Reliability of the S4GA Solar Permanent Runway Lighting: An independent field study report

Table of Contents

Introduction

This independent review details on field performance tested by the author in multiple airports which uses Civil and Military AGL and has incorporated his observations based on analyzing specifically S4GA brand solar AGL lighting under multiple criteria such as,

- Compliance
- Reliability
- Availability
- AGL Technology (LED and other technical prospects)
- Comparison to conventional electrical AGL systems
- Technical compatibility to existing airfields.

My reports are detailed as below with a first note of impression as below,

"While Solar AGL lighting are yet to be widely used, I was impressed of the existing product range and reliability
of S4GA lighting has offered us in terms of performance, technology, quality and pricing".

This report details a review in terms of Compliance, reliability vs. availability vs. continuous improvement, live study observation in terms of niche product availability and pricing comparison and various inputs which you will be requiring as an airport operator in deploying S4GA as your reliable AGL partner with its various competitive advantages over other conventional AGL methods including green solar energy.

Review of S4GA Solar lighting for civil, military or emergency deployment requirements

Following is my review of S4GA solar lighting, I am hereby pleased to cover my live observation in testing S4GA lights for a period of 4 years+ in utilization for my runway lighting requirements tests.

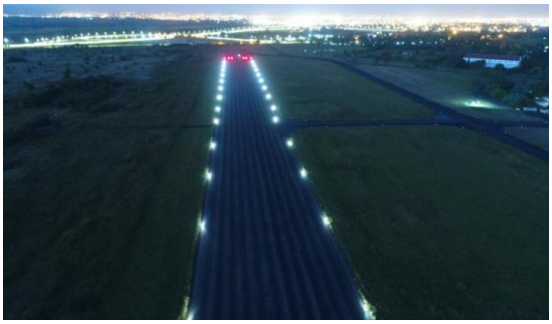
A few questions as an AGL specialization team when it came to our minds while we were studying S4GA lights and trying to fit it into our existing AGL system.

- Is S4GA solar AGL system as reliable as the conventional 6.6A powered AGL?
- Is S4GA solar AGL system performance greater than the conventional 6.6A powered AGL?
- Does the S4GA AGL system operate 365 days?
- Reliability vs. Availability vs. Continuous Improvement.
- Is the solar AGL system – wireless control safe to operate?

First Impression

S4GA was the only system we observed to have the complete set of AGL requirements. I have added the live study in the following sections where you can understand the product range and pricing of S4GA in comparison to other vendors.

The pictures which are live from the airfield shows the compliant AGL texture which gives the widely spread uniform standard of using S4GA system in these projects.



These pictures of live airfield deployments from S4GA can detail us the level of quality AGL gradient that can be deployed and becomes "Available" to cater the needs of the airport operator as a quality AGL partner.

Is S4GA solar AGL system as reliable as the conventional 6.6A powered AGL?

Technical explanation:

A conventional 6.6A Airfield Ground Lighting System consists of series connected electrical primary cables which are connected together by isolation transformers, connectors and other required components which are further connected to and powered by the use of Constant Current Regulators (CCRs). A typical conventional Airfield Ground Lighting system is schematically represented as below.

As per the earlier observation we find that the system is a series connection of CCRs → Connectors → Primary Cables → Isolation transformers → Lighting fixture etc.

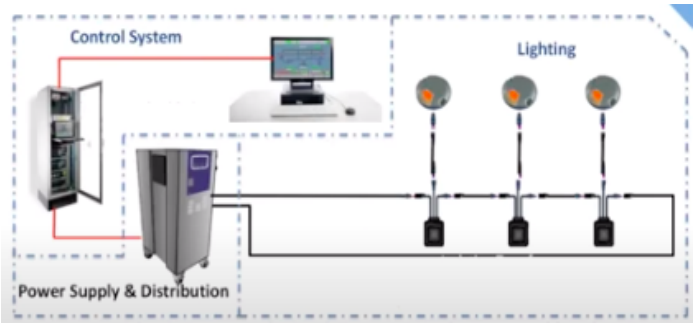
Analysis result: S4GA solar AGL system has **higher reliability** comparing to conventional 6.6A powered AGL because of the following facts :

- S4GA solar AGL system by its nature, a power distributed system and hence a single connection failure becomes impossible whereas in terms of conventional 6.6A AGL system, it is imminent that connected power failure (centralized power supply) happens if you happen to lose a substation or primary cable / transformer on a particular section or entire area of an airfield. This is not possible while you use a S4GA solar AGL system for your setup since the lights belong to a power distributed installation pattern. Hence, we won't lose a collective area of AGL section in comparison to the conventional 6.6A power pattern.

Is S4GA solar AGL system performance greater than the conventional 6.6A powered AGL?

As per conventional AGL engineering concept, a routine conventional AGL 6.6A system is connected in series through the following concept ensuring alternate failure lighting redundancy.

A typical simple routine AGL conventional lighting can be schematically represented as below.



As we can witness from the above simple routine AGL 6.6A schematic, the system works in the routine as,

AGLCMS → CCR → Primary cables → Isolation transformer → Lamp monitoring units (optional) → AGL light fixture.

The above circuitry however comes with its own advantages and disadvantages. For instance, if the primary cable fails, you will lose the entire AGL lighting circuit which is fed by that particular primary cable. Thus, it has its own time duration to perform corrective maintenance to bring back the circuit to operational requirements. Associated lighting serviceability requirements are lost during such cases.

In case of S4GA, the lighting system operates on radio communication based network with its individual control and back-up power supply (dual battery) along with its solar panels individually charging each fixture. Thus, such a potential failure as discussed for wired system in the above scenario will not happen if you are using S4GA AGL system instead of a conventional series connected AGL system.

This is a higher advantage while considering upgrading of an existing simple AGL system into state-of-art LED lighting system working with green energy solar source.

Additional features observed

S4GA is one of the few companies who provide HIRL (High Intensity Runway Lighting) in LED technology. Once during my project requirements, we were upgrading a conventional 6.6A CAT I lighting requirement. As we analyzed our requirement to move from halogen to LED and looking at higher reliability and availability, the only option we ended with which was efficient was to upgrade the airfield to S4GA Solar AGL system. This has resulted us greater than 55% of costing (CAPEX/OPEX/MAINTANANCE) in terms of conventional 6.6A lighting keeping in mind the savings from not installing manholes, ducts, cables and connectors in comparison to installing direct S4GA solar AGL lighting which becomes “Simply Efficient Solar AGL LED lighting with a greener energy”.

Does the S4GA AGL system operate 365 days?

The Reliability and availability of S4GA systems are relatively higher which can be noted from my serviceability vs. availability vs. continuous improvement study which follows in the report in a separate session as you progress.

Is the S4GA solar AGL system – wireless control safe to operate?

Technical Analysis:

In an engineering perspective, below are the frequencies which are typically supporting the aviation operations.

These are listed as follows,

- Localizer antenna = 108 till 112 Mega Hertz.
- Glide Path antenna = 328 till 336 Mega Hertz.
- DME antenna = 960 till 1215 Mega Hertz.
- TACAN system = 1000 Mega Hertz.
- DVOR system = 108 till 118 Mega Hertz.
- Instrument Landing System = 960 till 1105 Mega Hertz.

The wireless control of S4GA primarily operates in a frequency band of 868 Mega Hertz which does not fall in the aviation operating frequencies which are mentioned above which means technically there should not be any interference observed while using the S4GA wireless control to operate the lights.

Let us now see the field analysis observation as below,

Field analysis observation:

- The wireless control of S4GA is observed to operate in a frequency of 868 MHz which are operating in a form of Mesh network and hence the radio reaches till the last available solar AGL light in your airfield (in practice there is no distance limit to use S4GA fixtures)
- The comparatively distinct frequency of operation of S4GA system has hence been observed not to cause any interferences with other systems of the airfield such as Wireless Internet / network communications, ILS systems, DVOR, DME, VHFs etc.

Comparison of S4GA in terms of product range and pricing to that of other available solar lighting vendors on my live project works

A table of comparison between S4GA lighting and other vendors have been provided here for a referral study which I prepared during a collective data analysis as I was working for preparation of a new runway lighting requirements for emergency deployment works. Few challenges I had to face or to upgrade the existing runway lighting to LED with a higher reliability to keep the maintenance manpower in the site to bare minimum as per the requirements of the project maintenance client as well as the remote deployment requirement of the airfield where it is supposed to be kept at bare minimum levels of manpower.
After a collective analysis, it became relatively easy for me in terms of costing, technology (AGLCMS and LED) and reliability to choose S4GA Solar AGL system as the concluding solution.

The study below in the following table enables you a complete idea in comparing the available niche product range of S4GA in comparing to other vendors and I have given an indication of the pricing savings which will be obtained.

	EMERGENCY SOLAR AIRFIELD DEPLOYMENT LIGHTING REQUIREMENTS				
	CONSIDERATIONS				
	I. RUNWAY OF 3600 m length and 45m width.				
	ii. Optimal runway lighting required for complete coverage with redundancy.				
	iii. Considerations for appropriate lighting pattern and pilot zone accuracy for airfield lighting vicinity.				
S#	**Item Description**	**S4GA**	**Vendor 1**	**Vendor 2**	**Vendor 3**
1	Solar PAPI lighting for both the directions on the port side of the runway	✓	✓	✓	✓
2	Red/Green: Solar Threshold/End Light	✓	✓	✓	✓
3	Runway Edge lights (for 2900m)	✓	✓	✓	✓
4	Runway Edge lights: White / Amber (for last 600m)	✓	✓	✓	✓
5	Runway Approach Lights:	✓	✓	✓	✓
6	2 nos. digital radio control and monitoring set.	✓	✓	✓	✓
7	Barricade Red	✓	✓	✓	✓
8	ALCMS (Workstation based lighting control & monitoring system)	✓	**No Available Product**	**No Available Product**	**No Available Product**
9	HIRL (High Intensity Runway Lighting)	✓	**No Available Product**	**No Available Product**	**No Available Product**
	Delivery Conditions	**12 weeks**	**14-16 weeks from the receipt of LPO and advance payment.**	**Ex-works (8-12 weeks)**	**14-16 weeks from the receipt of LPO and advance payment.**

Following are the important information I have noted and hence displayed for your review which are relatively very impressive,

- S4GA is the only solar AGL company to give a quotation which were a complete set for runway lighting whereas other vendors are not able to provide a complete product set.
- Reliable HIRL (High Intensity Runway Lighting) availability.
- Delivery time was relatively faster than other suppliers.

- Though a full profile was not available from the other product vendors, S4GA's pricing was observed by us to by 55% better cost-effective (CAPEX/OPEX/MAINTANANCE) pricing in comparison to other suppliers as well as considering the full product availability.
- Upgradation from conventional 6.6A lighting which was halogen to state-of-art LED technology became easier due to the niche product suite.

Compliance requirements, backup power source and optical features studied

Compliance requirements

S4GA lights' compliance can be understood from the Intertek certifications which are achieved by them in terms of ICAO compliance requirements. Our clients had a compiled look on the individual certifications of S4GA for the wide list of LED lights which we have tested in our airfields and are ensuring compliance to the airfield requirements as stated by the standard recommended practices of ICAO annexes and aerodrome design manual recommendations.

Compliance matrix

Authority	Document	Other compliance references	Norm	Clause/Figure/Appendix	Requirements	S4GA specification	S4GA COMPLIANCE
ICAO	Annex 14, Volume I, 8th Edition dated July 2018	(Other compliance document references which contains similar requirements as per local aviation authority i.e., Public Civil Authority of Oman) CAR-139 (Part – I) Aerodrome Certification, Design and Operation Part - 1	Photometric	Clause 5.3.4.8 & 5.3.4.9	**Approach light –** intensity of the lights should be adequate for all conditions of visibility	1 800 cd	Meets
				Clause 5.3.8.3 & 5.3.8.4	**Runway threshold identification lights** should be flashing white lights with a flash frequency between 60 and 120 per minute. The lights shall be visible only in the direction of approach to the runway	1 200 cd White flashing, 94 FPM Unidirectional type	Meets
				Clause 5.3.9.8 & 5.3.9.9	**Runway edge light** – the intensity shall be at least 50 cd	1 200 cd Combined type optics (omni- and bidirectional type)	Exceeds
				Clause 5.3.10.9	**Runway threshold and wing bar lights** shall be fixed unidirectional lights showing green in the direction of approach to the runway	450 cd Unidirectional, Green	Meets
				Clause 5.3.11.4	**Runway end lights** shall be fixed unidirectional lights showing red in the direction of the runway	320 cd Unidirectional, Red	Meets
				Clause 5.3.18.7 & 5.3.18.8	**Taxiway edge lights** shall be fixed lights showing blue. The intensity of taxiway edge lights shall be at least 2 cd from 0° to 6° vertical, and 0.2 cd at any vertical angles between 6° and 75°.	11 cd Omnidirectional, Blue	Exceeds
			Chromaticity	Appendix 1, Figure A1-1b	Runway approach lights - White	Runway approach lights - White	Meets
					Runway threshold identification light - White	Runway threshold identification light - White	
					Runway edge light - White	Runway edge light - White	
					Threshold light - Green	Threshold light - Green	
					Runway end light - Red	Runway end light - Red	
					Taxiway edge light - Blue	Taxiway edge light - Blue	

Authority	Document	Norm	Clause/Figure/ Appendix	Requirements	S4GA specification	S4GA COMPLIANCE
ICAO	Aerodrome Design Manual, Doc 9157, Part 6 Frangibility	Jet Blast Resistance	Clause 3.2.2	Should withstand normal wind loading of 140 km/h; and should be capable of surviving a higher level of wind speed - 210 km/h	All S4GA lights can withstand 240 km/h wind loading	Exceeds
			Clause 4.9.1	Should withstand 240 km/h (for low intensity lights)	All S4GA lights can withstand 240 km/h jet blast	Meets
FAA	FAA AC 150/5345-50B Specification For Portable Runway And Taxiway Lights		Clause 3.2.2	Exposure to wind speeds up to 150 mph (240 km/h) from any direction	All S4GA lights can withstand 240 km/h wind loading	Meets
ICAO	Aerodrome Design Manual, Doc 9157, Part 6 Frangibility	Frangibility	Clause 4.9.2	The yield point should withstand a bending moment of 204 J without failure but should separate cleanly from the mounting system before the bending moment reaches 678 J	Yield point separates from the mounting system at 306 J	Meets
	Annex 14, Volume I, 7th Edition		Clause 5.3.1.3	Light fixtures and supporting structures Note.— See 9.9 for information regarding siting of equipment and installations on operational areas, and the Aerodrome Design Manual (Doc 9157), Part 6, for guidance on frangibility of light fixtures and supporting structures.	Frangible yield point of mounting for SP-401 Airfield Light separates from the mounting system at 306 J	Meets
FAA	FAA AC 150-5345-46E Specification For Runway And Taxiway Light Fixtures		Clause 3.4.2.1	Yield Device. a. Each elevated light fixture must have a yield point near the point or position where it attaches to the base plate or mounting stake. (1) The yield point must be no more than 1.5 inches (38 mm) above the threaded interface of the elevated light cover (see AC 150/5345-42 for more information). See AC 150/5340-30 for additional information about light fixture yield point above grade location. (2) The yield point must give way before any other part of the fixture is damaged, and must withstand a bending moment of 150 foot-pounds (203 Newton-meters (N-m) without failure. (3) The yield point must cleanly separate from the mounting system before the bending moment reaches 500 foot-pounds (678 N-m). (4) If the yield device uses a threaded connection to the base plate or stake, it should have a male external thread with either 2 inch (50.80 mm)-11.5 National Pipe Thread (NPT) or National Pipe Straight (NPS) thread, or 1.5 inch (38.10 mm)-12 Unified Fine (UNF) thread.	SP-401 elevated light is fully compliant with FAA frangibility requirements	Meets
	FAA AC 150 5220-23 Frangible Connections		Clause 3.2	Equipment located in airfield safety areas must be mounted on frangible supports to ensure the structure will break, distort, or yield in the event of an accidental impact by an aircraft.	SP-401 light is equipped with frangible mounting	Meets

Backup power source

- Every S4GA light is observed to have been built with highly efficient solar panels which efficiently charges the dual battery power banks in individual lights. Since all lights are equipped with dual battery power banks which operates in parallel and hence by design itself, due to dual battery power banks; we have a readily available backup power source.
- Every single light is monitored in the ALCMS (Airfield Lighting Control and Monitoring System) of S4GA and hence the status of battery charging can be observed by the maintenance team and appropriate action can be taken in case of observed battery malfunction. This has given a feature to efficiently monitor and ensure field AGL stability. As of my observation, we have not

seen any conditions where complete battery power bank failure was observed, the AGL lighting are very stable in operations.

Photometry, frangibility, jet blast etc.

- While we performed photometric tests for individual lights to look at the optical candelas and lighting spread of the beams, it was observed that the photometric characteristics of the individual lights provided to be of excellent standards.
- The body of the S4GA lights were observed to be carefully designed to withstand jet blasts. In our field tests on the installation, we have never observed to have a light jet blasted.

The summary table demonstrates compliance of S4GA products and products offered by other vendors.

Specification	Description	S4GA	Vendor 1	Vendor 2	Vendor 3
Full ICAO Compliance for permanent applications	Photometry & Colorimetry ICAO Verification Reports for every type of light (runway + taxiway	Yes	No	No	No
	Jet Blast Resistance (Wind Tunnel Test Verification Report)	Yes	No	No	No
	Secondary Power Source / Back-up battery (compliant w/ ICAO Annex 14, pt. 8.1.8 - 8.1.9	Yes	No	No	No
	Only system that can operate 365 days a year on Solar Energy Only	Yes	No	No	No
Designed to meet highest industry standards	5-Levels Protection against system failure	Yes	No	No	No
	Individual Light Monitoring	Yes	No	No	No
	Emergency On/Off Switch on each light	Yes	No	No	No
Complete Solution for commercial and military airports	For Precision Approach RWY: Solar High intensity runway light	Yes	No	No	No
	For Non-precision Approach: Medium Intensity Runway Lights with Highest Photometry available on the market	1200 cd	250 cd	350 cd	N/A

Other risks studied

One of the major risk as an airport operator is that we will be looking for availability of spares for the next 10 years. This is one of the risks we had in mind. S4GA is a government-owned company and hence the reliability and commitment of providing spares to us has not been a problem at all.

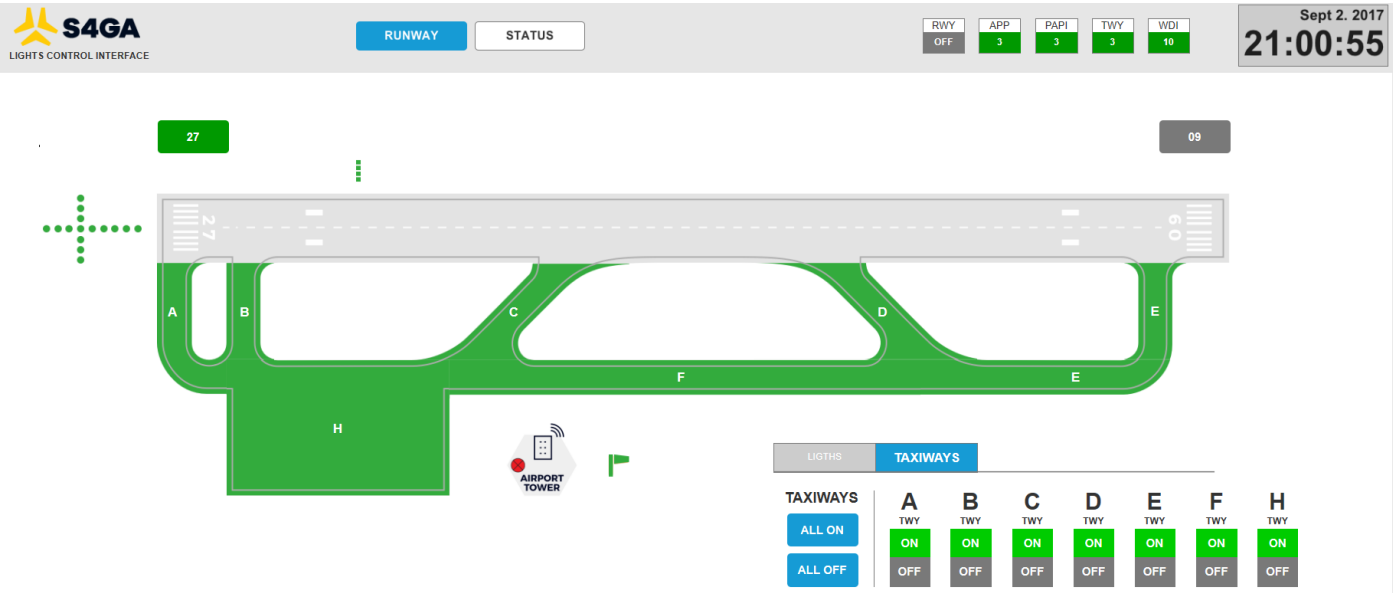
ALCMS

If we are looking for an option to have a single lamp controlled ALCMS which can be controlled from tower using a PC / workstation / server, the simplest and most reliable option is provided by the S4GA AGL Control and Monitoring systems which was our main impression to go with S4GA products in addition to the quality LED lighting.

The main feature which is only available with S4GA lights is the monitoring and display of battery conditions. We have observed that other vendor products only give the status of individual lights but not the battery status whereas the ALCMS of S4GA gives us both the status of individual lights and battery status which is a relative nice advantage for the tower controller as well as to perform proactive

maintenance by the AGL technical maintenance team personnel on the airfield. Additionally, S4GA system is monitoring battery working cycles allowing for preventive maintenance action, a unique feature among all competitors.

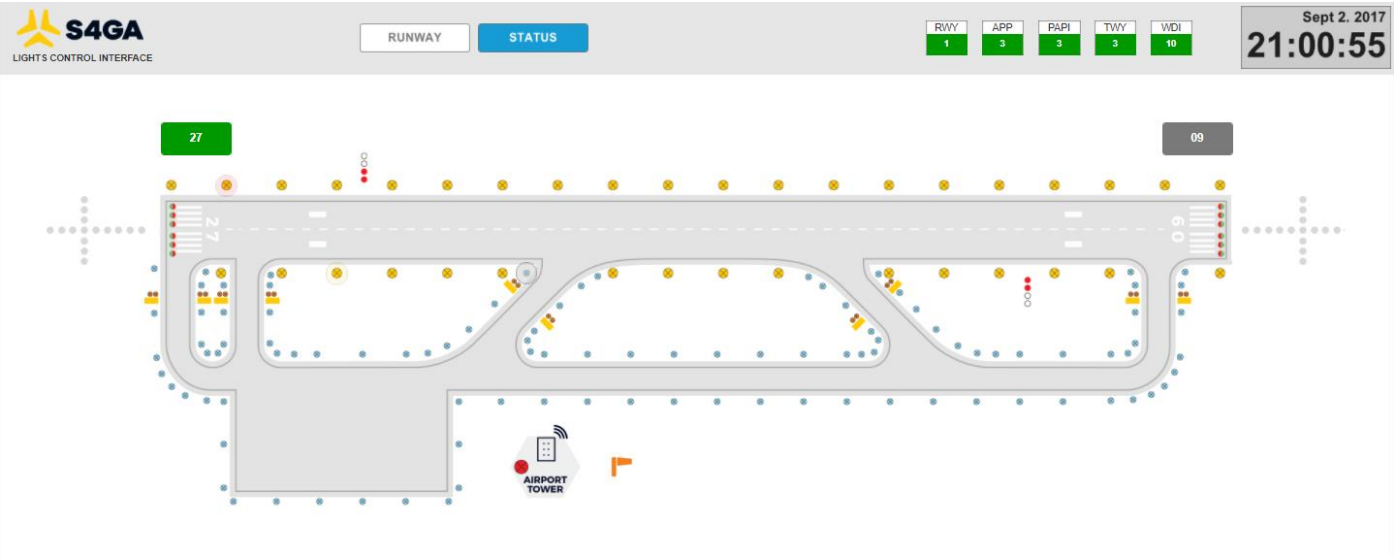
Below is the schematic representation screen of S4GA ALCMS. The lights can be segmented, grouped and displayed according to the requirement of the customer.



As discussed in the above paragraph, the niche advantage of knowing the individual light battery condition becomes a highly relative advantage for the control tower as well as the field maintenance personnel which is available only in S4GA AGL control systems.

Recommendation for ALCMS of S4GA

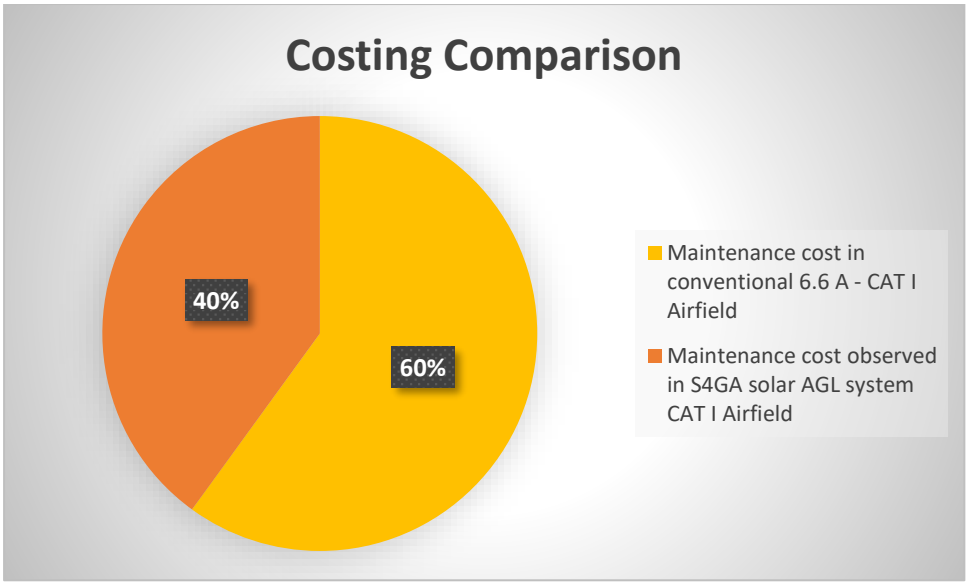
As an airport operator, we recommend you to install an SSD based all in one touch screen as the ALCMS host for the S4GA system. This will enable you to run 365 days without any problem since SSD systems are more reliable to physical system shocks and an all in one touch screen will enable a complete set of solution to keep your ALCMS running at full fledged ATC requirements.



Savings in cost looked at (Project cost and Maintenance cost)

- A study of the project implementation cost was discussed under section "Comparison of S4GA in terms of product range and pricing to that of other available solar lighting vendors on my live project works" which provided us a relative saving figure of 55% in terms of implementing S4GA AGL solar system in comparison with the conventional 6.6A lighting model. We have observed the similar observation that the relative savings of a project are >50% on every single project while we compare it with the conventional AGL 6.6A hardwired installations.

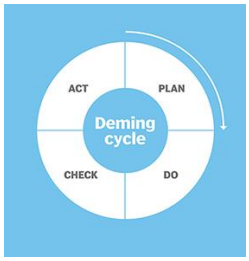
- Comparing maintenance, spares and associated cost collectively addressed as AGL OPEX for the airport operator is observed to be about 40% cost effective while we use S4GA solar AGL system in comparison to the conventional hard wired 6.6A AGL system. A schematic graph mentioning the projected operational maintenance cost savings is displayed below for your understanding which is evolved from our airports as we tested the solar AGL system from S4GA.



Serviceability vs. Availability vs. continuous improvement

- Serviceability of the AGL systems being dependent on the reliability factor of the assets being used by the airport systems plays a significant part in smooth operation of the airport.
- S4GA systems have been observed to have higher and reliable MTBF index and lower MTTR (Mean time to Repair) as observed to the MTTR of a conventional AGL 6.6A system.
- Consider an example of a mean time to repair an AGL isolation transformer failure and compare it to S4GA Solar AGL system which has a relative advantage that there are no isolation transformer or associated systems.
- Availability is the index we calculate for the control tower and aerodrome to utilize the lighting when it is required for them.
- Following index results are observed in terms of airport operational graphs.
    - Serviceability = 99%+
    - Availability = 99%+
    - Continuous improvement index = 99%+
- From the observation of the above results which are calculated over an annual reporting index, we can observe that the airfields where we have implemented solar AGL system have become six sigma compliant in terms of quality output.

Continuous Improvement



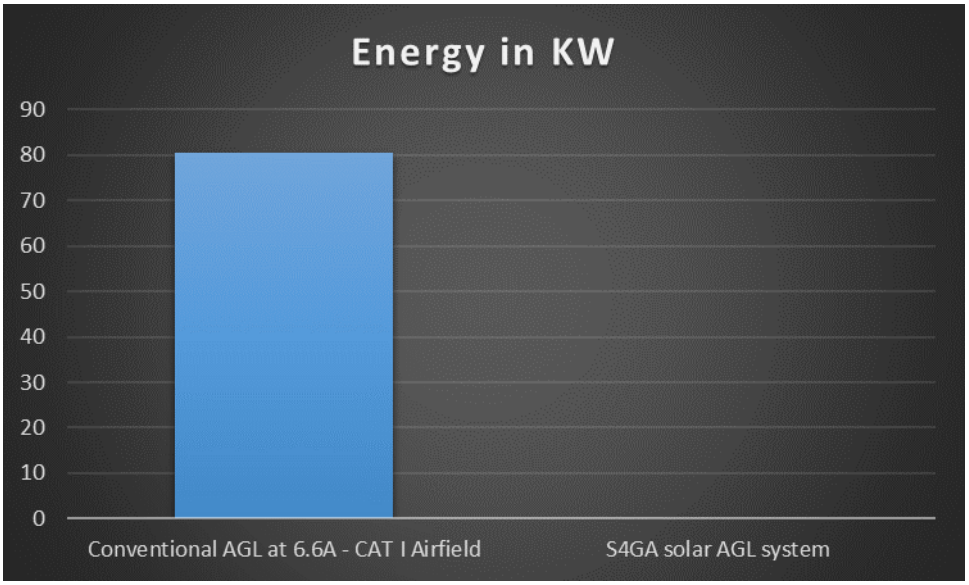
Continuous improvement of the airfields becomes an imperative requirement of the airfield operator and hence there are many requirements where an airfield light location is required to be modified. We might need to relocate lights or install new lights or close a taxiway as operation dictates. S4GA solar AGL system installation are easily deployable since one light can be installed by a single person.

Continuous improvement of airfield quality based on airfield operator's requirement becomes relatively easy while using S4GA Solar AGL system in comparison to routine AGL conventional 6.6A AGL system in terms of LED upgradation and also relocation requirements whereby it is not required to have a complete cable relocated. This becomes possible and thankfully due to solar AGL system availability.

Green energy and hence CO2 reduction achieved

If your airfield is looking for a Carbon accreditation, the easiest way is to have a solar airfield where you will be saving energy in terms of KW and MWs and replacing them with cleaner solar green energy.

In observing power consumption at one of the CAT I airfields which has been completely upgraded from the conventional 6.6 A to S4GA solar AGL system along with the ALCMS is displayed herewith on the projected savings of electricity consumption.



Power saving: Consumption electricity and graph

We can observe from the above graph the electrical energy saved in terms of power consumption on a monthly index pattern and hence following relative advantages are obtained.

- Electricity cost saving.
- Greener Solar energy.
- Reduced CO_2 emissions and hence carbon accreditation certification plans for the airport can be relatively and easily achieved.

Conclusion

- S4GA Solar AGL system suits best for new airport requirements of non-instrument or CAT-I runways for civil, emergency airfield requirements and military AGL airfield requirements.
- S4GA is a government owned continuous improvement quality based organization which provides risk free spares availability and provides seamless support to their airfield operators.
- Easiest way of upgrading a non-instrument, emergency deployment or CAT-I runway upgrade from conventional 6.6A halogen lighting to state of art green energy LED lighting is by using S4GA Solar AGL system.
- S4GA solar AGL system is having relatively niche advantages such as a full-fledged computer based ALCMS which has the capability to not only monitor individual lamps but also monitor and indicate the battery charging levels of the individual lamps allowing for preventive maintenance.
- Utilizing S4GA solar AGL system in our airfields have made a projected savings of about 60% of project cost and 74% maintenance cost.
- Reduced CO_2 emissions due to utilization of green solar energy.
  Higher values of reliability, availability and serviceability with an enhanced chance of improving the continuous improvement and operational requirements of the airfields as per the imperative requirements of the aerodrome operator.

About the Author

Dr. Prem Tennyson, PMP, ITIL V3 & six sigma certified core professional is a 18+ years experienced Airport Systems, IT and industrial control systems automation specialist who has worked with major airports and aviation companies such as GCC Federal Aviation, Dubai Airports, Oman Airports, Emirates Airlines etc. His report during his testing of AGL lights for several international and domestic airports is addressed hereby to cater the understanding of live study of S4GA systems and associated solar AGL lighting.

His major specializations and experience include in project as well as maintenance management of highly critical airport systems such as Airfield Lighting, Visual Docking Guidance Systems, Baggage Handling Systems, Ground Power Units, Pre-Conditioned Air Units, Passenger Boarding Bridges, Apron Flood Lighting and VHT Systems.

He is a master integrator of the above-mentioned airport systems. With his skill in Airport systems, IT, industrial control systems, he has prolific outputs in the related projects and maintenance management areas.

Innovative outputs displayed by him are displayed by his number of proud awards he has received for performance excellence from his employers amassing 14 professional awards particularly for innovative management of the airport systems and associated systems.

He has worked closely in Airport systems projects and maintenance management teams of Dubai, Al Maktoum International, Muscat International, Salalah International Airports and several other federal government and Gulf Country Airports.

The author has been a prolific AGL and Airport Systems speaker and has been an expert guest speaker in many of AGL conferences and other related conferences to Airport systems which are related to Visual Docking Guidance System, Baggage Handling, Airfield Pavement Engineering and other areas as well pertaining to Airport readiness, ICAO, FAA compliance to Airfield etc.

Dr. Prem Tennyson, PMP, ITIL V3, Six Sigma certified.