SunTracker vs. ADS-600 Pre-Development Evaluation

History

The active daylighting system, (mirrors that track the sun), was invented in 1978 by Lee Dominguez. After 22 years of attempting to bring the technology to market as So-Luminaire, Inc., the company entered into a joint venture with Sanyo Corporation (SNS) in 2000. The original Dominguez patents were given to the joint venture in exchange for ongoing development and operating capital.

Sanyo further developed the sun tracking mirror technology with So-Luminaire continuing as the marketing and sales arm of the joint venture. Sanyo filed for and obtained four related patents while So-Luminaire sold and installed over 1,000 units over the following four years.

After four years, discontinued further development and marketing A myriad of client problems surfaced and gradually dissolved SNS and licensed the manufacturing and marketing rights to Sun Tracking Systems (STS).

As a result, Nature's Lighting was formed in 2005 by two former So-Luminaire people, one financing agent and Michael Basch, who had been involved with So-Luminaire years before as a consultant. The company began operations in January, 2006.

The goal of the new company was to bring high quality active daylighting to the market.

The new company began with an intensive evaluation of both So-Luminaire and the Sanyo technology to determine value and whether or not it should pursue acquiring marketing and manufacturing rights - one from each.

After evaluating the technology, the company decided that there were several core system flaws with the Sanyo technology. As a result, the company decided not to pursue acquiring the technology and patents for the reasons listed below.

The company then conducted a concept development meeting with several engineers and a patent attorney with the goal of building a product that would:

- Operate flawlessly for a minimum of ten years
- Not violate intellectual property
- Be economical to manufacture and transport
- Enable unskilled installation at low cost

The result of the meeting was a concept that would meet the goals and, although visually similar, has nothing in common with the Sanyo ADS-600 system and is certainly not in violation of any intellectual property. The only similarity to the two systems is the mirror array and the size of the mirrors and dome - none of which is covered in the Sanyo patents.

Provisional patent applications were filed on May 27, 2006. The remainder of 2006 was spent bringing the new technology to production with the first installation at Office Depot in November, 2006.

On January 1, 2007, Nature's Lighting changed its name to Ciralight and began actively marketing its new product as the SunTrackerOne. Ciralight continued to evolve its product to resolve all known issues as it installed and retrofitted many of the So-Luminaire clients. During

the first eight months of 2007, the company has installed, retrofitted or contracted to install 995 units on 65 different facilities.

Ciralight patent applications numbered 6,433,932 and 6,493,145 were filed on May 27, 2007.

The original technology assessment is shown below:

ADS-600 Technology Assessment

Ciralight has no knowledge of the improvements made to the original ADS-600 technology and makes no reference to current technology. This information is a review of the Sanyo technology as it existed in early 2006. The evaluation uncovered several critical flaws:

1. The technology used a controller fixed to the top of the dome with the mirrors suspended from a moving shaft inside the dome. This was one of two core patent claims and, in our judgment at that time, was a critical flaw in the product design for the following reasons:
   (a) Since the unit is powered by a solar cell, the solar cell had to be integrated with the mirrors to continually track the sun. As a result, it was attached to the mirror array with a wire connecting the moving solar cell to the fixed controller. In the event anything went wrong with the software or the power system, the unit would continue to turn, wrapping itself around and creating a disconnect.
   (b) The hole in the top of the dome required an expensive gasket assembly to protect from leakage and had to be installed on the job site leading to more expensive and complicated installation.
   (c) The added weight of the mirror assembly combined with a poor dome quality caused dome implosion in extreme heat, particularly in the Southwest.
2. The controller electronic technology incorporated rechargeable batteries for power back-up and clock power. It is well known that batteries will not hold up over a ten year period especially with the extreme temperature swings on the top of a roof (-30º to +180º). Further, if the unit was without external power and batteries went dead, the unit would lose the critical location and time information to effectively track the sun.
3. The unit had no flash memory meaning that the RAM had to have constant power. In the event the unit lost total power, the RAM would lose its coordinates. This necessitated battery back-up and when all power was lost, a physical visit to the site for reprogramming the controller.
4. Time was kept using a crystal based real time clock. Electronic clocks gain or lose time over a ten year period particularly with extreme temperature variance. The first year or two would make little difference, but over ten years, the maintenance costs would be prohibitive to manually calibrate the clock.
5. The controller required roof top programming with a laptop computer as well as a complicated and time-consuming assembly process. Each unit required a control box that had to be plugged in and individually programmed. This meant higher installation costs as it required a trained and skilled technician. The extreme weather conditions on a roof, both summer and winter, made programming and installation very difficult.

6. Potentiometers were used to provide mirror array facing location to the microprocessor. Mechanical potentiometers would not allow 360º movement, in both directions, of the mirror system. This limited controller flexibility.
7. Due to the weight of the mirrors hanging from the dome and the thickness of the domes, the domes were imploding at high temperatures and, in some cases, became completely inoperable.
8. The mirror array consisted of plastic mirrors with an aluminum metal frame structure supported by cables and weighted for balance. This system was costly, overweight and warped with heat leading to loss in performance.
9. The ADS-600 had a gear ratio of 11,000 to 1. After analysis, it was determined that the most efficient mechanical advantage was between 450 and 900 to 1. Proper gear ratio design would drain more energy than necessary.
10. One advantage of the ADS-600 was easier maintenance in the event of electronic failure, however this was not significant in light of the other drawbacks to the technology.
11. Installation was difficult at best. The controller gasket had to be installed and the controller attached with bolts to the top of the dome. At that point, the mirrors were assembled with bolts and hung from the dome, faced south and placed over the curb.

    In order to install or maintain, the controller top was removed and the programming connection wire attached to the programming control box. The laptop computer was then used to enter latitude, longitude and time of day and year. The capacitors and, if necessary, the batteries had to be charged. This operation took place individually for each of the units on the roof.
12. The bottom line was in talking with So-Luminaire clients that had installed the ADS-600 units and experienced nearly 50% failure in the first two years which was fairly predictable considering the points above.

Although we believed each of these issues could be resolved, it was not worth paying a royalty on technology that was clearly not well designed for its purpose. Further, the “suspend from the top” and “use of rechargeable cells” patent claims were detriments rather than advantages.

Again, it is important to understand that Ciralight is not aware of any changes to the original ADS-600 technology which may have resolved several of these issues. We make no claims as to whether or not these issues exist today. We have focused solely on developing quality products and bringing them to market and not on what the competition is doing or not doing.

SunTracker Technology

After the above evaluation, several design parameters were developed in order to meet the ten year reliability goal:

1. Integrate the controller/solar cell/mirror array to enable 360º movement
2. Support the mirror assembly from within the dome
3. Eliminate all batteries for both back-up and clock operation
4. Update the clock periodically

5. Replace the potentiometer with up-to-date technology
6. Eliminate roof top programming and, if possible, all manual programming
7. Resolve dome construction issues
8. Resolve mirror expansion/contraction issues
9. Simplify and improve reliability of installation

The initial SunTracker has resolved these issues with the following technical advances. The SunTracker:

1. Integrates the controller/power/mirror array into one unit that revolves around a fixed shaft supported from the bottom of the dome. This makes installation simpler and enables the mirror array to travel 360º each day with no moving electrical connections. It also enables the software to optimize energy by finding the shortest route to sunrise at the end of each day.
2. Has no batteries. The power management system allows the unit to charge itself even in extremely cloudy conditions. You would have to throw a blanket over our unit to get it to stop. And if this happens our unit will come back to life and begin accurately tracking the sun without any human intervention.
3. Uses flash memory that holds information regardless of power. This enables programming at factory and storage on the job with no time constraint.
4. Can lose total power for any time period and yet awake and become functional in minutes. This means that no batteries are required for primary or secondary back-up of any kind. All power is stored in super-capacitors. Super-capacitors are able to store electricity without chemical interactions that dilute with time.
5. Programming is done for the project site at the Ciralight center in Plano, TX where it can be done efficiently under controlled conditions rather than on the rooftop. This includes latitude, longitude, time of day, time of year.
6. Utilizes a new dome manufacturing process including temperature controlled cooling. The dome is now thicker and no longer implodes under the most extreme thermal conditions.
7. Incorporates magnetic sensing technology (Molexis) to determine exact mirror location and communicate it to the processor rather than a potentiometer. This eliminated a critical moving part and provides complete 360-degree range of movement while providing the exact mirror location at any time. The SunTrackerOne can now accurately, and without failure, track the sun anywhere in the world. This also reduced the cost of manufacture.
8. Incorporates aluminum mirrors instead of the plastic and metal components. These are lighter and much easier to assemble on the roof while keeping their shape during extreme temperature swings. The reflective aluminum used comes with a 25 year warranty for reflectivity. The lighter mirror assembly combined with the support structure requires no additional weight for balancing.
9. Uses a gear ratio of 833 to 1 which was in the optimum range for mechanical efficiency. This more effectively uses the power available.

In addition, the new GPS version of the SunTrackerOne available in November will resolve these additional issues:

10. The GPS technology will enable Ciralight to ship SunTrackerOne controllers anywhere in the world and store them for an infinite time period. As power is picked up from the sun, the controller wakes up, the GPS determines the location and time information and automatically begins tracking the sun. This will streamline the entire commissioning process while improving onsite reliability and accuracy.
11. The GPS technology re-calibrates the clock automatically each day. The SunTrackerOne warranty requires that Ciralight retrofit any clock problem units with the new technology as required for the current product without the GPS technology.
12. Installation is very simple and can be accomplished with relatively untrained and unskilled people. It is simply a matter of mounting the light wells, dropping in the bottom diffuser, installing and sealing the top diffuser, mounting the cross bar, installing the mirrors and facing them south. At that point, the capacitors charge, the system wakes up, finds the sun and begins tracking. The only critical measure is that the mirrors must be faced south during the installation.

All of So-Luminaire's clients have been contacted and many have been retrofitted to the new SunTrackerOne technology. As a result of this program and sales, Ciralight has installed or retrofitted 65 buildings since January, 2007 and has sold and/or installed a total of 995 units. In the process of retrofitting, all of the above potential problems were experienced on the various projects.

Comparison of Technology

Component	**ADS - 600**	**SunTrackerOne**
Dome		
Shape/size	Same	Same
Strength	Thin walls	Special tooling/strong walls
Hole	Expensive install/weight	None
Manufacture process	Form molding	Precise zone temperature control
Support mechanism		
Controller/mirror support	Suspended from Dome	Supported from beneath
Installation flexibility	Must be square and level	Some room for adjustment
Mirror Array		
Mirror configuration	Same	Same
Mirror sizes	Same	Same
Mirror material	Plastic mirrors/aluminum frm	Aluminum only
Mirror support	Cables	Self supporting
Mirror assembly	Bolts and nuts	Clip in pin
Mirror weight	8#	3#

Control/mirror integration	Separate	One integrated unit
Controller		
Location	Inside/outside	Inside
Controller micro-processor	Factory mask chip	Programmable chip
Core information	Volatile Memory	Non volatile memory
Control back-up power	Supercap w/battery	Super Capacitors only
Clock power	Battery	Super Capacitors only
Clock calibration	None	GPS Daily
Programming	On Site	None required
Electronic Maintenance	Unscrew controller	Remove dome
Mirror position indicator	Potentiometer	Magnetic
Sun Sensing	Logic	Logic
Total Solution		
Light wells	Extra	Included
Light controls	Not included	Included
Business Analysis	Not included	Included
Guarantee	Not included	Included