

INNOVATIVE PATHS TO ENERGY EFFICIENCY: REGEN ENERGY

REGEN Energy is a technology company, founded on the basis of biomimicry, whose founders set out to transform the energy efficiency landscape and develop a sophisticated new energy management technology based on the communication patterns of honeybees. This innovative idea led to the launch of a company that has been able to grow and position itself for a strong future in emerging markets despite initial skepticism and a crowded and stodgy energy technology marketplace.

The Company

Toronto-based founders Mark Kerbel and Roman Kulyk began their careers designing software for the electricity sector. Roman Kulyk has deep experience in the IT field, in both electrical engineering and computer engineering, and his experience in custom building automation began during the hand-wiring era. Mark Kerbel, who has a background in mathematics and computer science, also gained exposure to utilities through involvement with the architecture and software of building management systems.

The two were close friends, and although they had previously successfully started and grown a utility software services company, they had become increasingly attracted to the concept of “natural capitalism,” in which companies can improve their bottom lines while helping to solve environmental problems. They hoped to start a venture with a meaningful impact on the way society manages energy, while making the process easier and more intuitive. They felt that existing energy efficiency technologies and services were too inconvenient, complex and expensive, with high up-front costs, multi-year payback scenarios, and extensive ongoing maintenance efforts.



REGEN co-founders Mark Kerbel and Roman Kulyk derived inspiration for their unique energy demand management system from the communication of bees in a hive.

Problem: Pollution and Peak Energy Consumption

During the summer of 2003, large stretches of the Northeast, the Midwest, and areas of Ontario experienced massive blackouts as the electricity demand outstripped the grid's supply. Mark Kerbel took refuge from the humid summer air in his cool basement, but as he left his house one day, Kerbel was struck by the clear blue sky he saw that afternoon, enabled by the lack of electricity generation. This was a rarity, since the high electricity demands of a summer afternoon normally lead to soot and smog, clouding the summer sky. As air-conditioner use in homes and offices increase to a peak afternoon period, the electricity grid struggles to accommodate this high level of energy demand. Older "peaker plants" are turned on to supply additional energy, using lower-grade and dirtier fuels, without the advanced scrubbing mechanisms that newer plants use to reduce pollution.



Kerbel and Kulyk sought to reduce the amount of electricity produced by the grid during peak hours, so that utilities could avoid operating inefficient and polluting "peaker plants."

Reducing peak loads benefits both the stability of the electricity grid and energy consumers. A substantial amount of the grid's generating capacity is reserved for satisfying demand during peak periods that may occur as rarely as a few dozen hours per year. That power is extremely costly, since it requires entire ancillary power plants. Peaker plants need to be activated quickly as demand on the grid spikes, and they are more concerned with a quick response than they are with efficiency or pollution control. If they fail to add power in time, the consequences can be cascading power outages such as the rolling blackouts common in recent years. The result is that the plants are costly, have a high carbon output, and are often highly polluting.

Kerbel pondered what it would take to reduce the energy grid's load during peak hours, given that he had limited resources with which to invent a solution. He discussed the matter with his business partner, Roman. As a result of their brainstorming, the two decided to approach the problem through buildings.

Buildings are a key source of peak energy demand. In general, buildings account for about 39% of total U.S. energy use. However, the contribution of buildings to peak energy demand is far greater, mostly due to cooling needs of buildings during the hottest parts of summer days. As they formulated their plan of action, Kerbel and Kulyk realized that a pressing concern for many users was the increase in their energy bills during peak demand times. Therefore, the two formulated a plan to invent a unique energy management system to help ease the burden of buildings on the electric grid, as well as to reduce energy bills for building occupants and owners.

For the consumer, buying energy during peak demand times can be daunting. Many power consumers are pushed into a higher pricing structure if they pass a certain demand threshold. Consumers who use large amounts of power often see half of their electric bill calibrated to the rate charged for the top 15 minutes of energy demand per month.

Kerbel noted, "Sometimes just over half of a customer's bill is based on peak consumption, and we saw that as an opportunity. From the building owner's perspective that goes right to their bottom line."

By reducing the peak consumption, ranging from 20-50% of the monthly utility bill, owners can achieve substantial savings.





Bees communicate with each other through body language and by leaving pheromone trails. There is no "top-down" management in a hive. Kerbel and Kulyk realized that they could manage appliance more efficiently if they adapted this logic to their technology.

Biomimetic Concept Development

The Need for Energy Demand Management Systems

Demand management systems are one way of addressing very high energy bills: such systems are designed to shut off non-essential equipment during periods of peak demand. Having designed customized demand management systems for buildings, Roman Kulyk knew their complexity firsthand. These top-down systems operate in a rigid all-or-nothing manner to limit loads. The result can be mediocre demand management with noticeable compromises in performance for the building occupants and equipment. Kerbel and Kulyk saw an opportunity to create a simple and intuitive tool to improve on current technology and accomplish demand management in a smarter way.

Kerbel and Kulyk read *The Innovator's Solution*, by Clayton Christiansen and Michael Raynor, which helped them realize that they must target a segment of the energy consuming market that is traditionally underserved. After analyzing the range of energy consumers, they realized that there was a thriving selection of energy demand management systems on the market for large, mega-industrial facilities, as well as for single family homes. However, there were few options on the market for mid-size building automation systems. After recognizing the dearth of options available to this segment of buildings of approximately 50,000-500,000 square feet (such as big-box retailers, theaters, distribution centers and warehouses), REGEN's co-founders knew that they had found their target.

Medium-sized buildings typically either have no building automation system, or have one that is highly inefficient, expensive, and so complex that employees are not sufficiently trained to operate it. Kerbel and Kulyk found that most owners of medium sized buildings would not even accept building automation systems at no cost, due to the added expense and complication of managing them. REGEN's co-founders decided that they needed to create a demand management system that could be used with the limited resources of most medium-sized buildings.

The Logistics of a Bee-Based Technology

Kerbel realized the ideal concept for their technology when he read Steven Johnson's *Emergence: The Connected Lives of Ants, Brains, Cities, and Software*. Emergence is a phenomenon exhibited by a number of biological systems, most notably hives of bees. Many social organisms seem to make sophisticated adjustments and





REGEN'S EnviroGrid Controller fits on the control box of each HVAC system, and then communicates with all the others to negotiate the best times for each appliance to cycle on and off.

decisions based on relatively simple rules. This is how bees are able to operate an adaptive colonial group, despite lacking top-down management or "intelligence" in the human sense of the word. Using simple rules and communicating constantly with pheromone trails, each individual bee contributes to the hive-level goal of survival. The phenomenon is called "emergence" because a complex system of communication and decision-making emerges from a large number of much simpler interactions.

Kerbel immediately shared the book with Kulyk, who was also captivated by it. When the two sat down in January 2005 to plan their new venture, they fixated upon the theme of emergence. Kerbel and Kulyk developed an algorithm based on the communication between bees that allows all pieces of building equipment to simultaneously detect each other, to red-flag unnecessary power consumption. Air conditioners, compressors, pumps and other building appliances constantly cycle on and off. The problem arises when they are ignorant of each other and turn on at the same time.

To solve this problem, REGEN developed the EnviroGrid Controller to connect to the control box on each piece of equipment, to function as a smart power switch. EnviroGrid Controllers can be installed on any electrical

heating, cooling, or discretionary electrical load in approximately 30 minutes, resulting in minimal operational disruption. Each device monitors its appliance's energy use every two minutes and broadcasts its reading to all the other controllers in the system. Once several controllers have been activated, they learn the power cycles of each appliance and use a networking standard called Zigbee to communally negotiate the best times to turn equipment on and off.

Every node connected to the REGEN "hive" thinks for itself. Before making a decision, a node considers the circumstances of other nodes in the network. For example, if an HVAC unit needs to cycle on to maintain a minimum temperature, a node connected to another HVAC unit will stay off for an extra 15 minutes to maintain power use below a certain threshold. Newer versions of the REGEN system focus almost exclusively on rooftop HVAC systems installed in medium-sized buildings. According to Kerbel, a typical building might have between 10 and 40 controllers working together to mimic the communications in a beehive, and the more nodes are linked to the system, the better it works.

In fact, the four core effects of the REGEN system are as follows:

1. Reduces monthly peak demand charges by automatically balancing large electric loads.
2. Ensures that loads only run as much as they are required, and do not run off-hours.
3. Simplifies a building's participation in utility demand response programs.
4. Identifies electrical loads that are running inefficiently, by drawing too much or too little current.



Logistics of Communication

REGEN Energy often begins each project with a data-gathering phase after the installation. A 1-2 week period provides energy baselines that show usage patterns specific to the building and its occupants. The EnviroGrid controllers are then set to follow the natural duty cycling patterns of each load. Because the current version of REGEN's system is typically connected to large rooftop HVAC loads found in buildings, the system is able to collect 1-2 weeks of baseline data that is fairly consistent across days with similar weather. Therefore, after the first 2 weeks, each controller can be instructed to operate at the maximum observed duty cycle for that period. Scheduling can also be configured to presets for recurring, or one-time events. Real time and historical data can be exported as a spreadsheet for future analysis.

To communicate with each connected load, the REGEN system does not have to integrate to the different communications protocols found in commercial equipment, although past versions of the REGEN system have managed to do so seamlessly. Since the system is mostly used to control rooftop HVAC units, it consistently encounters very similar controls languages, primarily due to standardized thermostat controls. The REGEN system taps into these standardized integration points, either allowing or blocking the signal to the HVAC's control board. Thus, the REGEN controllers essentially function as a group of on/off switches that communicate with each other to ensure that as few as possible are on at any given time.

REGEN's bee-based algorithms make it possible to have a power-reduction system that operates in a completely automated fashion to smooth out overall energy demand, not only ensuring that a building's energy use remains relatively constant at all times, but that overall energy use is reduced. In this way, a building can avoid spikes in electricity consumption that drive up utility bills graded to peak usage rates.

Each EnviroGrid Controller monitors the activity and energy use of an appliance every two minutes, and is capable of streamlining a machine's operations during off-peak hours as well. An innovation that REGEN

is pursuing to be able to better integrate into existing building automation systems, as well as its record energy usage data, is the development of a cloud server. Each of the system's EnviroGrid Controllers will contain a cellular modem that communicates with the system's cloud server by pushing power readings and controller decisions from the physical system up into the cloud every 5 minutes.



EnviroGrid Controllers record the energy usage of each HVAC system every two minutes and broadcast their readings via a ZigBee network. In this way, the devices act like a swarm of bees.

The EnviroGrid Portal, which will provide access to this aggregated data, is a secure web portal that is shared with property managers, utilities, or other relevant parties. The portal will require no software installation, and provides site-level permissions to allow view-only and manager roles. Authorized entities will then be able to view, in near real-time, the energy consumption of each individual load. Using the interface is not mandatory for operations. The system is



autonomous, but also provides an added option of streamlined data analysis and management. This data is powerful for identifying high-demand appliances, appliance run frequency, and statistics that show energy usage during occupied and unoccupied times of day.

Outcomes

For REGEN Energy

Since their 2005 start, REGEN has experienced growth measured in multiples: sales increased by a factor of 8 between 2009 and 2010. The company was also fully in the black during 2011, a notable and quickly achieved goal for a cleantech company of its kind. What began as a two-man garage innovation is now a 20+ employee company with installs throughout the U.S. and Canada.

The bulk of REGEN's installs were initially within the Province of Ontario, since REGEN is local and has the most developed network there. The region experiences high humidity, and substantial heat island effects. In the summers, this translates into a large peak demand problem and corresponding utility charges. REGEN has also targeted California, as high environmental awareness and interest from California utilities aid in promoting the product. REGEN has completed work with Sacramento Municipal Utility District (SMUD), a major utility company, and are currently in talks with other California and Texas utilities to increase their presence in both regions.

Many of their installs include big-box retail locations, smaller commercial office buildings, food processing plants, multi-cinema complexes, schools, distribution centers, warehouses, light industrial facilities, and sports and recreation centers. There are also plans to develop a system that could compliment existing building management to make REGEN's system viable for larger office towers. After expanding to California and other West Coast markets, the proportion of REGEN installations in the United States went from 0% in 2008 to over 67% of the electricity load under REGEN systems management in 2010.

A more fundamental shift in market share is also underway, as REGEN is in talks with California utilities to provide energy demand management services to a grid that will soon have to cope with the load of electric vehicles (EVs). The popularity of EVs in California have utility companies worried that neighborhoods affluent enough to afford first generation EVs will form dense groups of electric vehicle owners that will attempt to charge their cars at the same time. This could lead to regular brown-outs for California's already fragile electric grid over the next two to three years.

Kerbel, Kulyk and the REGEN team are already planning with utilities such as SMUD and ConEdison to begin to implement their technologies across multiple facilities. The model they envision puts a node in the charging station of each electric vehicle owner so that the all electric vehicles in a given area can communicate with each other, devising a plan to charge evenly without overwhelming the grid. REGEN already sells an electric vehicle jump-start kit for small fleets of EV cars, and are eager to roll their technology out on a larger scale. By leveraging their existing intellectual property in a new and lucrative way, Kerbel is excited to "take the swarm to the parking lot."

Most recently, in the spring of 2013, REGEN entered a partnership with Carrier to resell its demand management system to work alongside Carrier's commercial rooftop units for small and medium commercial buildings. While the partnership is REGEN's biggest to date, it already counts Sears, Kmart, and Dave & Busters among its clientele.

Since its establishment, REGEN Energy has been lauded by local and national media coverage for its innovation, and has been commended at clean-tech conferences. In fact, George Pappas, a professor of electrical and systems engineering at the University of Pennsylvania and an expert in distributed control systems, not only believes that REGEN's model of swarm logic is a natural fit for energy applications, but also believes that the company is "ahead of the curve." REGEN was ranked in the top 10 Smart Grid Companies to Watch Out For by SmartGrid News. The company was also an award-winner in the Clean Tech category of Canada's Top 10 Competition.



For the Customer

REGEN's technology has proved to be effective in reducing both peak demand and overall energy consumption for its clients. In fact, in 2010, REGEN installed EnviroGrid Controllers in a chain of movie theaters in New Mexico with impressive results. The installs ranged across several different areas of New Mexico, also ranging across three different utility companies. The results of this project are listed in the table below.

Portfolio		Peak Demand		Consumption	
Location	#RTUs	Reduction (KW)	Annual Savings	Daily Reduction (KWH)	Annual Savings
3 Sites	50	-46	\$3,462	1,623	\$34,093

The return on the initial investment (ROI) for this particular installation was an impressive 1.23 years, considering most competing technologies yield an ROI of around 3 years. Most REGEN installations yield an ROI of 2 years, and often end up with less when combined with the utility-sponsored financial incentives that many of these installations receive. Most of REGEN's clients see an overall energy demand reduction of 15-30%.

Additional benefits come from superior building operations and management and fewer unforeseen equipment problems, resulting from the fact that the EnviroGrid system closely records the energy usage of all major appliances and HVAC systems. With energy use data released every two minutes, equipment malfunctions are immediately obvious. The ease of using a fully automated system also reduces the burden on undertrained or understaffed building maintenance employees.

Lessons Learned:

- Sustainability and environmental stewardship do not necessarily come at a premium.
- Biomimetic, "disruptive technology" may exempt a company from the problems and shocks to which an industry standard is susceptible.
- Embracing biomimicry can establish a company as a thought-leader, improving public perception.
- Skepticism is a common but surmountable obstacle in the research and development process. Other industry players often show initial skepticism.

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Source Notes:

- Interview with Mark Kerbel
- Hamilton, T., "Managing Energy with Swarm Logic," MIT Technology Review. February 4, 2009; "Lots of Buzz Surrounding this Company," TheStar.com. September 03, 2007.
- Kerbel, M., "Swarm Your Building with Distributed Intelligence and Reduce Energy Costs," Monster Commercial. November 16, 2010.
- www.regenenergy.com
- Fehrenbacher, K., "Is Smart Energy Poised to Swarm California?" GigaOM. February 16, 2009.
- LaMonica, M., "'Swarm' converges on energy use in buildings," CNET News. March 24, 2009.
- Fehrenbacher, K., "The Future of Energy Innovation Is In Smart Algorithms," GigaOM. April 29, 2010.
- Tweed, K. "REGEN Energy and Carrier Partner for Rooftop AC Efficiency." Greentech Media. April 16, 2013.

