202
d2	0.0572	R2	6.202254	L2	1.685979
d3	0.0714	R3	6.32767	L3	1.902941
d4	0.0762	R4	6.304043	L4	1.962323
d5	0.0714	R5	6.32767	L5	1.902941
d6	0.0572	R6	6.202254	L6	1.685979
d7	0.0333	R7	6.262406	L7	1.292202

Figure 5: Mechanic clock mechanism built by Mercer (Mercer, 2014)

Proposed Thermal Storage Unit



Las Tunas Work Cooperative

Favorable characteristics to the creation of a cooperative:
- 50% of unemployed population on the neighborhood
- Unstable energy prices
- Buildings have a space with a lot of sun exposure

Advantages of creating a cooperative to increase adoption of the solar cooker:
- Reduction of manufacturing costs;
- Higher investment capital;
- Continuous improvement of construction process;
- Higher factors of community belonging;
- Positive retro feeding mechanism to disseminate the solar cooker;
- Sell outside the neighborhood;
- Local and families knowledge;
- Continuous adaptation to the reality of the users.

Conclusions

A pattern was not observed on the 9 interviewed families. The diversity of occupations, schedules and family size was taken as a design parameter.

High rates of oven usage, boiled food and fast food once per day, usually fried.

Design parameters were defined based only on the observed reality and diversity. Most important, families were clear about not changing their habits.

Solar cooker was designed for self construction and all local or national available materials, as well as it was easy to adapt to reused or recycled material available inside the neighborhood.

Cooperative work is a motor for social and economic benefits.

The anthropological study, combined with technical knowledge, opens a good development window for solar cookers on urban environments as Las Tunas all around the world, always and only taking into consideration the local practices and needs.