Tideland Signal Corp.
featuring Aids to Navigation Products

5.1 Power Systems

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A. Design Considerations

The “weakest link” in modern Aids to Navigation Systems is the power system. In most cases, a solar system must be used in remote site locations and, naturally, on buoys. When mains power is easily available, this is often the preferred system. A mains power system is very forgiving and capacity is not normally an issue. However, it may not always be completely reliable and, on occasions, may require a battery and charger in reserve. Solar powered systems should be designed with accurate climatic data and with sufficient design margins. Opting to save a few dollars in capital expenditure is false economy, risking disproportionate expense on failed equipment and extra maintenance visits.

So when designing a system what should be taken into account?

The essential consideration is the amount of energy used, which is expressed, either in ampere-hours per day (Ah/day) at input voltage or watt-hours per day (Wh/day). This figure tells us exactly how much energy needs to be replaced in the power system each day.

What else needs to be considered? Basically nothing. Once that figure is known, the power system requirements can be calculated.

Before providing some examples it is worth mentioning the operating voltage. For most AtoN companies the standard design voltage is 9V to 36V DC. The most common nominal systems are 12V or 24V. Both are equally acceptable but generally 24V is reserved for larger systems or systems with longer cable runs where power loss may be an issue.

All AtoN suppliers are capable of providing you with sufficient information to calculate Ah/Day or Wh/day power consumption figures. Some will even provide the actual calculations. Here are some examples:

Flash Character Duty Cycle
To calculate Ah per day to enable solar sizing we first need to know the duty cycle of the flash character. The duty cycle is the percentage “ON” time for a particular flash duration. For example;

> **0.3 s [sec.] on, 0.7 s [sec.] off**
> Duration of flash character or period = 1 s
> On time is 0.3 s
> Duty Cycle (%age) is on time divided by period x 100 = 0.3s/1s x 100 = 30%
> **Thus the duty cycle is 30%**
>
> **0.5 s on, 1.0 s off, 2.0 s on, 11.5s off**
> Period = 15s
> Total on time = 2.5s
> Duty Cycle = 2.5s/15s x 100 = 16.7%
> **In this case, the duty cycle is 16.7%**

Ah/day
Once the flash character duty cycle is known the Ah/day can be calculated.

> Assume:
>
> > lamp size: 12VDC 2.03A,
> > 17% flash character duty cycle

Lamp on time: 0.3 second (hence, average current is 2.76A) *Fig.1)*.
14 hour night.
Flasher quiescent power drain = 0.1 Ah/day

Calculation [for Ah/day]
(14 hours x 2.76A x 0.17) + 0.1Ah quiescent = 6.67Ah/day

Thus the Ah/day figure is 6.67 Ah/day

Two features of the calculations, above, are worthy of note: the hours of darkness and the average current

As a good “rule of thumb”, most calculations assume a mean night of 14 hours. Nonetheless at extreme latitudes, this might be increased.

The average current takes into account the surge of current that is applied to a filament lamp at contact closure. The table, below lists values of average current for sizes of lamp and contact closure times (CCT).

FIGURE 1. Average Lamp Current

	AVERAGE CURRENT (In amperes)				
LAMP SIZE (amperes)	**CCT 0.2 sec**	**CCT 0.3 sec**	**CCT 0.4 sec**	**CCT 0.5 sec**	**CCT 1.0 sec**
0.25	0.282	0.272	0.268	0.262	0.254
0.55	0.666	0.639	0.621	0.605	0.578
0.58	0.715	0.682	0.664	0.647	0.618
0.77	0.970	0.916	0.894	0.870	0.816
0.833	1.060	1.002	0.974	0.945	0.887
1.00	1.310	1.230	1.180	1.150	1.070
1.15	1.530	1.415	1.380	1.334	1.242
1.35	1.836	1.728	1.647	1.592	1.471
1.67	2.35	2.20	2.09	2.02	1.82
1.9	2.73	2.55	2.43	2.32	2.09
2.03	2.96	2.76	2.62	2.50	2.23
2.92		4.25	3.97	3.73	3.27
3.00			4.07	3.84	3.36
3.05	-	4.49	4.15	3.91	3.42
3.33			4.60	4.30	3.73
4.17			4.64	4.56	4.40
6.25					6.63
8.33					8.87

With LED Technology there is no surge/“inrush” current to be taken into account, so calculations are simpler.

Ah/day calculation for LED lights

Assume:

> Lantern is rated at 7W, so current = 0.583A at 12V DC. Most manufacturers quote LED lantern input power in Watts (W).
> Flash character duty cycle = 20%
> Flasher quiescent power drain = 0.1 Ah/day

Most manufacturers quote LED lanterns in terms of Watts (W). If we assume a lantern is rated at 7W the current is 0.583A at 12V DC.

Assume a 20% duty cycle flash character

Calculation:

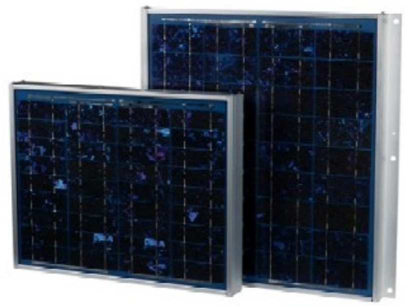
> (14 hours x 0.583A x 0.2) + 0.1Ah quiescent = 1.63Ah/day
>
> **Thus the Ah/day figure is 1.63 Ah/day**

FIGURE 2. Some useful conversion facts applicable to DC systems.

V = Volts	V x A = **W** (watts)	**s** = second
DC = Direct Current	W ÷ A = **V** (volts)	**CCT** = contact closure time
A = Amps (Current)	W ÷ V = **A** (amps)	**LED** = light emitting diode
I = Current (Amps)		
W = Watts	5A @12V = 60W	
Ah = Ampere hours	2.5A @ 24V = 60W	
mA = 0.000A (2mA = 0.002A)		
k = 1000 (2k = 2000)		

B. Solar Power Systems

Solar power systems are the most commonly used by AtoN. Their charging source, the sun, is free; they can be installed in most locations, with due regard to shading, fouling of arrays, and maintenance, requirements are simple.



In a solar power system, solar panels charge the battery by day and the battery operates the AtoN load as required. The battery also provides another important function, holding reserve energy (charge), thereby allowing for the lack of recharge on days when there is reduced or no solar charging. For given loads (in Ah/day or Wh/day), solar array charging power and battery capacity can be calculated.

Apart from ensuring sufficient battery power there is another consideration. When a lead acid (most commonly used) battery falls below a certain capacity it is much harder to re-charge. With such batteries, it is normal practice to design a solar system that does not allow the battery to fall below a certain level of capacity – 40% in temperate climes and 50% or more in locations where temperatures close to freezing may be encountered.

Batteries also degrade over a period of time and it is good design practice to include an aging factor of up to 20%.

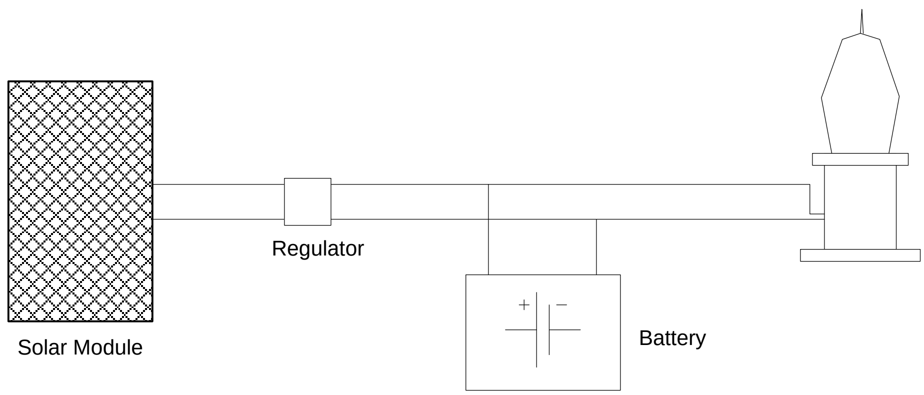
Solar panels are normally selected based on their wattage. Common sizes used in the AtoN industry are 5W, 10W, 20W, 30W, 50W, 65W and 85W. Output voltages are usually 12V or 24V; 48V is rare. 6V and 18V systems - once considered popular- are now obsolete.

When selecting solar modules it is of the utmost importance to select marine grade due to the very harsh environment. A solar module used on the roof of a house, for example, is probably not going to last long on a buoy in the open sea.

Finally, like batteries, solar modules also de-grade over a period of time. It is, therefore, good design practice to use a de-grading margin in solar sizing calculations. calculations.

With the following inputs, a calculation can be run, to size the solar array and battery bank.

Ah/day or Wh/day load
Battery Requirement + 20%
Solar Requirement + 20%



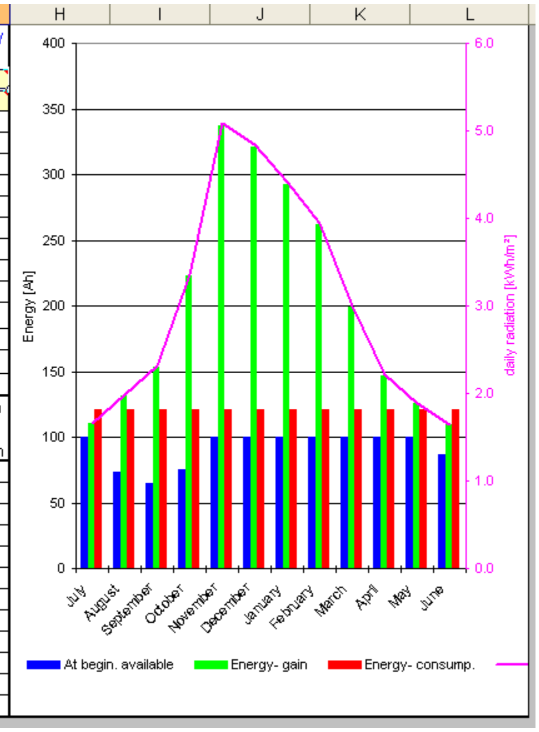
In the early days, solar sizing was based upon experience in different locations and on various "DOS" based programs. It then moved on to more sophisticated programs and recently IALA produced their own recommended solar sizing program.

All AtoN companies will have various methods and also solar panel companies will offer a design service. Many companies have now adopted the IALA solar sizing program as their standard. This program allows the designer to input equipment rating, duty cycle and various parameters to select a suitable solar and battery package. Figure 3 provides an example.

FIGURE 3. IALA Solar Program

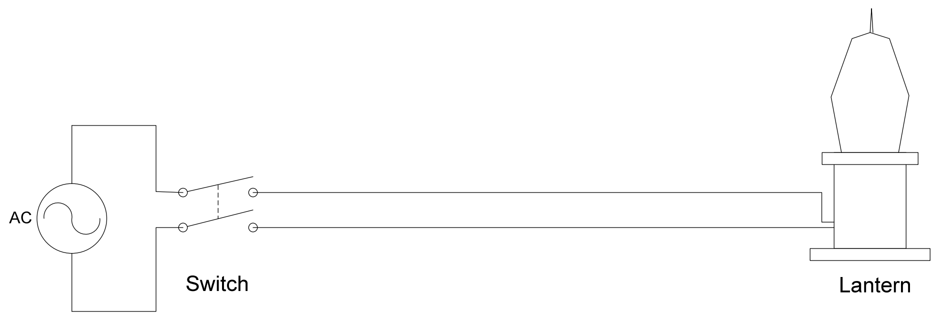
	A	B	C	D	E	F	G
1	Sizing of Photovolatic-Systems				Traffic Technology Center, Germany		
2	with daylight-control				DEMO-Version		
3	System	Racon on Unlit Buoy (2,5m diameter, panel up right 85°)					
4	Latitude / Station	29.5	°	Norderney			
5	Age	20	%	Deduction for ageing of solarpanels			
6	Voltage	12	Volt	Voltage of the system			
7	U_{MPP}	18	Volt	Voltage in the Maximum Power Point			
8	Power	70	W_{peak}	Power at solar radiation of 1000W/m²			
9	Orientation	0.7		Deduction for different panel orientations			
10	Lantern load	0	W	Lightswitched Powerconsumtion			
11	Duty cycle	100	%	Character on/off ratio			
12	Switch-level	1	h	added hours before dusk and after dawn			
13	continues load	1.98	W	e.g. Charge Regulator, AIS, Racon			
14	Batterycapacity	100	Ah C_{100}				
15	max. useable Cap.	100	%				
16	Battery efficiency[1]	1.17	85%				
17	Days without gain	16	days	number of days working without energy gain			

	A	B	C	D	E	F	G
18–20	Month of the first year	kWh/m² daily radiation	Ah Energy-gain	Ah Energy-consump.	At begin. available	At end available	Days wo. Gain [days] at begin of month
21	July	1.66	110	121	100	74	25
22	August	1.98	131	121	74	65	19
23	September	2.31	153	121	65	75	16
24	October	3.36	223	121	75	100	19
25	November	5.08	337	121	100	100	25
26	December	4.84	321	121	100	100	25
27	January	4.41	292	121	100	100	25
28	February	3.95	262	121	100	100	25
29	March	3.00	199	121	100	100	25
30	April	2.21	146	121	100	100	25
31	May	1.89	125	121	100	87	25
32	June	1.65	109	121	87	59	22



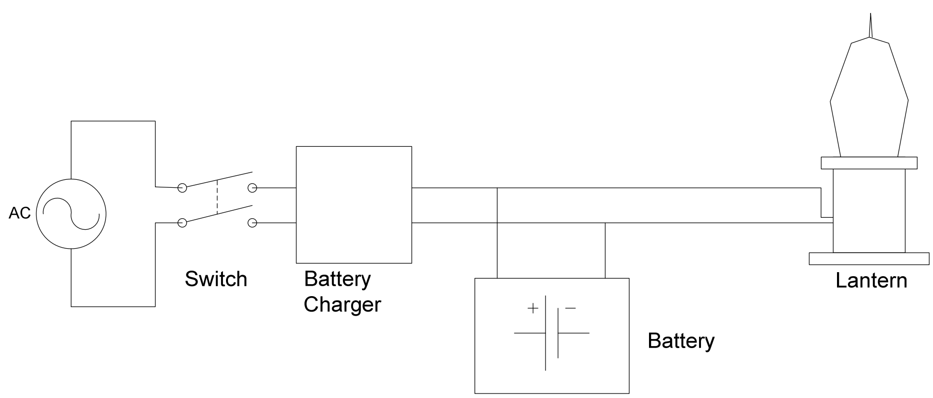
C. Mains Power and Battery Chargers

Sometimes it is convenient to install a lantern directly to a secure source of main power, in bridge light applications for example. In this case a lantern accepts 110V or 240V AC directly. Naturally total power requirements should be calculated but AtoN lanterns use so very little power that this is not normally a problem for mains powered systems.



Although some lanterns can accept a direct connection to main power, many cannot. In this case the AtoN supplier may install a small AC/DC converter within the lantern.

A common system is to install a battery charger that may run one or several AtoN's. This is a more robust system as it operates at mains power but has the added advantage of providing a back up in the event of mains power failure.



Mains power is supplied to the battery charger and charges a 12V or 24V DC system. Chargers are rated for the applicable duty and Tideland has a marine grade, 10A, charger that is also ATEX certified for platform use.

Battery capacities are usually chosen to provide a safety margin for possible power cuts. Even allowing for say 10 days reserve a 105Ah battery is often sufficient.

Although a main powered system is less challenging to design, care should be taken in selection of marine grade cables, switches and junction boxes.

Battery chargers come in all shapes and sizes but always remember "marine grade". One other point often forgotten is ambient temperature as equipment is installed in various climates. Tideland equipment is designed to -40ºC to +70ºC.

D. Batteries

A good reliable battery is of the utmost importance. Tideland has lost count of the number of times it has been called to “fix” an installation only to find poor quality batteries have been used.

Many buyers will look at a specification for a 12V – 105Ah battery and purchase a truck battery thinking it is cost effective and will last; WRONG!

A vehicle battery is designed for high ampere starting and a strong charge. It is also designed for a less arduous environment. A battery designed for a solar powered AtoN environment is designed for a slow solar charge and a slow power discharge. It is also designed for rough abuse, a buoy rolling for example.

Marine quality batteries are more expensive but how much does it cost to go out to an AtoN to replace a defective battery?

The most common battery used is a sealed lead acid battery. Lead acid batteries have been workhorses for AtoN applications for many years and continue to be the most reliable power source. Typical application lifetime of the lead acid battery is about 5 to 8 years with excellent cost efficiency and decent energy density (14 Watt*hour/lb). Its low self-discharge rate of 1 to 3% per month is the best among batteries of different technologies. The other advantage of the lead acid battery is the charge efficiency over the temperature range, which is excellent, compared with other types of batteries.

Lead acid batteries are manufactured based on different technologies such as:

- Pure lead (Plante)
- Lead Antimony – Antimony alloy additive to the lead.
- Lead Calcium – Calcium alloy additive to the lead.
- Hybrid – Employing a mixture of alloys such as tin, aluminum etc., added to the pure lead.

Other types of battery are available such as Nickel Cadmium (NiCad). These are sometimes used in colder climates, as they are better suited to recovery from deep discharges.

Tideland supplies various marine grade batteries, which have been proven in the field with life cycles from 3 to 5 years and higher. They include:

- P/N 182.1078-00 - V12MF : lead calcium type, sealed. 12V/105AH.
- P/N 182.1062-00 - V6MF : pure lead. 6V/100AH
- P/N 182.1083-00 - Energy Cell : Gel type, VRLA, 12V/105AH
- P/N 182.1073-00 – 2G-12 : primary cell, gelified, air polarized, 2.7V/1200AH
- P/N 182.1074-00 – 3G-12: primary cell, gelified, air polarized, 4.05V/1200AH
- P/N 182.1101-00 – sealed lead, 12V/38AH
- P/N 182.1104-00 - sealed lead, 2V/12AH
- P/N 182.1105-00 – NICAD battery system – 12V/105AH.

E. Battery Boxes

A battery box protects a power system and promotes longer battery life. Poorly designed boxes will lead to premature failure by allowing batteries to suffer environmental and physical damage.

Battery boxes should be designed to hold the batteries securely, to protect them from the environment and allow batteries to breath. Common materials include polyethylene for smaller boxes, GRP and sometimes galvanized or stainless steel. For most applications GRP is suitable as it is strong and lightweight.

The FG-2 holds one or two , 105Ah batteries rated at 12V and is a commonly used on small solar systems.

An FG-8 is a common site on offshore platforms and will hold up to six 105Ah batteries rated at 12V.

For special applications ATEX certified battery boxes are required. These are suitable for installation in explosive environments.