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| IALA Guideline  A number of queries and suggestions arose when this Guideline was being reformatted to the new IALA image, as shown in the comments throughout the document.  The ENG Committee is requested to respond to these queries and suggestions and submit to the Secretariat to enable completion of the reformatting. |

1039

Designing Solar Power Systems for Aids to Navigation

(Solar Sizing Program)

Edition 1.0

December 2004

Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

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| Date | Page / Section Revised | Requirement for Revision |
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# INTRODUCTION

This program provides an iterative method of designing a solar power system for fixed or floating AtoN installations.

To obtain the MS Excel program, including password, please contact the IALA Secretariat via e-mail: [contact@iala-aism.org](mailto:contact@iala-aism.org). A sample page from the Solar Sizing program is at ANNEX A.

# INPUT DATA

To use the program, it is necessary to input information on local solar irradiation, technical details of the AtoN loads, and details of the particular types of solar modules and batteries that are planned to be used. These are described below. The areas on the program spreadsheet with a yellow background require input data. References in brackets (‘[ ]’) are to the cells in the program spreadsheet in which the data must be entered.

When the cursor is placed on any of the red-edged boxes, information windows are displayed.

## Solar Irradiation

Solar irradiation information can be obtained from a solar atlas, from the local meteorological office or from various Internet sites. This is entered in the lower part of the table ‘simulation’ as average DAILY RADIATION [B21..B32] in kWh/m² for each month of the year for the chosen mounting angle. Information for angles of 0°, 30°, 60° and 90° are usually presented in a solar atlas. The date of the start of the annual solar irradiation cycle must be the month of maximum irradiation.

## Latitude

The LATITUDE [B4] of the station is entered as degrees North or South.

## Orientation

A value must be entered to account for ORIENTATION [B9] of the solar panels.

* if the panels are South facing in the Northern hemisphere (North facing in the Southern) this will be 1;
* if the panels are randomly orientated as would be the case on a floating AtoN, this will be 0.7.

## Voltage

The VOLTAGE [B6] must be entered. This is the nominal design voltage for the power system and will usually be 12 volts, but in some cases may be 6 or 24 volts.

## Electrical Loads

The electrical loads that the system will support must be entered as lantern load and continuous load.

* Lantern Load;

LANTERN LOAD [B10] is the load in Watts presented by the lantern (or other AtoN operating with a character) when it is switched on. The proportion of the time that this load is switched on is described as the DUTY CYCLE [B11], which is entered as a percentage (e.g., 2sec on, 8sec off, would be a 20% duty cycle). Note: Switch closure time must be used rather than incandescent time.

* Continuous Load.

CONTINUOUS LOAD [B13] is the fixed or continuous load in Watts, presented by the flasher, charge regulator and any other fixed AtoN (racon, RTE, communications etc.).

## Switch Level

SWITCH LEVEL [B12] is entered as the time (in decimal hours) that the light switches on before dusk and switches off after dawn (e.g., 30 min. would be entered as 0.5 hour).

## Solar Panels

The parameters of the solar panels that you intend to use must be entered.

* Voltage;

These are voltage at maximum power point, entered at Umpp [B7] in volts. This value can be obtained from manufacturers data.

* Age;

AGE [B5] is a measure of the reduction in the efficiency of the panel during its working life (e.g., if the panel degrades 1% each year of its working life and it will be used for 15 years then a figure of 15x1=15% will be entered). The manufacturer can provide some guidance on this.

* Power.

The peak power of the total number of solar panels that you will use (the array) will be entered as POWER [B8] in watts. This will be a multiple of the peak power of the individual panels that you have chosen. Again, this information will be available from the manufacturer.

In practice, the size and number of the panels will depend on available space at the AtoN site and possibly by transport constraints. An initial estimate (guess) will have to be made of the number and hence peak power of the solar panels. This will then be refined by iterative use of the program.

## Batteries

Information regarding the batteries must be entered. A battery type must be chosen that will be suitable for the AtoN environment (e.g., spill-proof batteries for buoys, NiCd batteries may be considered for very low temperatures, battery dimensions will be limited on buoys, weight may be limited by local lifting facilities, transport systems, etc.).

* Maximum Useable Capacity;

From manufacturer’s information and design guidelines, a value must be chosen for the MAXIMUM USEABLE CAPACITY [B15]. This is the percentage of the battery capacity that can safely be discharged without reducing the working life of the battery (e.g., 80%). The German Administration considers that batteries are completely discharged only once per year (during wintertime), and hence ten or twelve times in total battery life. Thus, they calculate with 100% of maximum useable capacity.

* Efficiency;

BATTERY EFFICIENCY [B16] sometimes called ‘Round Trip Efficiency’ is the recharge efficiency of the battery expressed as a ratio of the charge energy (input) to the energy delivered to the load (output). This is calculated as input over output. This figure can be obtained from the manufacturers.

* Capacity;

BATTERY CAPACITY [B14] is entered as Ah (Ampere hours) when the total battery bank is discharged over a 100-hour period. This will be a multiple of the capacity of the individual batteries. If an estimate (guess) is entered for the total battery capacity, then the program will calculate the number of days that the system will be able to work, without any solar gain, at the time of year when there is the minimum sunlight. It will also provide a graphical presentation of the solar system energy balance throughout the year.

# OUTPUT DATA AND ITERATION

The DAYS WITHOUT GAIN [B17] provides a measure of the reserve capacity of the system. This may be referred to as the ‘No Sun Reserve’. Numbers of days may be chosen, depending on the local weather conditions for recharging the system during the winter period, or the distance to travel to the site for repairs if failure should occur.

The system design can then be refined by varying the numbers of solar panels (POWER [B8]) or batteries (BATTERY CAPACITY [B14]) to achieve a practical solution to provide the required number of DAYS WITHOUT GAIN [B17].

If the initial system design is incorrect and the proposed battery becomes fully discharged then an ‘error’ sign will appear in the DAYS WITHOUT GAIN [B17] and Ah [E21..F32] columns.

The table ‘simulation 2-year’ calculates the system for a second year. In case the batteries are not fully charged at the end of first year, there will occur an error in the simulation of the second year.

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# ACRONYMS

Ah Ampere hours

AIS Automatic Identification System

AtoN Aid(s) to Navigation

C100 Annex A

EULA End-user Licence Agreement

IALA International Association of Marine Aids to Navigation and Lighthouse Authorities - AISM

kWh/m2 kilowatt hours per square metre

m metre(s)

min minute

NiCd Nickel Cadmium (battery)

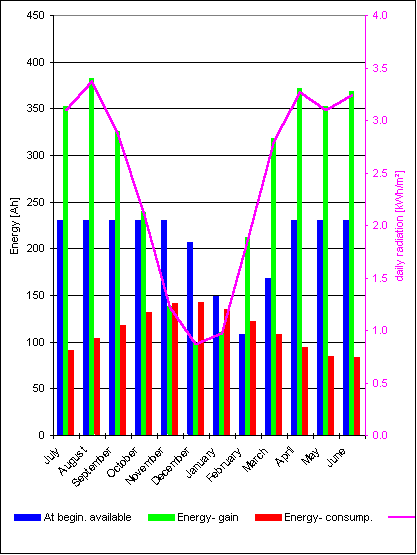
RTE Radar Target Enhancer

UMPP Volts maximum power (or power point)?? Annex A

W/m2 Watts per square metre

wo without?? (Annex A)

Wpeak Watts peak

2. SAMPLE PAGE FROM THE SOLAR SIZING PROGRAM

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sizing of Photovolatic-Systems**  with daylight-control | | | | Traffic Technology Center, Germany  DEMO-Version | | |
|
| **System** | **Light Buoy** (2,5m diameter, panel up right 90°) | | | | | |
| **Latitude / Station** | 53.6 | Volt | Voltage of the system | | | |
| **Age** | 20 | Volt | Voltage in the Maximum Power Point | | | |
| **Voltage** | 12 | Wpeak | Power at solar radiation of 1000W/m² | | | |
| **UMPP** | 18 |  | Deduction for different panel orientations | | | |
| **Power** | 120 | W | Lightswitched Powerconsumption | | | |
| **Orientation** | 0.7 | % | Character on/off ratio | | | |
| **Lantern load** | 3.2 | h | Added hours before dusk and after dawn | | | |
| **Duty cycle** | 78 | W | e.g. Charge Regulator, AIS, Racon | | | |
| **Switch-level** | 1 | Ah C100 |  | | | |
| **continues load** | 0.4 | % |  | | | |
| **Batterycapacity** | 230 | 85% |  | | | |
| **max. useable Cap.** | 100 | days | Number of days working without energy gain | | | |
| **Battery efficiency-1** | 1.17 | **Ah** | Days wo. Gain | | | |
| **Days without gain** | **27** | **Energy- gain** | **Energy- consumption** | | | |
| **Month of the first year** | **kWh/m² daily radiation** | **Energy- gain**  **352** | | | | **Energy- consumption**  **91** |
| **Energy- gain**  **352**  **383** | **Energy- consump.**  **91**  **104** | **230** | **At end** | **77**  **230** |
| **230** | |
| **July** | **3.10** | **326** | **118** | **230** | **230** | **59** |
| **August** | **3.37** | **240** | **132** | **230** | **230** | **53** |
| **September** | **2.87** | **139** | **141** | **230** | **207** | **50** |
| **October** | **2.11** | **99** | **143** | **207** | **149** | **44** |
| **November** | **1.22** | **110** | **135** | **149** | **109** | **34** |
| **December** | **0.87** | **212** | **122** | **109** | **168** | **27** |
| **January** | **0.97** | **318** | **108** | **168** | **230** | **48** |
| **February** | **1.87** | **372** | **94** | **230** | **230** | **74** |
| **March** | **2.80** | **352** | **85** | **230** | **230** | **83** |
| **April** | **3.27** | **368** | **83** | **230** | **230** | **84** |
| **May** | **3.10** | **368** | **83** | **230** | **230** | **84** |
| **June** | **3.24** | **368** | **83** | **230** | **230** | **84** |