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UPS Powered by Solar Renewal Energy

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Abstract: ***This paper includes the research and development of a solar powered UPS in India's electrical market to satisfy the alternate energy source requirements of homes and tiny offices. During this paper circuit configuration, inspection, research pattern used and also the findings of the market study. The planning of the solar UPS includes a specially designed inverter circuit and a solar battery. The inverter circuit has been designed in keeping with the wants of domestic needs. The paper shows study of possibilities of design and functionality of a solar powered UPS.***
It gives concept that solar UPS is a highly efficient and successful alternative to electrical UPSs within the electrical market. There are two parts during this research first one is solar array which converts solar power into voltage and second is solar inverter which converts DC into electricity.
Keywords: Alternative energized UPS, UPS model, Solar power, Electrical device.

I. INTRODUCTION

The world has seen an incredible improvement in solar array technology during recent years. Modern solar panels have proven to be more efficient and reliable in harnessing alternative energy and are available at relatively lower prices. Because the silicon shortage disappeared in half-moon of 2009 because of thin film manufacturing, the worth of the solar panels dropped from recent level of Rs per watt.

Solar technology has been capturing India's market on large scale and deployed in high investment terrestrial projects since its commercial launch in 1950s. Suburban facilities, army lands, hill tops and indeed all the places that don't have grid power available, use solar panels as energy source. The explanation for not deploying solar power at domestic level was due to high prices of silicon solar cells, lower efficiencies and better prices of charge controllers [1] and high cost of maintenance free batteries. Using alternative energy as an alternate energy source to switch grid power, a mean household requirement of 250kWh/month would force an investment people at high rate which is simply too high to be accepted by domestic users. Using solar power as a backup solution costs very high which is appropriate by domestic users considering the on-going energy crisis within the country.

I studied various options of deploying alternative energy in India and making use of accessible resources most efficiently to develop a practical solution for domestic users within the country. Most of the assistance received was from the test setup at a private lab with the foremost of the locally available and made charge controller and inverter circuits, with the experience of calibrating and fixing electrical UPS systems and interviewing some power experts within the marketplace for their knowledge and expertise to assist going to the foremost feasible solution. Also, the past experience within the field of engineering equipment power-up and DC storage systems helped to check feasibility of solar energy systems available within the market and their efficiencies. That included solar powered base station system solutions proposed by vendors including but not limited to Huawei, Ericsson Apex BP Solar and SunTech.

II. ADVANTAGES OF SOLAR POWER

If used with right location and orientation, the efficiency of electrical device to capture maximum sunlight is very high. the particular great thing about solar powered supply lies in its ability to capture light energy and generate power, that may be used both as online energy source (on-grid) just in case of power outage and also as independent/alternate energy source (off-grid), alternative energy also adds value to the tip user's home. Alternative energy doesn't fluctuate like fuel and might be utilized in remote and rural areas where grid power can't be reached. Last but not the least; solar technology is nice for earth. Solar power is renewable and viable for long-term. Eventually, the investment of user gets reimbursed and also the system becomes profitable within few years. There's no pollution in atmosphere because of oxide, greenhouse gas or the other pollutants. It's a limit less source of power which is free, unlike deleterious fossil fuels which are expensive moreover.

III. SOLAR UPS SOLUTION

Some country has been facing an unprecedented energy crisis since the previous couple of years [2].
The matter becomes more severe during summers. However, the winter of 2009 was no different as there was still a mean power failure of 3-4 hours daily. Those without generators and UPS faced tremendous problems in these outages. The costs of both continued to extend because of a pointy increase in their demand. The comparison of the available alternatives together with Solar UPS system is shown in Table I:

Table 1. Electricity Alternatives (1kW output)

Domestic Technologies	Online	Input	Air/ Noise Pollution	Efficiency	Price	Production Cost	Life Cycle Phase	Warranty (Typical)
Petroleum Generator	No	Petrol/ Diesel/ Gas Fuel	Yes	55-69%	30000 RS	5-8kW/ Gallon	Maturity	5 years
Electrical UPS	Yes/No	Grid Electricity	No	75-85%	35000 RS	Source Unit e cost	Maturity	2 years
Solar UPS	Yes/No	No Fuel	No	75-90%	48000 RS	Zero	Growing	25 years

As seen in Table I, though initial cost for petroleum and electrical UPS systems are low, still both have their specific disadvantages. For instance, rising petroleum prices in Pakistan, domestic and commercial gas shortage, noise and pollution caused by generators, offline system (needs to be started automatically or manually as breakdown occurs) and comparatively lower efficiencies are the problems addressed for Petroleum Generators. Similarly, damage to expensive battery banks in frequent electric failures (due to incomplete charging/discharging cycles) and inflation of grid electricity are a number of the key concerns for the people using or considering electrical UPS. Since the solar technology has not been deployed on domestic level and there's energy shortage within the country, the market is in need for a reliable domestic solar UPS solution which will act as a backup just in case of grid breakdown. India environment is good for Solar UPS deployment. The sun shines bright throughout the year. Global radiation estimates are made for many parts of the planet, and also for major cities of India which is crucial for the optimum design of solar power conversion systems [3]. We are able to make use of this inexhaustible resource and contribute towards meeting the shortfall of electricity. One among the most important advantages of being high solar content country is that the use of CPV (Concentrated Photovoltaic) in India. CPV at large scale has already been deployed and helps to realize efficiencies of above 40%. Low concentration CPV is produced from conventional silicon photovoltaic cell with no active cooling system or solar tracking requirements and hence is comparatively cheaper. Another advantage of being in India is that the already developed and mature industry of high efficiency inverters, charge controllers [4] and UPS Lead-Acid batteries that are all very cheaply available and repairable and has resulted during a decreased overall cost of the system. The concept for using solar energy in India isn't to use it as an alternate energy source, but as a backup system just in case of grid electricity failure. For the areas of the planet, that are low in solar power and where grid electricity is cheaper because of more feasible energy sources, solar power as an alternate to grid electricity isn't a suitable solution. However, in a very country like India that's rich in alternative energy throughout the year and where grid electricity and fuel costs for generators are high, solar UPS is a suitable domestic backup system.

IV. SYSTEM DESIGN

The system comprises of two outdoor solar panels SunTech Power STP270-24/Vb1 (540Watt) which cost high [5]. Locally manufactured MPPT charge controller (efficiency 95%) and inverter (efficiency 90%) are available well under high cost. High cost is required to get two 12V and 150AH Lead-Acid Batteries. More money is required for purchasing additional installation components and connectivity wires, shipping and other overhead charges.

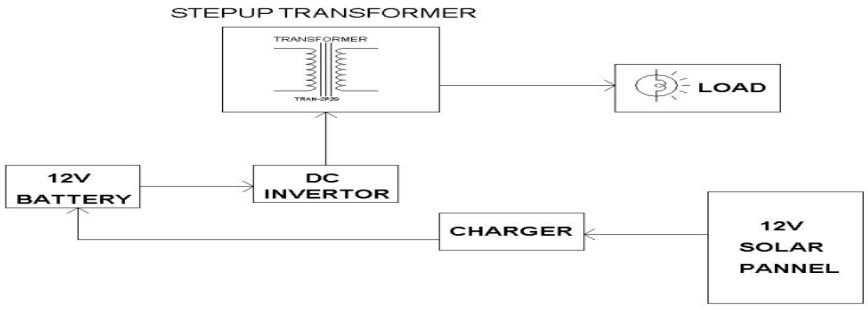

Fig. 1 "Solar UPS Indoor Circuit"

Fig. 1 explains the connectivity details for the indoor circuit. DC voltage generated by electrical device is fed to the charge controller which is stored within the main battery and/or additional batteries. Charge controller defines upper and lower voltage cut-off points, charging current to battery bank and maximum system efficiency by adjusting voltage and current in keeping with the available electrical device output. Variable resistors R1 and R2 are optional just in case of batteries with different AH ratings and might be adjusted to manage the charging current flow into each battery. Diodes D1 and D2 act as tangency from battery to inverter and thus no current limiting occurs on output to inverter. The 2 batteries are isolated from one another through Diodes D1, D2 and D4. It prevents for the batteries from getting
damaged if anyone cell in a very battery gets short. Reverse current flow to electrical device has been avoided through Diodes D0 and D1. a further diode is inserted at input of charge controller to avoid any reverse current ensue charge controller towards solar array in an unexpected scenario. Current limiting resistors dissipate plenty of warmth and must be placed faraway from the batteries. Also the system should have proper ventilation to avoid heating and damage especially during summers. An ATS power switch at the output of solar UPS can automatically switch load to UPS just in case of grid failure.

V. RESULTS

The monthly mean sunshine hours in India vary between 8hours/day (December) to 10 hours/day (April) with an exception to the monsoon season in months of July and August where this number might fall to as low as 4.7 hours/day [3].

Table 2. Analysis of power produced by Solar UPS round the year in India

Month (2009)	Panel Output Power (W)	Optimum Operating Voltage (V)	Optimum Operating Current (A)	Type of Storage batteries needed	Battery Capacity (AH)	Mean sunshine hours/day	Power Stored/day (kWh)	Power Available/day (kWh)
January	540	35	15.42	24V (2*12V)	150	7.7	3	2.7
February	540	35	15.42	24V (2*12V)	150	8.7	3.38	3.05
March	540	35	15.42	24V (2*12V)	150	8.89	3.46	3.12
April	540	35	15.42	24V (2*12V)	150	9.95	3.87	3.49
May	540	35	15.42	24V (2*12V)	150	9.06	3.53	3.17
June	540	35	15.42	24V (2*12V)	150	8.41	3.27	2.95
July	540	35	15.42	24V (2*12V)	150	7.07	2.75	2.48
August	540	35	15.42	24V (2*12V)	150	4.77	1.86	1.67
September	540	35	15.42	24V (2*12V)	150	7.72	3	2.71
October	540	35	15.42	24V (2*12V)	150	8.69	3.38	3.05
November	540	35	15.42	24V (2*12V)	150	8.89	3.46	3.12
December	540	35	15.42	24V (2*12V)	150	7.96	3.1	2.79

As shown in Table 2, the exceptional scenario is brief sunshine day in monsoon (August) where Power Available/day is 1.67KWh/day.

Otherwise, the facility available/day is capable or greater than 2.48kWh/day which is sufficient to require the load of 1000Watt households for 3 hours outage per day. In exceptional scenarios(e.g. heavy forecast and long outages), when batteries aren't fully chargeable by solar panels, dual input charge controller will be accustomed charge the batteries, which supplies priority to alternative energy when sun is shining and charges the batteries from grid power just in case of solar energy cut-off.

VI. CONCLUSION AND FUTURE PROSPECTS

The system comprises of two outdoor solar panels SunTech Power STP270-24/Vb1 (540Watt) which cost US $1440 [5]. Locally manufactured MPPT charge controller (efficiency 95%) and inverter (efficiency 90%) are available well under US $300. US $200 is required to get two 12V and 150AH Lead-Acid Batteries. US $150 is required for purchasing additional installation components and connectivity wires, shipping and other overhead charges.

A. First Solar's CdS-CdTe Technology

The only company that has managed to induce closer to the grid parity grail is "First Solar" which has recently brought technological innovation in its product by building the solar cells on glass substrate with CdS-CdTe thin film technology and scaling up the light-catching area from the scale of a token to almost the scale of a traffic-sign. Here, the active element is nineteen of the thickness of conventional silicon technology and production of panel takes 150 minutes, the time required in silicon equivalents is sort of one tenth. These are the explanations that First Solar is having the ability to sell all the cells it's making and has increased the scale of its production facilities leading to production capacity of over 1Gigawatt by end of 2009 [7]. Fig 2 shows CdTe-CdS based electrical device by First Solar.

Fig. 2 Glass Substrate based First Solar's CdTe-CdS Solar Panel

Today's CdTe modules manufactured by First Solar have 16% efficiency and 1.14$/Watt manufacturing cost. it's not barely enough for the primary Solar to match the grid generation costs as First Solar also must keep an economic edge over several other PV manufacturing companies. Since 1950s, when it had been commercially launched, conventional silicon technology has dominated the whole market and it still has some kick left.

The point at which PV electricity gets adequate to or relatively cheaper than the grid power, is named Grid parity. CPV technology or low cost cell manufacturing may be wont to achieve Grid parity. the purpose are first achieved in areas of the globe that have abundant solar power and expensive grid electricity including Pakistan. Some islands including Hawaii where grid electricity is produced using diesel generators, Grid parity has already been reached.

Analysis, conventional silicon manufacturers seem to be the most competitors of First Solar. Since the technology has matured, the efficiency doesn't seem to travel much beyond today's figure of 16%, but with disappearing Silicon shortage, Cost/Watt figure will decrease and competition will increase, thanks to reduced material costs. Also, the manufacturing equipment for conventional Silicon technology is well available as compared to CdTe technology, so barrier required for entry for brand new manufacturers is low.

Advantage results from the position of CdTe's absorption edge. a perfect photovoltaic cell starts absorbing sunlight at a wavelength of 910 nanometers. CdTe is near this wavelength, with absorption starting at 850 nm, while silicon starts to soak up at 1100nm. The major disadvantage of First Solar's CdTe technology is that the long-term availability of Te. Also, lower efficiency means large size of panels and increased cost in terms of area and support required to carry the panels.

B. CIGS Technology

Of the varied thin film technologies, CIGS (Copper Indium Gallium Selenide) has maximum efficiency in thin films (up to 20%). Fabrication involves vacuum processes including co-evaporation and sputtering that creates it very expensive. Recent developments are going down at IBM and Nano solar to use non-vacuum methods to lower the value. Until they achieve lowering the value, CIGS will remain out of competition despite of its high efficiency. [8]

C. Amorphous Silicon on Glass Technology

Amorphous silicon on glass technology is another thin film technology which has made an impression on the solar market. It's efficiency of around 7% and also the technology is unaffected by the silicon shortage because manufacturing requires only small quantity of Silicon. Also, since the manufacturing equipment is same like that of conventional silicon technology, it's more readily available and hence provides a chance to new - manufacturers with a lower barrier to entry. Though the manufacturing time is fast, the price per watt ratio remains slightly high for this technology.

D. Concentrated Photovoltaic

CPV- Concentrated photovoltaic technology reduces overall system cost in terrestrial systems by saving the price of enormous solar panels and using lenses and mirrors instead to focus sunlight on the solar cells. Thus achieving almost 100 times concentrated light, increasing the efficiency to almost 40%. Solar concentrators are usually mounted on solar trackers that focus the sunshine on cells because the sun travels within the sky as shown in Fig 4. Efficiency of solar cells increases in concentrated sunlight if the cell junction temperature is kept up to the mark using heat sinks. The advantage of CPV comes from the lower cost of solar concentrator as compared to equivalent electrical device area. Cost of CPV system including collector and tracker is well under $3 USD. To not forget that this technology can only be deployed in exactly 10-20% of the planet, the places which have sunny weather; since diffuse light, which is made by overcast conditions, can't be concentrated [9].

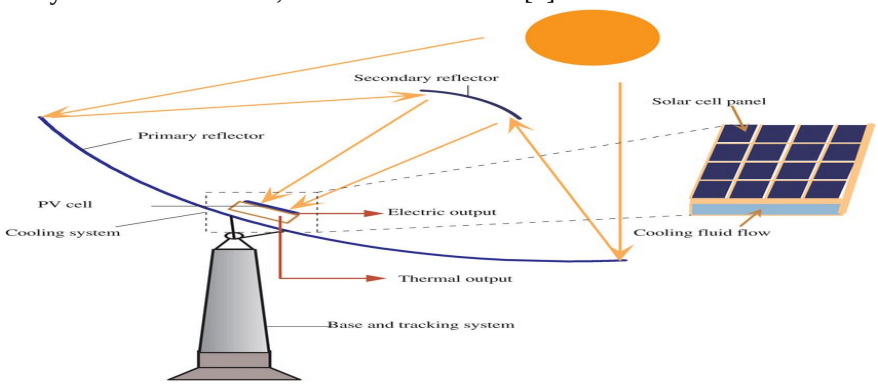

Fig. 3 CPV Panel with Tracker and CPV System

CPVT, Concentrated Photovoltaic and Thermal technology, within which single module is employed to supply electricity likewise as heat. I find it one in every of the viable options for Indian domestic market within the future. Solar thermal technology has already been deployed largely in India within the type of solar geysers and stoves, the longer term of CHAPS (Combined Heat And Power Solar) seems to possess lots of potential in our market. CPVT can increase overall efficiency of system in terms of energy output up to 40 to 50% as compared to 10 to twenty of normal photovoltaic cells.

E. Multi-junction Technology

Multi-junction electric cell technology is meant for non-concentrating aerospace applications like space satellites. It involves deposition of multiple layers of Ge, Ga-As, and indium gallium phosphide (In-Ga-P) over small Germanium Substrates. The cells are roughly 3 times as efficient as CdTe cells. Multi-junction cells are roughly hundred times as expensive as silicon cells thanks to relatively slower growth rates required during this technique for deposition over small Ge substrate [11]. Despite of of these drawbacks, multi-junction cells still got success in aerospace applications during which higher efficiency and reliability are required.

F. Nanotechnology

Nanotechnology is that the technology of solar arrays of nano antennas with high efficiency in capturing energy (up till 80%). Small metal spirals or squares are printed on polyethylenes that act as nano antennas to capture infrared radiations. Cyrium Technologies Inc. has recently started manufacturing high efficiency and cost-effective QDEC (Quantum Dot Enhanced Cells) for terrestrial applications using its proprietary nanotechnology [12].

G. Organic Solar Cells

Organic electric cell is another sort of nanotechnology that's still under research and testing, with price and energy payback time much less as compared to Silicon thin film technology. Reduction by 10 times to the present silicon based solar cells is predicted as a results of this technology [10]. A variety of dyes are developed in DSSC (Dye Sensitized Solar Cell). Naturally found organic compounds like Chlorophyll, Hemoglobin etc are accustomed prepare synthetic dyes. Green DSSC cells are made of titanium oxide which may be a non-toxic, plentiful and renewable natural mineral and thus are more environment friendly as compared to Silicon based cells. Another advantage of DSSC is that these cells perform well in diffused sunlight, whereas the Silicon based cells operate well only under direct light [13].

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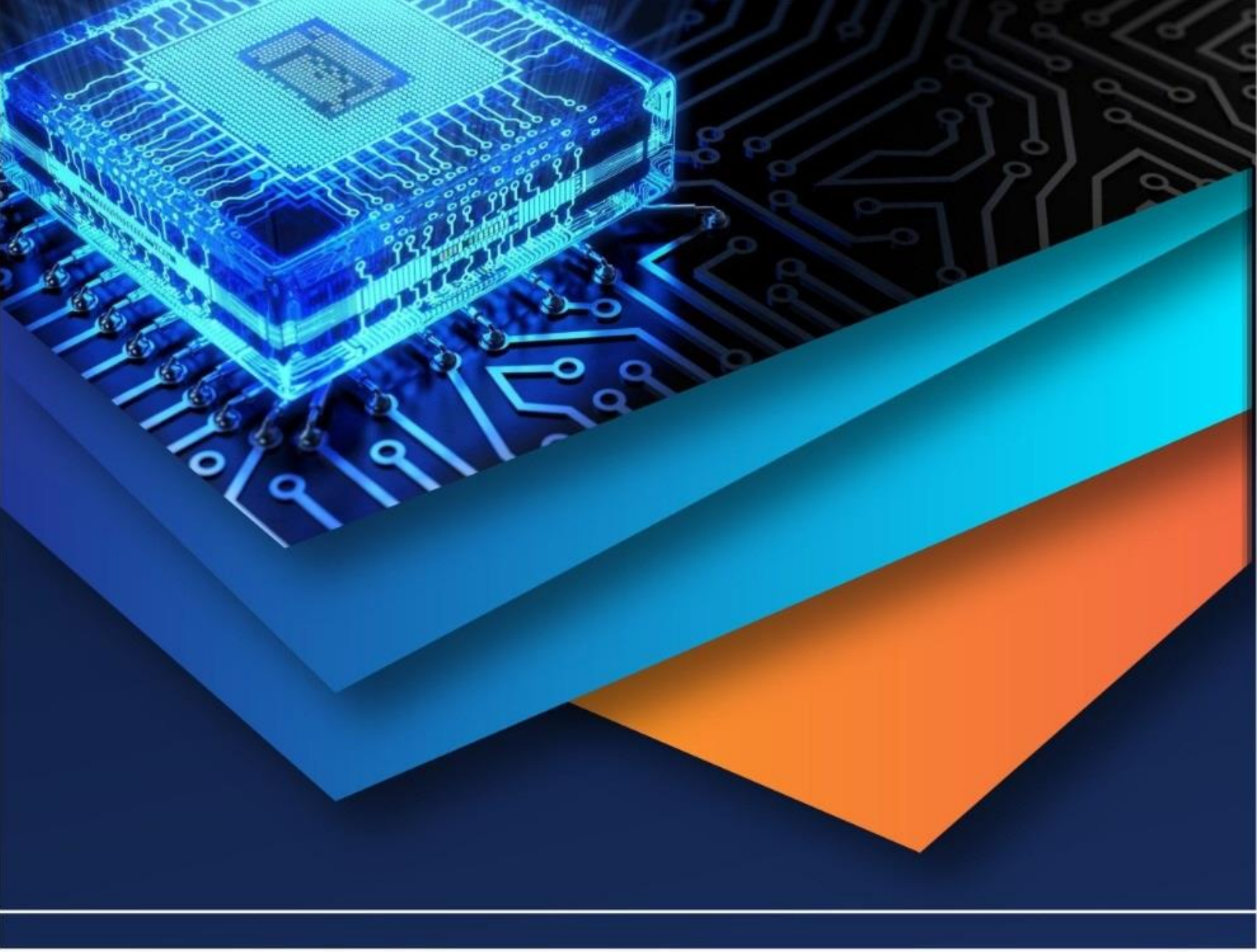

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