

CTG INSIGHTS

A BI-MONTHLY REVIEW OF KEY TRENDS AND UPDATES,
FROM ACROSS OUR GLOBAL INNOVATION COMMUNITY

2 FOREWORD: SHARING WHAT WE ARE SEEING »

4 DISSONANCE & DISRUPTION: A TIME FOR QUESTIONS, NOT ANSWERS? »

6 CAPITAL & SYNDICATION MATTERS: THE VENN THEORY OF CLEANTECH INVESTING »

10 AT THE CUTTING EDGE: ARTIFICIAL INTELLIGENCE: CLEANTECH OPPORTUNITIES »

14 DIGITAL + INDUSTRIAL: INTERNET OF ENERGY: NEW CONNECTIONS IN OIL & GAS »

17 INNOVATORS + INCUMBENTS: TECH GIANTS ARE STAKING OUT THE SMART HOME. WHERE DOES THAT LEAVE ENERGY? »

20 FRESH FACES: AN INVESTMENT COMPANY GIVING WESTERN COMPANIES MARKET ACCESS ACROSS ASIA »

23 AT THE CUTTING EDGE: GENE EDITING: THE EVER-HOTTER CRISPR »

25 FOLLOW THE LEADERS: GLOBAL CLEANTECH 100 »

SHARING WHAT WE ARE SEEING

BY RICHARD YOUNGMAN, CEO, CTG



FOREWORD

CTG Insights is our way to share more of what we are seeing, more regularly - by highlighting the trends, players and happenings in the space (amidst all the noise of the daily deal and news flow) that we think you should be paying attention to.

In our third edition of *CTG Insights*, we have settled into a bit of a rhythm, in terms of what the CTG team is sharing with you.

In this edition, our *At the Cutting Edge* series brings you our first primers on Artificial Intelligence (AI) and CRISPR. This is part of our ongoing focus to highlight for you enabling technologies which are starting to, or have the potential to have, an impact on many industrial areas. Some of those industries are outside of our purview (e.g. health), but others are clearly front and center – power and energy, construction and building management, automotive and transportation, to name but a few.

Such intersects between industries of interest and newer technological capabilities are the focus of the *Digital+Industrial* research stream. In this edition, the team addresses two such examples – a look at some applications that IoT is enabling in the Oil & Gas sector, and a new look at the Smart Home (and energy management) through the lens of what tech giants, Amazon and Google, are doing with voice technology. The second is found under *Innovators + Incumbents*.

These intersects between technology generally and the world of utilities, automotive, manufacturing, oil and gas, etc. explain well the continual flow of investment into the ongoing transition of the old industrial order. This edition's *Capital & Syndication* column shows how new capital has been quietly financing cleantech-like deals, without ever thinking of it as such. Resource efficiency is starting to become so mainstream, converging and interconnecting with all types of technologies and industries, that the cleantech idea of “doing more with less” is part of many investments, but often only a part.

This edition's *Fresh Faces* highlights a new name on the scene that also fits our *East meets West* theme. TRIREC, a new Singapore-based fund is looking for opportunities in North America where they can help innovators scale in Asia. A global approach may have just become more important since the US election, although my *Dissonance & Disruption* article on this topic concludes that what exactly will happen in the US may not be as obvious as some might think. There are many stakeholders with difficult strategic choices to make.

Keep telling us what you like, or don't like about *CTG Insights* – whether by writing directly to me, any CTG team member, or editorial@cleantech.com.

Meantime, enjoy this edition...

Richard Youngman

THEMES

EXPLORE

We will continue to explore key themes and research streams, as described below, that we think are of high importance, though not all themes will be included in each edition.

Dissonance & Disruption CTG Insights will provide you with a steady flow of signals we see as interesting and important indicators of a changing operating context.

Intersects CTG Insights will highlight examples of impactful and disruptive intersects occurring between traditional industrial sectors, that not only challenge cleantech's gravitational core, but also provide glimpses of the future possible.

Digital + Industrial CTG Insights will cover a key intersection – the digitalization of the physical, industrial world – and the state of change toward truly “smarter” industry.

At the Cutting Edge CTG Insights will keep an eye out, cut through the hype, and look to bring to your attention early warnings on trends we believe will be important enablers of future innovation waves.

Capital & Syndication Matters CTG Insights will track where capital is coming from, and how models and syndicates are changing over time.

Innovators + Incumbents CTG has been active in bringing corporations and start-ups together. This theme will highlight select strategic partnerships, to illustrate how this important dynamic is playing out in a more open innovation world.

Follow the Leaders Updates and news on our Global Cleantech 100, an annual list of 100 companies from across the breadth of the cleantech theme, identified by the market as the most likely to make significant impact within a 5-10 year timeframe.

Fresh Faces Recognizing the importance of new arrivals into our innovation ecosystem, we will highlight to you new players – a range of individuals, investors, multi-national corporations, and new innovation programs to watch out for.

East Meets West For some time we have been expecting to see a gradual rise in deals that exhibit the coming together of western technology/innovation with Asian partners, be that financial, industrial or government. As part of our tracking of the global cleantech landscape, we will highlight examples we see.

A TIME FOR QUESTIONS, NOT ANSWERS?

BY RICHARD YOUNGMAN, CEO, CTG

■ DISSONANCE & DISRUPTION

CTG Insights will provide you with a steady flow of signals we see as interesting and important indicators of a changing operating context.

If ever we needed a re-confirmation signal that the “old order” (in everything, everywhere) is breaking down, and that millions have lost faith in those most associated with it (the so-called elitists), we just got it. It appears Brexit wasn’t enough, and Trump’s victory will probably not be the last of its kind. Such is what happens when disruption achieves “tipping point” momentum; it is too late to react for those anchored in the status quo. Events take over until a new normal is reached again.

Naturally, our community is obsessing about a series of questions, unanswerable at the time of writing. Will Trump take the US out of the Paris accord? Can he do so immediately or is he bound by the 4-year rule? Will he roll-back the EPA and the Clean Power Plan? Is he serious about trying to revitalize coal, even when the economics (let alone the carbon implications) make no sense? They are all good and important questions but ones none of us can really answer today. Maybe Trump and his transition team don’t even know. (If Brexit is anything to go by, it is possible to win a vote in today’s environment on a series of soundbites, not expect to win, and so have no real “ready to go” plan.)

I am not going to be the 101st person to speculate on the above questions. My tack is going to be to suggest some other questions we should be asking ourselves. In particular, I am going to focus on how the financial investors might be thinking, be they institutions or multi-national corporations. It is non-obvious how to think and what to do. For some, Trump could present a real bind in how much capital, financial and reputational, they would allocate towards the coming infrastructure spend, especially if the proposed projects do turn out to be “bridges to the past.”

“ *Not only is there a populist movement against the status quo politically, there has also been a growing divestment movement against the fossil fuel industries. Will the global financial markets actually back projects to bring back coal, to drill for more gas, to build more nuclear, etc?”*

Not only is there a populist movement against the status quo politically, there has also been a growing divestment movement against the fossil fuel industries. Will the global financial markets actually back projects to bring back coal, to drill for more gas, to build more nuclear, etc? Not only are the economics questionable for some such projects, there is also the possibility that these projects might never pay back, as by the time they get to the point when they should start producing cash flows, who knows where we will be politically, or where we will be in terms of the exponential growth of renewables. What if this US administration does prove to be aggressively anti-clean energy and, for whatever reason, doesn’t last beyond 4 years? How financeable will the new administration’s pet projects actually be? Will they create jobs more effectively than distributed energy has already been doing?

Boardrooms who have gradually been seizing the “future” and coming out in support of the need to act more responsibly and sustainably in developing the next-generation industrial set-up have strategic questions to answer as well. As recently as November 4th, the heads of the 10 oil and gas companies that comprise the \$1bn OGCI (Oil & Gas Climate Initiative) **said**: “The creation of OGCI Climate Investments shows our collective determination to deliver technology on a large-scale that will create a step change to help tackle the climate challenge. We are personally committed to ensuring that by working with others our companies play a key role in reducing the emissions of greenhouse gases, while still providing the energy the world needs.”

Will they and others who have come up with initiatives and cited targets back off from them (in effect, admit it was “greenwashing”)? What damage would that do to their credibility and reputation, if indeed the US remained in the global minority on tackling emissions only for a short period? Could they survive such?

It is simply not obvious how key actors will respond in 2017+. The future just got more uncertain and more interesting.



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THE VENN THEORY OF CLEANTECH INVESTING

BY TROY AULT, DIRECTOR, CTG

CAPITAL & SYNDICATION MATTERS

CTG Insights will track where capital is coming from, and how models and syndicates are changing over time.

Key Takeaways

- A common cross-applicability of technology platforms is changing what it means to be “a cleantech company.”
- That same cross-applicability is bringing new, sometimes otherwise unlikely investors into the cleantech ecosystem.
- Both of these facts suggest that investors should adapt their deal-sourcing and syndicate-building strategies.

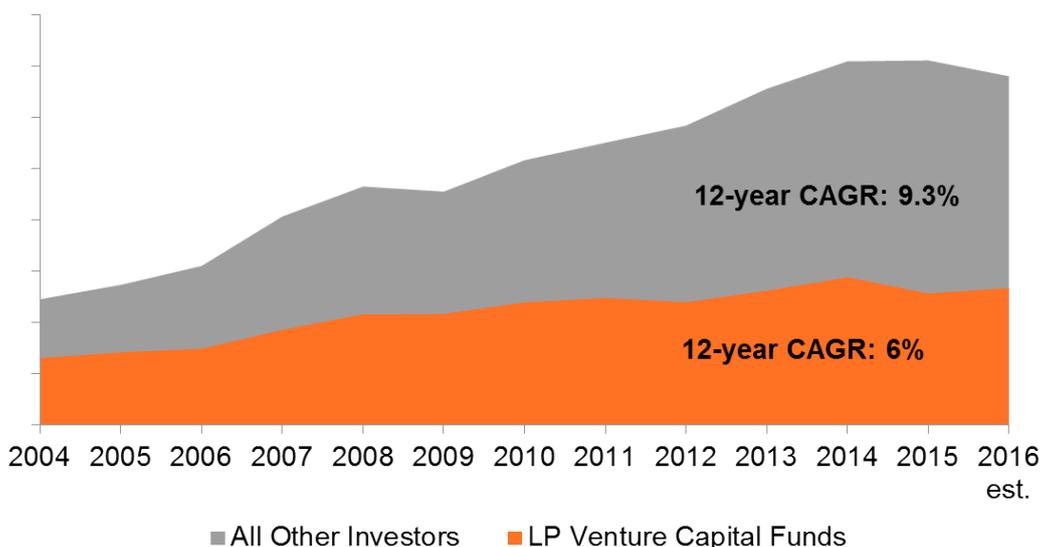
Setting the scene

The story goes, beginning in the 2011-2013 period, and following company failures like [Solyndra](#), [A123 Systems](#), [Fisker Automotive](#), and [Better Place](#), venture capital firms collectively decided that the hard-science, plant-and-equipment businesses that constituted the cleantech ecosystem simply did not fit the venture capital fund model of 5- and 10-year fund cycles. The investment horizon was too long, the development cycles (often regulatory-dependent) too slow, and the quantity of capital required to scale these companies was too large. And so these investors retreated from anything that looked like a cleantech deal.

Our data tell a slightly different story, namely that the absolute number of investors in fact kept growing year on year, but that the gloom was reflected in lower dollars and fewer active limited-partner venture capital funds. Typically responsible for the bulk of investment dollars and thought to have been the retreaters-in-chief, the activity of venture capital funds actually grew, albeit at a slower pace, with the shortfall made up by a diverse mix of investor types from corporate strategic investment to alternative investment funds.

The absolute numbers aside, there was a VC retreat during this time, and it typically materialized in three ways. First, there were fewer new investments made by these funds, though almost all of them did continue to support their existing portfolios through follow-on rounds. The distinction between investors actively sourcing new investments and investors participating only in follow-on rounds is not reflected in the chart below, as both types of investments are counted as “activity” during the period surveyed. Second, there were indeed fewer funds that positioned themselves exclusively as cleantech funds or any amalgam thereof. Most of these funds did not retreat entirely from clean technology investing; they merely saw reason to diversify their portfolios into adjacent sectors and rebrand. Common stand-ins were “energy,” “resource,” and/or “infrastructure” funds. Finally, investors at the margin who had only dipped their toes in the pool with one or two investments – chasing a popular trend in the 2007-2012 period – largely dumped the term as soon as it fell out of vogue.

Active investors in cleantech venture deals



Did the Cleanweb bring them back?

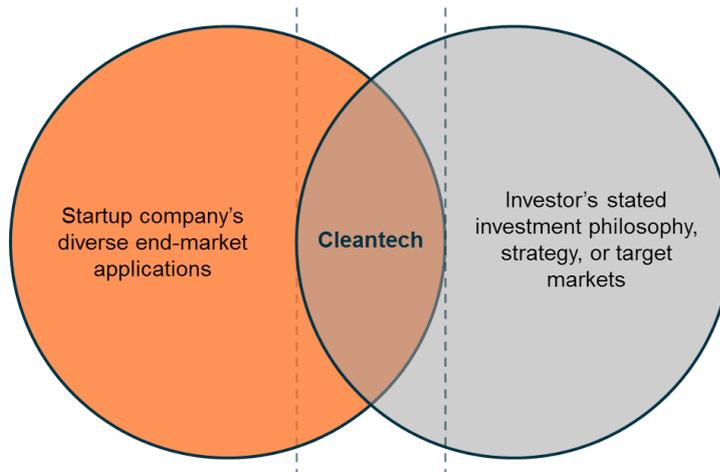
Entrepreneurs, incubators, and angel investors heard the message loud and clear. By 2012, most new company creation relevant to the clean technology theme comprised of capital-light software and service businesses that traditional venture funds typically like. By late 2012 and early 2013, “Cleanweb” was the new term du jour as companies like [KiloWatt Financial](#) (now [Spruce Finance](#) via a merger with Clean Power Finance), [Ayla Networks](#), [Bidgely](#), [Mosaic](#), [Vicarious](#), and [FirstFuel Software](#) were being founded and raising healthy first-round funding. This trend of entrepreneurs and early-stage investors pursuing innovation that better fits the typical investment mandates of LP funds certainly changed the face of cleantech investing.

Our Quarterly Investment Monitor suggests steady quarterly increases in the number of traditional LP venture funds actively investing in the sectors that CTG tracks since the third quarter of 2015. We would normally first turn to the above theory of start-up founders currying favor with LP funds via capital-light technology for an explanation. Digging into our dataset, though, we’ve uncovered another related trend. Namely, that a second driver of new investors into the fold is the increasing cross-applicability of some VC-friendly technologies from outside the traditional cleantech ecosystem into energy and resource sectors. It is this second trend that has led us to coin what we call the *Venn Theory of Cleantech Investing*.

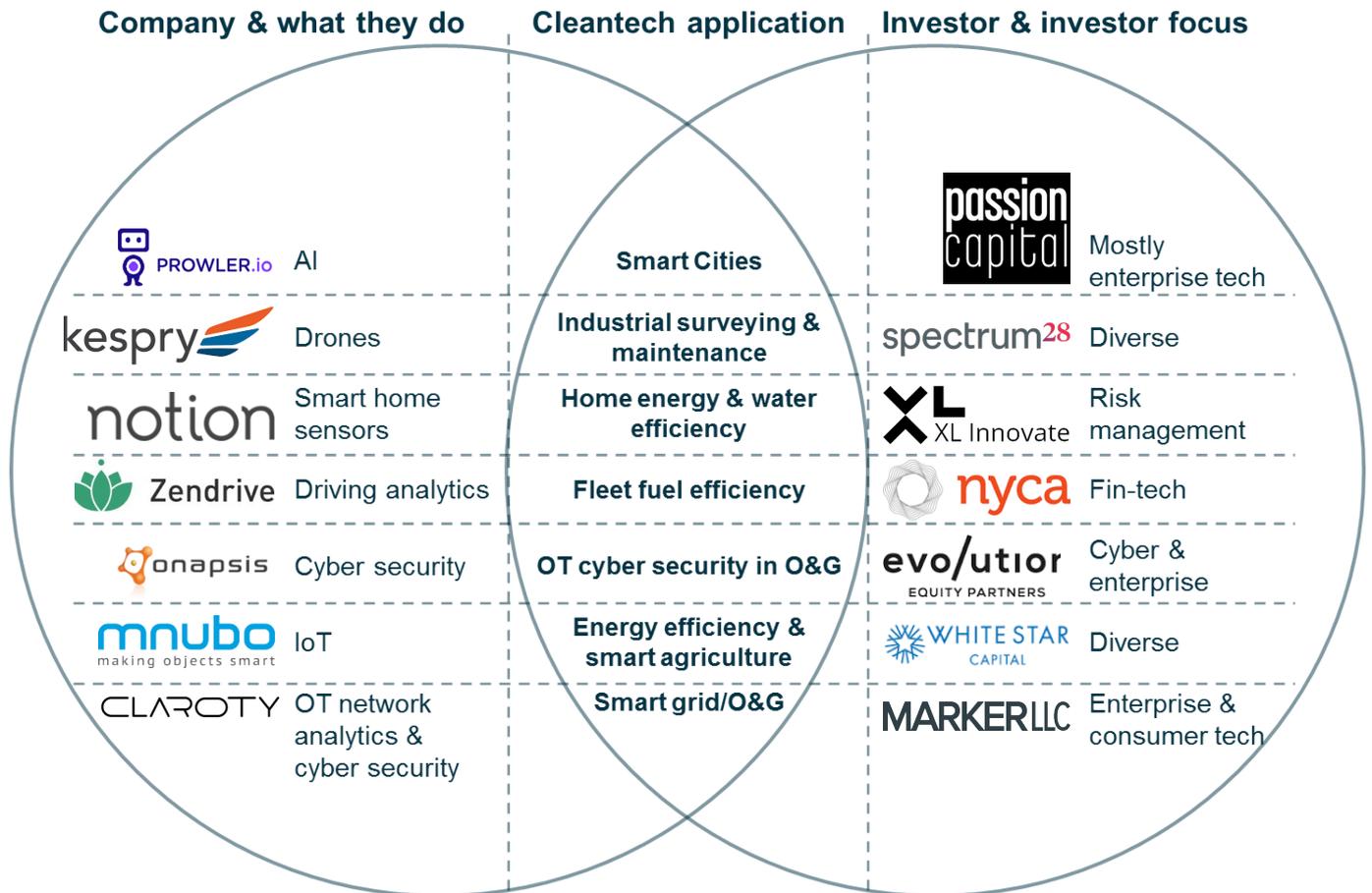
The Venn Theory of Cleantech Investing

Our theory suggests that companies innovating in new technology and services that bridge into the cleantech theme – that is, perhaps one of a company’s five market applications could be deemed cleantech-relevant – are not only changing what it means to be “a cleantech company,” but are also drawing in new investors that might not otherwise look at businesses targeting energy, infrastructure, and other heavy industries.

The Venn Theory of Cleantech Investing



It's no stretch to argue that prevalent themes in traditional tech, wearables, and fin-tech are finding lucrative applications in energy and industry, as trends like the internet-of-things (IoT), drones, artificial intelligence (AI), and blockchain gather momentum. To further illustrate our point, however, we've selected a set of recent deals that exemplify the Venn theory.



In the previous table, two deals in particular stand out for their drawing in fin-tech, and specifically risk management-focused venture firms, into the cleantech ecosystem.

Zendrive's driver analytics are primarily used to enable safer driving through automated coaching. Nyca Partners, a fin-tech focused venture firm, therefore unsurprisingly recognized the potential financial impact of improving the risk pool of insured drivers, investing in the company's Series A round earlier this year. However, Zendrive also directly acknowledges the knock-on fuel efficiency benefits of its app, particularly for vehicle fleet operators. Applying the Venn theory, Nyca Partners – an otherwise unlikely clean technology investor – has clearly found its way into the theme.

In the second deal of note, **notion**'s smart home monitoring and awareness platform presents clear benefits to home insurers, helping prevent problems like fires, water damage, and burglaries. XL Innovate, the seed venture capital affiliate of the XL Insurance Group, represented a sensible strategic fit for the company's seed round in June. The start-up also recognizes the energy- and water efficiency benefits that accrue for its users, and markets its product accordingly. In this example, we see the Venn theory at work again, with another financial services-focused investor backing development of a clean technology company.

Implications for syndications

It's easy to take the Venn theory to mean that we anticipate seeing "a return to cleantech" by VCs, but this would be flawed logic. The first thing to note is that there has been a slow but fundamental change to the notion of, "what is cleantech." Platform technologies like those discussed above have several end-market applications, perhaps only one of which extends into energy or resource-heavy industries. However, they now make up a sizeable share of our clients' interests. Investors are already looking further afield for investment opportunities than in the past, and the first implication of our Venn theory would be: so should you.

The second implication of the Venn theory is that long-standing cleantech investors should expect to encounter new faces in the syndicate-building process. This could mean embracing new partners for deal flow and deal syndication, as well as new competition for deals. It could also indicate a return of investors at the margin – investment firms without specific industry expertise who find themselves backing innovators that could very well change those industries. However, perhaps this time it will be for true cross-applicability of technology platforms and the complementary expertise they *do* bring – not for investors following the herd and keeping their portfolios in vogue.

In an upcoming edition of Capital & Syndication Matters, we will detail the ratios of active investor types discussed at the start of this article and keep an eye on how the Venn theory might impact them.

ARTIFICIAL INTELLIGENCE: CLEANTECH OPPORTUNITIES

BY JULES BESNAINOU, DIRECTOR, CTG

■ AT THE CUTTING EDGE

Our At the Cutting Edge series will keep an eye out, cut through the hype, and give early warnings on trends we believe will be important enablers of future innovation waves. Expect articles and interviews on topics like 5G, gene editing, virtual reality, artificial intelligence and more.

Over the past few years, sensors have become ubiquitous in energy, industry and transportation. The data they generate provides increasing intelligence to businesses, and enables efficiencies for business models old and new. Artificial Intelligence leveraging that data to automate complex tasks and operate systems like grids and plants is now a reality. With an investment lens in mind, we talked to some of the most impressive start-ups innovating at the intersection between cleantech and AI.

From these conversations, three key opportunities arise:

- Making sense of sensor data to operate physical assets;
- Providing context for machines to understand their environment and make decisions;
- Collating complex datasets and giving them a voice.

This article aims to detail these opportunities for our corporate and investor clients, and surface some examples of AI successfully applied to energy and industrial problems.

Bringing physical assets to life

Founded in early 2014 by industry veteran and IBM Watson advisor Amir Husain, [SparkCognition](#) is developing several AI applications, notably in physical asset management and cybersecurity. In talking with John King, a director at the company, the use case that stood out most is how SparkCognition is helping Invenergy run wind farms with algorithms. In one deployment, [Invenergy](#) supplied SparkCognition with data from the operation of 100 turbines over four years, based on more than 25 different variables. The company then used the data to profile thousands of operating states, showing how certain variables affected each other. The result was impressive: the team was able to build predictive, self-updating models to give more than a month's foresight into impending failures and degradation.

These failure events can cost up to \$200k in maintenance costs and shortfall in revenues for an energy supplier like Invenergy. King noted that SparkCognition is already profitable, and has grown to 70 employees in just two years. Major investors include Verizon Ventures, CME and The Entrepreneurs' Fund.

Another example of industrial AI opportunities, Germany-based [Konux](#) started by developing sensors that could monitor vibration, torque and acceleration for applications in transportation and machinery. However, its efforts quickly moved to software, building analytics and AI to make sense of the vast amounts of data its sensors collect.

Konux has built a strong partnership with Deutsche Bahn, the main German railway operator. The company observed that railway switches had very high maintenance costs and could cause significant train delays. Those switches are surveyed twice a year by teams of engineers, and there is no way to predict faults between these inspections. After installing sets of sensors on the switches, Konux built analytics and algorithms that could predict their wear – and alert maintenance teams in advance. In the future, Konux will also be able to recognize specific trains based on their vibration signature, and recommend maintenance for these as well.

According to Natalie Weiss, a director at the company, the railway use case is generating a lot of interest globally, even though it is not plug-and-play quite yet. However, the company's industrial use cases, such as detecting wear on machines, are much easier to set up. Konux is also increasingly solicited to provide software solutions only. Founded in March 2014, the company now employs 35 people, and has received investment from New Enterprise Associates (NEA) and major angel investors – to the tune of \$9.5 million.

Cognition and decision-making

One of the most publicized applications of artificial intelligence is autonomous driving. [Civil Maps](#), a Ford-backed start-up, is building advanced mapping technology to guide self-driving cars. Sravan Puttagunta, the company's CEO, sums up driving to the equation below:

$$\textit{Sight} + \textit{Cognition} + \textit{Decision Making} + \textit{Action} = \textit{Driving}$$

With sensors that can make sense of on- and off-road signals, and precisely position vehicles relative to those signals, Civil Maps aims to fully automate the cognition element of the equation. To accommodate for the low-latency requirements of autonomous driving, the company is also becoming an expert at boiling down key signals to get to 100 kilobytes of data per kilometer (from a whopping 10 gigabytes per kilometer of data collected). At the moment, the company pays for about 10 vehicles to drive around target cities with their sensors and collect the data. In the next couple of years, however, it aims to set up a crowdsourcing system, in which fleet operators and ride-hailing companies contribute data to the maps, in exchange for map usage credits.

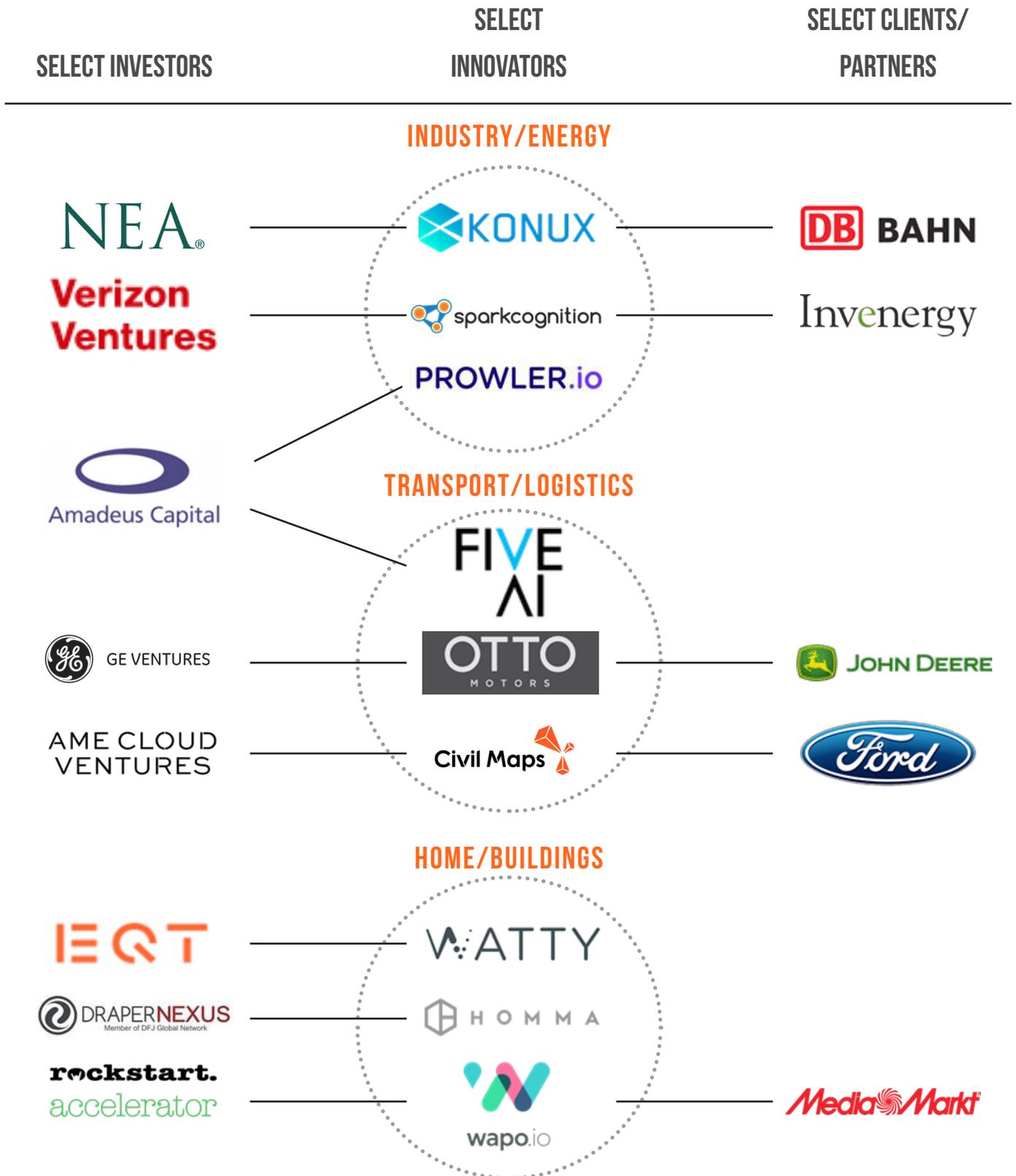
[Prowler.io](#), a UK-based research company, is developing algorithms to help autonomous systems make decisions. While techniques for data gathering and analysis are becoming widespread, decision-making is still reliant on hand-written, inflexible decision trees. This is slowing down applications in robotics and simulation. Vishal Chatrath, Prowler's chief executive, says his company's software could help power complex systems, like swarms of drones working together to plant a field most efficiently based on variables like wind speed.

One of Prowler's first use cases is to help city planners model how thousands of entities interact with each other and make decisions. This uncovers phenomena like the propagation effect, supporting decisions such as placement of a road block to cause minimal traffic jams. With a recent \$1.9m seed round from Amadeus and Passion Capital, the company is growing fast. Vishal's last company, Vocal IQ, was acquired by Apple after only 13 months of operation – showing how reactive the AI market can be.

Giving voice to the data

While assistants like Siri are good at processing your language, their conversation abilities are limited, and they usually recite back facts from Wikipedia. London-based Arria NLG has developed artificial intelligence on the other end of the spectrum – it converts large data sets into plain sentences and reports. Matt Gould, the company's Chief Strategy Officer, told us about a few business applications, including

Our View on the AI Ecosystem



one he called “Dave in a Box.” In a past engagement with Shell, Arria engineers combined datasets from sensors on a large deep-water platform with the expertise of Dave, an experienced operational manager. After learning patterns of his instructions to other operators, the team was able to crunch data sets and send email instructions in Dave’s stead, with his “voice.” Arria is starting to release some applications of its technology more widely. One in particular, Articulator Light, a cloud-based application allowing companies to generate insights and narratives from their data, will soon be available for free.

In a promising data play, New York-based Enigma specializes in helping enterprise clients do predictive maintenance and big data analysis by collating public and private data sets. Its core technology is in the ability to deal with large numbers of distinct datasets, process them, and combine them into actionable insights and dashboards. A typical deployment in energy or logistics will start with the need to explain a discrepancy, or the goal to improve an operational outcome. To solve it, Enigma will build a relevant dataset coming from the company’s operational data, sensors and public data, use triangulation to provide hypotheses on what causes the negative outcome, and keep refining them with a continuous feedback loop from the client’s experts. According to Hicham Oudghiri, the company’s CEO, such deployments are “unlimited journeys with immediate results.”

With an impressive roster of investors, such as NEA (who led the company’s \$28m series B round last year), Comcast, American Express and The New York Times, Enigma is growing at a fast pace. It doubled its staff in the past year (now at 70 people) and aims to continue on the same trajectory over the next two years.

Coming out of a series of fascinating conversations with top AI innovators, it is clear that Artificial Intelligence can be applied to more and more use cases relevant to our ecosystem. With ever-growing needs in making sense of large datasets, and managing increasingly complex physical assets, we are quite bullish on the three types of opportunities presented above. If you think differently, drop us a line at editorial@cleantech.com.

Interested in hearing more about AI? Amir Husain, CEO of SparkCognition, will speak on our Cutting Edge session at [2017 Cleantech Forum San Francisco](#). Register [here](#) today to participate in the discussion.

INTERNET OF ENERGY: NEW CONNECTIONS IN OIL & GAS

BY LEO ZHANG, SENIOR ANALYST, CTG

DIGITAL + INDUSTRIAL

CTG Insights will cover a key intersection – the digitalization of the physical, industrial world – and the state of change toward truly “smarter” industry.

Key Takeaways

- IoT has enabled new applications across the entire O&G value chain
- Upstream O&G leverages IoT to enable real-time data collection and analytics to optimize exploration & production
- For midstream and downstream O&G, IoT provides real-time visibility of pipelines and refinery infrastructure

The Internet of Things (IoT) phenomenon has seen rapid adoption over the past few years, particularly in the consumer market, in areas such as consumer wearables and smart TVs. For industrial markets, we provided a glimpse of how IoT has enabled a number of new applications in the industrial power and energy industries, and highlighted this theme as Internet of Energy (IoE) in our pilot edition CTG Insights in June. For this edition, we will zoom in on IoT in the oil & gas (O&G) sector, explore recent trends, and highlight some current innovators.

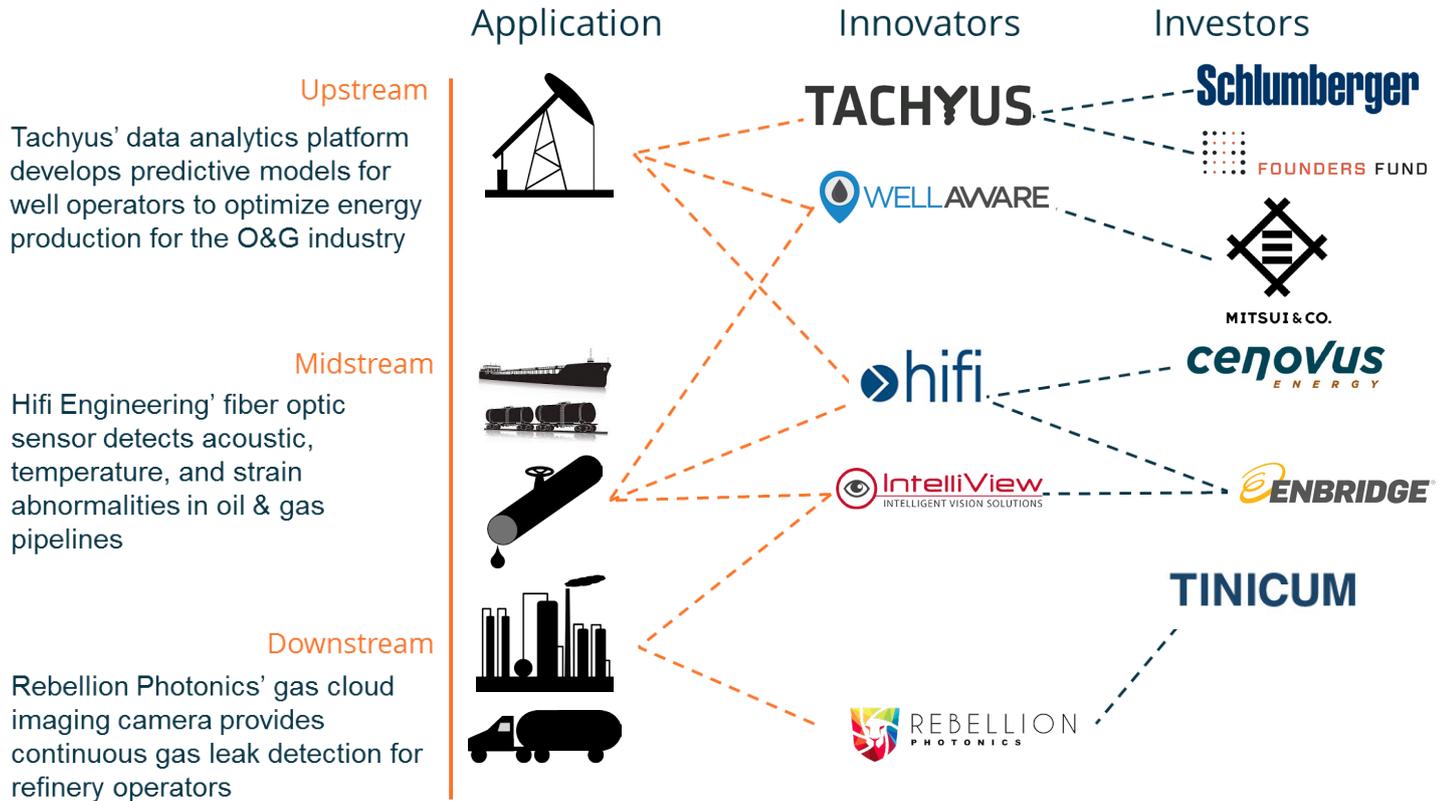
The introduction of IoT has enabled a number of new applications that span across the entire value chain, ranging from upstream exploration to downstream distribution in the O&G industry. Perhaps the area that would derive the most value from IoT technologies is on the upstream side of the value chain, for which real-time data collection and analytics can significantly optimize exploration & production operations. For companies in the midstream and downstream of transport, storage and refining, IoT enables a smarter network of pipelines and refinery infrastructure, such as tank farms and fractionating columns, and provides operators with real-time visibility into key processes.

Upstream – Exploration & Production (E&P)

Profit margins for the entire O&G sector have declined right in line with crude oil prices in the last two years. Consequently, cost efficiency becomes a key factor for all stakeholders in the industry. Particularly for the upstream segment of the value chain, where exploration & production make up a significant percentage of the total cost structure, efficiencies gained through the incorporation of IoT technologies play a pivotal role in reducing production cost.

Perhaps the simplest form of IoT application in upstream exploration & production is the automation of data collection, enabled by sensors and cloud networking. These large datasets serve as the foundation for subsequent IoT applications in optimizing operational efficiency. [WellAware](#) has developed a data collection and analytics platform for the O&G industry. Through the company's partnership with [Ingenu](#)

Select IoT Companies in Oil & Gas



(formerly On-Ramp Wireless), which integrates Ingenu's connectivity and communication channels, WellAware's software platform automatically collects critical production data, such as measurements of oil, chemical, and gas levels.

In speaking with Dave Milam, Executive Vice President – Product at WellAware, one of the most critical needs for well operators is the automation of data collection. He pointed out that WellAware's enterprise full stack subscription service (hardware, networking, and software) has the ability to continuously collect well data, even during network irregularities, as the system's built-in storage can house the data offline, which can be backhauled to the cloud at a later time. With the availability of such comprehensive real-time data, well operators can easily track their assets remotely, reduce the number of human inspections, and identify potential maintenance priorities.

Another O&G IoT company, [Tachyus](#), is a 3-year-old California-based start-up that has developed a data analytics platform for the industry. The company's platform uses real-time data (enabled by IoT-connected sensors) to build models that optimize the efficiency in oil extraction. For instance, Tachyus provides operators with predictive models on steamflood, waterflood, and CO2 optimizations, so that operators can minimize costs while increasing production yields. In addition, Tachyus' models can also analyze equipment performance data, and allow operators to identify failures before they occur, thereby minimizing equipment downtime in the field. The company has just raised \$5 million in equity financing in October 2016, and it's worth pointing out the two new investors joining Tachyus' round – Schlumberger and former CFO of Shell Oil Co., Jeri Eagan – suggesting real industry confidence in Tachyus delivering substantive cost savings in the oilfield.

Midstream & Downstream – Transport, Pipeline & Refining

IoT also plays a significant role in midstream operations, particularly in real-time pipeline monitoring for issues such as leak prevention and precision-measurement of fluids flowing through the pipe. These applications become more valuable in remote regions or areas with harsh weather conditions that would be difficult for human inspection. [Hifi Engineering](#), a Calgary-based developer of fiber optic sensor technology to detect acoustic, temperature, and strain in oil and gas pipelines, is able to provide real-time sensing, condition monitoring, and event reporting because the physical sensors are connected to General Electric's Predix cloud-based platform, which then provides real-time status updates back to operators. Steve Koles, CEO of Hifi Engineering, pointed out that current pipeline monitoring technologies, such as a conventional flow meters and mass balance sensors, cannot pinpoint the leak's specific location. These sensors are placed within specific segments of the pipeline, and therefore, can only give an appropriate location of the leak. With Hifi Engineering's continuous and fully distributed fiber optics sensor, it measures every inch of the pipeline and can isolate the leak's specific location instantaneously.

Downstream oil & gas can also benefit greatly from IoT-enabled technology, with one prime example being to ensure continuous operation and reduced downtime at refineries. [Rebellion Photonics](#), a Texas-based developer of optical sensor technology, sells its proprietary Gas Cloud Imaging (GCI) camera plus an annual service agreement to refinery, tank farm, and pipeline operators for continuous gas leak monitoring. The company's core innovation rests in its ability to analyze the density and composition of a gas cloud from distance to give a precise reading on what's leaking and how much. Oil majors care a great deal about knowing ahead of time whether a leak is minor or major so that employees can prioritize necessary repairs, but also because repairs may not be required of them at all. Most current regulations set a threshold of 500 parts-per-million of a gas present in the vicinity of the leak before fixing the leak is required. Even the \$40K-\$200K purchase price on the Rebellion Photonics' cameras, plus the \$12K-\$36K annual monitoring service fee, is far less than current safety inspection and maintenance costs.

These are only a few of the newly-connected operational technology examples across the O&G value chain. It's clear that IoT brings significant value to the sector, especially in the current market, and will likely become a more important source of cost efficiencies for O&G companies to improve profit margins amid lower crude prices.

TECH GIANTS ARE STAKING OUT THE SMART HOME. WHERE DOES THAT LEAVE ENERGY?

BY KEN-ICHI HINO, DIRECTOR, CTG

INNOVATORS + INCUMBENTS

CTG has been active in bringing corporations and start-ups together. This theme will highlight select strategic partnerships, as well as the interplay between incumbents' offerings and those of disruptive start-ups to illustrate how this important dynamic is playing out in a more open innovation world.

Key Takeaways

- Amazon and Google have entered the smart home market with voice-enabled smart speakers
- Utilities and innovators both see the smart home as a potential enabler of next-generation electric grid
- While the smart speakers' direct impact on energy is unclear, their early success suggests they will have a positive impact on broader adoption of smart home technology

The path to the smart home is through...the voice

The smart home market has attracted both large companies across a range of industries and new innovators with varied value propositions. Non-energy companies that offer residential services have viewed the smart home as a key expansion opportunity, with companies such as Comcast, Verizon, Cox, and ADT all selling smart home products. A number of electric utilities have also been active in the smart home, with utility incentives for smart home devices, most commonly thermostats. Innovators have been at work as well, with smart home cleantech (energy analytics, efficient devices, smart plugs, smart thermostats, and lighting) attracting over \$500MM in capital over the last 5 years.

However, a key hurdle for smart home companies has been in establishing a platform to integrate different products into a single user experience. Works with Nest, Works with SmartThings, and Wink are examples of solutions developed to address this issue of interoperability, but no single platform has garnered enough market share to become the dominant solution. Tech giants Amazon and Google have recently rolled out products that may over time resolve this challenge, enabled by improvements in an unexpected area: far-field voice recognition.

Amazon's Echo smart speaker is a voice-enabled AI assistant (Alexa) with current capabilities including search, music, weather and traffic, lighting control, and (of course) shopping. Echo's early success has caught the attention of other major companies, with Google being the first to respond with its Google Home smart speaker. Microsoft is rumored to be working on a smart speaker as well. Apple, meanwhile, has created the Home app and HomeKit framework for its existing set of devices, such as the Apple TV and iPad, using Siri for voice-enabled controls.

Amazon and Google are racing to build out ecosystems of voice-enabled capabilities around their smart speakers. Amazon is courting third-party developers to build new capabilities for Alexa, and has also launched its \$100MM Alexa Fund. The fund has invested in 20 companies with value propositions ranging from improving voice recognition to home network security to the connected car. Smart thermostat maker [ecobee](#) was the most recent benefactor, raising \$35 million from the Alexa Fund, Thomvest Ventures, and Relay Ventures. While Google Home is more limited in features, having only launched last month, it has a deep set of applicable experiences from Android development. The fact that these smart speakers are a new, easier way for homeowners to access services for which they would otherwise use phones, combined with the tech companies' balance sheets, may enable Amazon and Google to create the dominant platforms and consolidated interfaces that smart home products have long needed.

While the tech giants' activity in developing smart home platforms is certainly a positive sign for the sector, what is less clear is the impact this will have on the smart home's potential to optimize energy use. Product pages for Echo and Home mention integration with devices like Nest, ecobee, Wink, and Philips Hue. While these products implicitly offer energy savings, convenience is the explicit benefit highlighted. This is likely due in part to the challenge in communicating the energy benefits of the smart home, as the path to optimizing residential energy usage is complex and will involve many more participants than just Amazon or Google.

Residential energy management

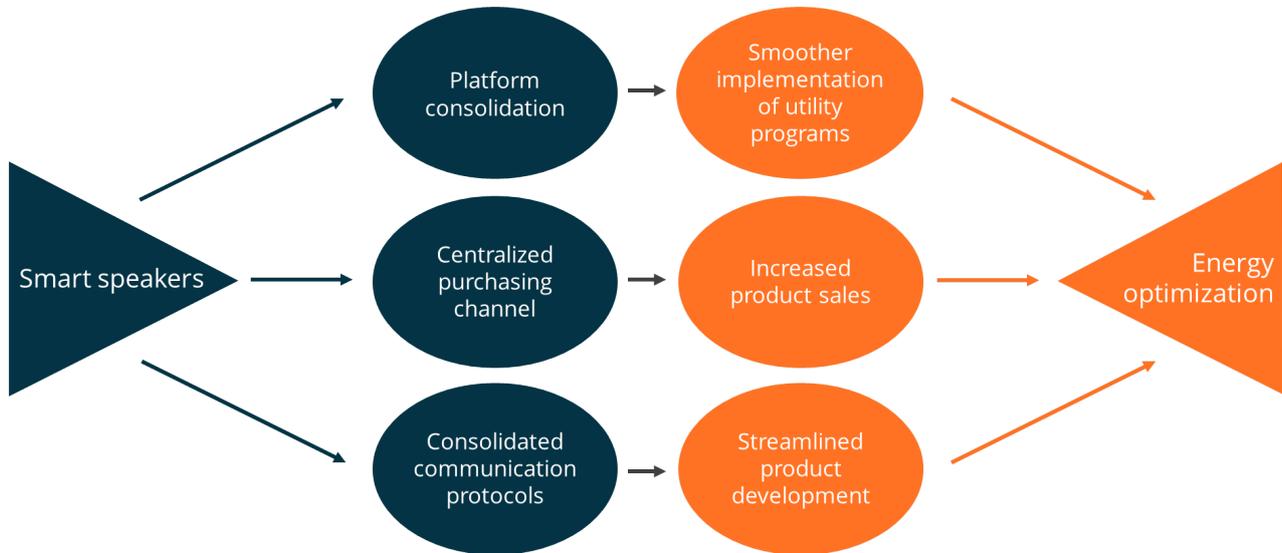
To date, Nest, Honeywell, and ecobee have made inroads in improving residential energy use by providing demand response (DR) functionality through smart thermostats. However, the value of DR and utility approaches to smart thermostats vary dramatically across utilities – some utilities do not have residential DR programs, while in other territories, DR programs not only exist but homeowners also enjoy rebates for purchasing smart thermostats. The economic value of smart thermostats therefore varies significantly across utilities, making energy savings a challenging purchase rationale to effectively communicate across broad customer bases for platform players like Amazon or Google.

Forward-looking states such as California, New York, Massachusetts, and Rhode Island are currently evaluating ways to send market signals for residential energy management, including DR policy, through grid modernization initiatives. Terry Sobolewski, Chief Customer Officer of National Grid, suggests that such initiatives make clear that regulators, utilities, and third-party providers “recognize there is significant societal value that can be created by improving residential energy usage.” However, as technology continues its rapid evolution, changing the ways in which consumers interact with their energy, no single participant in the value chain can settle on the best way to create and capture that value. We are currently in an evolutionary phase in which, as Sobolewski states, “the question of customer value creation mechanisms has different answers today than it will in the near future.” Even though uncertainty exists, National Grid is piloting residential energy improvement projects, such as its [Clifton Park, NY energy program](#) and [Connected Solutions](#) demand response program in Massachusetts and Rhode Island. Such pilots may help shape residential energy regulatory policy, at which point clearer value propositions of smart home energy optimization may spur more direct involvement with residential energy from Google and Amazon.

Technological innovation is running parallel to regulatory innovation, yielding new ways to improve home energy management beyond current demand response capabilities. One example is Tendril's [Orchestrated Energy](#) (OE) offering, which optimizes cooling by shifting as much as 12 hours of energy usage to earlier in the day without impacting personal comfort. While smart cooling can reduce peak HVAC load by up to 50 percent, and energy consumption by 20 percent, Dr. Marissa Hummon, Senior Energy Scientist at Tendril, does not believe we will see smart homes with every appliance connected to the grid. She states that, “Cooling and electric water heating are the biggest energy opportunities in the home because consumers use them to create predictable outcomes – keeping the temperature in the home comfortable or heating hot water in a storage tank. Down the road, we may see electric vehicle

charging or behind-the-meter storage supplant cooling and electric water heating in terms of valuable load to be managed.” However, because most other loads are smaller and/or have unpredictable usage, energy management of these devices does not offer significant value.

Smart Speakers’ Indirect Benefits to Energy



How do Google Home and Amazon Echo benefit energy?

Dr. Hummon points out that, though the Alexa Fund’s investment in ecobee is exciting, “it is unclear if Amazon will actively participate in developing energy solutions.” In the first place, voice interaction may not be a meaningful breakthrough for energy management. In fact, homeowner interaction is typically something that energy management providers seek to avoid. Dr Hummon certainly noted this distinction in Tendril’s Orchestrated Energy running “in the background so that people can optimize energy usage without paying attention to it.”

Tarun Kapoor, an Expert Product Manager for Emerging Technologies (EE) with PG&E, echoes the importance of energy staying in the background “so that homeowners can focus on experience and lifestyle rather than worrying about individual device management.” He goes on to suggest, however, that by bringing energy products seamlessly into a platform the homeowner uses anyway, platform hubs such as the Echo or Home could enable resolution of precisely this challenge. Kapoor notes the potentially integral role the hubs could one day play as, “a single point for data collection and device control, making it easier for utilities to engage homeowners and create measurable value.”

Ultimately, the chief impact tech giants’ platforms have on energy efficiency may come from the integration and sales channel benefits they’re likely to provide. The Echo product page offers the Belkin WeMo Switch, Philips Hue, and Insteon Connected Home kits as accessories, and the Echo Dot is offered as a package with ecobee3. The proliferation of smart home energy devices may, in turn, smooth the path for regulators and utilities to move to policies that reward optimization of home energy consumption. The combination of product demand and evolving regulatory structures are key reasons to believe we are on our way to not only the smart, but also the energy-optimized, home.

AN INVESTMENT COMPANY GIVING WESTERN COMPANIES MARKET ACCESS ACROSS ASIA

BY STEPHEN MARCUS, DIRECTOR, CTG

FRESH FACES

Recognizing the importance of new arrivals into our innovation ecosystem, we will highlight to you new players – a range of individuals, investors, multi-national corporations, and new innovation programs to watch out for.



TRIREC

This edition highlights a new investment holding company, TRIREC, based in Singapore looking to invest in cleantech companies across the globe. We spoke with one of the Operating Partners, Christopher Yu, to find out more.

EXECUTIVE TEAM & INVESTMENT COMMITTEE



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Partner
Investment Committee



LAWRENCE WU
Co-founder/Director
Investment Committee



MELVYN YEO
Co-founder/Director
Investment Committee



CHRISTOPHER YU
Partner;
Investment Committee

CTG: *Tell us more about TRIREC and your investment activities.*

CY: TRIREC is a Singapore-headquartered investment holding company focused on investing in the cleantech and renewable energy sector. It was set up in June 2015 after the founders noticed severe capital raising restrictions and challenges faced by a number of high potential cleantech and renewable firms that the founders are involved or familiar with.

TRIREC is set up as an investment holding company. We have a dedicated capital allocation from our shareholders. We don't have a finite fund life and aren't restricted by concentration limitations

or investment types that a typical investment fund is restricted by. We have flexibility to invest in anything from early-stage to late-stage investments including infrastructure projects, which help us more effectively address the capital dislocation needs we see in the market.

CTG: *What is the background of the TRIREC partners and shareholders?*

CY: TRIREC was set up by two co-founders, Melvyn Yeo and Lawrence Wu, who have crossed paths with one another in various previous roles. I personally know Melvyn from our days at Goldman Sachs and got involved with TRIREC as I work

closely and represent one of the Hong Kong-based single family offices who are major shareholders of TRIREC. The fourth operating partner is Hock Chuan Tam who previously headed up the cleantech and ICT investment teams of EDBI, which is a quasi-government organization.

We have a Board that has representation from the TRIREC management team as well as the three anchor investors who are Singapore- and Hong Kong-based single family offices. The Investment Committee is separate from the Board and is represented by the two co-founders and the two operating partners. In addition, we also have a number of other high net worth individuals and other single family offices as shareholders.

CTG: *What size of investments are you looking to make?*

CY: We broadly see the investments we want to make fitting into three categories: early-stage ventures, growth equity and late-stage equity or credit investments.

For early-stage ventures, we have appetite to deploy between \$500K and \$5 million, with the ability to follow on over time. In this bucket, we are looking for businesses that we believe are able to reach near-term milestones and bring themselves to significant commercial inflection points.

For growth stage investments we are comfortable to invest anywhere between \$5 million to \$30 million. For these businesses we are looking for business models that are de-risked and need further capital for scale.

For larger and late-stage equity or credit opportunities, we have appetite to invest north of \$30 million per opportunity and look for businesses that can offer yield-like cash flow returns.

As an investment holding company, we are very fortunate to have the support of several multi-billion dollar single family offices and are hence able to size up our investments accordingly if we see very compelling risk adjusted investment opportunities.

CTG: *What sectors are you looking to invest in?*

CY: We have five core strategies that we are

investing in: renewable energy generation, energy storage, energy management, energy efficiency and recycling and reverse logistics.

Within these five core areas we have found ourselves focusing more time on three in particular: energy generation, energy storage and energy management. This has come about because we see a lot of structural tailwind driving these sectors forward, and we feel strongly that there are a number of interesting companies growing in this space – but a dearth of capital funding to help these companies to grow to the next stage.

However, our flexibility has meant that we have reviewed a broad set of businesses in the cleantech sector, with the likes of marketplace funding for solar projects, electric vehicles, renewable energy insurance underwriting and sustainable agriculture.

Within our investment activities, we are always looking for companies that have a visible path to de-risking their business model, can viably reach near-term quantifiable milestones, and have a strong management team with a good execution track record.

CTG: *Tell us about the type of access you can give to Western cleantech companies into the Singapore or broader Asian markets?*

CY: We are now in the midst of appointing a Venture Partner in the US to help us build stronger relationships with the cleantech ecosystem there. In the near term, we would want to probably do the same thing in other parts of the world. Our investing sweet spot is currently North America and Asia. When we invest in Asian companies, we think our value-add is to help them scale. For Western companies, we want to gain exposure to the team and the technology. One of our significant value propositions to Western companies is our ability to plug them into our Asian ecosystem and help them scale across Asia.

As an example, lately we have been working with several US-based battery storage companies and have been deploying the batteries via our Singapore-based portfolio company, [Sunseap](#), which is a leader in the solar industry and has installed power generation across Singapore and all major countries in South East Asia. Through

this partnership, the US battery companies have immediate access to renewable energy assets across Southeast Asia stretching from Singapore to Thailand.

And secondly, all our shareholders, in particular the three anchor single family offices who sit on the TRIREC Board, run family conglomerates with operating assets across all major Asian countries in all major industries. We constantly leverage their access and knowledge base to help our cleantech portfolio companies grow.



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GENE EDITING: THE EVER-HOTTER CRISPR

BY JULES BESNAINOU, DIRECTOR, CTG

AT THE CUTTING EDGE

Our At the Cutting Edge series keeps an eye out, cuts through the hype, and gives early warnings on trends we believe will be important enablers of future innovation waves. Expect articles and interviews on topics like 5G, gene editing, virtual reality, artificial intelligence and more.

A few months ago, during the inaugural *Cutting Edge* session at Cleantech Forum Europe, geneticist Anna Gilles explained the basics of CRISPR to an audience of energy investors and corporates. This method, re-discovered five years ago and dubbed “the copy-paste of gene editing,” has revolutionized the field and allowed scientists around the world to edit organisms in an easier and cheaper way than was previously possible. The rapid rise of CRISPR-related medical research has been inspiring – as we wrote this article, the first trial on humans was taking place in China. Since the Europe Forum in April, we have also detected signals of CRISPR being applied to agriculture, industrial biotechnology and biomaterials. This article provides an update on the latest developments in the field.

Capital news

On the funding front, two big announcements have hit the wires since our Forum in April. First, [Caribou Biosciences](#) raised a \$30 million series B round mid-May, with a few new investors joining Novartis and Mission Bay Capital, such as our friends at Anterra Capital. Interestingly, Rachel Haurwitz, the company’s CEO, explicitly called out development of applications in agriculture and industrial biotechnology as potential use of funds.

In late 2015, Caribou announced a strategic alliance with DuPont to develop products in those two areas. The company has also made the [2016 Global Cleantech 100 Ones to Watch](#) list, a sign that top corporate and venture capital players in our ecosystem are keeping an eye on the field.



The second announcement comes from [CRISPR Therapeutics](#), a competitor with a focus on gene-based medicines for serious diseases. The company went public in early October in an IPO that valued the company around \$500 million. Note that the listing was less successful than anticipated, raising some \$56m instead of the planned \$66m. The related filings revealed that Bayer AG owned a pre-IPO stake of 8% in the company, from its lead in the series B round in 2015.

A hand in the Bayer/Monsanto merger?

Bayer's involvement with CRISPR Therapeutics runs deeper than its venture equity investment. Earlier this year, the two companies launched a joint venture, Casebia Therapeutics, to discover and commercialize gene-based medicines for blood disorders, blindness and heart disease. Bayer committed more than \$300 million in R&D funding to the venture.

Meanwhile, major agriculture player Monsanto is notably late in the CRISPR game. It announced a licensing deal to use the technology in late September, long after DuPont and Bayer made their respective moves. While Bayer's CRISPR focus is on the therapeutics side, many commentators have noted that the merger could jump-start Monsanto's forays into CRISPR GMOs.

Unregulated mushrooms

In early April, the US Department of Agriculture decided that a genetically engineered mushroom developed by Dr. Yinong Yang of Penn State University was not a regulated product. Deleting some genes with CRISPR, Yang was able to extend the shelf life of mushrooms by reducing the production of browning enzymes. In its decision, the USDA explained that the modified mushrooms did not contain foreign DNA such as viruses and bacteria – which would have been necessary with older gene engineering technologies – and as such did not fall under its regulatory purview.

While the mushrooms – and future genetically-engineered agricultural products – may still be regulated by the FDA, this was a landmark decision for CRISPR, and one that will encourage researchers to experiment with it.

IP wars

As funding and research keeps up, a battle rages over who should reap licensing fees and royalties from the technology. Three researchers, and co-founders in four of the top start-ups in the field (Intellia Therapeutics, CRISPR Therapeutics, Caribou Biosciences, and Editas Medicine), are claiming paternity of the method. In September, a Korean biotech company, ToolGen, joined the fray and was awarded a Korean patent. With such large sums in the air, it's unlikely that any of the contestants will fold.

The uncertainty over the paternity of the discovery is weighing on the pace of its development. Indeed, entering a licensing deal with one of the researchers is risky, and while large conglomerates like Monsanto could afford a loss, smaller players and investors are bound to be more cautious.

We'd be glad to hear from you as you consider this space. Feel free to email editorial@cleantech.com with any comments or questions.

FOLLOW THE LEADERS

BY CHRIS SWORDER, ANALYST, CTG

GLOBAL CLEANTECH 100

Updates and news on our Global Cleantech 100, an annual list of 100 companies from across the breadth of the cleantech theme, identified by the market as the most likely to make significant impact within a 5-10 year timeframe.

Introduction

In our November edition of *Follow the Leaders*, we have not seen a similar volume of deals as in our previous two editions, with only 15 financing rounds – just 10 of which are growth equity rounds – and 1 M&A item to discuss. However, despite lower numbers, one thing is clear. Growth equity is being directed to those on our list that are facilitating and enabling the growth of distributed energy resources.

Distributed Energy Resources & Grid 4.0

[Sonnen](#), [Gridco Systems](#), [Space-Time Insight](#), [EnergySavvy](#), and [M-Kopa Solar](#) were recipients of 5 out of the 10 growth equity rounds in this period. These companies are grouped due to the various solutions they offer to solve the problem of an unstable, inefficient, inflexible, and sometimes inaccessible, grid. Gridco Systems is working on hardware solutions that will power the Agile Grid, improving grid resilience by increasing peak capacity, energy efficiency, and system reliability. Space-Time Insight and EnergySavvy are both working on software solutions. EnergySavvy is aiming to improve customer intelligence and engagement for utilities, while Space-Time Insight is developing software that accelerates real-time decision making across the vast range of data created by the IoT. Sonnen is offering an energy storage solution that also gives you access to a community of power storage and generation units, and M-Kopa Solar's 'Pay-as-you-go' solar installations is delivering energy access to increasing numbers. Taken together, the various roles these companies are offering something of a road-map to Grid 4.0.

Key Investment

Due to the news that surrounded the growth equity round announcement, Sonnen is worthy of the spotlight in this edition. The company raised \$85 million in a growth equity round, with investment coming from Envision Ventures, the venture capital arm of Envision Energy, and Thomas Putter, the former CEO and ex-Chairman of Allianz Capital Partners.

The investment round is just one of three pieces of good news announced recently. First, this investment was complimented by speculation that Sonnen will conduct an IPO in the next 1-2 years. Second, Sonnen announced a partnership with [Autogrid Systems](#) (a fellow Global Cleantech 100 company also backed by Envision Ventures) in order to develop software that will help energy project developers, utilities, and other service providers, optimize and aggregate their sonnenBatterie product. Combined with the rapid development of SonnenCommunity (their virtual power plant system) since they received their utilities license in Germany, and it is easy to see why this IPO has become eagerly anticipated in the industry.

M&A Key Deal

While we saw less M&A activity for this issue of CTG Insights, there was one key M&A event. [Airware](#) acquired [Redbird](#), a provider of drone-based data collection and data analysis services. Airware has been running a Commercial Drone Fund for some years in order to invest in innovative drone companies, and even participated in a funding round for Redbird in 2015. However, the acquisition of Redbird was a first for Airware. The combined technology platforms will offer a comprehensive Unmanned Aerial Vehicle solution from hardware to software to analysis.

KEY STATS (September 22 to November 16, 2016)

- **10 deals** for a total of **\$196.4M** venture capital invested
- **67 deals** for a total of **\$7.5 billion** of venture capital investment in GCT100 alumni in 2016YTD
- **44 deals** for a total of **\$6.9 billion** invested in 2015 GCT100 companies in 2016YTD

The following deal table shows all venture equity and non-dilutive funding events for GCT100 alumni companies in the third quarter to November 16, 2016. *Our 8th Global Cleantech 100 will be released on January 23rd at the 2017 Cleantech Forum San Francisco.*

Recipient Company	GCT100 Year	Sector	Investment Type	Amount	Investors
 sonnen	2014, 2015	Energy Storage	Growth Equity	\$85M	Envision Ventures, Thomas Putter
	2013 → 2015	Energy Efficiency	Growth Equity	\$40M	UBS, GGV Capital, Huaneng Invesco WLR, Tsing Capital, Lookout Capital, Eastwood Capital, Venrock, Oak Investment Partners, Wellcome Trust, REX Health Investors
	2015	Agriculture & Food	Growth Equity	\$23M	TPG Alternative and Renewable Technologies, AIS-JV, Osceola Capital, Pontifax AgTech, Florida Opportunity Fund, Evans Property
	2010	Biofuels & Biochemicals	PIPE	\$20M	-
			Project Finance	\$10M	-
	2015	Energy Efficiency	Growth Equity	\$14M	GXP Investments, Inherent Group, Prelude Ventures, EnerTech Capital

Deal table continued...

Recipient Company	GCT100 Year	Sector	Investment Type	Amount	Investors
 SPACE-TIME INSIGHT	2013 → 2015	Smart Grid	Growth Equity	\$12.6M	ClearSky Power & Technology Fund, EnerTech Capital, Opus Capital Ventures, Novus Energy Partners, NEC Corporation, EON Ventures
 GRIDCO SYSTEMS™	2013 → 2015	Smart Grid	Growth Equity	\$12M	General Catalyst Partners, Lux Capital, North Bridge Venture Partners, Maschinenfabrik Reinhausen (MR)
 d.light	2010, 2015	Solar	Structured Debt	\$7.5M	Developing World Markets
 M-KOPA SOLAR	2014, 2015	Solar	Growth Equity	\$6.35M	-
 NANO STEEL STEEL. REDEFINED.™	2014, 2015	Advanced Materials	Growth Equity	\$2.5M	-
 Orbital Systems	2015	Water & Wastewater	Grant	\$2.28M	Swedish Energy Agency
 Geostellar	2012	Solar	Growth Equity	\$1M	-
 BEYOND MEAT	2013	Agriculture & Food	Growth Equity	-	Tyson Foods



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