eWant 24V DC cooker – fit for purpose

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Working Paper for Comment

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1 Executive Summary

This document presents the findings from testing the eWant 24 volt Direct Current (DC) Electric Pressure Cooker (EPC).

The cooker is considered as an appliance suitable for use on Solar Home Systems (SHS), or directly with battery energy storage.

The assessment follows where possible the recently published Global Leap protocols.

Safety : We find that it has all the expected safety features. The lid locking feature is available, and the pressure cut out switches off the heating element when the device has reached pressure. A thermal safety fuse is incorporated. Weighted safety release valves are in place in the lid. The entry points for the locking pin is open and the entry to the weighted valve is covered to prevent food clogging as found on most other EPCs. It is not easily tipped over. The lid has a plastic moulded cover, which means the lid upper surface only reaches 60 degrees during pressure, and the handle remains touchable.

Performance: -The device performs as expected, bringing the food in the pot to pressure and then timing its maintenance of that pressure. During this period it switches itself on and off to maintain the pressure. The energy efficiency of the device is comparable to other quality electric pressure cookers. At 24V it operates at 225W. At this low power setting heating can take time and the half full unit took 36 minutes to come to pressure. This is not surprising given the power rating and is comparable to other low power devices. The unit does not have an open-lid or sauté setting, but it also does not have a lid sensor – so any of the setting can be used with the lid off. Frying temperatures were not in the 'sweet spot' of 140 to 180 degrees C, with the thermostat switching the unit off at 141 degrees. This may make some types of frying difficult.

Category:- It is a small device with a stated 2.5 litre pot, which can practically only be filled to 2 litres. This is likely too small for a larger rural family, although even with the low power the comparative ease of starting, and the time for the overall cooking experience may compensate for this by enabling several smaller meals to be cooked in the same time a single larger meal may have taken. The convenience of being able to put everything in the pot and leave it may make it attractive.

Loughborough University
ESMAP Energy Sector Management Assistance Program
UKaid from the British people

SPECIFICATIONS		
Capacity (L)	2.5 litres	
Nominal Voltage & Frequency (V / Hz) **Company** **Foshan Shunde Ewant Electrical technology Ltd**	24 Volts Direct Current (24V DC)	

TEST RESULTS		
Heating Phase	Total Energy Consumption (Wh)	135
	Average Power Draw (W)	225
	Thermal Efficiency (from 30-90°C	64%
	Temperature: Max (°C)	109
	Time to Reach Pressure Cooking Phase (min:sec)	36
Pressure Cooking	Total Energy Consumption (for 30 min; Wh)	19.8
	Average Power Draw (W)	39.5
	Temperature: Max / Min / Ave (°C)	109/107.5/108.5
	Pressure: Max / Min / Ave (kPa)	Not measured
Saute Cooking	Calculated Total Energy Consumption (for 20 min; Wh)	46
	Average Power Draw (W)	138
	Temperature: Max / Min / Ave (°C) 1	141/128/136
	Temperature Stability (% time in ideal range)	Majority less than 140
	Time to Reach Sauté Temperature (min:sec)	16 mins
Affordability*	Unit Price ($-$$$$)	$$
	Estimated Annual Operating Cost (at USD$0.20/kWh)	$14
	Estimate cost per capita assumed 0.3 litre per person to cook 365 meals (at USD$0.2/kWh)	$3.5

*Affordability as defined in the Global Leap protocol barely works in this category of EPC. They designed the protocol to be a comparative measure for within a single class. We have added a cost per capita of cooking 0.3 litres of water.

Contents

2 Background

The background as to why modern energy cooking services is a needed strategy to tackle the enduring problem of biomass and polluting fuel based cooking is explained many times across our programme and is not reiterated here – see www.mecs.org.uk.

Other work has established that electric pressure cookers have good possibilities for households to save money on their fuels and to move towards a clean cooking, modern energy cooking experience. Building on that breadth of work we note that while most commercially available electric pressure cookers work on 110V or 230V Alternating Current (AC), there has been some discussion in the off-grid solar home system community and the off-grid solar DC mini-grid community of a need for a Direct Current EPC.

In the light of this potential market for off-grid solar home systems that can deliver electrical cooking, the discussion around the need for a **DC** cooking system centres on three ideas:-

- Efficiency (and simplicity) of the system
- Lower power demand leading to lower discharge rates from batteries
- Cost effectiveness resulting from the above features

Efficiency (and simplicity) of the system. In theory, maintaining the direct current form of electricity from the battery, without inversion, and using it to power a DC EPC, could be more efficient than converting to AC electricity. In most solar home systems, energy storage is used to time shift energy from the middle of the day to the evening when there is stronger demand (lights, TV, etc). In theory a solar home system strong enough to cook would also likely have to use energy storage to match supply and demand. In most cases at the moment, energy storage on domestic systems tends to be a chemical battery, and in recent years this has shifted from being lead acid based to lithium iron phosphate. Conversion of the direct current of a battery to an alternating current to power an AC EPC would involve an inverter, and there would likely be losses during that process. [This paper is not the place to discuss which energy storage is the best medium, indeed recent work suggest there is significant value in using heat and phase change energy storage, but for the moment the chemical batteries based on lithium hold considerable potential and are reducing in price.]

Lower power demand leading to lower discharge rates. A lower power has a potential to ensure that batteries are not subject to rapid discharge that exceeds their C rate.

The actual and optimal load on the battery will be determined by the capability of the battery to discharge. Until recently lithium cells tended to be 1C, where C means that it takes one hour to fully discharge (to the assumed depth of discharge). Most manufacturers offered the performance of the battery in terms of C10 (sometime written as 0.1C) meaning its performance if it discharges over 10 hours. However, new demands on batteries, everything from flying model aircraft to electric vehicles, are continually changing the landscape and 3C batteries (high power cells that can discharge in 20 mins) are now available at scale and are being increasingly used.

Nevertheless, although the trend is towards batteries that can manage higher rates of discharge, a low power device will be useful for the transition and upgrading from home lighting systems to systems that can include the cooking load.

From an appliance point of view, about 600W seems to be the sweet spot. 600W on an electric cooker with a 6 litre pot can easily do stir frying while also bringing ‘heavy’ food up to heat and maintaining the pressure. A 6L pot is still quite small for many rural households that have large families, but it seems to be the most commonly available size on the market for AC cookers (although most AC 6L EPCs operate at 1kw). (Recent research in Bangladesh also suggests that 600W is a power rating that could fit hotplates and induction stove options, although these appliances offer lower efficiency than an EPC. However, a low sided uninsulated frying pan would need higher power input to produce the same temperature in the pan than a high-sided, insulated EPC pot.)

600W is considered by some manufacturers of AC EPCs to be less than ideal. Their point is that at 600W it is possible to have a viscous meal that cannot circulate, and that the base might begin to burn or be turned off too soon by the overheat protections. The common power rating for 6 litre pots is 1kW, and from experiments if one has a viscous enough foodstuff, one can also burn the bottom and not get circulation –it doesn't dep[end on the power rating – more about the foodstuff and the amount of fluid.

However, with direct current, the current is important. At 12V the wiring for a 600W device needs to be substantial to avoid resistance losses and consequential overheating – this can lead to a significant increase in cost, particularly if the appliance is any distance from the battery. Of course as the voltage increases, the current (for the same power) decreases, and the thickness of the wire can also decrease.

In the appliance tested in this paper, the power is at 225W at 24V, and therefore the current is only 9.3amps, and 'normal' (and common) 13amp wiring can be used. However, as we shall see, the size of the pot may be small for a family, and it does not yet touch the 'sweet spot' of 600W and 6 litres.

Cost effectiveness resulting from the above features. Nevertheless, a direct current appliance does remove the need for an inverter, and as such reduces the system cost, contributes to the overall system design and system efficiency. If the appliance is cost effective, then this can lead to an overall cost effectiveness of the solar home system.

The above is the substance of many discussions among the solar home system community, and therefore the availability of the appliance in this report adds to the toolkit of possibilities for solar home systems inclusive of cooking.

However, it is worth noting in passing that there are market challenges. The market for such SHS devices is potentially quite small, particularly as the grid expands. The World Bank states that of the 770 million people not yet connected to a grid, about 500 million will get their supply through mini grids. Most mini grids now operate with alternating current, and so a commercial EPC sold for the national grid is likely to also fit a mini grid. There are some DC minigrids, but the majority seem now to be AC. Nevertheless that leaves 200 million who may not get connected to a grid in the next ten years, and they may want modern energy cooking services, perhaps through a solar home system.

A key market challenge though is that a) such people live in very remote areas and reaching such people will need support, and b) the availability of firewood for collection in such areas is such that people don't necessarily pay for their polluting cooking fuel. As many analyses of the solar home systems sector show, SHS need support in their roll out and a purely private sector profit orientated approach can barely work. However, subsidies in the form of results based financing that focus on the co-benefits of health, environment and gender equity, are being proposed to support the SHS sector, and therefore there will likely be a viable SHS sector for the coming ten to twenty years. A recent example of this is Rwanda's REF Window 5.

Regarding this support, it may also make the most sense not to sell a new SHS to a family for cooking but to upgrade existing SHS to include cooking.

In which case, any efficiency gains and possible enhancements to the system will find a reach to the people who need it. So as stated above, these points all create a discussion among the off-grid solar home system community, and such discussion sometimes lands on and variably calls for a **Direct Current, low power, electric pressure cooker.**

2.1 DC electric pressure cooker experience to date.

The BES Tesga Direct Current cooker – the disappointment. In a fairly extensive search online and in discussion with Chinese factories, during 2017 to 2019, the only direct current electric pressure cooker on the market was the BES 12V and 24V versions (figure 1). BES also produce DC rice cookers, kettles and blenders, all seemingly targeted at the domestic 'truckers' market of China.

Figure 1 Advertising of the BES Tesga 12V DC EPC

These devices were tested by Loughborough University, Centre for Renewable Energy Science and Technology (CREST). In a 'A Comparison of Functions and Safety Features on Electric Pressure Cookers' (Barton et al 2019) available from https://www.mecs.org.uk, the CREST team at Loughborough documented the functions and safety features of a range of commercial electric pressure cookers. Most are designed for 230V Alternating Current (AC), while one was the BES 12V Direct Current model. The paper stated concerns over the safety of the 12V EPC – based on an absence of safety features, poor quality finishing (particularly the wiring), and the use of a 'kettle' plug male and female that could be confused with a 220V AC cable.

Post publication of that paper, the team issued another paper "A brief performance and safety assessment of a 24V DC Electric Pressure Cooker intended for the Chinese domestic market" (Monk et al 2019) which described a 24V DC EPC from the same factory as the 12V they had previously tested.

They concluded that both devices, ex-factory, were not safe enough to pass European certification.

Since then the Global Leap Awards have undertaken lab tests, and are currently undertaking user tests more systematically on a wider range of devices. They have published their results, but all indications are that they concur with the CREST assessment –the BES Tesga electric pressure cooker was not reported on due to its lack of safety features and its low quality.

The two approaches agreed that in the absence of key safety features the Tesga BES could not be used in internationally financed programmes.

With a lack of alternatives on the market the MECS programme has been actively seeking to stimulate production of a DC cooker. This has included visits to key factories in China, and discussion with designers and manufacturers.

2.2 Methodology

The appliance was powered by a EA Elektro-Automatik Desktop Power Supply, , 1.5kW, 1 Output , , 0 → 80V, 60A, with data logger.

Temperature readings were taken by an DS1922E-F5# Thermochron 8K Data Points Extended Temp. The use of an ibutton allows for a safe seal during the pressure phase. For the Sautes phase, the temperatures were checked by a ThermoPro TP07 Wireless Kitchen Food Cooking Thermometer.

The FLIR pictures were on a IR Infrared Thermal Imaging Camera. Model HTI-19.

The examinations and tests followed where possible the Global Leap protocol. Additional tests of higher voltage responses were undertaken.

3 The eWant 24V DC EPC – a good next step

In 2020, a new Direct Current EPC was identified, made by the Foshan Shunde Ewant Electrical Technology Co Ltd who market their products under the name eWant.

Ewant Foshan Shunde Ewant Electrical Technology Co., Ltd.
Tel : +86-18928601297 E-Mail : sales1@wewantooker.com

Although focused on a range of AC EPC including larger sized devices for catering in institutions, MECS worked with eWant to acquire a 24V DC EPC.

3.1 Non destructive assessment

Six appliances were delivered unharmed during transport, and packaging was tight and secure.

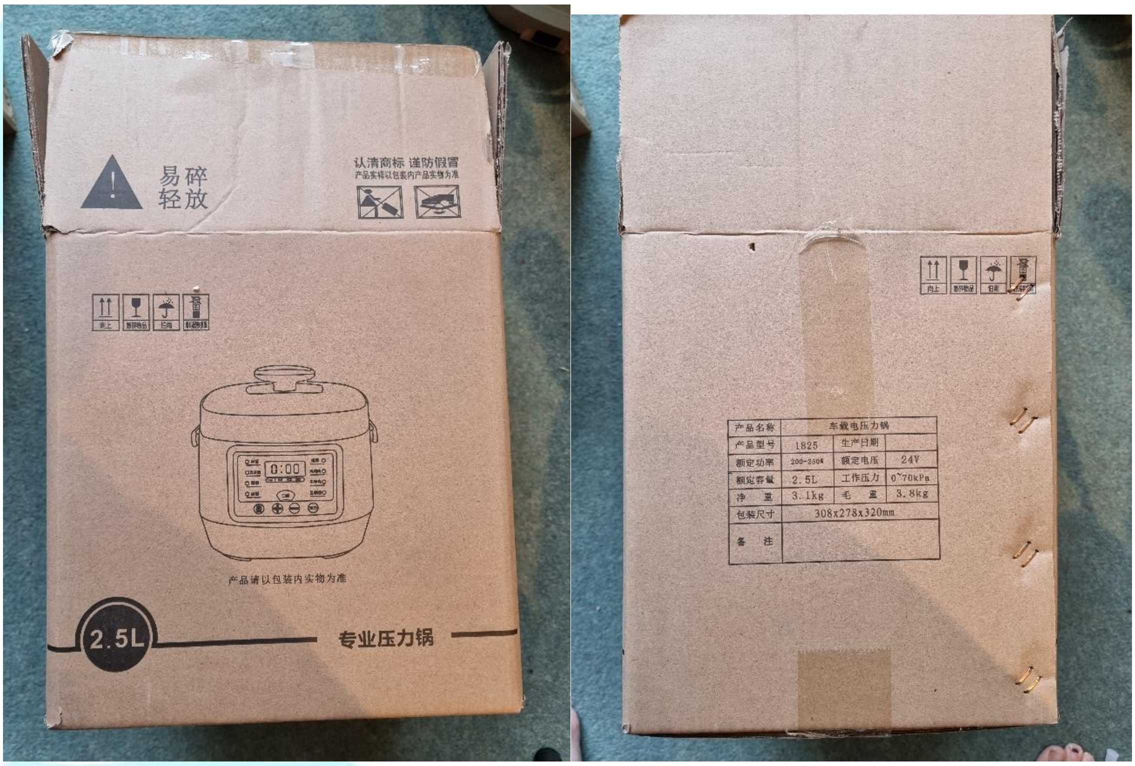


Figure 2 Packaging for the eWant 24V DC EPC sample

Figure 3 Unpacking and first images of the eWant 24V DC EPC sample

The presentation is of a durable moulded plastic with a two toned colour effect of light and darker brown. The lid is not hinged, but it presents clearly where it should fit, with a flat edge to line up on appliance and lid. It interlocks with the main chassis in the same way as most EPCs. The lid holds the steam vents, and a drainage tray allows for the removal of fluids from the process of putting it on and off. The lid does not contain a lid position sensor, and therefore any of the programme can be run without the lid being in place.

> It is not within the assessment criteria for EPCs but most lids of circular construct can be confusing to the user. A lid has to be placed at a particular position, with the gaps lined up. The lid is then secured in place by twisting it. For most EPCs the twist is anti clockwise, which in itself can be confusing to the new user. More importantly, it takes some learning to know the exact position to place the lid to start the lock, and there are often no obvious markers.
>
> The eWant presents a very obvious starting position for the lid and in that sense makes its placement that much easier than many common AC cookers. It still requires an anti clockwise twist.

Figure 4 Images of the eWant 24V DC EPC - handle, locking pin, weighted safety valve, overflow

Figure 5 Images of the eWant 24V DC EPC underside of lid showing protector of valves, and shape of lid illustrating the clear indication of how the lid fits.

The underside of the lid supports an aluminium plate with the silicon sealing ring and with the steam vent protected from contamination or blockage from food splashes, etc. A standard locking pin actuated by the pressure is built into the lid. This prevents the lid from being turned to open when the unit is under pressure the mechanism is a standard steam and pressure actuated mechanical lid interlock. Like other standard actuators the escaping steam forces a post upwards through a hole in a slider, locking the slider, while internal pressure then keeps the post in position. The slider is connected to a push rod that prevents the lid from turning.

Built into the lid is a replaceable silicone seal. When pressurised, the silicone sealing ring seals the lid and cooking pan which together form the pressure vessel.

Figure 6 Images of the eWant 24V DC EPC - bowl marked up for rice and congee

The cooking pan is small at a stated 2.5 litres. This means that the practical capacity will be less, 2 litres although maybe 1.8 litres is more realistic to avoid spillage from bubbling. Even less capacity is available if the foodstuff is foaming or likely to swell. EPC manufacturers generally advise not filing more than half full due to this swelling. The pan is marked up for rice '4' which equals 1 litre in volume, which we take to mean 4 cups of rice and water? Congee or soup is marked at 0.6 with another mark 0.3 half way up from the base. Congee 0.6 also equals one litre of water in volume, which we assume to be the catty or Kan measure of the Hong Kong Macau region at 604 grams, and so we presume is an indicator of the mass of the congee (0.6kg)?

The pan is sturdy with a bulge in the side giving it strength, having the usual concave base to sit on the heating element, and with a non stick coating on the inside. The quality of the non stick looked good, but only long term use will confirm this.

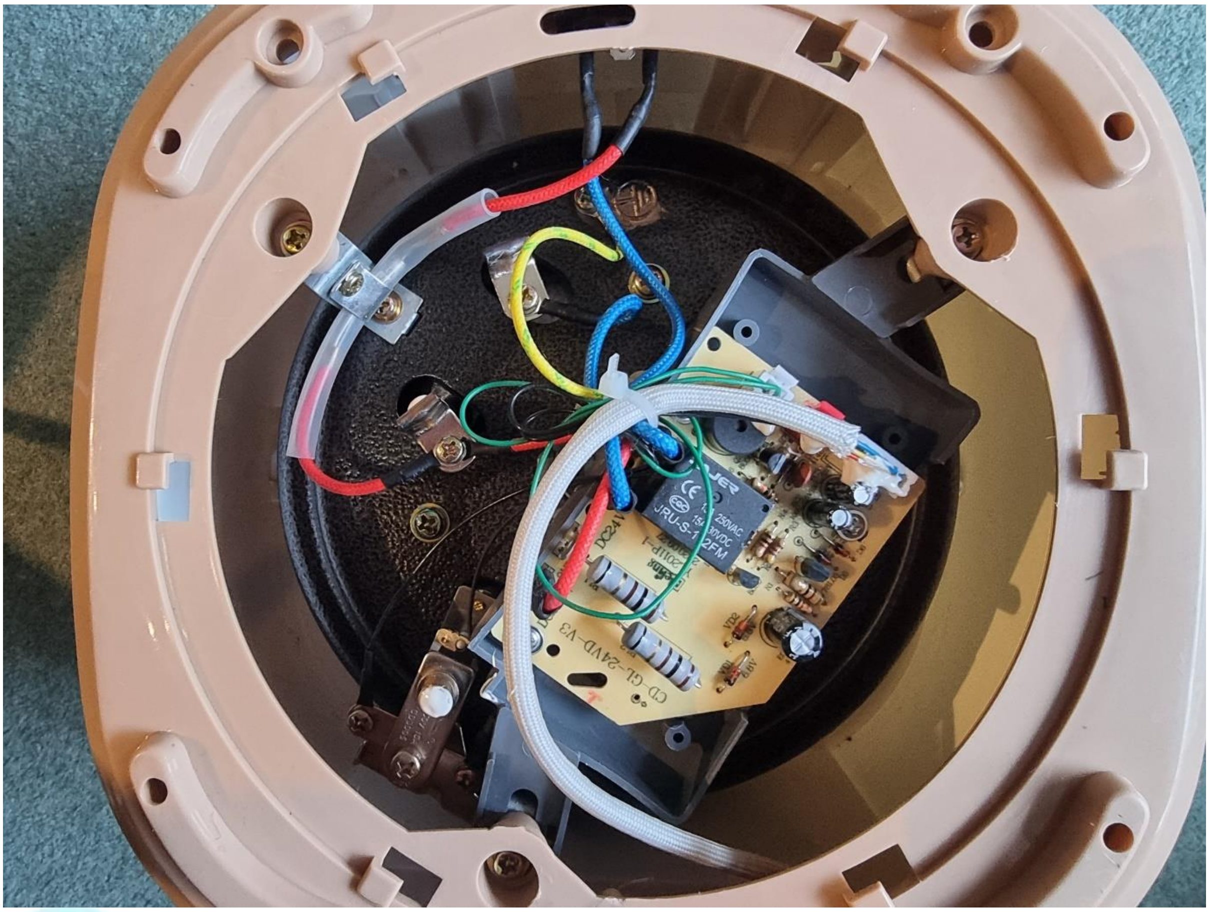


Figure 7 Images of the eWant 24V DC EPC - underside with cover removed, showing protected wiring, pressure switch and thermal fuse.

The heating element/hotplate assembly, and therefore the pan when installed and with the lid fitted, present as being supported via a strong tempered steel disc. This should act as a spring to allow the pan to move away from the lid as pressure builds between them. a switch actuated by this movement will either directly cut power or signal the controller to cut power to the heating element. This generally appears to be used to mark the completion of the pre-heat or pressurisation stage and commencement of the cooking phase.

The pan sits on a sprung loaded thermistor and the device reaches pressure and then switches itself off and on to maintain pressure without exceeding the target pressure. There is also thermal bimetallic switch on the chassis. According to Barton et al 2019, most EPCs also use one or more larger bimetallic strips outside the chassis. The bimetallic switch is activated by the combination of temperature and pressure rise. In the eWant 24V DC EPC, the switch acts on the main power wire. The pressure-operated switches are connected to a post through the chassis, connected to the hotplate. The hotplate is forced downwards by the pressure inside the pot, against a circular spring plate.

There is a thermal cut out held on a spring against the pot bottom (as common in most EPCs), and which operates at 140 degree C. This is the basis of control for the Saute or 'Open Lid' cooking with oil, but also offers extra safety at any point should it be necessary.

The eWant EPC also has a thermal fuse to protect against over-temperature. Once activated, a thermal fuse breaks a circuit that prevents the EPC from working until the fuse is replaced. We did not test at what temperature this operates.

The wiring at the base is well organised and suitably sheathed, all held securely in place, with no sharp edges.

The appliance is connected via a male and female connector that initially presents as a C13/C14 kettle plug. However, the earth or ground pin presents horizontally and a standard 230 Ac main cable cannot be accidently plugged in[1]. The cable supplied was adequate for the expected current of 10.4 amps.

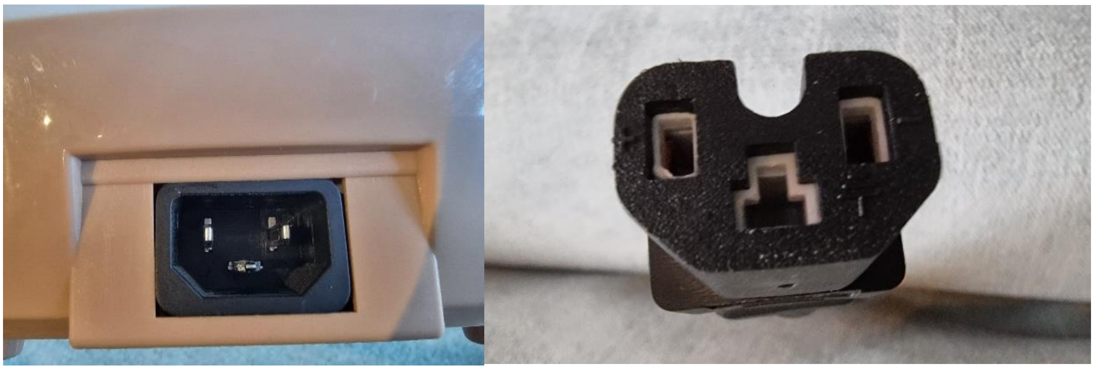


Figure 8 Images of the eWant 24V DC EPC - the female part of the plug cannot receive as standard kettle lead.

4 Confirming its operation

In this section the unit is tested under different simulated cooking conditions, and the methodology follows as closely as possible Global leap testing protocol. The Global LEAP Awards EPC testing process included 1) thorough visual screenings to evaluate product quality, workmanship, and some safety elements; 2) simulated cooking tests with water to measure energy performance and service delivery; and 3) stress tests to evaluate safety features and suitability for us in weak- and off-grid settings.

The control panel (figure 3) has four buttons marked up as Rice (12), Ribs (25), Multigrain (20) and Chicken (15). Each presents a different time for the pressure phase. The unit does not countdown the timer until the pressure phase is initiated. The timer can be increased or decreased by the plus/minus buttons, or by the taste button which decreases or increases the time by approximately a third (eg Rice becomes either 8 minutes, or 18 minutes). The unit cannot go beyond 30 minutes, although it is easy enough to push the button again if a longer phase was required – the unit recognises it is at pressure and if another 30 minutes is added it maintains pressure and counts down for that time.

Figure 9 shows what we might expect. Loaded to a half capacity with water and set to undertake 30 minute of pressured cooking, we see that after 46 minutes the water reaches boiling, the locking valve shuts, and the chamber pressurises. After a further 5 minutes rising to 109 degrees, the unit switches the heating element off and starts the 30 minute timer. When the temperature falls to 107.5, the unit switches the heating element on again to bring it back up to pressure. It reaches back up to 109 deg C, on and off until the 30 minute timer finishes, and the unit switches itself to 'keep warm'. The temperature decreases, including releasing the locking pin at 80 minutes, and continues to decrease until at 154 minutes when the unit senses the temperature is at

[1] At the time of writing we were unable to identify the official designation for this plug. But given its similarity to the C13/C14 we assume it is rated for higher temperature operations.

72 deg C and switches itself on briefly keeping the water at between 72 and 74, until the operator cancels the warming and lets the unit cool naturally.

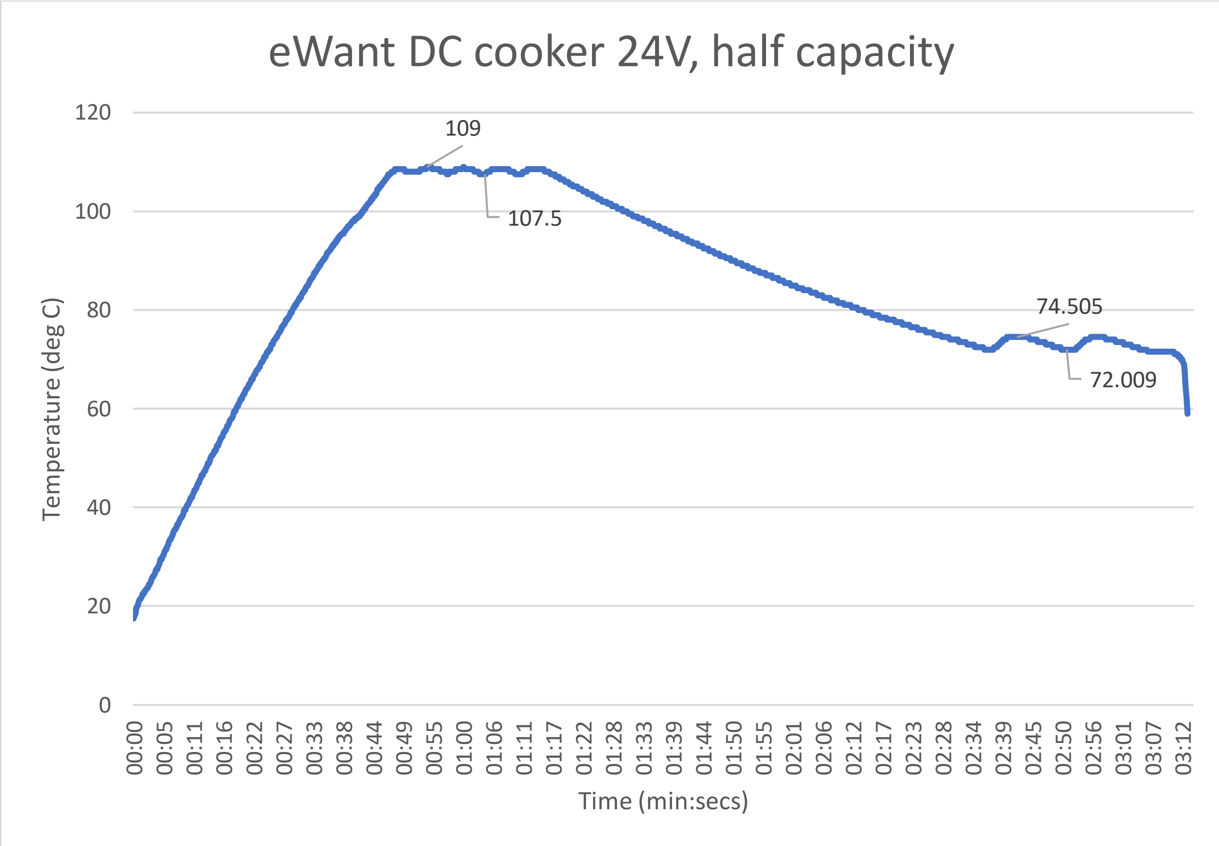


Figure 9 Test run of the eWant 24V DC EPC – 12 minute pressure phase

4.1 Overview

The Global Leap protocol states that devices be filled to half capacity, and that the ratio of the heating phase to the energy consumed during the pressure phase and a sauté phase be compared as a percentage of the whole.

"Sum of the energy consumed during three cooking phases: heating/pressurization phase, 30-minute pressure cooking phase, and 20-minute sauté phase. The heating and pressure cooking phases were done on a high-pressure setting using water volume equivalent to 50% of each product's total capacity; and the sauté phase was done with corn oil filled to a depth of 1.9cm." Global Leap Buyers Guide 2020

In the following, we adhere to Global Leap protocols as closely as possible.

4.2 Heating Phase

"EPC performance during laboratory testing from the turning on pressure cooking mode until, through heating phase, until pressure cooking phase begins. Product was filled with water to 50% of pot capacity and set to high-pressure cooking mode."

During this phase the unit remains on. The end of the phase is taken as when the locking pin shuts.

Heating phase		**2.5 litre eWant 24V DC**	
Average power draw	W	225	Average power draw by the product during the heating phase.

Energy consumption during heating phase, at 50% capacity	Wh	135	Energy consumed during the heating phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from the beginning of the test until the water/steam temperature reaches its initial peak (and the pressure cooking phase begins).
Same metric, in kJ	kJ	486	
Specific energy consumption during heating phase, at 50% capacity	MJ/kg	0.405	Energy consumer per kg of water during the heating phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from the beginning of the test until the water/steam temperature reaches its initial peak (and the pressure cooking phase begins).
Time to reach pressure cooking temperature/pressure, at 50% capacity	minutes	36	Time required for the product to reach its pressure cooking phase (as defined by the pressure pin closing).
Time to reach pressure cooking temperature/pressure per liter of water, at 50% capacity	min/L	30	Time per liter of water required for the product to reach its pressure cooking phase (as defined by the pressure pin closing).
Maximum water temperature reached during heating phase	°C	109	Maximum temperature the water/steam reached during the heating phase.

While 36 minutes is twice as long as AC EPCs of the same size tested by the Global Leap it is important to keep in view the time taken for the whole meal. Both AC and DC cookers would have the same time 'preparing the food', (say 10 minutes to get it ready, chopping). Both do not require preparation time of the appliance (unlike lighting a biomass stove), then while the DC EPC (at 225W) would take 36 minutes and the AC EPC (at 600W) would take 18 to 20 mins (see below), both would take 30 minutes for the pressure phase. So in total, the time for the meal would be preparation, heating and pressure, with 76 minutes for the DC low power appliance and 60 minutes for the higher power AC EPC.

4.3 Pressure Phase

"*EPC performance during a 30-minute laboratory test, measured once the device was pressurized. Product was filled with water to 50% of pot capacity and set to high-pressure cooking mode*." Global Leap Buyer Guide 2020

For pots this small, the unit works relatively hard to maintain the pressure.

Pressure cooking phase		**2.5 litre eWant 24V DC**	
Average power draw during 30-minute cooking phase at 50% capacity		39.5	
Energy consumption during 30-minute cooking phase, at 50% capacity	Wh	19.8	Energy consumed during the pressure cooking (steady-state) phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from 30-minutes once pressurized (as defined by the pressure pin closing).

Same metric, in kJ	kJ	72	
Specific energy consumption during 30-minute cooking phase, at 50% capacity	MJ/kg	0.06	Energy consumed per kg of water during the pressure cooking (steady-state) phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from 30-minutes once pressurized (as defined by the pressure pin closing).
Average temperature during steady state cook phase	°C	108.5	Average temperature of the water/steam during the pressure cooking phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from 30-minutes once pressurized (as defined by the pressure pin closing).
Steady state temperature range	Δ°C	2.5	Temperature range of the water/steam during the pressure cooking phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity, from 30-minutes once pressurized (as defined by the pressure pin closing). A smaller range reflects a more consistent cooking temperature, which is assumed to improve cooking quality.
Temperature: Max / Min (°C)		109/107.5	

4.4 Insulation

The fact that this unit does not require much to sustain the pressure phase demonstrates that they are well made, and have good fitting valves with appropriate insulation . The sides have an air gap which previous papers researching domestic sized unit show that such air gap is equal to and in some cases better than an actual insulation material.

Where there is heat loss is in the lid. Figures 10 and 11 show FLIR heat photos of the units at start and during the pressure phase.

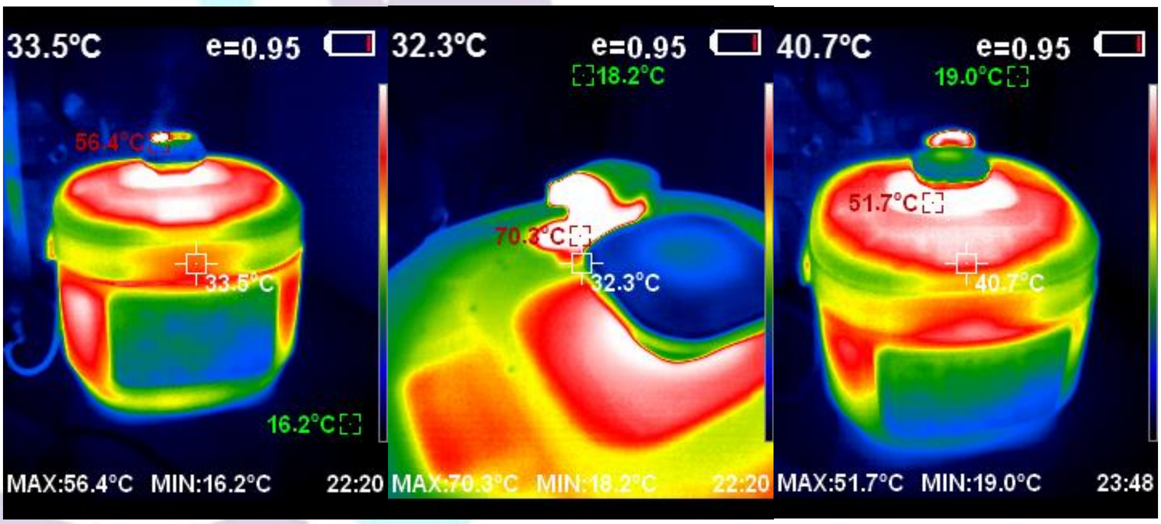


Figure 10 eWant 24V DC FLIR diagram (note how cool the handle remains).

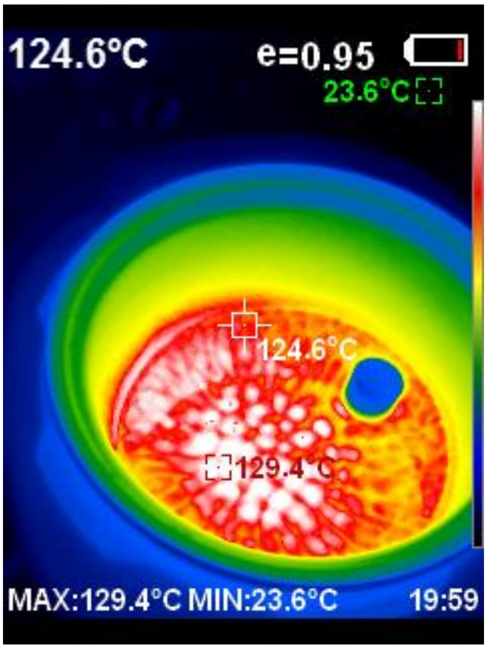


Figure 11 FLIR of the Saute phase.

Finally regarding the insulation, the appliance has a keep warm facility once the pressure phase has finished. This keeps the food at between 68 and 70 degrees centigrade. The power required to keep this food at this temperature is an indicator of how well the unit is insulated. The table below shows the relevant data.

	2.5 litre eWant 24V DC
Lowest Temp during warming phase	72
Highest temp during warming phase	74
Average power used to keep food warm (W)	30

4.5 Saute phase

"EPC performance during a 30-minute laboratory test. Product was filled with vegetable oil to depth of 2 cm and set to sauté mode (or high-pressure cooking mode if no sauté mode) with the lid off" Global Leap Buyers Guide 2020.

It should be noted that this unit does not have a sensor for whether the lid is shut or not – therefore it does not have an open lid button, since any of the heating regimes can be used with an open lid.

Sauté cooking phase		**2.5 litre eWant 24V DC**	
Average sauté power draw	W	138	Average power draw by the product during the sauté cooking phase.
Calculated energy consumption during 20-minute sauté cooking phase	Wh	46	Energy consumed during the sauté cooking phase, as calculated by power and duration (20 minutes)
Same metric, in kJ	kJ	165	
Time to heat	seconds	960	Time required for the corn oil to reach initial maximum temperature.
Average sauté temperature	°C	139	Average temperature of the corn oil during the 20-minute sauté test (discounting the first growth to 100C).

Sauté temperature stability, % of time between 140-180 °C	%	Majority just under 140	Percentage of time that the corn oil temperature was between 140-180°C (which are ideal sauté cooking temperature boundaries).

The low input power results in the temperature during saute mode being lower than typical frying temperatures. As a result, recipes that require frying are likely to be difficult in this model of EPC, as frying will be significantly slower and it may not be able to obtain the characteristic browning of some foods.

4.6 Total Energy Consumption

Bringing the above together.

Total Energy Consumption		**2.5 litre eWant 24V DC**	
Total energy consumption of combined heating phase, 30-minute pressure cooking phase, and 20-minute sauté phase, at 50% capacity	Wh	201	Sum of the energy consumed during three cooking phases: heating/pressurization phase, 30-minute pressure cooking phase, and 20-minute sauté phase. The heating and pressure cooking phases were done on a high-pressure setting using water volume equivalent to 50% of each product's total capacity; and the sauté phase was done with corn oil filled to a depth of 1.9cm.
Same metric, in kJ	kJ	724	
Energy consumed during heating phase as percentage of total energy consumption	%	67%	Percentage of energy consumed during the heating phase relative to overall energy consumed during all three cooking phases.
Energy consumed during pressure cooking phase as percentage of total energy consumption	%	10%	Percentage of energy consumed during the pressure cooking phase relative to overall energy consumed during all three cooking phases.
Energy consumed during sauté cooking phase as percentage of total energy consumption	%	23%	Percentage of energy consumed during the sauté cooking phase relative to overall energy consumed during all three cooking phases.

4.7 Efficiency

The Global Leap protocol suggests that efficiency be taken as "*The product's thermal efficiency as water was heated from 30-90°C during the heating phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity.*"

Given that definition, the energy used for the change from 30 degrees to 90 degrees is given in the table below.

		2.5 litre eWant 24V DC
Energy consumed during heating phase from 30°C to 90°C, at 50% capacity	Wh	119

Heating thermal efficiency, from 30°C to 90°C, at 50% capacity	%	64%	The product's thermal efficiency as water was heated from 30-90°C during the heating phase - on high-pressure setting, using water volume equivalent to 50% of each product's total capacity.

4.8 Cost effectiveness

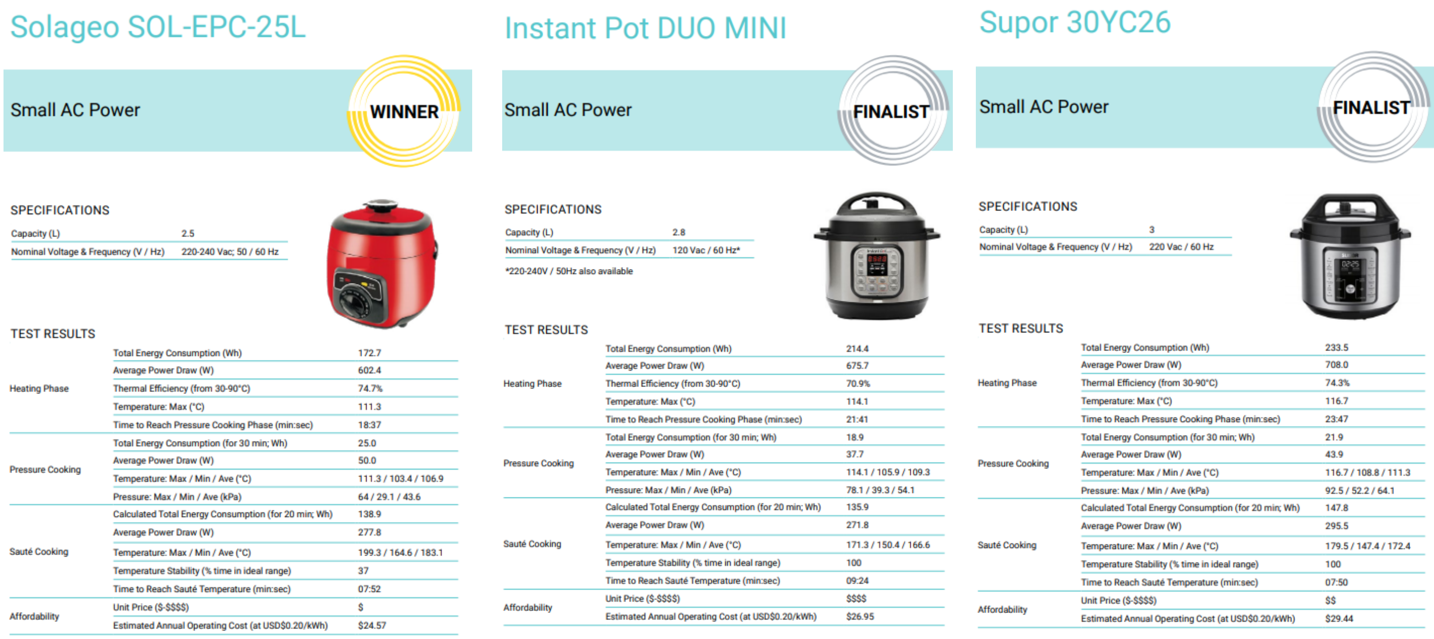
		2.5 litre eWant 24V DC	
Declared FOB price of a single EPC from an order of one thousand (1,000) units	$USD	20 (paid 23 for sample)	Wholesale price of a single unit based on a 1,000 unit purchase order, as declared by nominating company.
Estimated operating cost to cook 365 meals (at USD$0.20/kWh)	$USD	14	Estimated energy costs to cook 365 meals, assuming USD$0.20/kWh
Estimate cost per capita assumed 0.3 litre per person to cook 365 meals (at USD$0.2/kWh)	$USD	3.5	This figure is not in the Global Leap but was added to be able to compare EPCs of very different sizes.

It could also be noted that the per capita cost is slightly lower but of the same order as many EPCs in the buyers guide (Global Leap Buyer Guide 2020).

Brand and Appliance	**Stated Capacity (litres)**	**Estimated energy costs to cook 365 meals, assuming USD$0.20/kWh ($)**	**Estimate cost per capita assumed 0.3 litre per person to cook 365 meals (at USD$0.2/kWh) ($)**
Solageo SOL-EPC-25L (Mini)	2.5	24.57	6.14
SESCOM MY-CJ6001W (Medium)	6	43.67	4.37
Aufla ASC 4L (Medium)	4	31.86	4.78
Instant Pot DUO 80 V2 (Large)	7.6	56.07	4.43
BURN MY-8001	8	61.09	4.58

4.9 Comparison

So how then does this compare with an AC EPC. The Global Leap presents 3 appliances in the same category size (Small Appliances). Figure 12 shows the Global Leap Buyers Guide summary for each.



Solageo SOL-EPC-25L — Small AC Power — WINNER

SPECIFICATIONS

Capacity (L)	2.5
Nominal Voltage & Frequency (V / Hz)	220-240 Vac; 50 / 60 Hz

TEST RESULTS

Heating Phase	Total Energy Consumption (Wh)	172.7
	Average Power Draw (W)	602.4
	Thermal Efficiency (from 30-90°C)	74.7%
	Temperature: Max (°C)	111.3
	Time to Reach Pressure Cooking Phase (min:sec)	18:37
Pressure Cooking	Total Energy Consumption (for 30 min; Wh)	25.0
	Average Power Draw (W)	50.0
	Temperature: Max / Min / Ave (°C)	111.3 / 103.4 / 106.9
	Pressure: Max / Min / Ave (kPa)	64 / 29.1 / 43.6
Sauté Cooking	Calculated Total Energy Consumption (for 20 min; Wh)	138.9
	Average Power Draw (W)	277.8
	Temperature: Max / Min / Ave (°C)	199.3 / 164.6 / 183.1
	Temperature Stability (% time in ideal range)	37
	Time to Reach Sauté Temperature (min:sec)	07:52
Affordability	Unit Price ($-$$$$)	$
	Estimated Annual Operating Cost (at USD$0.20/kWh)	$24.57

Instant Pot DUO MINI — Small AC Power — FINALIST

SPECIFICATIONS

Capacity (L)	2.8
Nominal Voltage & Frequency (V / Hz)	120 Vac / 60 Hz*

*220-240V / 50Hz also available

TEST RESULTS

Heating Phase	Total Energy Consumption (Wh)	214.4
	Average Power Draw (W)	675.7
	Thermal Efficiency (from 30-90°C)	70.9%
	Temperature: Max (°C)	114.1
	Time to Reach Pressure Cooking Phase (min:sec)	21:41
Pressure Cooking	Total Energy Consumption (for 30 min; Wh)	18.9
	Average Power Draw (W)	37.7
	Temperature: Max / Min / Ave (°C)	114.1 / 105.9 / 109.3
	Pressure: Max / Min / Ave (kPa)	78.1 / 39.3 / 54.1
Sauté Cooking	Calculated Total Energy Consumption (for 20 min; Wh)	135.9
	Average Power Draw (W)	271.8
	Temperature: Max / Min / Ave (°C)	171.3 / 150.4 / 166.6
	Temperature Stability (% time in ideal range)	100
	Time to Reach Sauté Temperature (min:sec)	09:24
Affordability	Unit Price ($-$$$$)	$$$$
	Estimated Annual Operating Cost (at USD$0.20/kWh)	$26.95

Supor 30YC26 — Small AC Power — FINALIST

SPECIFICATIONS

Capacity (L)	3
Nominal Voltage & Frequency (V / Hz)	220 Vac / 60 Hz

TEST RESULTS

Heating Phase	Total Energy Consumption (Wh)	233.5
	Average Power Draw (W)	708.0
	Thermal Efficiency (from 30-90°C)	74.3%
	Temperature: Max (°C)	116.7
	Time to Reach Pressure Cooking Phase (min:sec)	23:47
Pressure Cooking	Total Energy Consumption (for 30 min; Wh)	21.9
	Average Power Draw (W)	43.9
	Temperature: Max / Min / Ave (°C)	116.7 / 108.8 / 111.3
	Pressure: Max / Min / Ave (kPa)	92.5 / 52.2 / 64.1
Sauté Cooking	Calculated Total Energy Consumption (for 20 min; Wh)	147.8
	Average Power Draw (W)	295.5
	Temperature: Max / Min / Ave (°C)	179.5 / 147.4 / 172.4
	Temperature Stability (% time in ideal range)	100
	Time to Reach Sauté Temperature (min:sec)	07:50
Affordability	Unit Price ($-$$$$)	$$
	Estimated Annual Operating Cost (at USD$0.20/kWh)	$29.44

Figure 12 Small Appliance results from Global Leap Buyers Guide 2020

These appliances have a similar capacity but operate at a significantly higher power rating. They operate between 600W and 700W, which on a 24V supply would create a current of 25 to 29 amps. The wiring and fuses to handle such would have to be substantial. As described below, the unit can operate briefly at 550W (at 37V DC), but this is not its recommended operating condition.

The cost of the eWant is of the same order as the Solageo, and a similar shape and form although the Solageo is a dial control. However, its cost for 365 meals is 60% of that of the Solageo (but of course at a slower cooking speed), although its cost per capita is of the same order (and slightly lower) as the medium and larger EPCs reported in the buyers guide.

5 Summary

In this section we summarise the guidelines and protocol proposed by the Global Leap as presented in the Buyer guide.

SPECIFICATIONS	
Capacity (L)	2.5 litres
Nominal Voltage & Frequency (V / Hz)	24V DC
Company Zhongshan HanHong Electrical Appliance Co Ltd	

TEST RESULTS		
Heating Phase	Total Energy Consumption (Wh)	135
	Average Power Draw (W)	225
	Thermal Efficiency (from 30-90°C	64%
	Temperature: Max (°C)	109
	Time to Reach Pressure Cooking Phase (min:sec)	36
Pressure Cooking	Total Energy Consumption (for 30 min; Wh)	19.8
	Average Power Draw (W)	39.5
	Temperature: Max / Min / Ave (°C)	109/107.5/108.5
	Pressure: Max / Min / Ave (kPa)	Not measured
Saute Cooking	Calculated Total Energy Consumption (for 20 min; Wh)	46
	Average Power Draw (W)	138
	Temperature: Max / Min / Ave (°C) 1	141/128/136
	Temperature Stability (% time in ideal range)	Majority less than 140
	Time to Reach Sauté Temperature (min:sec)	16 mins
Affordability	Unit Price ($-$$$$)	$
	Estimated Annual Operating Cost (at USD$0.20/kWh)	$14
	Estimate cost per capita assumed 0.3 litre per person to cook 365 meals (at USD$0.2/kWh)	$3.5

6 Destructive voltage assessment

The device is sold to be operated at between 22V and 26V. As such it varies its power rating between 190W and 270W. However, some solar home systems are sized to deliver between 28V and 32V (e.g. Sunculture).

In order to facilitate its use within existing higher power solar home systems the appliance was tested over a range of voltages. Figure 12 plots the power rating as the DC voltage is increased to 38 Volts. At 38 Volts the pressure switch that switches off the heating element to hold the device at its working pressure failed. The result was that the pressure continued to build until the weighted safety back up left its seating and vented the steam to the air. Given that the device is intended to be run at 24 volts, we do not see this as a fault of the device – we were testing the limits. However, it does suggest that running the device up to 32 Volts would still be acceptable.

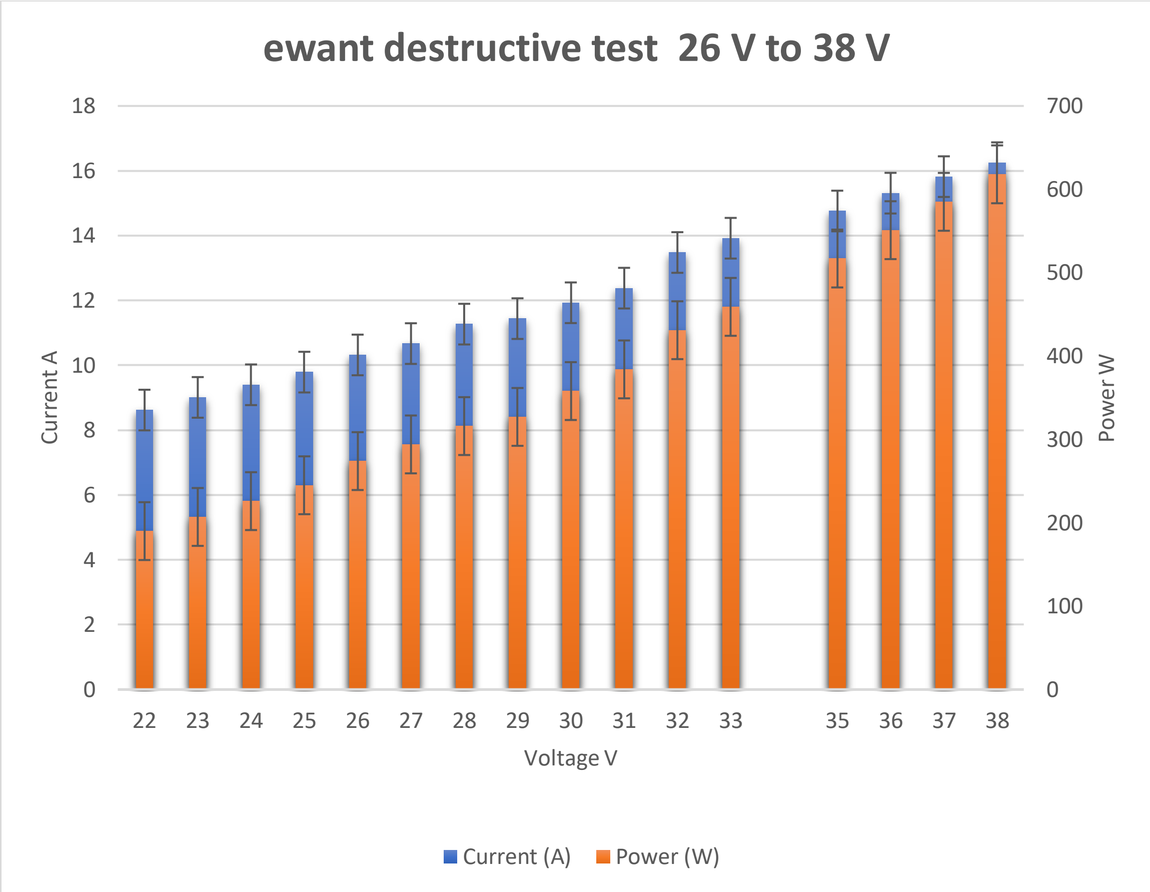


Figure 13 Increasing voltage test for the eWant 24V DC EPC

7 Company overview - Foshan Shunde Ewant Electrical technology Ltd.

The 24V DC appliance was shipped from Foshan Shunde Ewant Electrical technology Ltd.. The Alibaba company profile are given below (Figures 13 to 15). It should be noted that the company does not advertise the 24V DC product we presume because it has only recently been stimulated by MECS.

As figure 13 illustrates, the company overview of Foshan Shunde Ewant Electrical technology Ltd., indicating that it has been operating since 2014, and has declined to state its turnover. The company has been very responsive to enquiries, and has other products of interest suggesting it is a young but potentially more innovative company.

COMPANY OVERVIEW

Company Album ✔ 18 1

Basic Information

Foshan Shunde Ewant Electrical Technology Co., Ltd is located in Guangdong Shunde which is the professional manufacturer of electric pressure cooker. Ewant has the first-class production lines and advanced testing equipment, product development, test procedure has advanced international quality level. Ewant products pass certifications UL, CE, CB,GCC with high quality.

4.9/5 Satisfied 8 Reviews

Supplier Index	♦♦♦
24 Transactions	10,000+
Response Time	≤6h
Response Rate	89.04%

Verified by SGS Group

Business Type	Manufacturer		Country / Region	Guangdong, China	✔
Main Products	Electric Pressure Cooker	✔	Ownership	Private Owner	✔
Total Employees	101 - 200 People	✔	Total Annual Revenue	confidential	✔
Year Established	2014	✔	Certifications(2)	ISO9001, ISO9001	✔
Product Certifications(1)	CB	✔	Patents	-	
Trademarks	-		Main Markets	Domestic Market 40.00% Mid East 30.00% North America 10.00%	✔

Figure 14 Company profile Foshan Shunde Ewant Electrical technology Ltd. (Extract from Alibaba.com Accessed March 2021)

Figure 14 gives a view of the factory and workforce, and indicates that it is a sizeable well establish production unit. The photo montage also hints at the testing facilities which suggest that products undergo quality control and the factory has room for innovation, and figure 15 affirms the idea of quality through demonstrating certification (albeit 2019). Given that this is one of the few companies offering DC EPCs, the impression is of an new company with reasonable quality control, innovating according to customer requirements.

Figure 15 Workshop views Foshan Shunde Ewant Electrical technology Ltd. (Extract from Alibaba.com Accessed March 2021)

Figure 16 Certification claimed by the company Foshan Shunde Ewant Electrical technology Ltd. (Extract from Alibaba.com Accessed March 2021

8 Conclusion.

The eWant 24V DC electric pressure cooker presents as a well-made appliance that would safely deliver a cooking experience. It pressurises, switches itself on and off, locks the lid under pressure and has most of the features of modern electric pressure cookers used in Europe and the USA on mains AC electricity. At such a low power rating, the EPC takes longer than most commercial AC EPCS to reach the pressure phase, and those experienced in the use of EPCs might find that 'slow'. However, this unit will likely be used by rural households who are used to gathering firewood, preparing a fire, waiting for the fire to get to heat and then cooking – and when considering the total time required for cooking, the appliance will likely give a much appreciated reduction in overall time. It will also give a clean, convenient (the unit can be left while cooking) and aspirational experience. Some types of frying may not be possible – further research is required.

As a DC appliance it is a very welcome addition to the toolkit of off-grid appliances that can work on solar home systems where there is no grid connection. It can be considered an energy efficient appliance, that utilises pressure cooking to reduce cooking times for 'long cook' foods such as beans. As a DC appliance it alleviates the need for an inverter between battery and appliance, and may enhance system efficiency.

Since many rural families are relatively large, there is a hesitation that the users may find that it is too small at 2 litres pot (officially 2.5 litres). However, if it used as an introduction to an aspirational product that alleviates smoke and has the convenience of modern energy cooking then it may find a market.

It is an energy efficient appliance for cooking.

Certainly this unit offers a safe research opportunity.

It is worth noting that the early lights of Solar Home Systems were not powerful and could barely give enough light to see, let alone read and do homework. As the solar lights have been introduced learning gains have been made and products on the market now are sophisticated and with significant energy efficiency. This EPC offers a similar starting point where it may not fulfil the optimum needs of the household but brings a level of modernity that leads on to learning gains.

9 Annex 1 Quality and Safety Assessment based on Global Leap Guidelines

The following table seeks to assess the products following the Global Leap guidelines for quality and safety assessment.

		eWant 24V DC 2.5L	
Control and safety devices			
	List of safety device features	Lid Lock; Automatic Pressure Control; Manual Pressure Release Valve; Thermal Fuse;	A list of the primary safety device features built into the product to protect the end-user.
	Is there a safety device separate from the pressure control device? *Yes = good*	Yes	An examination of whether the product has a safety device different from the pressure control device, which provides safety redundancy in the event that the pressure control device malfunctions.
	Are there multiple safety devices that successfully released pressure before it surpassed 300 kPa?	Yes	A test to assess whether the product has at least two functional safety devices that prevent the internal pressure from surpassing 300kPa.
	Did a safety device prevent a user from opening the product when pressurized?	Yes	A test to assess whether the product prevents a user from opening the lid while the internal chamber is pressurized (thereby allowing a user to open a pressurized unit).
	Is it possible to assemble the safe opening system incorrectly?	No	A test to assess whether the product's safe opening system (usually the float valve) can be removed and replaced in a manner that marginalizes the lid locking mechanism.
	Is it possible to fit the lid incorrectly?	No	A test to assess whether the product's lid can be accidentally installed incorrectly, in a manner that could both create a seal that enables pressurization and override the lid locking mechanism (thereby allowing a user to open a pressurized unit).
	Did the first safety device create a steam jet that could hit a user?	No	A test to assess whether a user could be hit by pressurized steam ejected from the product when one of the safety devices is triggered (in response to over-pressurization).
	Is the manual steam release device hazardous to user?	No (but potential scalding of wrist if opened by hand)	A test to assess whether the product discharges steam via the manual (user-operated) steam release in a manner that is controlled and safe to the user.
Circuitry and wiring durability			
	Shock hazard and ground assessment	Not grounded (DC)	A test to assess whether the product is ungrounded or presents a potential shock hazard to the user.
	Overall circuitry and wiring quality rating (as determined by the testing lab visual inspection)	Satisfactory	A qualitative assessment of the product's overall circuitry and wiring quality rating, as determined by the testing laboratory visual inspection.

	Test lab comments	Wires firmly attached. No sharp edges. Wires have insulation.	Notes from the testing laboratory providing context for their assessment.
External temperature			
	Handle temperature rating (as determined by the testing lab based on burn potential)	Good	A test to assess the potential for the handles to burn a user by measuring their maximum temperature during cooking phases.
	Body temperature rating (as determined by the testing lab based on burn potential)	Good	A test to assess the potential for the exterior body of the pressure cooker to burn a user by measuring their maximum temperature during cooking phases.
	Lid temperature rating (as determined by the testing lab based on burn potential)	<80 degrees – very good	A test to assess the potential for the exterior lid of the pressure cooker to burn a user by measuring their maximum temperature during cooking phases.
Tipping			
	Lifting grips above centre of gravity?	Yes	A test to determine whether the product's handles are above its centre of gravity, which reduces the risk of dropping, inverting, and/or spilling.
	Minimum tipping angle	Good	A test to assess the stability and balance of the product, specifically its risk of being tipped over.

Workmanship and materials evaluation			
	Boil-over protection	Yes	A test to assess if the product prevents liquid from spilling directly onto the control panel, if water were to boil over from the inner pot.
	Interior ingress protection	yes	A test to assess if the product's electronics would be protected in the case of an interior spill, based on the testing laboratory visual inspection.
	External workmanship quality rating	Good	A qualitative assessment of the product's overall external workmanship quality, as determined by the testing laboratory visual inspection.

	Test lab comments	A good solid product.	Notes from the testing laboratory providing context for their assessment.
	Internal workmanship quality rating	Satisfactory	A qualitative assessment of the product's overall internal workmanship quality, as determined by the testing laboratory visual inspection.
	Front panel quality rating	Good	A qualitative assessment of the product's overall front panel quality, as determined by the testing laboratory visual inspection.
Warranty			
	Declared duration of warranty	12	The number of months the product is covered under warranty, according to the nominating company.
High voltage performance			
	Functional after testing under high-voltage condition	Can go to 38V DC	A pass/fail assessment of the product's ability to operate after undergoing sustained high-voltage power supply conditions.
Packaging, labelling & manuals			
	Packaging rating	Good	A qualitative assessment of the product's packaging, as determined by the testing laboratory visual inspection.
	Labelling rating	Good	A qualitative assessment of the product's labelling, as determined by the testing laboratory visual inspection.
	User manual rating	Basic	A qualitative assessment of the product's user manual, as determined by the testing laboratory visual inspection.

10 References

In this version references are embedded as Hyperlinks