SOLAR CELLS ON ISO 1C CONTAINER

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Abstract: *The focus of this article is utilizing solar cells to reduce the dependence of military logistical support on traditional energy requirements. The emphasis is drawn from the US Army experience with the logistical requirements of energy support in multinational operations - especially Iraq. As the Iraq experience has demonstrated, frequently logistical convoys are attacked during their supply missions. Cut down the dependence of military forces on traditional energy supplies, and one markedly reduces the ensuing risk associated with convoy attacks.*

Keywords: *multinational operation, solar cell, solar energy, support.*

1. INTRODUCTION

Solar power or solar energy is a source of energy that uses radiation emitted by the Sun. It is a renewable energy source that has been used in many traditional technologies for centuries.

It is also in widespread use where other power supplies are absent, such as in remote locations and in space [1]. In multinational operation it can especially replace utilization of fossil fuels, which must be transported by military convoys.

The reduction of needs for petroleum at the outlying bases can decrease the frequency of logistics convoys on the road, thereby reducing the danger to soldiers. A bigger picture of the need for „renewables“ was sketched out in a key 2004 Pentagon study titled "Winning the Oil Endgame," by the Rocky Mountain Institute, an energy think tank in Snowmass, Colo. It found a number of areas where efficiency would boost combat effectiveness, including:

- More than 50 percent of fuel used by the Army on the battlefield is consumed by combat support units, not frontline troops.
- Until recently, the Army spent about $200 million on fuel annually, but, each year, it paid $3.2 billion on 20,000 active and 40,000 reserve personnel to transport it [2].

2. LIMITATION

Precise solar radiation in Kosovo and Iraq was the main limitative factor. It was estimated from a solar map. There are considerable differences between the southern and the northern parts of Iraq. Resulting values were calculated from average annual values. The article is limited by these presumptions:

- no differences between summer and winter season,
- no reflection losses, losses in distribution system, thermal losses (all partially estimated),
- no battery changes.

The price of foldout construction for solar cells variable gripping is concluded in 1 kWh calculation for horizontal and vertical gripping.

3. SYSTEM PARTS

3.1. ISO 1C CONTAINER

ISO 1C Container is modern and the most often exploited container in the Czech Army. It is fully suitable for logistic needs.

Container is designed for transportation and manipulation with military vehicles and it is fitted with binding means (fastening straps and multipurpose strips).

Container is manufactured in many versions that differ in specific interior and exterior layout (storage, cooling, quarter, lavatory, catchments, water reservoir, cooker, dining hall, other special ones). ISO 1C CONTAINER – OFFICE is under consideration for this analyses.

The container fully meets the needs of the Czech Army for station posts at the various levels of command. It also serves as a field office. Its design is based on the ISO 1C Quarter-container, type 5414 (ACCOMMODATION).

These containers with interior equipment are used for military purposes and for the stay of armed forces (especially in UN campaigns, humanitarian and peace-keeping operations, support of certain military operations during non-military situations and disasters, building of military camps, special armed forces training, etc.).

Container dimensions - Outside

- Length 6 058 mm
- Width 2 438 mm
- Height 2 438 mm

Container dimensions - Inside

- Length min. 5 770 mm
- Width min. 2 150 mm
- Height min. 2 100 mm

Tare 4 118 ± 5% kg

Maximum gross mass 12 000 kg

Table 1 Possible example - electrical interior establishment for military need

Electrical establishment	Number	Power consumption (W)	Time of utilization (h/day)	(kWh per day)
Notebook	2	40	16	1,280
Fluorescent	2	11	5	0,110
Emergency lighting	1	7	8	0,056
AC	1	400	16	6,400
Total without AC	-	-	-	**1,446**

Air-conditioning is the most serious problem of the planned container. Supposed 6,4 kWh per day will be probably unreachable for solar cells.

Energetic power requirement of AC would be replaced from other sources. However, electric input can be lower, it depends especially on AC characteristic, local conditions, isolation and temperature requirements and differences.

Charging station for radiators, transmitter or additional lighting could be solar-powered as well.

3.2. PHOTOVOLTAIC CELLS

Only one producer of solar cells exists in the Czech Republic. These cells were utilized for analysis.

Table 2 Analysed photovoltaic cells and their main characteristics[1]

No.	Cell specification	Proportions (mm)	Cells per container	Tract of cells (m^2)	Total solar output (kWp)
1.	PV mono 106 Wp	1305 x 667	13	11,32	1,38
2.	PV mono 55 Wp	1010 x 455	26	11,95	1,43
3.	PV mono 155 Wp	1578 x 813	10	12,83	1,55

It was necessary to keep free space (corner element) for container manipulation. Scheme of photovoltaic cells lay-out is visible on the figure 5.

Three ways of cells placing were taken in the analysis: vertical, horizontal, sloping (slope 25 – 60 degrees).

3.3. SOLAR SYSTEM PARTS AND PRICES[2]

All systems include:

* 1 pcs of regulator (System 3 needs 2 pcs of regulators),
* 1 pcs of changer 1000 W - stand-by,
* 14 pcs of accumulator 100 Ah (1 day autonomous operation),
* 1 pcs of carry frame,
* changer disconnection control unit,
* connecting material, conductors,
* assembly in the Czech Republic.

1. PV system with PV mono 106 Wp:

* 13 pcs of cells 106 Wp.

Total price: EUR 9,962.00

2. PV system with PV mono 55 Wp:

[1] Solar output can be calculate by product cell output and numbers of cells

[2] All prices is without VAT and all systems with carry frame.

* 26 pcs of cells 55 Wp.
Total price: EUR 10,756.00
3. PV systém s PV mono 155 Wp:
* 10 pcs of cells 155 Wp.
Total price: EUR 10,369.00

4. LOCAL CONDITION

Local condition will have critical influence on electric energy production. Main affecting factor for solar output is a solar radiation in the given region. Others can be dustiness, frequency of rains, elevation etc.

Table 3 Supposed solar irradiation rates[3]

Country	Average input solar radiation power per year (kWh/m^2)			Comparison with Czech Republic
	vertical	horizontal	sloping	
Czech Republic	700	850	1000	-
Kosovo	1400	1700	2000	double higher
Iraq	2800	3400	4000	4 times higher

5. ENERGY CALCULATION

The calculation procedure of energy output is not complicated.

Ignorance of exact local condition is the worst difficulty in conjunction with statement of losses (in region and loss solar systems – solar cell efficiency, changer, accumulator and wire losses etc.).

Daily energy production = (area of PV cells x solar radiation per year per m^2 / 365.25) * total efficiency of PV system (incl. losses)

5.1. PROCEDURE EXAMPLE

Let`s assume energy input per 1m^2 in the Czech Republic <u>for sloping gripping</u> (1000 kW per year) and cell efficiency of about 10.5 – 12.0 %, which will be reduced in the course of 20 years of utilization and limited by dustiness.

Cell efficiency will be restricted to 9 %.

Subsequently multiple:

) 1 000 kW (solar radiation rate)
* 0.09 (cell efficiency)
* 0.85 (changer efficiency incl. system losses)
= 76.5 kWh (solar cells output per 1 m^2 of cells per year)
) 76.5 kWh
* 11.32 m2 (area of solar cells on container)
= 865.98 kWh (solar cells output per total area 11.32 m^2 per year)
) 865.98 kWh
/ 365.25 (days in year)
= 2.37 kWh (solar cells output per total area 11.32 m^2 per 1 day)

Electrical output will be 2,37 kWh per 24 hours. Output for other panels, countries and cells gripping is calculated accordingly.

The highest energetic output will offer the third photovoltaic system because of the largest area of solar cells.

These results can be reduced with presumption of distribution, temperature, reflection, tilt losses (20 – 30 %). The lowest efficiencies of solar systems were used in the calculation. Punctual calculation demands practical tests in the given region.

System PV 3 is the most economically optimal solar system. Currently, electric energy price is lower (only in Iraq and **under the given limits**) than domestic electric energy price in the Czech Republic.

The most advantageous cells gripping is sloping, followed by horizontal and vertical ones.

6. SOLAR SYSTEMS COMPARISON WITH CURRENT WAY OF ELECTRIC ENERGY PRODUCTION IN MULTINATIONAL OPERATIONS

Czech army use generators, more powerful than solar cells. But, on the other hand, solar cells can bring sure **benefits**:

- increasing independence on other sources, especially fossil fuels;
- solar energy production doesn`t cause noise or smoke;
- sporadic repairs and no operational fluids;
- 15 – 25 years guarantee for solar cells function;
- environmentally friendly.

[3] Solar radiation in Kosovo and Iraq was estimated from solar maps. Big difference of solar radiation exists in north and south part of Iraq

Drawbacks:
- difficulty camouflaged before air reconnaissance;
- high demands for careful manipulation (vibration limitation);
- more difficult for container stacking (cells permanently gripped on container);
- higher container, limitation of vehicle passability;
- regular maintanance (dust out) for higher efficiency.

6. 1. ECONOMIC COMPARISON

Modern petrol generator BC 25 (not utilized in the army) was used for first economic comparison.
- Rated output: 2500 W
- Electric tension: 230 V~
- Storage capacity: 15 l
- Engine type / system: DJ200 / OHV
- Volume of cylinder: 196 cm^3
- Output: 5.5/4.0 HP/kW
- Fuel consumption: 0.35 l/kW/hod
- Proportions LxWxH cm: 59x43x44
- Noise level: 98 dB
- Price: **463.50 EUR**

Total output of electric energy for PV3 with sloping gripping is 2.69 kWh per day, 982.5 kWh (per year) and 19650.5 kWh (for 20 years) in the Czech Republic.

Mentioned generator can produce this quantity in uninterrupted running in 327,5 days, thus 0.897 year.

Consumption for producing 2.5 kWh is 0.875 l per hour, thus 21 litres (l) per day or 6877.5 l per 327.5 days. Total costs (average petrol price 1.06 EUR/l per 2006 in the Czech Republic) including the price of generator will be 7,745.50 EUR (7,282.00 EUR + 463.50 EUR).

The old and less effective petrol generator EC 1kW (utilized in Czech army) was used for second economic comparison.
- Rated output: 1000 W
- Fuel consumption: 1 l/kW/hod
- Price: **577.50 EUR**

This generator needs 2.24 years for the same energy quantity production (19 650.5 kWh) and continuous operation (24 kWh per day).

The generator consumes 1 litre of petrol for 1 kWh. It means 19 650,5 litres and in moneyed formulation 21,384.00 EUR (20,806.50 EUR + 577,5 EUR). And it represents difference **11,014.50 EUR** (including purchase price and operational costs for 20 years) for the benefit of solar cells.

No included factors:
- maintanance costs (higher for generators – cylinder grinding, oil and filter change, etc.; for solar cells – cleaning, battery change)
- mounting price of fossil fuels (c. 4 % per year)
- fuel transportation
- environmental influence of fossil fuels burning

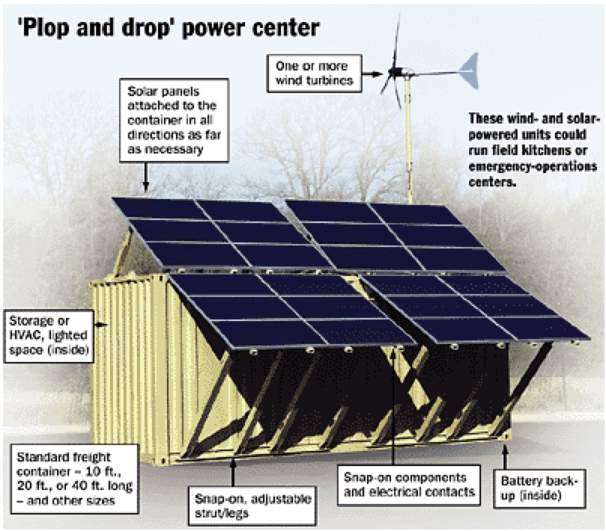

Fig.1 ISO 1C container with solar cells [4]

7. SUMMARY

Generators appear to be less effective than solar cells, detrimental to the environment, noise occasioning, but are able to produce more quantity of instantaneous electric energy. They can operate at night in contrast to solar cells. However solar cells are more profitable in a long time.

It is necessary to adjust solar systems for military needs, especially their facility of operation, transportation and maintanance would be the main priorities for their future implementation to army.

8. CONCLUSION

Solar technology development is constantly in progress in the world and its price decreases. This is the main reason for the necessity of annual calculation.

The anticipated solar cells efficiency 9 % is low, but easier for comparison because of a lack of amourphous or polycrystalline cells manufacturer in the Czech Republic. Contemporary solar cells can reach efficiency 40 % and planning 75 % at 2010.

This energy can mean absolute independence from fossil fuels.

The container equipped by solar system will be prepared for individual operation in remote locations.

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