Photovoltaic solar cooking
without batteries and storage

General summary of the documentation :

Web Sites:
FR Français
DE Deutsch
EN English
ES Español

...and some news on

Each part is the subject of a PDF document. Each part has its own pagination.
The footers indicate, among other things, the name of the part, the page number, the date of last access for revision, and possibly the name of the chapter within the part.

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Part 6 : DESIGN ELEMENTS

Page

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Chapter I   ABOUT SOLAR PANELS

The Photovoltaic ENR Guide is a major source of information
Only a few useful reminders are provided here for our use.

Section I - SOME MAIN FEATURES

We can distinguish two groups of characteristics, both of which are of interest: the STC Standart Test Condition characteristics, measured under 1000 W/m² sunshine, which is in practice the maximum possible sunshine, and the NOCT Normal Operating Cell Temperature characteristics, measured under 800 W/m² sunshine, which are closer to field conditions.
By "good sunshine", the reality will be between the two.
The STC characteristics are more flattering than the NOCT characteristics; on the commercial documentation, the dealers emphasise the STC characteristics.

The following are indicative values for a 1.65 * 0.99 m panel of average quality, which is the benchmark for our solar cooker

STC characteristics, at 1000 W, for our benchmark panel:
nominal power, at maximum power point Pmpp = 280 W

Open circuit voltage: When the panel is exposed to the sun but no energy is being drawn, a voltage can be measured between the two terminals of the panel, known as the open circuit voltage Uco = 39.9 V
Note that, even on very cloudy days, there is an open circuit voltage of around 34 V, - but there is no current, so no power

The short circuit current: this time, by connecting an ammeter (of a suitable calibre!) between the two terminals of the panel, a short circuit is created, and the ammeter measures the current flowing through it:

Icc = 9.35 A

The voltage at the Maximum Power Point, when energy is drawn: Umpp = 31.1 V

The current at the Maximum Power Point Impp = 9A

If we wish to have round figures (upwards), easy to remember, summarising the characteristics of our reference panel as presented by the retailers, we can retain :

300 W / 10 Amps / 30 Volt;

NOCT characteristics, at 800 W, for our benchmark panel:
Nominal power Pmpp = 207 W
Open circuit voltage Uco = 36.4 V
Short circuit current Icc = 7,57A
Voltage at Maximum Power Point Umpp = 28,4
Current at Maximum Power Point Impp = 7.29 A

The electrical characteristics of a photovoltaic panel are well defined by the current/voltage curve network, see the GuideEnR on this point.
Panel dealers are reluctant to provide these curves, those published are very often false (they are sometimes the same curves for all the panels of the same dealer...) It should be possible to obtain them, see for example the Cahier N° 9 from Chauvin Arnoux, or the documentation on the FTV 200 photovoltaic analyser, (page 139) which contains in its library the characteristics of thousands of photovoltaic panels.

Section II - TESTING PHOTO VOLTAIC PANELS

A minimalist test bench for characterising solar panels includes
- a solar irradiance meter
- a voltmeter/ammeter/wattmeter, such as the one proposed for the control panels of the cooker
- a power rheostat
- an Ohmmeter
- a "2-pole 3-position" rocker switch, such as the one proposed for the cooker control panels.

The test consists of
- have the panel delivered to the rheostat, and move the rheostat cursor until the power delivered by the panel is maximised (reading on the Wattmeter)
- at the maximum power point, read the solar radiation, power, voltage and current,
- immediately switch the rheostat to the Ohmmeter using the toggle switch, and read the Resistance displayed by the Ohmmeter.

Because of the speed of the operation, it is essential to work under video recording.
The resistance measurement is not essential, it can be obtained by simple calculation of Ohm's law, but it provides a confirmation of the other measurements.

However, for the purposes of this documentation, only the above-mentioned reference panel with the characteristics usually available on the market has been used. In fact, the coupling between the panel and the ceramics was not only established via the I/U curves, but rather according to the powers involved. Moreover, the synthetic concept of power is easier to handle than the concepts of voltage/current/resistance. When it comes to testing the heating resistors of the cooker (which play the same role with respect to the photovoltaic panel as the power rheostat of the test bench), it is also the power that will be emphasised.

Solar cooking -photovoltaic.org.org has power rheostats that can be made available.

Section III - SOME SPECIFIC ASPECTS OF PHOTO-VOLTAIC PANELS

The output of a photovoltaic panel depends on the amount of sunlight AND the load applied to it;

When you are used to using grid electricity, it is understood that the grid adapts to the load imposed on it. In the case of photovoltaic electricity, the output of the panel varies according to whether the load is more or less well adapted to its current capacity.
It is the regulation of the cooker, manual or automatic, that is responsible for achieving this adequacy, by implementing the number of ceramics that allow, at a given moment, the production of the panel to be optimised.
Ceramic resistors are very rustic objects, which do not require very fine regulation; in particular, they self-limit their temperature to about 220°C. In the case of a manually operated cooker, three switches are sufficient to set up the cooker in the optimum configuration for the available sunlight.

Lifetime of the panels

The guarantees are 10 and 25 years for the panels (see more details in the GuideEnR).

The reason for this apparently high lifetime is that the panels are used for photovoltaic plants, which are built on the basis of bank loans. It is therefore highly desirable that the lifetime of the panels is longer than the duration of the loans... The quality of the panels can therefore be seen as a requirement of the banks (thanks!)

Panel yields

For our purposes, this is a completely minor aspect: it doesn't matter to a few percent how much energy/sunlight the panels yield, what matters most here is the price of the panel. But of course it is thanks to the constant progress in research and industry that photovoltaic panels are now affordable for solar cooking.

Mechanical strength of the panels

The panels are surrounded by a metal profile, which is sufficient to ensure their stability during transport, for some minor handling carried out with care, and to place them on a support. However, the panel, covered with a glass plate, does not tolerate being warped (i.e. not being perfectly flat).
A panel must never be fixed directly from its frame, it must rest on a support along the whole length of its four sides. The support must also never be warped: it must therefore be strong, and if it is an adjustable support, it must rest on only three points (for example, on an axis, and on a support to ensure the tilt) in order to always define a plane.
Three support points, or a line (e.g. a tilt axis) and a point (e.g. an adjustment stand) always define a plane.
Four points, or one line and two adjusting legs, never define a perfect plane: the panel's protective glass plate, which has limited flexibility, will inevitably split along a diagonal.

Adjustable or fixed panel?

It is obvious that a panel that is rotated 4 or 5 times a day produces much more energy than a fixed panel. However, it is now found that in almost all large photovoltaic installations the panels are fixed, most probably because of the lower cost of the panels, compared to the cost of sun tracking devices.

In the case of the cooker, if it is possible to track the sun with, for example, a few manual manipulations during the day, then this is not to be denied. It's all a matter of circumstances. In addition to the increase in production, sun tracking gives the user much more freedom to define his working hours.

If the panels are fixed, it is preferable to plan the production peak at the beginning or middle of the day for the heating up (which is the most energy consuming), and to carry out the boiling up when the sun starts to decline.

The notion of renewable energy and the notion of adapting to circumstances are inextricably linked: you realise this even before you decide where and how to install photo-voltaic panels.

The cooker is an investment, not a luxury item

It should be used every day, all day long; even if the cloud cover does not allow cooking or pre-cooking food or other activities, it can still be used to charge mobile phones or a small battery for lighting in the evening.

As for the price of photovoltaic panels, you can now find some like the one described above, for 100 Euros (end of 2019). This price should be compared with the cost of gas bottles to be bought for 10 years to do the same work: it is up to each person to make his or her own calculations, as this is also a matter of circumstances - and of anticipation.

Chapter II CERAMIC HEATERS

SECTION I CERAMIC HEATERS : GENERAL PRESENTATION

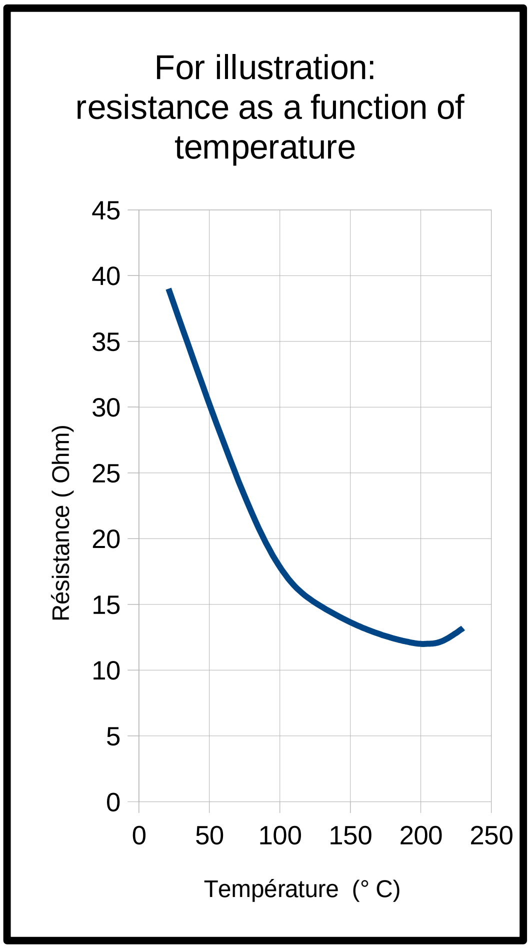
The use of ceramic resistors (= ceramic heaters), and the consequences that follow, are the main specificity of the electro-solar cooker proposed here.
The heating elements of the cooker are not classic resistors (like those of a toaster or an iron), nor devices of the glass-ceramic or induction type, but ceramic resistors.

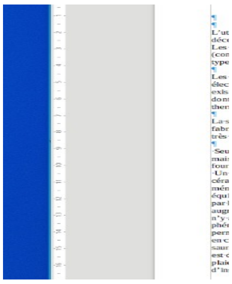
Ceramic resistors are components whose electrical resistance varies significantly according to their temperature; the company TDK / EPCOS, a subsidiary of Siemens and Matsuhita, specialising in the manufacture of passive electronic components, publishes extensive documentation on PTC ceramics and NTC ceramics.

You can also consult
- the article thermistor on Wikipedia
- resistorguide.com
- Yongli Electronic Ceramics Co, Ltd Manufacturer & Supplier
- Tiancheng Co documentation

Ceramics are commonly used in electronics, sometimes presented as "resettable thermostat".

Only PTC ceramics are of interest here. They are little known, but nevertheless omnipresent in our daily life, cf. the examples provided in the introduction to the EPCOS document.




Electric Fan Heater

One example among others: the small "ceramic auxiliary radiators" available in all the heating/household electrical departments of supermarkets. These heaters are all equipped with a fan, which allows the thermal energy produced by the ceramic to be extracted; without this fan, the temperature of the ceramic increases, as does its electrical resistance, the high temperature stagnates but there is hardly any heat production... This is exactly the phenomenon used in the cooker: it is essential to constantly extract the thermal energy produced by the ceramics, for example by heating the contents of the cooking vessel, but the temperature cannot exceed a certain threshold. This threshold is lower than the ignition threshold of the cotton, so it is possible to insulate the firing vessel and limit losses, which are the bane of all thermal installations (all the more so as they are small installations, subject to the merciless effect of scale).

SECTION II - RESISTORS AND ELECTRICITY / SOME BACKGROUND INFORMATION

About resistors: "A resistor [e.g. a ceramic] does not operate at a nominal Voltage, so it cannot have a nominal Power. On the other hand, when the Power increases [for example, if the Voltage increases, or if the Resistance decreases], the amount of heat increases, which can heat up dangerously and destroy the component. The manufacturer indicates a maximum power that should not be exceeded: this is the Maximum Allowable Power." (Académie Bordeaux)

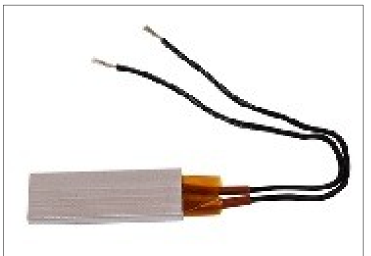
In an electric circuit, it is the generator which applies (within the limits of its capacities) a Voltage to the terminals of the receiving dipole, and it is this receiving dipole which imposes the Intensity (according to its own resistance), provided that the voltage applied to it does not exceed its capacities.

Two categories of thought that are well established in the usual reasoning must be remembered here:
- in classical electricity, the Resistance is a constant, or at least considered as such, and this is (almost) true for most of the usual resistors: resistive wires, wound resistors, etc...
- in everyday life, the Voltage is a constant: the 230 Volt available at an electrical outlet is a constant, to within 10 or 12 Volt, but one cannot imagine that it could go down to 140 or 60 Volt.

In the case of the cooker we are talking about here, these two categories of thought must be left aside. It is of course technically possible to place oneself in a "classic" situation of using electrical energy with a set of solar panels / MPPT regulator / battery storage / inverter, but financially, for cooking as we understand it here, it is a completely prohibitive solution. Fortunately, with a minimum of manual or automatic regulation, solar energy (eminently variable) and ceramic resistors (also eminently variable) are able to work together. The regulation, manual or automatic, is responsible for optimising the collaboration between the two

Regarding the flexibility of ceramic resistors, the company TDK / EPCOS, in a document "PTC thermistors as heating elements" concerning "12 Volt" ceramics, indicates the following values
VR = Rated Voltage = 12 V
V max = Max operating Voltage24 V
VBD = Breakdown Voltage > 40 V
This is a far cry from the narrow operating ranges of conventional nickel-chromium resistors, which burn out in the event of overvoltage.

SECTION III CERAMICS USED IN THE KOOKER AND THEIR SUPPLY



PTC ceramic heater

A ceramic resistor is made of
- a ceramic plate sandwiched between
- two thin aluminium sheets, to which the wires are welded.
- a silicon sheet to provide insulation
- the whole inserted in a rectangular aluminium tube

The only sources of supply (by the end of 2019) are the large online sales platforms in Asia, which distribute "PTC heaters".

They are intended for uses such as bottle warmers, chick incubator heaters, electric hair straighteners, glue guns, perfume sprays, etc., with an indicated operating voltage of 12 to 220 Volt

On an online sales site, for example Aliexpress, the query "PTC heaters" brings up a gallery of several dozen pages. Look for thumbnails similar to the one above, click on the seller's name (at the bottom of the thumbnail), and select only those that offer a wide range of "PTC heaters"; in the end, only a handful of online shops remain in the running
For example: Tony Tang's store, or GD Store, or LJXH Electric Specialist Store or MENGSHAX tools&heater store
Within these shops, on the query "PTC heaters", several hundred references are available.
Another source of supply: Y Yidu electronics Co LTD. On this query in a generalist engine, we end up on https://yidu-sh.en.alibaba.com then search for "PTC Heater with Aluminium".
Or: http://hn-yongli.com or hn-yongli.en.alibaba.com

The Achilles heel of these heaters is the invisible soldering between the wires and the aluminium plates above and below the ceramic. So don't hold them up by the two wires unnecessarily.
A good precaution is to measure the resistance of the ceramics with an ohmmeter before assembly, to be compared for verification with identical measurements after assembly of the heating plate.
Note that the resistance varies with temperature, especially at low temperatures: just hold the ceramic in your hand for a while and the resistance will vary; nevertheless, it is still interesting to make measurements before and after assembly.

SECTION IV THE CHOICE OF CERAMICS

The only information we have concerning ceramics is the operating voltage, but we have just seen above that "a resistor does not operate under a nominal voltage; it cannot therefore have a nominal power".

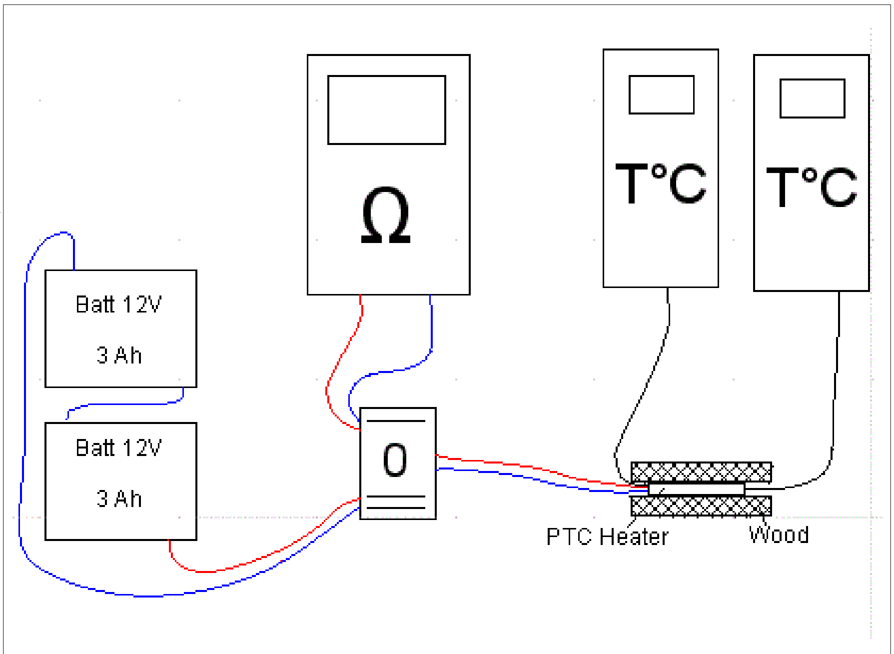
This is very insufficient to configure a cooker.
The only solution is to test the ceramics on a test bench which allows to measure the evolution of the resistance according to its temperature. Almost all the ceramics available on the market have been tested.

Furthermore, a major problem is the lack of identification of the ceramics; it can be assumed that it is the composition of the ceramic that determines the operating voltage, and that it is the surface of the ceramic plate that determines the power, but there is no indication of this on the aluminium shells. Only a handwritten indication of the voltage ... on the packaging bag is sufficient to identify a particular type of ceramic: this opens the door to all kinds of errors.

In addition, since around mid-2019, dealers no longer specify the wattage of the ceramics; since the wattage varies with temperature, these wattage indications, which did not indicate the corresponding temperature, could not be reliable; but they did more or less allow the ceramics to be classified in relation to each other.

The test bench is therefore to be used prior to the design of the kooker, to make choices, and after receipt of the goods, for spot checks.

Schematic diagram of the test bench:
The ceramic "PTC heater" is held between two small pieces of wood or cork. The rocker switch allows either to heat it or to measure its resistance at the same time as its temperature. 7 to 8 readings per ceramic are sufficient.



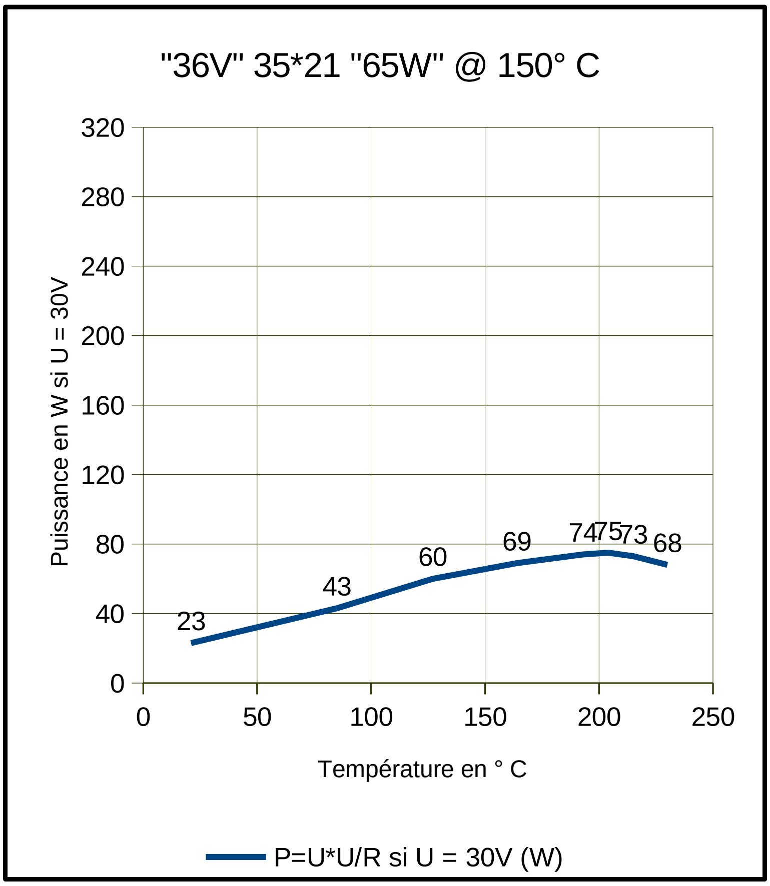
Schematic diagram of the ceramic test bench

SECTION V   FEATURES OF THREE CERAMICS

In order not to overload the documentation, only three of the most interesting ceramics are presented here, and for each of them only one representative ceramic of each batch is presented, with the corresponding measurements and graph.
The ceramics known as 12 V and 24 V are not suitable, nor are those known as 110 or 220 V.
To date (2019), the "36V / 35*21mm" ceramic below seems to be the most suitable for our purpose, The ceramics "36V 60*21mm" and "48V /35*21mm" are also suitable.

36 V   35x21 mm

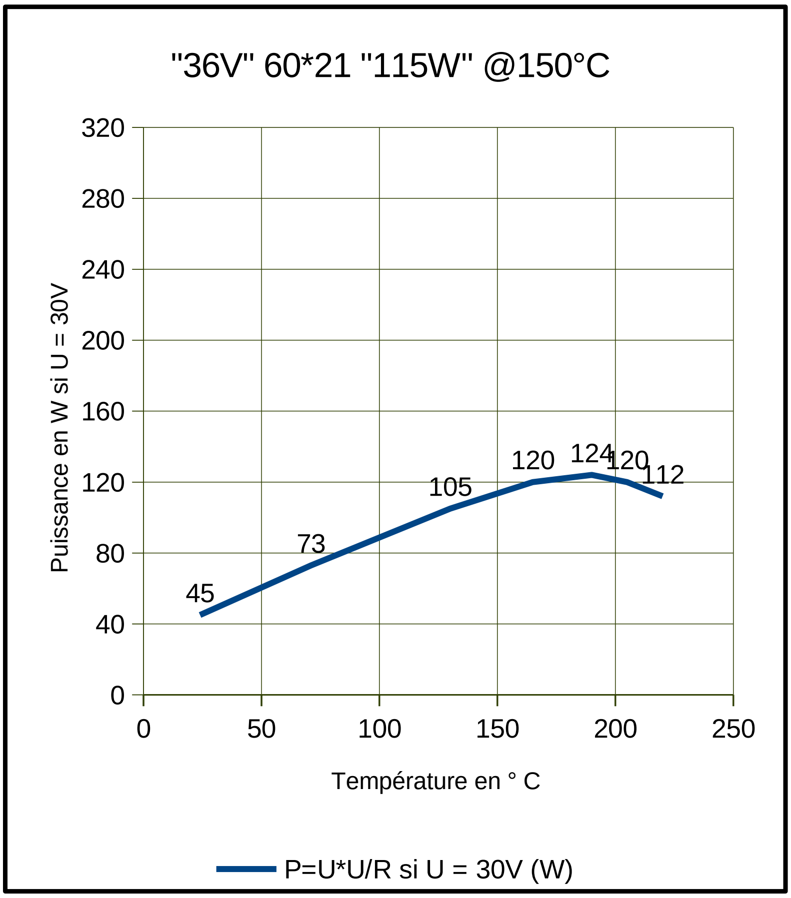
"36V" 35*21 "65W" @150°		
Tempé rature (° C)	Résis tance (Ω)	P=U*U/R si U = 30V (W)
21	39	23
85	20,8	43
127	15	60
164	13	69
193	12,1	74
204	12	75
215	12,2	74
230	13,2	68



The working temperature of the hotplate is considered to be around 150° . This value has been used in other solar firing projects; it varies according to the temperature of the firing vessel (heating or maintaining temperature), and is to be confirmed.
Taking into account this temperature of 150°, we can see graphically that the corresponding power of the ceramic is 65 W. *The announced power is a power calculated* on the basis of the estimated voltage delivered by the solar collector at cruising speed; this is why it is carefully indicated in inverted commas.

36 V   60x21 mm

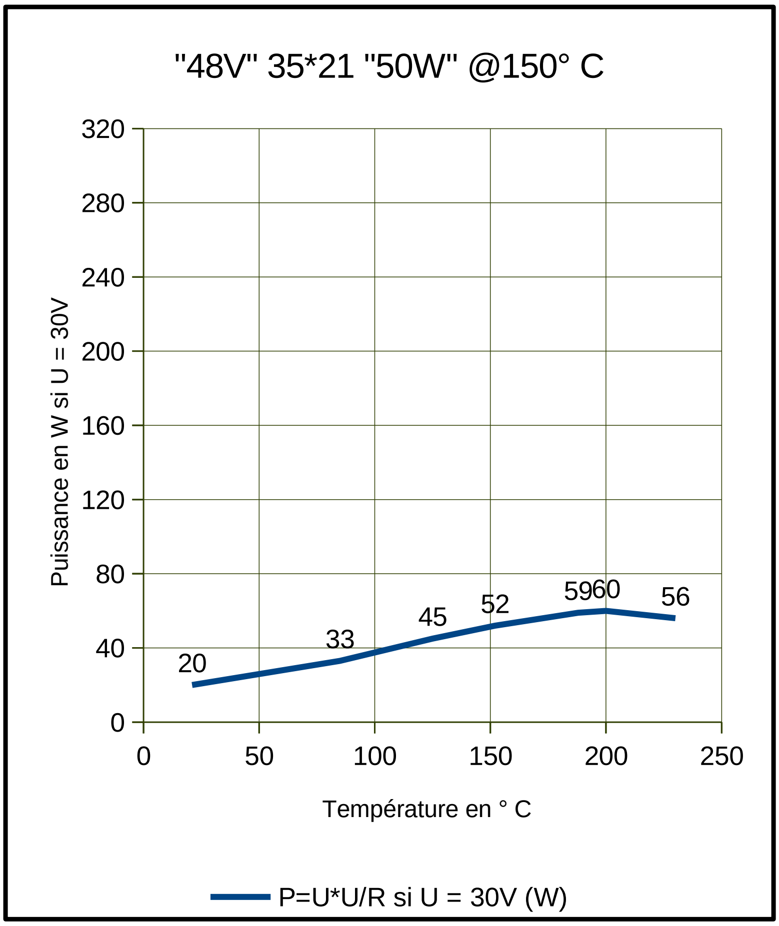
"36V" 60*21 "115W" @150° C		
Tempé rature (° C)	Résis tance (Ω)	P=U*U/R si U = 30V (W)
24	20	45
71	12,2	74
130	8,5	106
165	7,5	120
190	7,25	124
205	7,5	120
220	8	113



The important thing is to identify the operating limits, within which the manual or automatic regulation can fully play its rôle.

48 V 35x21 mm

"48V" 35*21 "50W" @150°C		
Température (° C)	Résistance (Ω)	P=U*U/R si U = 30V (W)
21	45	20
85	27	33
125	20	45
152	17,2	52
188	15,2	59
200	15	60
230	16	56



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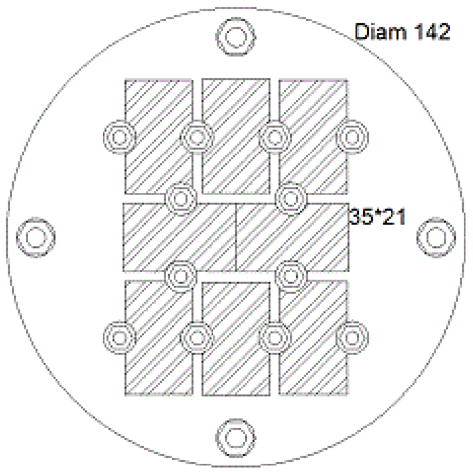
SECTION VI ARRANGEMENT OF CERAMICS

UNDER THE HOT PLATE

For the "One panel" cooker, 300 W Max, 40 V Max, 10A Max, the following configuration has been chosen:

Céramics"36V" 35*21 mm
"65 W" @ 150° C

The wiring is different in the case of the manual and the automatic cooker; it is specified in the documentation in the construction documents

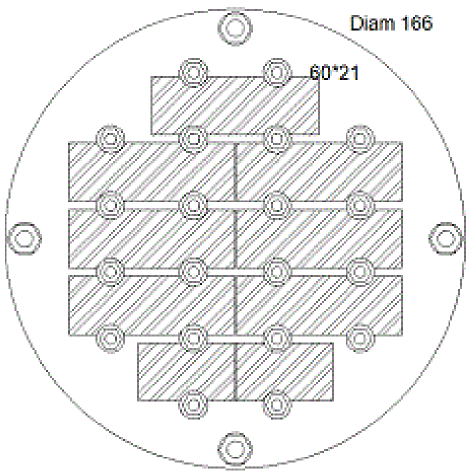


A ceramic arrangement for a 300W single panel cooker

For a "two panel" cooker

This configuration has not been implemented

Céramics "36V" 60*21 mm
"115 W" @ 150° C



an arrangement of ceramics for a "two panel 300W" cooker"

Chapitre III   COOKING AND THERMICS

WHAT IS COOKING?

Among the various definitions of cooking, we can retain here that cooking is the fact of maintaining food at a certain temperature so as to make it more easily assimilable.

It breaks down starch molecules into more digestible fragments,
It "denatures" protein molecules so that their amino acid chains are broken, and digestive enzymes can attack them more easily.
And heat physically softens the food.
This makes it easier to digest, and even if the content is not more calorific, the body needs fewer calories to assimilate it.
This is Dr Wrangham's thesis, set out in his 2009 book "Catching Fire: How Cooking Made Us Human", which was featured in The Economist (http://www.economist.com/node/13139619). "Cooking and other forms of food preparation are decisive for humanity: it is the fundamental evolutionary element that underpins all the others that have set humanity apart."

Temperature level and cooking time

All other things being equal, the successful completion of cooking depends on the temperature level and duration. For example, the time it takes to cook potatoes in water at 100°C is longer than in oil at 170°C; or the time it takes to cook ham overnight at 60°C is longer than for a steak on the barbecue.

HEAT LOSS AND LEAKING BATHTUB

In the last century, in the tests for the late Certificat d'Etudes, problems with leaking taps and bathtubs were common, such as: you want to fill a 120 litre bathtub with a tap that delivers 10 litres per minute; but the bathtub leaks at a rate of 2 litres per minute; how long will it take to fill the tub?

It is obvious that the bigger the leak, the longer it will take to fill the bathtub; the longer the filling time, the more water will be wasted. If you are only interested in the time it takes to fill the bathtub, and the leak is large, "just" turn the tap on tighter; if you are interested in the overall water consumption, you should focus on reducing the leak.

For cooking, replacing the water in the bathtub with thermal energy, it is strictly the same; there are always heat losses. If they are large, for example if a pot of water is boiled without a lid, it will take longer to reach boiling temperature, and the total amount of heat energy required will be very large, much of it wasted. If the cooking vessel is insulated, the losses are significantly reduced.

From a thermal point of view, cooking can be considered as a war lost in advance, since everything (container, contents...) will ultimately return to the ambient temperature level, but it is a war in which every battle must be won, since the desired temperature level must be reached to cook the food

COOKING AND TEMPERATURE LEVELS

At first sight, three temperature levels can be distinguished:
- cooking in water at 100°C,
- cooking in an oil bath at 170°C
- grilling, at a higher temperature.

Due to the technology of the ceramic heating elements, the last two cooking modes are not accessible to the cooker presented here;
We will not be interested in low-temperature cooking either, and will only consider cooking at 100°.

The benchmark of 100°C is provided by physics; when the temperature of the water reaches 100°C, and if heat energy continues to be supplied to it, then the water turns into steam which escapes into the environment, but its temperature will not exceed 100°C even if it boils heavily.
Once the water has reached its vaporisation point, there is no need to heat it further: the energy input should only compensate for the losses (of course, if the bathtub leaks a lot...).

The 100° benchmark is valid for both water-bath cooking (potatoes and other foods) and braising, which is defined here as cooking without the addition of liquid, the food cooking in the water it contains. From a physical point of view, there is no difference between cooking in a water bath and braising.

However, the benchmark of 100° C must be modulated. The vaporisation of water at 100° is valid when the water is at atmospheric pressure, which is about 1 bar (1013 millibar) at sea level, or about 1 kg per cm². This is the weight of the air column above our heads.
- Physics tells us that if water is subjected to a higher pressure, for example if it is enclosed in an enclosure such as a pressure cooker, then it only turns into steam at a higher temperature. For example, in conventional pressure cookers, the pressure is set by the valve at 0.5 bar above atmospheric pressure, corresponding to a temperature of 110°C; in Lagostina pressure cookers, the pressure is set at 1 bar, giving a temperature of 120°C. A higher temperature means faster cooking, as mentioned above. And the instructions for use specify that the heating should be reduced to a "whisper" from the valve: there is no need to make it whistle.
- Physics also tells us that if water is subjected to a pressure lower than 1 bar, it vaporises at a lower temperature. This is what happens when you climb to higher altitudes: the air column is lower, the pressure is lower, and the water will never rise above a certain temperature.

Elevation in meters	Pressure in bar (approx.)	Vaporisation temperature in °C
0	1	100
1 000	0,9	96
2 000	0,8	93
3 000	0,7	90
4 000	0,62	86

The air pressure also varies according to the weather, but these small variations are completely irrelevant.

At an altitude of 2000 metres, the temperature of the water will never exceed 90°C; yet it is possible to cook food there, provided that the cooking times are extended.

THE NORWEGIAN POT

All these notions of insulation, temperature and cooking time lead us of course to the Norwegian pot, presented as follows by Wikipedia:

> "The Norwegian kettle (or fireless cooker, insulation cooker, wonder oven or self-cooking device) is a method of finishing cooking food by placing it in a container that is itself contained in an insulating receptacle: after being heated in the traditional way - but for less time than the usual cooking time - the food can finish cooking in it autonomously, without further expenditure of energy. Contrary to what the name suggests, it is not necessarily a pot and it is not certain that it is of Norwegian origin."

The solar photovoltaic cooker proposed in this documentation *is* a Norwegian pot. Once the food has reached temperature, it is only necessary to remove the power supply.

See for example on the home page / other cooking examples / Coral Lentil Dahl: once the temperature of 100°C was reached, and after removing the power supply, the cooking continued in a Norwegian pot, the temperature still being 90°C after half an hour.

Norwegian kettle cooking has not become part of the cooking culture at all, and this is probably due to the heat

- if the pot used is much too large for its contents, the unused material surfaces of the pot work like radiator fins and disperse all the heat: obviously a few potatoes in a little water at the bottom of a six-litre pot will never cook in Norwegian cooking.
- even if the pot is properly filled, it is up to the pot to heat up the insulation of the Norwegian pot, so the temperature drops from the start and the cooking time increases.
- the price of energy is not high enough...

In the case of the photovoltaic cooker proposed here, the operating conditions in the Norwegian kettle are ideal: the container remains in place, the insulation is already at temperature. And the photovoltaic panel can power a second cooker.

HEATING UP AND TEMPERATURE MAINTENANCE

It is important to distinguish between the two phases of cooking, on the one hand the heating up, and on the other hand the maintenance of the temperature.
For the first phase, which requires the most thermal energy, the cooker is at the back of the pack because of its low power: 280 W peak, and 200 W under 800 W/m² of sunlight, whereas we usually have power ratings of the order of 1000W or more for gas, electricity or wood. Even with losses of 40 or 50% for the usual cooking methods, the game is uneven.
But then, when it comes to temperature maintenance, the cooker is well ahead of the pack, especially when cooking in a Norwegian pot, because of the insulation.

BOILING AND BRAISING

Boiling is defined here as cooking food in a volume of water
Braising is the cooking of food without the addition of liquid, the water in the food being sufficient to ensure that it cooks without "sticking" to the bottom of the pot.

Physics teaches us that, apart from a few very marginal exceptions, water is the body that requires the most thermal energy per unit weight. In other words, there is nothing more difficult to heat than water.
When it comes to cooking with water, you have to heat the water, and you have to heat the food (for example, tubers). The cooker is not well suited to this type of operation; or else: keep the cooking water to cook several small quantities of pasta in succession, for example.
In the case of braising, the cooker is much more comfortable, even though the food often contains 80% or more water; at least it is liquid that is part of the cooked dish, not discarded at the end.

ABOUT THE COST OF THE COOKER

The usual electric heaters require a properly regulated electric current. Due to the fluctuating output of photovoltaic panels, it is necessary to store the electricity in batteries, with a regulator at the input and an inverter at the output.
- Ceramic heating resistors allow for very wide variations in electrical current. The cooker that we have designed does not require a battery, an input regulator or an output inverter. It is composed only of ceramic resistances (whose price is derisory) and switches (in the version with manual regulation). The laws of physics and electricity are scrupulously respected.
On the other hand, in case of weak sunlight, the cooker does not work.

The cooker designed by our small team is therefore intrinsically cheaper than any other photovoltaic cooker. It is even impossible, in view of the laws of physics, to make more minimalist: photovoltaic panel, switches, and ceramic heaters.

About the price
As for the price for a unit production, or in small series, or in large series, it is beyond our field of competence. Our small team " photovoltaic-solar-cookoing.org " has limited itself to provide all the necessary indications for a simple construction by a local craftsman or small company, or even a "Do It Yourself" construction. All other aspects (small or large scale construction, distribution, etc... etc...) are not our domain.