
GRAVITYLIGHT
GRAVITYLIGHT
Inventors’ Pack

Our Mission

Our mission is to eliminate kerosene lamps and their damaging effects.

1 in 7 people do not have access to electricity; in sub-Saharan Africa it is as high as 2 in 3.

Without electricity, the majority of families use kerosene lamps to light their homes.

A typical kerosene lamp is made from an empty bottle or tin can with a wick in the middle, filled with fuel and lit.

There are many good reasons to eliminate kerosene lamps:

Dangerous
Their fumes cause coughing, eye irritation and respiratory diseases. Unprotected flames and over-turned lamps can cause severe burns.

Unsupervised containers of kerosene can lead to unintentional ingestion, currently the leading cause of child poisoning in the developing world.

Polluting
Collectively, kerosene lamps cause 3% of the world's CO_2 emissions. They are a significant source of black carbon, with even more intense local warming impact.

An ongoing expense
The cost of kerosene is a poverty trap. Amongst the poorest households, it consumes up to 20% of their income. The amount of light families can have - for reading, cooking and socialising - each evening is limited by what they can afford.

Our Approach

Using good design to tackle poverty

We are committed to creating solutions informed and guided by the needs and feedback of low income households living in energy poverty. It's not enough to create affordable solutions, to have a scalable impact these need to be reliable, robust and attractive too. This is why focus groups, trials and pilots are central to both our product development and route to market planning.

Sustainable and scalable

If we gave away GravityLights to the over 1.1 billion people that don't have access to electricity, we would need to raise a lot of money! Give-aways also risk undermining local livelihoods of those selling lighting solutions.

Instead, by creating a product that people value and are willing to pay for, GravityLight will be able to reach far more people, more quickly, without it's fate being solely reliant on continuous fundraising.

Creating livelihoods, locally

As well as enabling people to save money by switching from kerosene lamps to a GravityLight, our plan is to partner with local organisations to create jobs and help people earn an income through distributing GravityLights.

Collaborative

Building trusted local partnerships will be integral to our work. From manufacturing to assembly, distribution and impact measurement, we will be working with a number of organisations, benefiting from their experience and reach to maximize our impact.

Our Solution

GravityLight has been designed as a safe, clean and affordable alternative to kerosene lamps.

Powered by the lift of a weight, GravityLight offers instant, limitless light, whatever the weather outside.

GravityLight has multiple benefits, including:

Money saving: with no running costs it pays for itself within 4 months of switching from kerosene lamps.

Safe and clean: with no fumes nor fire.

Instant: no charging needed

No sun needed: a year-round solution.

Limitless: GravityLight can be used over and over again, not limited by battery capacity or lifespan.

How GravityLight Works

GravityLight transforms the pull of gravity into electricity.

The potential energy of a raised weight is turned into kinetic energy as the weight descends and turns a gear traln.

The gears power a generator, turning mechanical energy into electricity that powers an LED (light emitting diode).

GravityLight is installed at around 6ft/ 1.8m from the ground. The bag is filled with 12kg of weight – such as rocks or sand.

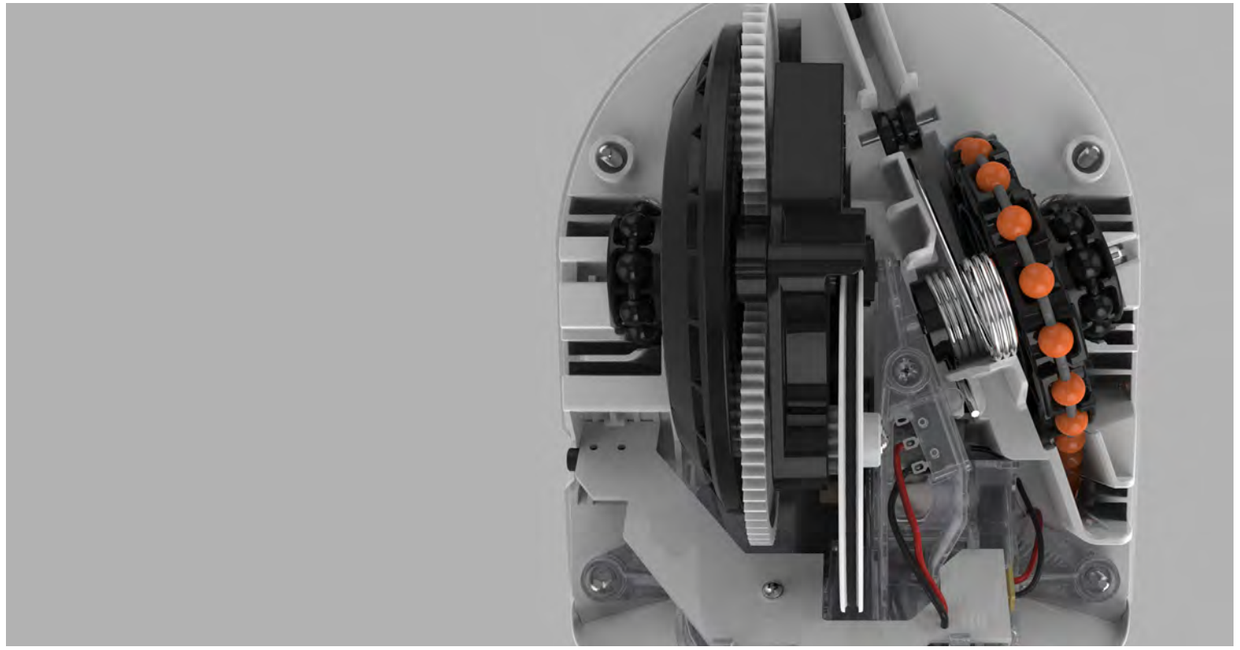
The orange cord is pulled to lift the weight and, as the weight gradually descends (about 1mm per second), it turns a drive sprocket at high torque (force) and low speed.

This sprocket drives a gear train at increasingly higher speed and lower torque (force), driving a DC generator – a motor run backwards - at thousands of rotations per minute.

In this way, GravityLight generates just under a deciwatt (0.1 watt) of electricity, which we use to power LEDs to create light.

After 20 minutes, the weight will slowly reach the ground and the gears and motor will stop turning. If this happens, the light will turn off. For more light, simply lift the weight again, or for continuous light, raise the weight back up before it touches the ground.

Watch a video of GravityLight' geartrain in action and explaination of how it works in Destin Sandin's Smarter Everyday episode.



How GravityLight Works: FAQs

Why hasn't a GravityLight been made before?

Using the force of gravity and kinetic energy to create electricity is not a new idea. What is new – and continually improving – is the efficiency of LED technology in turning electricity into light. The 0.1 watt produced by GravityLight equals 16 lumens of light – over 5 times brighter than a kerosene lamp. LEDs are currently at about 30% efficiency. As they continue to improve, the amount of light produced by GravityLight will also increase.

How do the gears withstand the 12kg weight?

The side of the GravityLight closest to the weight (where forces are larger) uses internal gearing. This means one gear running in the inner diameter of another gear, to ensure multiple teeth of the gear are engaged at a time.

This is important for transmitting the force of the weight over multiple teeth thus decreasing the contact stress and increasing the life of the gear.

The further through the drive train you go, the fewer teeth are needed to engage because the torque gets lighter and lighter as the speed runs faster – with the generator running at 1600 rotations per minute.

What stops the bag from falling fast to the floor?

The LEDs. The fastest gear is running at a high speed but such low torque (force) that even a small bit of resistance can reduce the speed of the gear.

Once the generator turns up to a certain speed and the voltage limit of the LED is reached, the LED will not let it turn any faster. This means the weight falls at a slow, constant speed.

Evolution of GravityLight: Concept Testing

Product designers, Martin Riddiford and Jim Reeves, first heard about the challenge of kerosene lamps and scale of the issues through UK charity, Solar Aid, in 2009.

They set out exploring solutions that could avoid the high costs and limited life span of batteries and that use an energy source as ubiquitous and accessible as weight and gravity.

To prove the principle, Martin and Jim developed several prototypes, from a bicycle wheel and dumbbells, to creating Selective Laser Sintering (SLS) gears connected to a motor and LEDs.

With the incredible, worldwide support of our first crowdfunding campaign, this concept was developed further. We manufactured the first small batch of GravityLights to be tested in a range of different environments.

The objectives of the trial were to:

- prove the concept: Would people use a GravityLight instead of a kerosene lamp?

- test demand: Would people buy one?

- gather feedback: What did people like about GravityLight and what needed improving?

GL01

Our production prototype, GL01, was a critical milestone in the development of GravityLight. It enabled us to test our technology on a large scale and determine the viability of the concept.

90% of GL01 trialists reported that they would use GravityLight instead of a kerosene lamp. What was even more useful was finding out why some people would not:

Accessibility: Some people struggled to lift the 12kg weight from the ground up to the full height.

Product failure and misuse: Several children used GravityLight as a swing, overloading and breaking the gears. The power setting, choosing between brightness and duration, was rarely used but also occasionally caused failures.

Lifespan: This was as short as 3 months for some units vs a 1 year minimum target.

GL02

Our revised design, GL02, incorporates this feedback and two further years of development to optimise its efficiency, reliability and lifespan.

Improvements with GL02 include:

More accessible: Introduction of a pulley system to lift the weight, it feels like lifting a 2kg weight rather than 12kg.

Brighter: GL02 is 50% more efficient than GL01 through material selection and re-design of the gear train. This additional power has been used to make GL02 brighter at a longer duration than GL01.

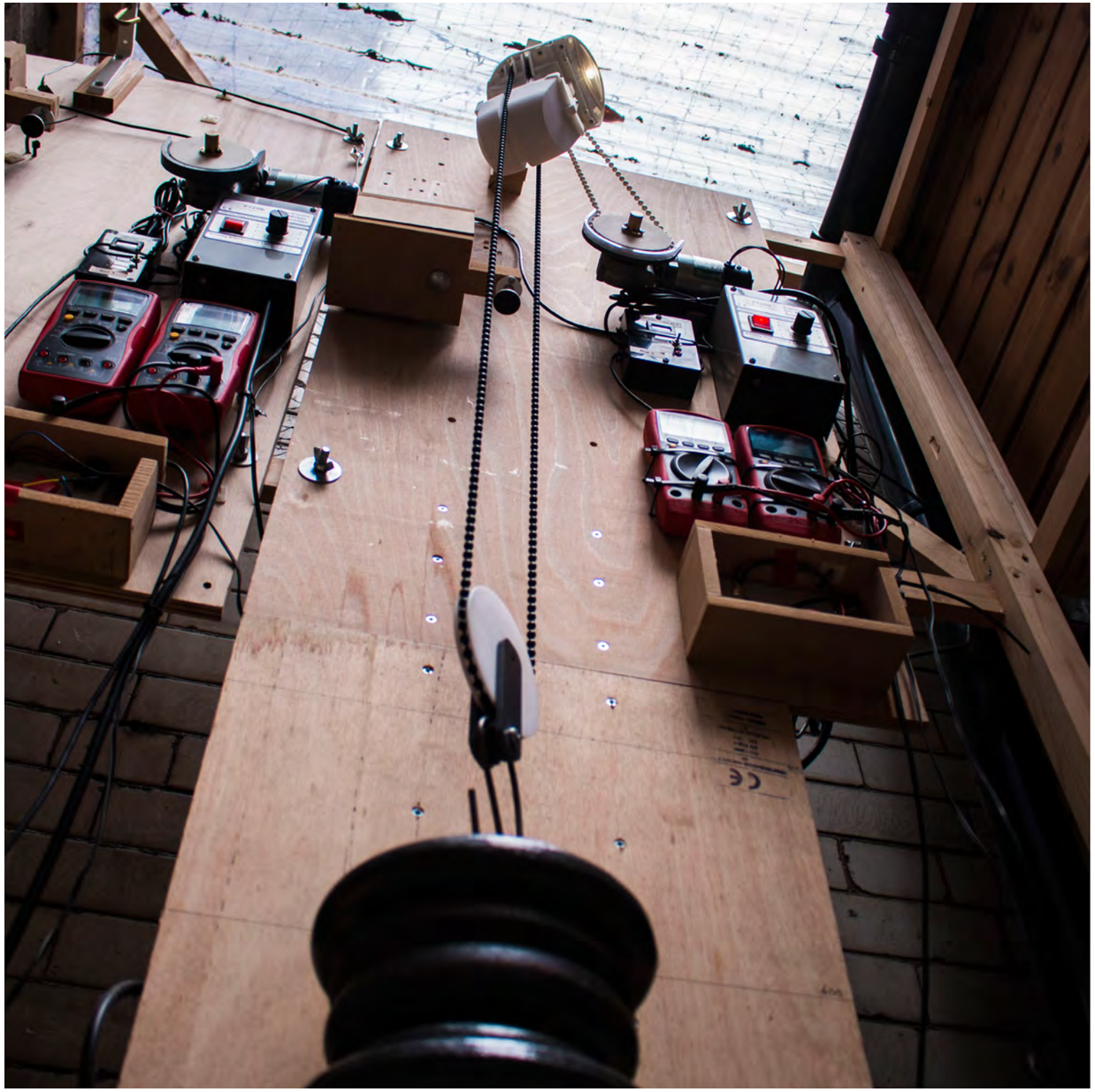
Longer lifespan: Extensive accelerated life testing has helped us identify and address causes of product failures. The geartrain is 9 times stronger, GL02 comes with a 1 year warranty and our test rigs in the UK have lasted over 3 years of continuous use.

SatLights

Each GravityLight comes with 2 SatLights, ancillary lights that are powered by GravityLight. SatLights transform GravityLight from a single, ambient light into multi-user, home lighting.

The first SatLight plugs into the GravityLight, with subsequent lights in the chain plugging into each other. With a 5 metre stereo cable, these lights can be hung around a room, for both ambient and task lighting.

A SatLight consist of two plastic mouldings, a Printed Circuit Board (PCB) and a surface mount LED. The PCB (a development since GL01 SatLights) enables the use of stereo cables and the ability to switch each light on and off as needed.
By twisting the upper and lower plastic mouldings, users can change the light settings and decide when and where they want light. This feature also adjusts the brightness of the light;users can choose a single, bright task light to work by or three lights that share the 0.1W power between them.



Value Added Engineering

Designing a solution that is as affordable as possible, for families living on the equivalent of just a few US Dollars per day, can risk focusing solely on cost.

Such a *value engineering* approach may help reduce costs to a minimum, but at the expense of performance, durability and – importantly for our ability to sustainably scale - attractive design that people aspire to have.

Our aim is for GravityLight to scale through market forces, which means that GravityLight needs to be an aspirational product with elegant design for people to want to buy one and proudly use it in their home.

Even more importantly, people with limited incomes can't afford to buy cheap, unreliable products. They need confidence that purchasing a GravityLight will be a good investment, with a sufficient lifespan to pay for itself and generate savings by switching from kerosene.

Value Added Engineering

So how do you design a product that does not compromise quality and durability, but is also affordable for low income households? The answer comes in adopting a value added engineering approach. At its root, value added engineering is a commitment towards spending longer on finding solutions. Adopting a value added engineering approach generally requires a higher R&D budget; it interrogates each individual aspect of the overall design with rigor and recognises that the time cost spent on the intensified level of focus will be justified in the long term with a lower bill of materials.

A large amount of the time that we spent in R&D was dedicated towards testing the same components using a plethora of polymers and metal alloys. A narrower approach would usually be employed for western market products, however with GravityLight, small degrees of difference matter. We interrogated a large array of materials to arrive at the final configuration – one that was low in cost, but uncompromising of quality.

Rigorous testing procedures are also a vital component of a successful value added approach. Understanding and improving GravityLight's durability and lifespan was paramount. To We did this by creating a custom-made Accelerate Life Testing rig, that runs GravityLights continually.

Families using kerosene lamps typically use them for four hours a day. This rig enabled us to condense one year of use into two months of non-stop running.

Our Accelerated Life Testing rig meant that we could monitor GravityLight's performance over time, taking readings every few days to monitor power output. If an issue was identified, the rig would be dismantled and components tested until the root cause found and addressed.

Although this is a long, iterative process that needs to be re-set with each change, in this way we were able to improve GravityLight's efficiency by 50% and lifespan from 3 months to 3 years.

Martin Riddiford (Co-Inventor)

Product design is a very broad and varied job and although the variety of products and ideas that we work on are very broad, there is one running theme which tie all these projects together, and it is integral to designing successful new products; being able to succinctly state ‘the problem’. With GravityLight, SolarAid provided us with a problem – kerosene lighting.

Being able to work with the potential of human power was the perfect solution – I realised that through the use of gravity and weight you could create an energy store, with no running costs. After some quick calculations I reckoned we could get about a deciwatt of power, which would provide more light than a kerosene lamp - this led to our first bicycle wheel prototype.

The development of GL02 was a major step forward. One ‘eureka moment’ was the development of the SatLight, we developed GravityLight to be able to power other things, other LEDs. It would provide less power to the main light but seemingly create brighter light through the spread and separate pools of light. This was exciting for a number of reasons, as not only did it spread the light, it solved a problem that off-grid families have, the lack of wired home, it enabled the sophistication of being able to turn light on and off with a switch.

Product design can come with many challenges even after you have developed a solution, and GravityLight was no different. One of the main things I have learnt through the development of GravityLight was the need to assess the risks of each decision, to be able to assess what could go wrong.

Coming from a designer background I often have to go in with an optimistic hat on, this was not the case with GravityLight, it required us to be positive but also assess all angles and risks. This has made GravityLight such a unique project to invent and develop.

It can be very easy to design a variety of interesting products for the West, but when you step back you can realise there is little long term worth, they quickly become just another gadget.

GravityLight is different. It has been designed with a focus on a fundamental problem, affecting millions of people, that needs real solutions – and that’s what makes it so unique.

Thank you for your support - to help make GravityLight a reality and start to realize it’s potential for huge positive impact.

Jim Reeves (Co-Inventor)

From initial analysis of the problem, through multiple concepts and numerous iterations, all the way to the creation of a supply chain network, delivery, and international product launch, GravityLight has been a more rich, varied and demanding journey than I ever could have imagined.

The successful delivery of viable and reliable products that truly answer the needs, expectations, and aspirations of users takes a lot of key ingredients. While the essence of the idea is the critical start point, the approach to developing solutions is what makes the difference between an interesting 'almost' and a real answer. Product development also requires a lot of resource and our challenge has been wider than merely developing and delivering a truly unique and innovative product, it has also been about how to build the resource, support and funding to do so.

As a designer and engineer I am driven by a desire to solve the problems I see. Sometimes just for their own sake - because they are interesting, or hard. To do this, we make continual evaluations of the effectiveness and potential of different development options and paths. A dogged focus and determination to reach a complete and working solution is not enough. You also need to know when to change tack and explore other options; to recognise when it isn't working.

This can be one of the hardest parts: being critical of your own thinking when a particular route showed such compelling potential. GravityLight is made up of a lot a functional bits. Each needs to be developed and delivered at minimum cost, and each needs to work, time and time again.

We set ourselves some quite unreasonable challenges when we set out to make GravityLight a reality, and we continue to work toward meeting them. The requirement for rigorous and thorough engineering development and verification may not be self-evident - the concept is simple after all. Making the product deliver, delight and surpass expectations, however, has taken a sharp focus on the smallest of details. Small aspects can be transformative, both for better and for worse.

I consider myself very lucky to have had the opportunity to design and develop a product with such valid aspirations. One of the key measures of whether a product is interesting to me is how much it 'deserves' to exist. Is it really needed? For me, GravityLight truly fulfils this requirement.

Thank you for your support on this journey. We look forward to sharing GravityLight's progress and impact with you.

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