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## Letter From Sand Hill Road: Vinod Khosla's Cleantech Portfolio

He fell in love with biofuels and they broke his heart.



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*Photo: TechCrunch*

The first mention of VC investor Vinod Khosla in the pages of GTM occurred almost a decade ago. He said, "Forget plug-ins," during a keynote speech. "They are nice toys. But they will not be material to climate change."

He did suggest, "They will be great investments."

We've covered [Khosla's contrarian strategies \(http://www.khoslaventures.com/wp-content/uploads/Google-4-22-09.pdf\)](http://www.khoslaventures.com/wp-content/uploads/Google-4-22-09.pdf) and tactics in energy investing, and we've published position papers from Khosla Ventures on [thin-film solar \(http://www.greentechmedia.com/articles/read/what-really-matters-in-thin-film-solar-startups\)](http://www.greentechmedia.com/articles/read/what-really-matters-in-thin-film-solar-startups) technologies and biofuels. ([Khosla on energy storage \(http://www.greentechmedia.com/articles/read/vinod-khosla-with-some-tough-love-for-energy-storage\)](http://www.greentechmedia.com/articles/read/vinod-khosla-with-some-tough-love-for-energy-storage) is a personal favorite of mine.)

In this GTM Squared piece, we take a look at Khosla's 60-plus cleantech investments over the last decade. The investments are broken out by sector, without regard to fund.

We're not looking to examine every investment in detail here (we've done that at GTM since 2007), but we are looking for VC returns and more broadly, how the Khosla Ventures cleantech investment thesis has performed and shifted over time.

True story: Years ago, when Khosla was still a partner at Kleiner Perkins, I dropped by the KP offices to visit a friend -- accompanied by Cookie, a border collie. Khosla's assistant spotted me (actually, the dog) and briskly escorted us to the great one's office, introduced me to Khosla while transferring possession of the pet, and ushered me out the door. A few minutes later, Cookie was returned intact.

Khosla just needed some quality dog time.

Here's a look at the KV cleantech portfolio, past and present.

## He fell in love with biofuels and they broke his heart

*"My real love is cellulosic biofuels." -- Vinod Khosla, 2007*

*"You can't be wise and in love at the same time." -- Bob Dylan, 2005*

It was the first time a Silicon Valley investor confronted an incumbent energy market in a full-frontal assault.

The billion-dollar venture capital firm had studied the global fuels industry (<http://www.greentechmedia.com/articles/read/biofuels-primer-part-one-with-professor-khosla>) and saw immense, albeit risk-laden, opportunities for improved and new biofuel pathways across feedstocks and end products. The ability to scale was paramount.

Khosla was optimistic (<http://www.khoslaventures.com/wp-content/uploads/Biofuels-A-Case-Study.pdf>) about biofuels in 2006 when he wrote, "I believe we can replace most of our gasoline needs in 25 years with biomass" and suggested that existing energy firms were not "used to innovation and the rate of innovation we are likely to see in this business."

Over the course of a few years, Khosla Ventures invested in 20 biofuel or biofuel-related companies.

Company	Technology	Funding	Situation
<b>Cilion</b>	Modular, standardized 55 million gallons per year corn-to-ethanol plants	KV and Western Milling JV	Aemetis acquired Cilion in 2012 for an undisclosed price
<b>GreenLight Biosciences</b>	"cell-free bio-manufacturing" of sustainable chemicals from renewable feedstocks	>\$30M from KV, Kodiak, MLS, Syngenta	Early, just signed deal with Bayer Crop Sciences
<b>Mascoma</b>	Converting wood and switchgrass into ethanol with proprietary yeasts	>\$120M from SunOpta, KV, Flagship, KPCB	Lallemand acquired Mascoma's yeast-related assets 2014
<b>Range Fuels</b>	Cellulosic ethanol using gasification and syngas conversion over catalysts	>\$200M from KV, DOE, USDA, Calpers	Bankrupt in 2012, factory closed in 2011
<b>Coskata</b>	Microorganisms and bio-reactors producing ethanol from MSW	>\$85M from KV, Total, Greatpoint, Globespan, ATV	Defunct, switched feedstock to NG after withdrawn IPO
<b>Lanza</b>	Biological method to convert carbon-rich waste gas into fuels and chemicals	\$160M from KV, NZ Super Mitsui, Qiming, Siemens	JVs "on multiple continents with multiple partners."
<b>Amyris</b>	Yeast designed to convert plant- sugars into renewable hydrocarbons	KP, KV and TPG made 4X returns at 2010 IPO	Focus on higher-margin products, stock at historic lows
<b>Draths</b>	Fermentation technology to produce renewable-based monomers	>\$27M from KV, CMEA and TPG Biotech.	Sold to Amyris in 2011 for \$7 million in Amyris stock
<b>Segetis</b>	Bio-based plastics from renewable agricultural and forestry feedstocks	>\$50M from IRRRB, SABIC, KV, MLSCF, Royal DSM	Plans to build a commercial-scale plant in Minn.
<b>LS9</b>	Genetically modified <i>E. coli</i> to produce a variety of green chemical alternates	>\$75M from Chevron, Flagship, KV, Lightspeed	Acquired for \$40M+ by Renewable Energy Group
<b>Gevo</b>	Isobutanol from agricultural waste	Burrill & Company, KV, Total, Virgin Green Fund	IPO in 2011 at \$15 per share, currently trading at \$0.62
<b>Altra</b>	Biofuels and ethanol developer	>\$200 from KPCB, Omninet, KV, Angeleno Group	Altra bankrupt, spin-out EdenIQ still in cellulosic business
<b>Kior</b>	Catalytic cracking process to convert biomass into renewable crude oil	KV held majority of voting shares and invested >\$160M	Kior bankrupt in 2014, KV and execs sued for fraud
<b>Virdia (former HCL)</b>	Extracting highly refined sugars and lignin from cellulosic feedstocks	>\$5.5M from Burrill & Company and KV	Finnish papermaker Stora Enso bought Virdia for \$33M+
<b>Cello Energy</b>	Biomass converted to diesel-like fuel, using heat, pressure, magic	\$15M from KV, Parsons & Whittemore	Bankrupt in 2010, fraud cases, EPA mess
<b>Hawaii Bioenergy</b>	Large land owners locating, operating ethanol bio-refinery plants in Hawaii	KV, Finistere Ventures	On old KV portfolio lists, since removed
<b>Ethos</b>	Developing sugarcane and cellulosic biofuels in Latin America, excluding Brazil	KV, Greatpoint Ventures	On old KV portfolio lists, since removed
<b>PRAJ</b>	India –based public firm is "one stop shop for ethanol plants."	Bought 10% stake in 2006 while still at KP	On old KV portfolio lists, since removed

Khosla has repeatedly said, "If you're not afraid of failure, it frees you up to succeed." In the case of biofuels, Khosla was extremely unafraid of failure.

At the time, Khosla assumed oil would be \$150 to \$200 per barrel in the 2015-2020 time frame.

Three of these firms went public, arguably prematurely, with Kior now bankrupt and Amyris and Gevo trading at record-low prices. Coskata, Altra and Cello are defunct. Four firms were acquired at disappointing prices. One firm, HCL, favored by Khosla, was acquired at a good multiple but at a relatively modest price.

Only a few million gallons of cellulosic biofuel were produced in the U.S. last year.

Robert Rapier (<http://www.greentechmedia.com/articles/read/The-Bell-Tolls-for-Khosla-Funded-Biofuel-Startup-KiOR>) has some biofuel expertise and has referred to Khosla Ventures' biofuel efforts as "a debacle, with billions of investor dollars and tax dollars flushed down the toilet. What Khosla didn't appreciate is that he isn't smarter than the people in the oil industry." Rapier suggests that Khosla has not had a single success in the advanced biofuels arena, defined as "economically producing biofuels at scale."

"Almost everything that appears novel to an outsider like Khosla has almost certainly been investigated by multiple companies," said Rapier in an article published by GTM.

Some wealth, but little value, was created in these biofuel IPOs. No oil majors have swept in to acquire these biofuel innovations. A few firms in the biofuel portfolio -- Lanza, Segetis and GreenLight Biosciences -- soldier on. But it looks like a confluence of many factors such as oil prices, thermodynamics and the regulatory climate has served to invalidate the Khosla biofuels strategy.

## Searching for the black swan in energy storage

Khosla has said that energy storage is the key to better power utilization, a more reliable grid, and not having to hassle consumers with programming their dishwashers.

But Khosla focused on biofuels before energy storage because he thought the rate of improvement would be faster in biofuels. He was wrong. Lithium-ion battery performance and price are following a solar silicon-like path.

The KV energy storage thesis a few years ago was: lithium-ion batteries are "toys that can't be deployed at scale (<http://www.greentechmedia.com/articles/read/vinod-khosla-with-some-tough-love-for-energy-storage>)." Khosla said that lithium-ion was "too volatile" and "too expensive." The market is proving that wrong as well.

Khosla sets the bar for storage as round-trip efficiency better than that of lead-acid batteries with costs below \$100 per kilowatt-hour. He also said that batteries for electric cars are going to need a black swan, and his energy storage portfolio reflects that wide-open mentality.

Company	Technology	Funding	Situation
<b>Ambri</b>	Liquid metal battery from Don Sadoway's MIT lab	>\$50M from KV, KLP Enterprises, Bill Gates, Total	Recent reduction-in-force and technology reset
<b>Sakti3</b>	Solid-state rechargeable lithium ion battery	>\$50M from KV, GM Ventures, Itochu, Beringia	Acquired by Dyson for \$90 million
<b>Firefly</b>	Advanced carbon foam lead acid battery spun out of Caterpillar	>\$15M from KV, Quercus, Infield Capital in 2008	Firefly, in business, on old KV portfolio lists, then removed
<b>Pellion</b>	Magnesium battery with potential high energy density	KV, DOE	Early, dialing in materials, cathode
<b>Recapping</b>	High energy density capacitor based on a 3D nanocomposite	\$500K seed round in 2008	On old KV portfolio lists, then removed
<b>Quantumscape</b>	An "all electron battery" solid-state electrolytes	>\$50M from KPCB, KV, Gates, VW	Scaling efforts curtailed, back to the drawing board
<b>Alveo</b>	Prussian Blue dye-based high power, long cycle life batteries	>\$1M from KV, Prelude, The Molecular Foundry	Early stage, \$4M from ARPA-E
<b>Seeo</b>	Li-ion batteries, polymer solid-state electrolytes, metallic lithium anodes	>\$40M from KV, GSR, Google.org, Presidio, Samsung	Acquired by Bosch for undisclosed sum
<b>Lightsail</b>	Energy storage systems using compressed air thermally gamed	>\$42M from Total, Peter Thiel, Bill Gates, KV	A work in progress, coping with early markets, containers

The KV energy storage portfolio has seen two low-return acquisitions and some reductions in force as these startups struggle with a growing storage market very much in transition in terms of technology, price and applications.

Developing a new, ready-for-market electrochemistry from scratch is tough work. Stealthy battery firm QuantumScape with its "all-electron-battery" has had to "go back to the drawing board" and slow its scaling efforts, according to sources close to the firm. Seeo had to pivot on its electrochemistry. Ambri has hit commercialization roadblocks.

Despite its flaws and Khosla's arguments to the contrary, lithium-ion has become the dominant technology in the energy storage market. [GTM Research](http://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor) expects the U.S. to deploy 192 megawatts (<http://www.greentechmedia.com/research/subscription/u.s.-energy-storage-monitor>) of energy storage this year, predominantly of the lithium-ion variety.

## What really matters in thin-film solar?

Khosla rightly viewed First Solar (<http://www.greentechmedia.com/articles/read/what-really-matters-in-thin-film-solar-startups>) and its cadmium telluride cost/efficiency trajectory as the benchmark for thin-film solar aspirants. What he didn't anticipate was that [First Solar's](http://www.greentechmedia.com/articles/read/First-Solar-CEO-By-2017-Well-be-Under-1.00-Per-Watt-Fully-Installed) progress (<http://www.greentechmedia.com/articles/read/First-Solar-CEO-By-2017-Well-be-Under-1.00-Per-Watt-Fully-Installed>) would accelerate to a still improving 16 percent module efficiency at less than 40 cents per watt. Khosla also expected silicon vendors to "generally start declining rapidly by 2015 unless they reinvent silicon." And he expected some "improbable pyro-nano-quantum-thingamajig technology" to emerge to challenge silicon and thin film.

Early in the technology's existence, KV viewed concentrated solar power (CSP) as a meaningful carbon-reduction solution.

Company	Technology	Funding	Situation
Izar Solar	High efficiency PV	\$1.5M	Izar appears on earlier KV portfolio lists, since removed
Stion	CIGS thin-film PV modules	>\$200M from KV TSM, Lightspeed, AVACO	KV gained a controlling interest after an ABC
Ausra	Linear Fresnel CSP	\$93.3M led by KV, KPCB	Acquired by AREVA in 2010 for ~\$250M, closed down in 2014
Infinia	Stirling engine CSP	>\$70M from GLG, KV, Wexford, Vulcan, Idealab	Filed for chapter 11 in 2013
EchoFirst	Combined solar electric and solar thermal	>\$14M from KV, Sigma	Acquired by SunEdison at an undisclosed price
Cogenra	Pivoted from LCPV to cell architecture in PV module	>\$10M from KV	Acquired by SunPower at an undisclosed price

Stion continues to build thin-film CIGS solar panels, although at small scale, while still trailing First Solar on performance and price. The Ausra acquisition created some wealth for equity holders, but its CSP technology ultimately proved uncompetitive. Khosla's firm did not invest in the wave of U.S. residential solar sales or financing startups such as SolarCity or Sunrun, shunning that "velocity-of-money" play.

## Utility-scale power, grid control and analytics

According to Khosla, "Automating your meter reader is not the smart grid. The grid really equals smart power electronics. It's not even about the networks." He added, "We need a whole new class of devices and systems. A 50-year-old transformer made of copper wire wound around a ferrite core can't respond to a signal, so we can't control it." He continued, "If we invest in new power electronics devices, things will change radically. The design of existing systems will change based on these new components."

"We need new gallium nitride devices and transistors, and we will bypass Westinghouse's law," according to Khosla.

Here's a grouping of utility-scale generation companies with some smart grid startups in the KV stable.



Company	Technology	Funding	Situation
<b>Greatpoint</b>	Coal-to-natural-gas via catalytic hydromethanation	>\$1.2B investment from Wanxiang, KP, DOW, AES, KV	Focus on China
<b>Altarock</b>	Geothermal services	KV	Acquired Blue Mountain Faulkner geothermal power plant
<b>TerraPower</b>	Traveling wave reactor, a "self-sustaining deflagration of breeding and burning"	>\$30M from KV, Bill Gates, Charles River Ventures	Nuclear science project
<b>Sunborne</b>	Indian utility-scale solar project developer	KV	India power plant development
<b>Nordic Windpower</b>	1-megawatt 2-blade wind turbine design	>\$38M from KV, NEA and Novus Energy Partners	Bankrupt 2012
<b>Ciris Energy</b>	Microbial bio conversion of carbon in buried coal and hydrocarbon deposits	KV, APC, Triple Point, Rho, ETV, Braemar	Converting coal to methane
<b>Varentec</b>	Power management and monitoring solutions for the electric grid	>\$28M from 3M, Bill Gates, KV	Early customers and pilots
<b>Bigdely</b>	Analytics that can itemize home energy usage data to the appliance level	>\$24M from KV Constellation, E.ON, RWE	Early customers and pilots

This sector still holds promise for the VC with market traction for Varentec, Bigdely, AltaRock, and GreatPoint, along with Bill Gates as co-investor in Varentec and TerraPower.

## Investing in engines and motors with Bill Gates

One expects high failure rates in venture capital -- but the metabolic mismatch between startups and the automotive industry is even more of a stressor.

Company	Technology	Funding	Situation
<b>Etagen</b>	Free-piston gas-fired engine for backup power and CHP	KV, Bill Gates, PIER	Early stage
<b>Ecomotors</b>	Opposed-piston, opposed-cylinder engine	>\$65M from KV, Bill Gates and Braemar Energy Ventures	JVs with Chinese engine builders
<b>Transonic Combustion</b>	Next-generation fuel injection systems	>\$32M from KV, Venrock, Rustic Canyon, Saints	Assets auctioned in 2015
<b>Tula</b>	SW, DSP for variable displacement engine via cylinder deactivation	GM, Delphi, KV, Sequoia, Sigma	Startup working with auto makers means 2020 market intro
<b>Pax Streamline Caitin</b>	Air-cooling and blown-wing wind blade technology	>\$12M from KV	Dissolved
<b>Nrg-Dynamix</b>	Hydraulic hybrid power train	Ridgewood, KV	Still in business but no longer listed in the KV portfolio
<b>Ramu</b>	Switched reluctance motors efficiencies, speeds, temperatures	KV	Regal Beloit acquired the non-revenue-generating firm 2011
<b>Danotek</b>	Permanent magnet generators for wind applications	>\$40M from KV, CMEA, GE, Statoil, ECP	Bankrupt 2012
<b>Nanostellar</b>	Nanoscaled catalytic materials for diesel emissions control	>\$14M from KV, Firelake, 3i	Sold to after-market catalytic converter manufacturer in 2012

Here we see Transonic, Pax and Danotek were not able to keep the venture pace.

## Investments in lighting and homes

Company	Technology	Funding	Situation
<b>View</b>	Dynamic electrochromic glass tints windows electronically	\$500M from KV, Corning, Madrone, GE, DBL, Sigma	100 window installs and "an additional 100 underway."
<b>Soraa</b>	GaN on GaN LEDs replacing halogen MR16	>\$100M from KV, NEA, Angeleno Group, NGEN	Building new factory in NY
<b>Lumenz</b>	Zinc oxide-based LEDs	>\$8M from General Catalyst, KV	Defunct
<b>Group IV Semiconductor</b>	Silicon-based nanofilm for solid-state lighting	KV, BDC, Garage Technology, Applied Ventures	Closed 2010
<b>Topanga</b>	Plasma based HID lighting	KV, Nth Power	No longer listed in the KV portfolio
<b>Living Homes</b>	greener, cheaper, LEEDS qualified homes using a modular system	KV	Still in business but no longer listed in the KV portfolio

## Investments in water technology

Company	Technology	Funding	Situation
<b>NanoH2O</b>	Reverse osmosis membranes for desalination	>\$85M from KV, Oak, BASF, Total, CalPERS	Acquired by Korea's LG Chem for \$200M
<b>Quos</b>	Removing salt and impurities without reverse osmosis	KV, Gas Technology Institute	Defunct

## Investments in efficiency, etc.

Khosla had this to say about investing in renewables and energy efficiency: "We're in a crisis, and there is an opportunity to reinvent our energy infrastructure; it would be a folly to waste it."

Company	Technology	Funding	Situation
<b>Avogy</b>	Efficiency and reliability of power conversion systems. GaN on GaN	KV, Intel Capital	Making small consumer chargers through subsidiary
<b>PSP</b>	Low-cost solid oxide fuel cell powered by the heat of a cook stove	KV	No longer listed in KV portfolio

## Investments in new materials

Vinod Khosla on innovation: "Only small companies do impressive things."



Company	Technology	Funding	Situation
Arcanum Alloys	Driving surface property performance in metal alloys via vapor deposition	KV	Addressing the steel market
Calera	Conversion of CO2 into industrial chemicals	>\$20M from KV, Peabody	"chemical equivalent of a perpetual motion machine"?
Silicium	High ZT silicon thermoelectrics for wearable electronics	KV	Seed

## Khosla is going to continue to take shots on goal

*"All progress depends on the unreasonable man" -- A George Bernard Shaw quote Khosla likes to cite*

Despite his brilliance, many of Khosla's early assumptions about biofuels, storage and solar have proven wrong or at least mistimed.

Still, the occasional home-run exit in a venture capital portfolio can make up for a multitude of singles and market miscues. That home run hasn't happened yet in the KV cleantech portfolio. The black swan has not yet landed. In the case of Khosla Ventures, the firm invests across a number of sectors, so the home run might come from a lucrative exit for a synthetic meat, payment system, or nontoxic snack company.

Khosla is going to continue to take a lot of shots on goal. He has suggested that 1,000 VC firms in the KV mold would up the odds of solving our climate challenge. Khosla wrote, "To get to the energy-independent future we need, we must continue to try and sometimes fail, but the consequence for not trying is guaranteed failure. We will keep accepting intelligent and selective failure."

A colleague and former Khosla employee spoke of a phase Khosla went through where he was somewhat fixated on reinventing wood. Not as a mental exercise, but as a potential option for the planet.

Sounds unreasonable, right?



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Eric Wesoff is Editor-at-Large at Greentech Media. Prior to joining GTM, Eric Wesoff founded Sage Marketing Partners in 2000 to provide sales and marketing-consulting services to venture-capital firms and their portfolio companies in the alternative energy and telecommunications sectors. Mr. Wesoff has become a well-known, respected authority and speaker in these fields.

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