THE ROAD TO SUSTAINABILITY

Tsing Capital Whitepaper

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青雲創投
TSING CAPITAL

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Authors

Qi Lu

Strategy & Research Partner

T: +86 (0)10 59756601-35887
E: qi@tsingcapital.com

Jing Wan

Research Manager
Tsing Capital

T: +86 (0)10 59756601-35872
E: jing@tsingcapital.com

Jing Ge

Senior Research Associate
Lawrence Berkeley National Laboratory

T: +01 (510) 486 4000
E: jjge@lbl.gov

Djavan De Clercq

PhD Candidate
Department of Environmental Engineering, Tsinghua University

M: +86 18201579910
E: zhoujw15@mails.tsinghua.edu.cn

WHO WE ARE

Established in 2000, Tsing Capital is the first venture capital firm in China and one of the earliest in the world which focuses on sustainable technology investment. Through its China Environment Fund series, Tsing Capital works intimately with its global portfolio companies with advanced environmental, energy/resource, new material, or intelligent technologies, to explore their applications in the following areas in China:

- Sustainable Industries
- Sustainable Transportation
- Clean Energy Supply
- Environment & Ecosystem
- Green Buildings & Appliances
- Future Cities
- Sustainable Food & Agriculture
- Health & Wellness

Tsing Capital's dedication to Cleantech investment and its achievements have been recognized via numerous awards, including 2016 "Top 100 VC Firms in China"and "Top 10 VC/PEs in New Material and New Energy Industry" by Zero2IPO, 2016 "China's Top 30 Venture Capitals by China FOF Alliance, 2016 "China's Top 10 Green-tech Investors in New Energy and Clean-tech Industry"and 2015 "China's Top 50 Venture Capital Firms" both by China Venture, 2013-2014 "Top50 GPs with the Most LP Investment Value, No. 20" by China Limited Partnership Association, 2013 "China's Top Venture Capital Firms" by Forbes, 2003-2012 "Top 50 VC/PEs in China" by Zero2IPO, 2009-2012 "China VC/PE Green Investment Leadership Award" by the China Environment Investment Network, and 2008 "Cleantech Leadership Award" and 2005 "Pioneer Award", both by the Cleantech Group. Tsing Capital's founder, Don Ye, is widely regarded as the "Evangelist of Chinese Cleantech Investment". He was selected as one of 2016 "China's Best Investors in New-energy and Clean-Tech Industry TOP10" by China Venture, 40 "China's Most Powerful People 2009" by Businessweek, and "Top 50 Venture Capitalist in China" by Forbes in six consecutive years from 2009 to 2014.

Tsing Capital champions the "Triple Bottom Line" investment practice and its own "Doing Well by Doing Good ©" investment philosophy in China, which has won itself "Social Investor of the Year in Asia" in 2012 by PE Asia and the 2009 "China's Outstanding Corporate Citizen" by the China Committee of Corporate Citizenship and Ministry of Civil Affairs, the first of its kind awarded to the VC/PE community. In 2010, Tsing Capital was selected as one of the 10 "Companies That Will Shape the World in 2020" in Aron Cramer's book Sustainable Excellence. With a distinguished track record, international recognition and operating within a giant market, Tsing Capital has become a frontrunner in global cleantech investment and selected as the best case practice in Doing Well and Doing Good by the World Bank and a case study in sustainable investment by Harvard Business School.

Don YE

Founder and Managing Partner
of Tsing Capital

The world is making great strides towards combating climate change, but tremendous challenges still remain. Such challenges are not only technological in nature; factors related to global politics and relentless consumption are also obstacles to building a less polluting and more energy efficient society.

While solutions born within the traditional Cleantech industries – renewable energy, waste management, water treatment, and so on – are effective, new technologies and innovations from outside of these industries will help to accelerate the march towards sustainability. Examples of such technologies and business models include the Internet of Things, artificial intelligence, the sharing economy, and many more. The application of such tools across a wide range of sectors can drive economies to become less environmentally damaging, more productive and more efficient.

In this paper, we identify why the application of such tools can drive sustainability, and how Tsing Capital intends to respond to these trends from an investment perspective. We hope that the analysis will present to our partners about the vast opportunities in the sustainability field, inspire new ideas for discussion, and help us to build a more sustainable future.

Executive Summary

Today, we are witnessing the next wave in the Cleantech evolution—Sustaintech. Intelligent technologies and innovative business models have disrupted the traditional Cleantech landscape and opened up tremendous new opportunities in the sustainability industry. And China is leading the way in sustainable development and investment.

The road to sustainability calls for disruptive innovation—and these innovative technologies don't necessarily originate in the Cleantech sector. But rather, technologies like IoT and AI are now driving the sector, and investors are following. Emerging companies enabled by these disruptive technologies are unlocking enormous sustainability potential and creating a better future for humanity.

The Sustaintech White Paper details the current state of the Sustaintech market and the disruptive innovations driving its growth, why application of such technologies can drive sustainability and the vast opportunities that exist in the sustainability field. The following section highlights the report's key points:

Globalization and Urbanization Transforming World Economies—but Creating Environmental Challenges

- Rapid globalization, expansion of the middle class and the digital revolution have increased living standards and brought prosperity but are causing environmental challenges. Global emissions of carbon dioxide increased by 50% between 1990 and 2013. The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century. The case for climate action has never been stronger.
- International governments and businesses are addressing these environmental issues, such as the signing of the Paris Agreement, establishing Mission Innovation to boost investment in R&D, and launching The Breakthrough Energy Coalition to bridge the technology commercialization gap.
- China is taking a leading role in addressing climate change challenges. China R&D expenditure in clean energy totaled $3.8 billion in 2015. China aims to double governmental and/or state-directed investment in clean energy R&D over five years.

The Changing Sustainable Development Landscape—China Leading the Way

- In response to rapid urbanization, industrial overcapacity and environmental deterioration, China's economy is shifting into a more sustainable model. According to Bloomberg New Energy Finance, by 2015, total investment in clean energy in China reached a record of $101.2 billion.
- Favorable policies such as "Made in China 2025" along with public demand and awareness, have opened up several trillion-dollar sustainability markets in China. China has overtaken the EU in terms of clean energy investment. According to China's 13th Five-Year-Plan, from 2015 to 2020, new investment in renewable energy will reach RMB 2.3 trillion (roughly $334 billion). And, China will invest $368 billion in ultra-high voltage grids, smart grids and distribution grids in the next five years, necessary infrastructure for power generation from solar/wind energy. By 2020, China will have five million electric vehicle on the road, a tenfold increase compared to 2015.
- Innovation is the new engine in China. From startups to incubators, and to the technology giants, innovation

in China is flourishing, especially in the most developed cities such as Shenzhen, Beijing and Shanghai. China's innovation drive has had tangible results on both a domestic and global scale, and China is already a global leader in certain technology areas with internationally recognizable brands. "Traditionally, Chinese companies were fast followers, but we are starting to see true innovation."

Road to Sustainability Calls for Disruptive Innovation—Innovation that is Creating a New Market and Value Network

The road to sustainability requires the application of exciting new tools from outside the traditional Cleantech sectors.

Two technology mega-trends—Internet of Things and Artificial Intelligence—are re-shaping sustainability around the world

- IoT can enhance sustainability by connecting networks of "things" across a wide range of applications in order to make data-driven decisions, which can enhance the efficiency and resource productivity in a variety of processes. According to Gartner, 20.8 billion "connected things" will be in use worldwide by 2020.
- AI refers to a broad range of applications, including computers capable of understanding human languages, virtual personal assistants, and robots which can "see", "hear", and react to other sensory stimuli. Adoption and use of AI over the next decade ranges from $1.49 trillion to $2.95 trillion. There's been a dramatic increase in investments, with equity funding for AI startups reaching $2.34 billion in 2015, up from $282 million in 2011, a 747% increase in just five years.

Disruptive technology sectors are playing a key role in sustainable development such as sensors, machine learning, AR/VR, Blockchain, 3D printing, and advanced materials.

- *Disruptive technology I: Sensors are connecting the world's "things," allowing monitoring and data collection*

  IoT sensor technology is poised to play a key role in enhancing sustainability with regards to energy efficiency, water resources and transportation, to name a few. IoT sensor technologies have attracted major investment since 2006 –$4.3 billion over 780 transactions. Investments grew from $180 million in 2006 to $625 million in 2015, an increase of more than 13%.

- *Disruptive technology II: Machine Learning makes better use of big data*

  The machine learning market is growing rapidly at 38%. There are numerous examples of endeavors that are combining machine learning with sustainability. One example is Stanford University's sustainability and artificial intelligence lab which is working on (1) combining satellite imagery and machine learning to predict poverty and (2) modelling crop yields using computational methods to increase productivity and enhance food security.

- *Disruptive technology III: AR/VR helps make intelligent decisions.*

  Virtual Reality and Augmented Reality (AR/VR) technology has shown signs of potential to enhance global sustainability, both directly and indirectly. Although gamers are the earliest adopters of VR, some research firms believe that the technology has the potential to transform business processes in a wide range of industries. There is potential for annual unit shipments of 10 million in three to five years and 50 million in five to 10 years.

- *Disruptive technology IV: Blockchain can create a distributed and connected energy future*

  Blockchain can enable tokenization of energy – this means that in a local energy trading market, the actual monetary value of energy traded may not be as valuable as the fact that the energy was generated from a renewable source in a certain neighborhood. Any revenue transferred will return to the local economy. The blockchain technology market is estimated to grow 61.5% from $210.2 million in 2016 to $2.3 billion by 2021.

- *Disruptive technology V – 3D printing can reduce resource-intensity in manufacturing*

  3D Printing help improve resource efficiency in manufacturing by eliminating unnecessary production steps

and significantly reducing unnecessary material use. It also provides strong environmental benefits by using green materials. According to Lux Research, the total market for 3D Printing could range between $7 billion to $22.8 billion by 2025, with the most likely market size being $12 billion.

- *Disruptive technology VI: Advanced materials can replace depleting non-renewable resources*

  Advanced materials have strong linkages to sustainability, due to their features such as low environmental impact, recyclable, or enabling efficiency in power devices. In addition to large projected market size, advanced materials companies attracted $4.9 billion in investment over the 13 years prior to 2013, according to The Cleantech Group. Compared to other Cleantech sectors, advanced materials attracts a wider range of funding types, from corporate investment to government grants.

The Future of Sustainability Investment

Sustainability investment is booming

- According to Bloomberg New Energy Finance, global new investment in sustainability has reached a historical high at $329 billion in 2015. This total investment includes venture capital/private equity investment, government R&D grants, corporate R&D grants, and asset finance. The Asia Pacific region was an especially significant contributor to global sustainability investment. With strong government policy support, China, in particular, has experienced a rapid increase in sustainability investment over the years.

- Sustainability market has gone through three phases—Envirotech, Cleantech and Sustaintech. First stage (Envirotech) saw companies focus on sectors such as environmental protection, which is policy-driven, CAPEX-intensive and relies on rapid growth to achieve better economies of scale. Second stage is when innovation took over as a driver, producing high value and CAPEX- efficient companies (Cleantech). The third and current stage is demand driven, with disruptive innovation in both technology and business model (Sustaintech). Intelligent technology, internet connection and innovative business models have disrupted the traditional Cleantech landscape and opened up tremendous opportunities in the sustainability industry.

- Successful companies in this phase have innovative technologies as well as business models. They are leveraging intelligent technologies and have a high degree of internet-integration. A number of world-leading companies have demonstrated their success and uniqueness as Sustaintech companies, including TESLA, Solarcity, Nest and Opower.

Examples of early adopters of Sustaintech

- Disruptive technologies and business models are emerging in multiple fields, creating tremendous investment opportunities. Two examples are:

  A sustainable future of mobility will be shaped by shared, driverless electric vehicles. In particular, autonomous driving technology, creating many innovative startups, will enable shared mobility and reduce car purchase. According to Market Research Future, the global Autonomous Vehicles market is expected to grow over the CAGR of 26.2% during the period 2016 to 2027 from USD 3.6 billion in 2015.

  Smart homes are an area with application of multiple intelligent technology to achieve energy conservation, security and well-being. According to Lux Research, smart homes have attracted $550 million in venture investment from 2005-2014, and we have already seen the first wave of sizeable exits.

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Encouraging Global Sustainable Development

Rapid globalization and digital revolution are transforming the entire global economy. Expansion of the middle class is encouraging consumption, but increased economic prosperity, human development and people choosing to live close to the work have also caused environmental and urbanization challenges that society must address now. International governments are increasingly united in addressing these environmental issues, such as the signing of the Paris Agreement to combat climate change. China is taking a leading role in addressing climate change challenges in both public sector and private sector engagement. Meanwhile, carbon reduction presents a strong economic opportunity to bring increased profit and employment.

Rapid Economic Development Brings Environmental Challenges

The world is changing: Trade and digital revolution are transforming the entire global economy. Expansion of the middle class is encouraging consumption, but increased economic prosperity and human development has also caused environmental challenges that society must address. Moreover, as illustrated by recent political developments in Britain and the United States, society is exploring new forms of globalization going forward.

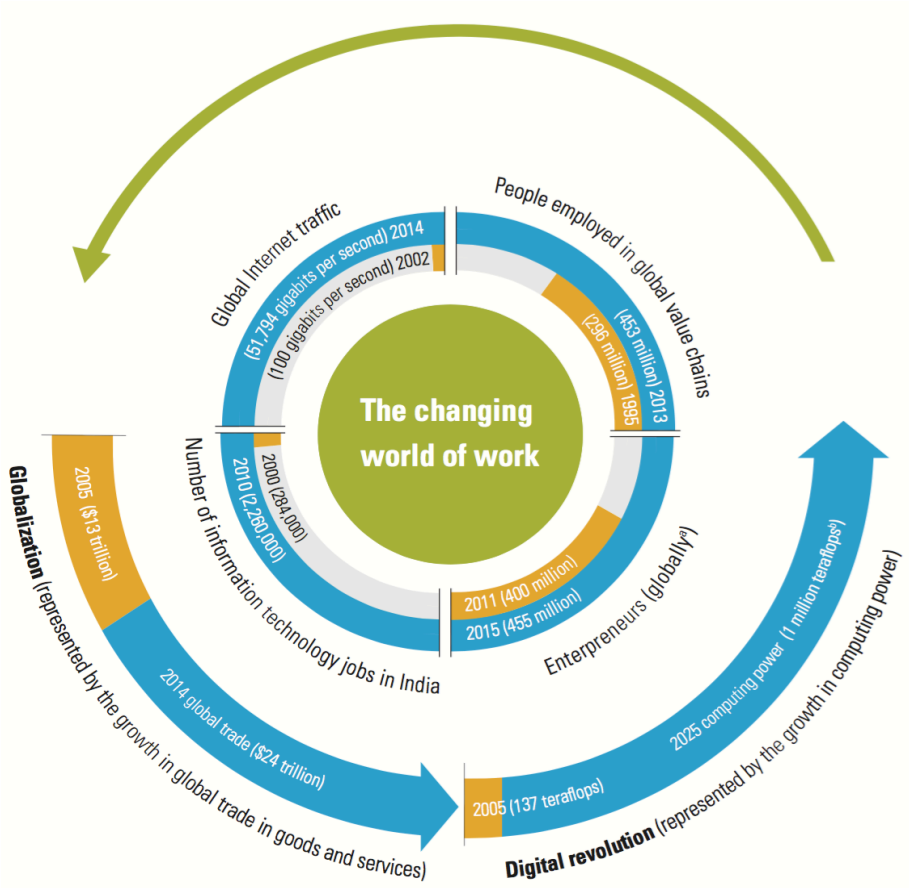
Globalization and Digital Revolution is Changing Our Lives

Globalization and technological revolution, in particular the digital revolution, has profoundly changed the professional/social landscape. In the past 10 years, global trade in goods and services has almost doubled, reaching nearly $24 trillion in 2014, up from $13 trillion in 2005. By the end of 2015, the world was predicted by UNDP to have more than 7 billion mobile subscribers and more than 3 billion internet users.

Technological advancement is the engine for creativity and innovation, thus transforming work. Innovation in computers and electronics have been central to growth. From 1990 to 2012, the share of computer/electronic patents as a share of all new patents more than doubled, from about 25 percent to 55 percent.

Some of the technologies with the highest potential to transform work include mobility, cloud technology, data informatics, 3D printing, advanced robotics , new materials, energy storage and the automation of knowledge work (for example, AI, IoT). Intelligent software systems will transform the organization and productivity of knowledge work and enable millions to use intelligent digital assistants [1].

Figure 1
Globalization and digital revolution



Source: UNDP, 2015

Sizable Expansion of Middle Class is Shifting Consumption Patterns

The world's population is projected to rise from 7.3 billion to 9.6 billion from 2015 to 2050. One dimension of population growth is the expansion of a sizable global middle class, which is defined to be a household with daily expenditure of $10-$100 per capita (in purchasing power parity terms). The global middle class is expected to be 4.9 billion – nearly 57 percent of the global population in 2030, with 3.2 billion in Asia and the Pacific, mostly in China and India.

Consumption by the middle class in the 10 countries with the largest middle-class populations (Brazil, China, France, Germany, India, Indonesia, Japan, Mexico, the Russian Federation and the United States) is forecasted to be $38 trillion in 2030. These shifts will have major implications for the consumption patterns and living standards of a large share of the global population. It will also affect environmental sustainability and other aspects of human development [1].

Climate Change and Other Environmental Consequences

Globalization and technological advancement have brought prosperity in living standards and greater prosperity to the middle class. However, increased consumption has also brought environmental consequences. Global emissions of carbon dioxide increased by 50 percent between 1990 and 2013. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the United States and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century [2]. The case for climate action has never been stronger. Current extreme weather, which is causing storms,

floods and drought, are becoming more frequent and intense. Climate change is threatening global water and food security, agricultural supply chains and numerous coastal cities.

The poor are particularly vulnerable to the impacts of climate change, thus it is urgent to take action. According to a recent report released by World Bank, “Shock Waves: Managing the Impact of Climate Change on Poverty”, without immediate action, climate change would result in an additional 100 million people moving into poverty by 2030 [3]. On a national level, poorer countries are disproportionately vulnerable to disasters and the effect of climate change due to a lack of resources and low capacity to respond. Developed countries experience a larger proportion of property damage (75 percent), but recovery costs are higher for developing countries. Developed countries pay 0.1 percent of GDP in losses, while developing countries pay 2-3 percent or even up to 15 percent, as seen with hurricanes in the Caribbean. Developing countries also experience a greater loss of life, with 90 percent of all deaths [4].

Other environmental consequences are also severe. For example, about 1.3 billion people in the world live on ecologically fragile land. Water scarcity affects more than 40 percent of people around the world [1].

Breakthrough in International Agreement on Climate Change

2015 was a year of breakthrough in international agreements on climate change. The Paris Agreement was signed with 195 countries, and 20 initial countries have joined Mission Innovation, which is committed to doubling annual R&D investments to combat climate change. 28 major global private capital providers, led by Bill Gates, have formed the breakthrough energy coalition, which aims to invest in early stage technologies that could address climate issues. China has also taken a leadership role in international efforts to combat climate change.

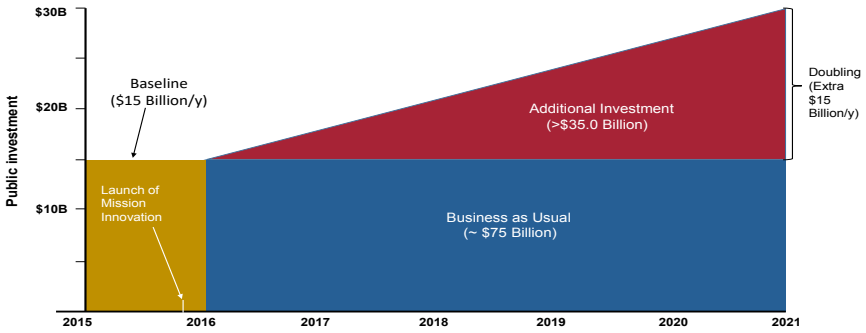
Paris Agreement: Countries are United

The Paris climate conference (COP 21) in December 2015 resulted in a historical moment: 195 countries adopted the first-ever universal, legally binding global climate deal. Under this agreement, the global action plan is to limit global warming to well below 2°C. The agreement will enter into force in 2020 [5].

Mission Innovation: Governments Double Clean Energy R&D Budgets

Mission Innovation was announced at COP 21. This initiative states that 20 initial countries representing 80 percent of global clean energy research and development (R&D) budgets are committing to double their respective R&D investments over five years. Mission Innovation represents immediate action that international society must take to combat climate change, as well as the opportunity to foster technological innovation.

Figure 2
Clean energy R&D investment chart for mission innovation



Note: MI baseline of US $15 billion per year in clean energy R&D is compiled from reports of 21 MI members
Source: Mission Innovation, 2016

China's Commitment to Mission Innovation

China R&D expenditure in clean energy totaled 25 billion RMB (roughly 3.8 billion US dollars) in 2015. This amount and the corresponding year were established as China's baseline regarding "Mission Innovation". China aims to double governmental and/or state-directed investment in clean energy research and development over five years. The areas will include:

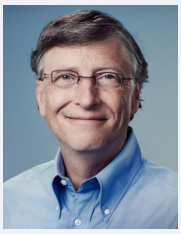
- Industry & buildings
- Vehicles & other transportation
- Bio-based fuels & energy
- Solar, wind & other renewables
- Nuclear energy
- Clean fossil energy
- CO_2 capture, utilization and storage
- Electricity grid
- Energy storage

Breakthrough Energy Coalition: Major Global Private Capital Investors are Committed

The Breakthrough Energy Coalition was an independent initiative launched simultaneously by Mission Innovation and Bill Gates. It includes a coalition of over 28 significant private capital investors from 10 countries to invest in the technological solutions that came out of Mission Innovation [6]. According to the Coalition, the existing system of basic research, clean energy investment and regulatory frameworks/subsidies fail to sufficiently produce transformative energy solutions to combat climate change. This is why they need leading investors to drive innovation and bridge the gap between the lab and the marketplace. The Breakthrough Energy Coalition will form a network of private capital committed to building a globally advanced energy future [7].

Breakthrough coalition partner quotes:

Bill Gates, Co-chair, Bill & Melinda Gates Foundation, United States



"We need to move to sources of energy that are affordable and reliable, and don't produce any carbon. The renewable technologies we have today, like wind and solar, have made a lot of progress and could be one path to a zero-carbon energy future. But given the scale of the challenge, we need to be exploring many different paths—and that means we also need to invent new approaches. Private companies will ultimately develop these energy breakthroughs, but their work will rely on the kind of basic research that only governments can fund. It is great to see so many government leaders and investors making these commitments and showing how the public and private sectors can come together to work on big problems. I am optimistic that we can invent the tools we need to generate clean, affordable, reliable energy that will help the poorest improve their lives and also stop climate change. I hope even more governments and investors will join us."

Jack Ma, Executive Director, Alibaba Group, China

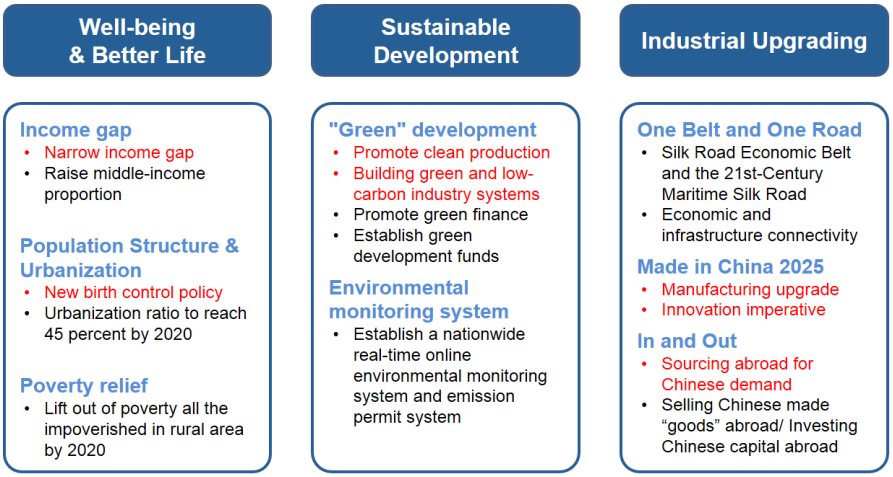
"We should not waste precious time placing blame for today's environmental challenges. What we need to do is solve the problem together. A solution and a way forward will only come about by combining the efforts of government, private sector, scientists, sociologists, and philanthropists. We must work together to create the tools necessary to combat climate change for this generation and those to come after." [7]

China is Leading in Addressing Climate Change Issues

China is taking on a leadership role in the international community to address climate change issues. During 2016's G20 conference, China and U.S. were the first countries ratifying the Paris Agreement. This was a significant step showing commitment from the world's two largest emitters.

Under the Paris Agreement, China has committed to peaking CO_2 emissions by 2030. It will increase non-fossil energy to 20 percent of its energy consumption by 2030, which will require installing 800 to 1,000 gigawatts of non-fossil capacity, equivalent to the entire current US generating capacity. China has shown leadership in putting a price on carbon by committing to build a national cap and trade system, which will launch in 2017 and become the world's largest. It has also pledged 20 billion RMB ($3.1 billion USD) to the South-South Climate Cooperation Fund to help developing countries adapt to climate change. Other initiatives relate to carbon intensity, adaptation and forestry [8]. Lastly, it is encouraging to see that sustainable development has been a cornerstone of the 13th Five-Year Plan (FYP), as shown below.

Figure 3
13th FYP - focus on people's well-being and sustainable development



Source: Tsing Capital Strategy&Research Center, 2016

The Uneven Yet Encouraging Route to Combating Environmental Issues

The last 100 years have seen rapid technological development and increasing environmental challenges. Recent decades have also witnessed increased environmental awareness and international movements to combat those environmental issues. Combating environmental issues is not a smooth process, and the road towards success is full of obstacles.

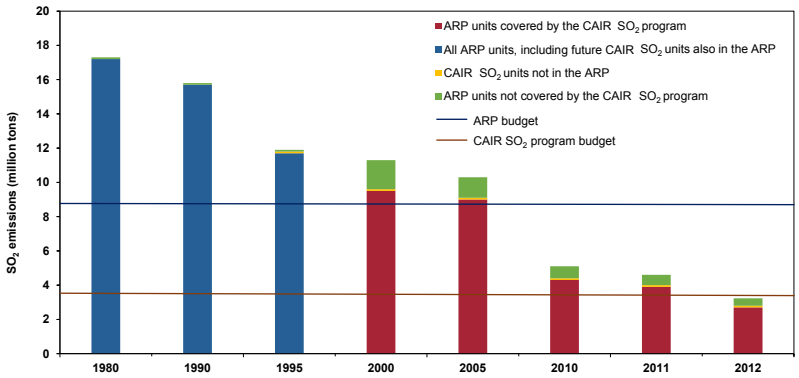
Ozone-Depleting Substances are Being Eliminated

The effort on behalf of the international community to combat environmental issues has been promising. The Montreal Protocol on Substances that Deplete the Ozone Layer was agreed on 16 September 1987 [10]. As a result, the world almost eliminated ozone-depleting substances: their consumption fell by 98 percent between 1986 and 2013 [1].

Emission Trading Schemes Successfully Reduced Acid Rain

International efforts to combat acid rain have also been well received. The combination of the Clean Air Interstate Rule (CAIR) and the Acid Rain Program (ARP) have achieved significant emission reductions. By 2012, CAIR and ARP have reduced SO_2 emissions by 79 percent from 1990 levels. CAIR and ARP together have reduced NOx by 73 percent compared to 1990 levels.

Figure 4
SO_2 emissions from CAIR SO_2 annual program and ARP sources, 1980-2012



Note: For CAIR units not in the ARP, the 2009 annual SO_2 emissions were applied retroactively for each pre-CAIR year following the year in which the unit began operating.

Source: EPA, 2013

Difficult Path to Reach Global Climate Change Agreements

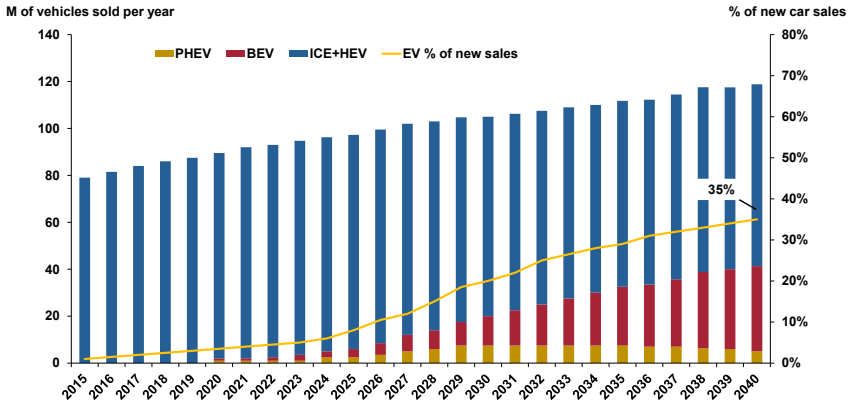
The Paris agreement was a great milestone in reducing greenhouse gas emissions; it was the culmination of years of effort by the international community. The Kyoto Protocol, negotiated in 1997, is seen as an important first step in providing a truly global emission reduction regime that will stabilize GHG emissions, and it can provide the architecture for future international agreements on climate change. However, the Kyoto Protocol only included developed countries and excluded China's obligation. Moreover, a major setback to the Kyoto Protocol occurred when the United States' Bush administration stated "no interest in implementing" the Kyoto Protocol in 2001. Another setback came in 2011, when Canada officially renounced the Kyoto Protocol. Peter Kent, Canada's Minister for the Environment, said that Kyoto's goals are unworkable because the U.S. and China never agreed to the Protocol, and that a new pact is needed to address global emissions [11]. Despite these setbacks, the Kyoto Protocol has set significant international milestones to combatting GHG emissions, and initiated important international collaboration efforts such as carbon trading markets.

EV Market Increased Due to Battery Price Reduction

Recent developments regarding the promotion of new energy and low emission vehicles have been encouraging. Governments across the world have implemented higher subsidies and tax cuts for the manufacturing and production of new energy vehicles and low emission vehicles. New research by Bloomberg New Energy Finance in February 2016 suggests that big reductions in battery prices lie ahead and that during the 2020s, EVs will become a more economical option than gasoline or diesel cars in most countries.

The study forecasts that sales of electric vehicles will hit 41 million by 2040, representing 35 percent of new light duty vehicle sales. This would be almost 90 times the equivalent figure for 2015, when EV sales are estimated to have been 462,000, some 60 percent up from 2014 [12].

Figure 5
How electric vehicles would account for 35 percent of global new car sales by 2040

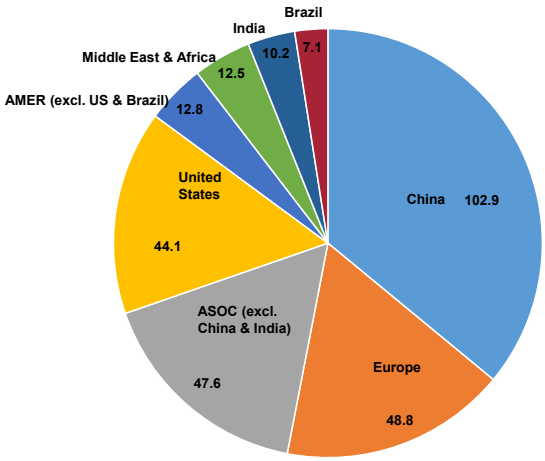


Source: Bloomberg, 2016

Subsidies and Lower Cost Promoted RE Market

Rapid growth in the renewable energy market is strong, in both developed and developing countries. China especially is leading the way. In the past 20 years, despite the fluctuations in the global renewable energy market, there has been steady growth in renewable energy investment and installation. Moreover, there has been a shift from the initial dominance of the European market to markets in Asia, the United States, and a number of developing countries. Renewable energy, excluding large hydro, accounted for the majority of gigawatts of new generating capacity installed in 2015 for the first time ever. In 2015, the percentage was 53.6 percent, compared to 49 percent in 2014 and 40.2 percent in 2013. The growth in renewable energy has benefitted not only from cost reductions in renewable energy technologies and their installation, but also government support such as subsidies, policy innovation (such as feed-in tariffs and net-metering), and business model innovation (such as power purchase agreements and leasing models) [13].

Figure 6
Renewable investments in 2015: China is leading the way

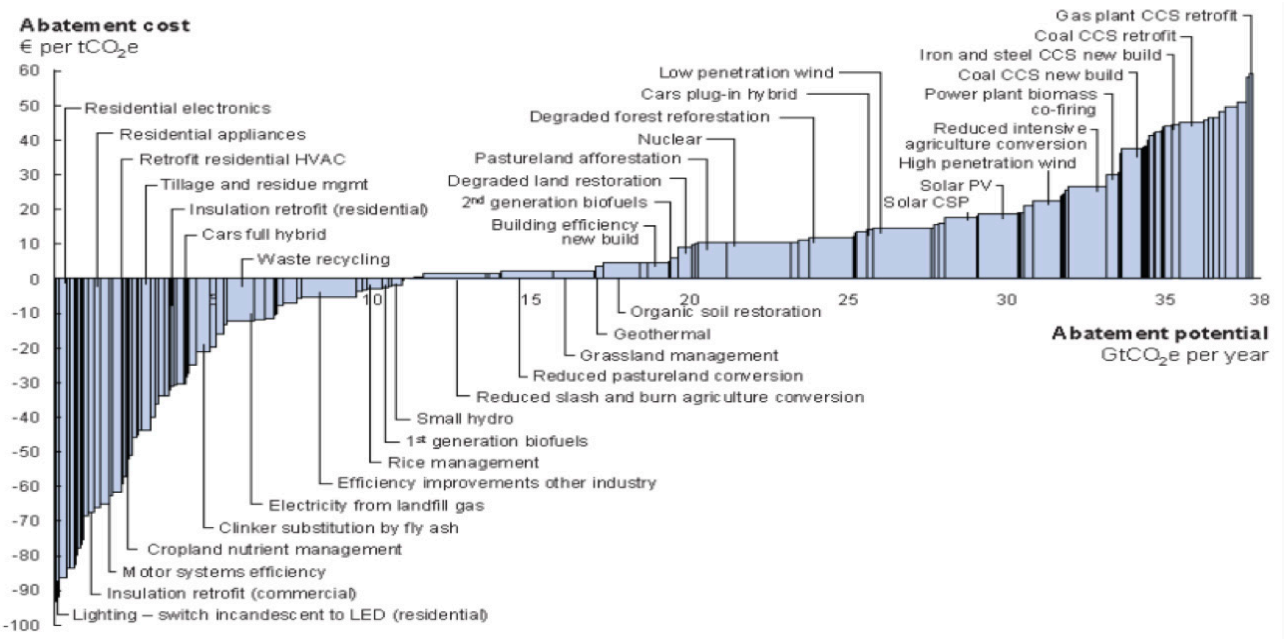


Source: UNEP, Bloomberg New Energy Finance, 2016

EE Improvements Has Negative Abatement Cost

According to the 2009 McKinsey report, “Global cost curve for the year of 2030”, energy efficiency improvement is forecasted to have a negative abatement cost, which means that energy efficiency improvements are preferred over other carbon reduction approaches, because a positive payback brings global emissions abatement [14].

Figure 7
McKinsey’s global cost curve for the year 2030 - version 2 of the global greenhouse gas abatement cost curve



Note: The curve presents one estimate of the maximum potential of all technical GHG abatement measures below 60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: McKinsey & Company, 2009

Despite better returns for energy-saving and cost-saving via energy efficiency investments, there exist considerable barriers regarding implementation of energy efficiency improvements. There are issues of capital, and predictability of savings within a certain time period. Because holding periods for properties for financial investors can be low, payback periods for retrofits can often take longer than property owners or financial institutions can tolerate the expense on their books. Property owners also have concerns regarding disruption in daily activity when conducting energy efficiency improvements. Tenants who benefit from energy efficiency improvements often do not have access to the right to conduct energy efficiency improvements without lease renegotiations. Because of the scale of the opportunity, access to low cost capital is a must. Governments have to provide considerable support for energy efficiency to take place [15].

Carbon Reduction Brings Opportunities for Greater Profit and Increased Employment

Combating climate change and environmental issues can drive countries' economies, making such efforts truly "sustainable". The International Energy Agency (IEA) showed that $13.5 trillion in investments are needed in energy efficiency and low-carbon technologies between now and 2030 to meet the Paris Agreement's

temperature reduction target [16]. On a global level, in order to limit a global surface temperature increase of between 3.7- 4.8˚C above pre-industrial levels by 2100 to the 2˚C agreed upon during the Paris Agreement, a decrease in emissions of 40-70 percent (relative to 2010) must be achieved by 2050. This reduction will create millions of jobs [1]. For instance, as shown in Table 1, the transportation sector will create 88 million jobs, while the agriculture sector will create more than 1 billion jobs.

Table 1
How climate change is creating jobs

Sector	Share of increase in greenhouse gas emissions over 2000-2010[a] (%)	People directly employed (millions)
Energy, including electricity and heat	34.6	30
Agriculture, forestry and other land use	24.0	1,044
Industry	21.0	200[b]
Transport	14.0	88
Buildings	6.4	110

Note: a. Represents a composite measure of the total annual anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, fluorinated gases) based on IPCC (2014b). According to IPSCC (2014b), global greenhouse gas emissions caused by human activities rose from 2000 to 2010 by 1 gigatonne of carbon dioxide equivalent (2.2 percent) a year, reaching 49 gigatonnes of carbon dioxide equivalent a year.
b. The actual number is larger. The value reported is for resource-intensive manufacturing only, likely to be more important from a sustainability standpoint.

Source: IPCC 2014b; Poschen 2015.

The World Wildlife Fund (WWF) and Carbon Disclosure Project (CDP) recently released a report called "The 3 percent solution: Driving Profits through Carbon Reduction". Their analysis demonstrates that if US businesses act now to reduce emissions by an average of 3 percent annually, they can save up to $190 billion in 2020 alone or $780 billion over 10 years. Based on this report, a reduction in carbon emissions by 3 percent from now to 2020 is equivalent to cutting total greenhouse gas emissions in 2020 by 1.2 gigatonnes of CO_2 from 2010 levels. This reduction pathway aligns with what the IPCC says is needed by 2020 to help avoid a global temperature increase above pre-industrial levels. The report shows that 4 out of 5 S&P 500 companies see a greater financial return on their carbon reduction investments than their overall capital investments. To unlock the billions of dollars in cost savings, on average, the US private sector would need to invest 3 percent to 4 percent of their capital expenditure each year on profitable, low-risk carbon reduction projects [17].

The Changing Sustainable Development Landscape in China

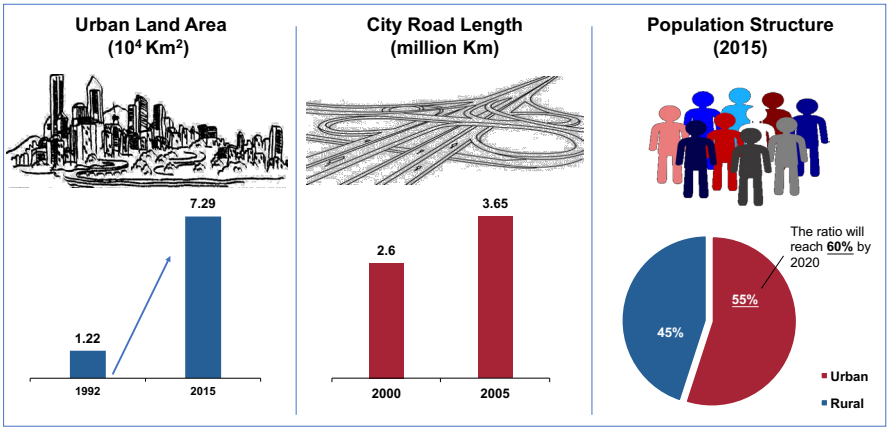
In response to rapid urbanization, industrial overcapacity and environmental deterioration, China's economy is shifting into a more sustainable model. To ensure a smooth economic transition, the country is making great strides in several areas. The government is formulating market- oriented policies and establishing more favorable financial conditions. Moreover, stimulated by higher public awareness and large-scale innovation, diversified consumption demands are emerging. Moreover, investment in sustainability is increasing. All of these reflect China's strong determination for sustainable development.

Economic Transition in China

China has gone through an astonishing transformation over the past three decades: it has become an industrial powerhouse; rapid urbanization has created new economic centers; and an increasingly prosperous middle class is taking form. After having reached a peak growth rate that elevate China's economy to the number 2 world wide spot, China is stepping into a "new normal", defined as a transition from high growth to medium-high growth at an average rate of 6.2% until 2024 [18]. Furthermore, the "new normal" also includes a decrease in government interference in the economy and encouragement of market forces [19]. This transition is leading to an economic model that is more innovative, environmentally friendly, and which actively pursues sustainable development to create business opportunities [20]. There are three major factors in this economic transition.

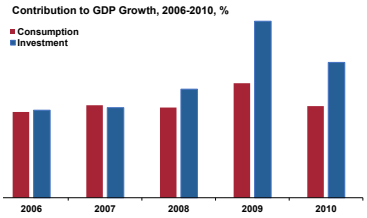
The pace of urbanization in China is extremely fast. From 1992 to 2015, urban land area has increased almost 5 times. By the end of 2015, the total length of city roads increased by 40 percent compared to the 2010 level [21]. By 2014, the urban population reached 749 million, 1.2 times of rural population, while the urban population was only 75 percent of the rural population in 2005.

Figure 8
Rapid urbanization in China



Source: Tsing Capital Strategy&Research Center, 2016

Figure 9
Investment was the biggest contributor to GDP growth in the past



Source: Wind

The 10 key sectors including in Made in China 2025:

Rapid urbanization has driven investment to occupy a larger proportion of China's GDP. After the Chinese government launched a stimulus package in 2008, investment contribution to GDP growth increased, while consumption's contribution to GDP growth declined. The investment-driven model is built upon savings and is difficult to sustain, as it creates many social problems such as industrial overcapacity, economic fluctuation and environmental pollution.

China is reducing industrial growth and tapering investment in infrastructure to reduce overcapacity in steel, cement and glass manufacturing. Moreover, China has launched a new round of consumption upgrades[1] to enhance consumer demand.

This has led to increased innovation, which is starting to permeate into China's manufacturing sector. In 2015, the State Council unveiled a plan called "Made in China 2025", which focuses on nine priorities: "improving manufacturing innovation, integrating information technology and industry, strengthening the industrial base, fostering Chinese brands, enforcing green manufacturing, promoting breakthroughs in 10 key sectors, advancing restructuring of the manufacturing sector, promoting service-oriented manufacturing and manufacturing-related service industries, and internationalizing manufacturing."

Another recent government initiative is the "One Belt One Road" strategy, which helps to transfer excess capacity overseas and establishes international trade/collaboration with neighboring countries [22]. The Asian Development Bank has estimated that Asia requires $8 trillion to fund infrastructure construction for the next 10 years until 2020. China is aware that its future development is inextricably linked with the wider Asia region; responding to its neighbors' massive infrastructure needs may result in positive externalities for China in the long run. A key objective of the strategy is the development of an unhindered road/rail network between Europe and China. "One Belt One Road" involves more than 60 countries, half of the global population and a third of the global economy [23].

Strong Enforcement of Environmental Regulations Brings Opportunities

Economic progress has come at a high environmental cost: air quality in hundreds of cities is worsening and water/soil resources across the country are deteriorating. Such environmental pollution is pushing China to reconsider its development model. Fortunately, China has shown strong determination in addressing environmental problems. As President Xi Jinping emphasized during 2016's B20 conference, China has set a high-level sustainable development strategy: by 2020, China will reduce water consumption by 23%, energy consumption by 15%, and CO_2 emissions by 18% [22] respectively per unit of GDP.

Market-Oriented Policy Design

Policy in China is becoming "smarter" and focusing on long-lasting benefits instead of short-term results. In the past, command-and-control approaches and subsidy mechanisms have often been ineffective. For example, the large scale of subsidy fraud in the new energy vehicle (NEV) market has shocked China. In this case, five major manufacturers participated in fraud worth 1 billion RMB. Simple subsidy approaches have demonstrated flaws and require smarter policy design. As a result, the government has improved subsidy policies by considering market driven approaches, tax incentives for both consumers and manufacturers, encouragement of charging infrastructure deployment, and the introduction of special purchasing

1 "Consumption upgrade" means that consumer commodities become more diversified and advanced. Details will be discussed in section 2.3

quotas and special permits [24]. Policy reforms with regards to the NEV market are just one example of how social impact policies are transforming China overall.

In addition to NEV policies, the government has made attempts at more creative financial incentives apart from subsidies in other fields. Seven governmental ministries in China jointly published the "Guidelines for Establishing the Green Financial System" on Aug.31, 2016. The publication of this guideline is not just an important step in demonstrating the Chinese government's commitment to climate change mitigation and environmental protection, but also a strong signal of a shift from a centralized policymaking approach towards a market-based approach to address environmental issues. Green finance utilizes financial instruments such as green bonds, credits, stock indices, green development funds, green insurance, carbon finance, as well as relevant policy incentives that support the green transformation of the economy [25]. On a local level, governments provide basic financial support through equity investments from local industry funds, replacing subsidies and tax exemptions. This is very common in local industrial parks nowadays.

PPP Encouraged in Green Financing

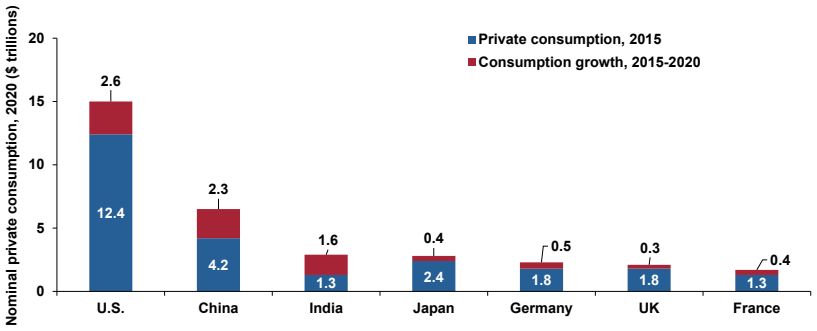
In addition, the Chinese government is exploring new channels to direct fiscal support in more effective ways, for example through Public-Private Partnership (PPP) funds. For many years, subsidies were the default tool used to cultivate new markets. However, this traditional approach has been gradually replaced or accompanied by investments in PPP financing funds. The Ministry of Finance and 10 other major financial institutions have hitherto established 180 billion RMB worth of PPP financing funds [26]. In many of these PPP funds, the government invests in 10-30% of the total fund, while taking less than 25% of overall equity share. In 2015, local PPP funds reached a level of 1.5 trillion RMB [27]. This trend also applies to sustainable development. The "Guidelines for Establishing the Green Financials System" has largely encouraged PPP to attract social capital to establish regional and local green development funds. Numerous publicly listed environmental companies have signed 50 billion RMB worth of PPP contracts [28].

China also encourages trading instead of command-and-control approaches to management of environmental issues, which is an innovative market approach. Next year, China is slated to establish a nationwide carbon market. This trading approach is not limited to carbon. Similar trading systems include pollution right trading, tradable energy quota systems for energy conservation, and green certificate trading systems for renewable energies.

Public Awareness is Driving Demand for Better Design, Quality and Green Products

China's consumer economy is projected to expand to $6.5 trillion by 2020, even at a low GDP growth rate of 5.5%. The incremental GDP of $2.3 trillion as a result of this growth in the coming 5 years is larger than the German or UK economies.

Figure 10
China's consumption will grow by $2.3 trillion by 2020, even as GDP slows down to 5.5%



Note: Assuming the annual Chinese GDP growth rate of 5.5%; Not all numbers add up to the totals shown because of rounding.

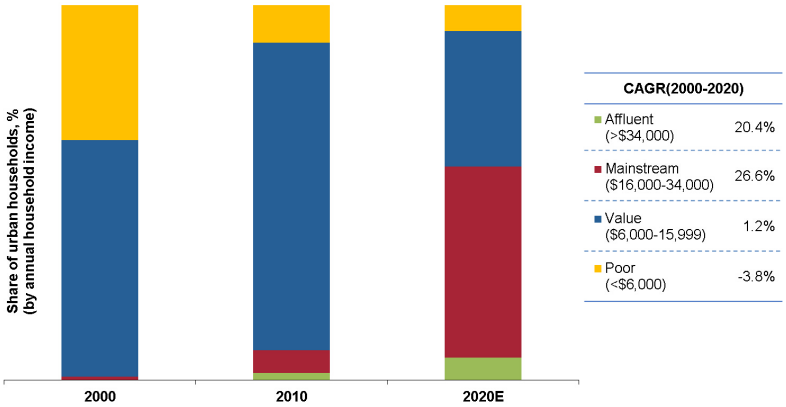
Source: Economist Intelligence Unit; BCG analysis.

In a recent report by BCG, the types of consumer products booming in China's consumer market are also changing. Customers are increasingly embracing premium goods and services, such as healthy foods, education, and travel [29].

Significant Increase in Demand for Premium Goods

In China, the share of the Chinese middle class will increase dramatically by 2020. As shown in Figure 11, changes in economic profiles have been and will continue to be the most important trend shaping the consumer landscape. The Chinese are getting richer fast: the per-household disposable income of urban consumers will double between 2010 and 2020, from about $4,000 to about $8,000.

Figure 11
The share of Chinese households in each income level will shift dramatically by 2020, with a strong increase in middle class



Source: McKinsey

Consumption accounted for *66.4%* in GDP in 2015

Such an increase in income also leads to an "upgrade" in consumption. In the past 50 years, China has experienced three instances of such "upgrades", each with its own implications for China's economy and technological landscape [30].

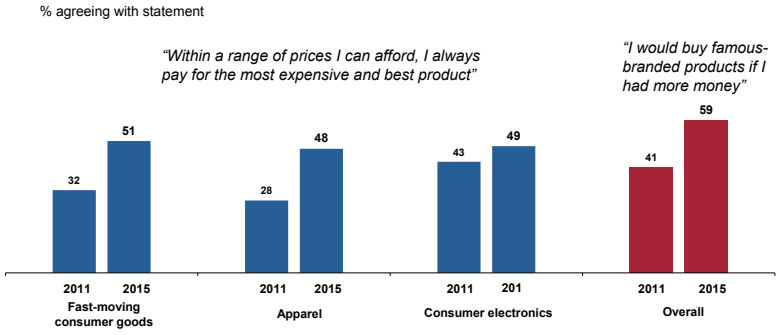
Table 2 The three consumption upgrades during the past 50+ years

	The 1st Consumption Upgrade	The 2st Consumption Upgrade	The 3rd Consumption Upgrade
Time Period	1960-1989	1990-1999	2000-present
Purchase Level (by RMB)	100 RMB	1,000 RMB	10,000~100,000RMB
Benefit Industries	Light industry, Textile	Electronics, Iron and Steel, Manufacture	IT, Automobile, and Real Estate
Features	Provide adequate food and clothing	Make a comfortable living	Demand for premium and luxury

Source: Tsing Capital Strategy&Research Center, 2016

From McKinsey's 2016 China consumer report, it is clear that Chinese consumers are spending more on lifestyle services and experiences, and also moving from mass to premium sectors.

Figure 12
Chinese consumers increasingly desire premium products



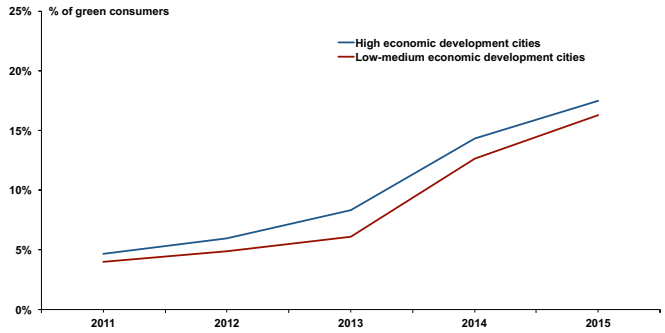
Source: McKinsey

Greener Consumption Promoted by Chinese Government

Green consumption has long been an international trend, and this trend has spread into China. In February 2016, ten Chinese ministries jointly issued guidelines on green consumption. Furthermore, China will improve economic policies to support green industry, and provide subsidies to encourage green consumption [31]. The government intends to create a green consumption society, and part of this willingness comes from an increase in environmentally aware consumers. A recently published article from the National Bureau of Economic Research found that Chinese people are willing to pay $5.46 to remove one microgram per cubic meter of pollution out of air they breathe for five years [32]. According to a report

by AliResearch, green consumers on Alibaba's platform have increased from 3.4% to 16.2% of total consumers. Out of green[2] consumers, about 45% once purchased products that saved energy or resources. Young mothers especially are embracing green products. Out of every two green consumers, one is a young mother. An interesting side-note to this trend is that the percentage of green consumers does not correlate with regional levels of economic development, as shown in Figure 13.

Figure 13
Green consumer penetration in Alibaba's portfolio in different economic areas



Source: AliResearch, 2015

Both offline public media and online social media have played significant roles in enhancing environmental awareness and promoting green consumption in China. International organizations also actively promoted green consumption in China.

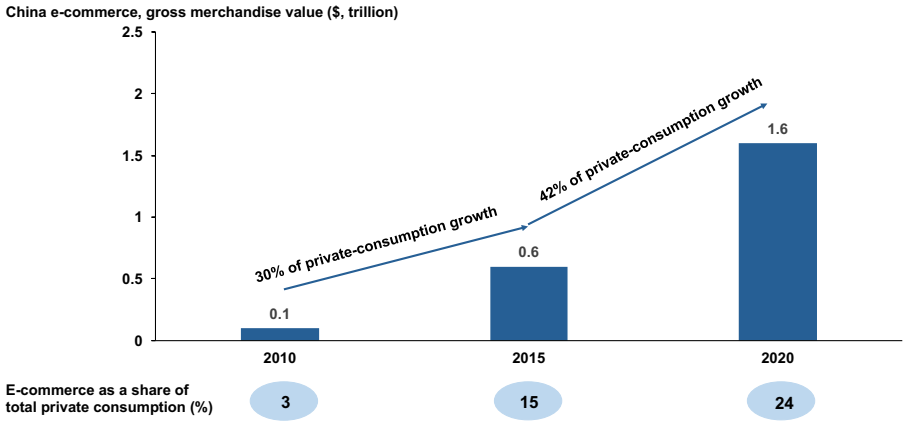
Service Has Overtaken Manufacturing in GDP Share

In 2015, the service sector accounted for 50.5% in GDP, as the major contributor to GDP growth for the first time. In the coming years, the service sector will continue to be the chief economic growth engine, estimated to be at least 55% of GDP growth by 2020 [29].

Fast-paced urban lifestyles lead to greater demand for convenience and efficiency, which is fueling e-commerce and mobile businesses. By 2016, online sales channels accounted for 15% of private consumption, and they are projected to account for 20% by 2020, indicating a 42% growth rate in private consumption over the next 5 years. Mobile e-commerce accounts for 51% of all online sales in China, which is higher than the global average of 35%. It is projected that mobile payments will account for 74% of all online sales in China by 2020 [29]. Payment systems in China are a reflection of how fast-paced the Chinese are nowadays. A recent news article by Reuters conveyed that Chinese mobile payments are amongst the most convenient in the world [30]. 10 years ago, only 7 million people had credit cards. In the last year, however, 356 million Chinese have used mobile payment, representing half of the entire country's internet users. The total amount of transactions made via mobile platforms such as WeChat and Alipay has reached 16.4 trillion RMB, a doubling from the 2014 amount and 12 times the 2013 amount [33].

2 "Green consumers" refers to people who demand products that are manufactured and utilized in an environmentally friendly way.

Figure 14
By 2020, online sales channels are projected to account for 42% growth in private consumption



Note: Differences in addition to reach Incremental-growth estimates are due to rounding.
Source: IResearch; BCG analysis

Innovation is the New Engine

From the technology giants in Shenzhen, to incubators in Shanghai, to Beijing's Zhongguancun startup scene, innovation in China is flourishing. The central government has boosted R&D expenditure throughout the country in a bid to transform into a global leader in science and technology. Research institutes and universities are engaged in advanced research on a range of fields including biochemistry, nanotechnology, big data, and robotics. Moreover, close collaboration between research institutes and science parks is making the commercialization of such innovation possible. Chinese entrepreneurs are pioneering both products and business processes, adapting to the ever-changing demands of a growing Chinese consumer market.

Innovation and Entrepreneurship Rapidly Spread in China

China is actively moving towards a more innovation-based economy. Chinese Prime Minister Li Keqiang delivered a keynote speech during the 2015 World Economic Forum, emphasizing that China will encourage mass entrepreneurship and innovation [34]. In recent years, the trend has clearly been in the right direction: in 2015, average daily registrations of new firms reached 120,000, a 20% increase compared to 2014. In 2015, co-working spaces for entrepreneurs reached over 2,300, and the numbers of accelerators and incubators is now over 2,500. 11 national science parks and 146 National High-Tech Industrial Development Zones have been established, containing over 100,000 startup companies, 600 public listed companies, and 1.8 million people. Government national funds that encourage innovation have supported the establishment of 206 companies, with a total funding value of 57.7 billion RMB, and have also been invested in 1,233 companies [35].

R&D is the engine behind innovation. China's R&D spending has increased by 73% in the last five years [36], reaching a total value of 1.42 trillion RMB in 2015, or 2.10% of GDP [37]. This R&D as a percent of GDP is well within the range of advanced economies such as Australia (2.12%), France (2.26%), the United Kingdom (1.70%) the Netherlands (1.97%), although still short of Japan (3.58%), South Korea (4.29%) and Israel (4.11%) [38].

China's innovation drive has had tangible results on both a domestic and global

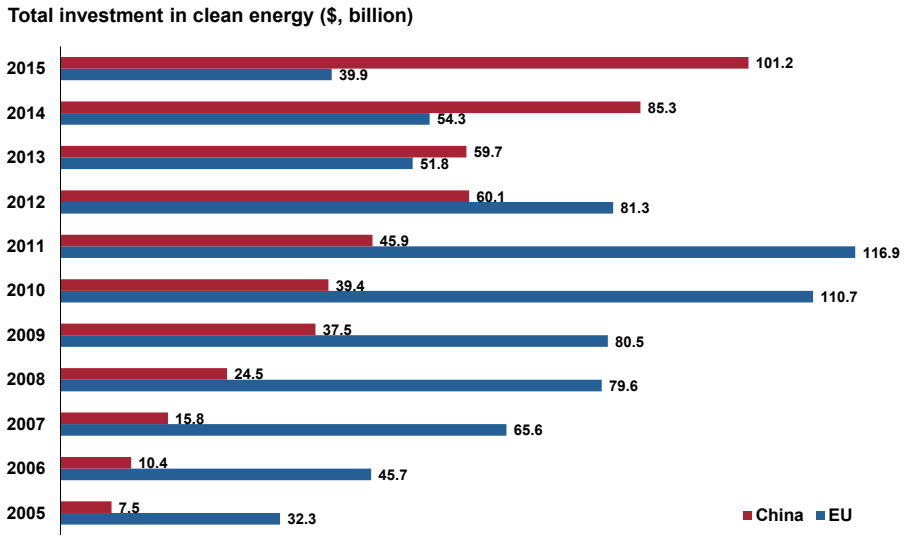
scale, and China is already a global leader in certain technology areas with internationally recognizable brands. "Traditionally, Chinese companies were fast followers, but we are starting to see true innovation," says Colin Light, a partner at PwC.

One example of this is Tencent Holdings, the innovative domestic tech company which owns WeChat, a multi-purpose smartphone application that combines chatting with a host of other features. The functionality of such an app is largely unheard of in most western economies. The app already has 272 million monthly active users in China, but Tencent also has international ambitions: the company has spent $200 million on overseas marketing campaigns to push WeChat markets including India, South Africa, Spain and Italy. The app already has 100 million downloads abroad. In addition, Huawei—an ICT giant in China, recently announced that in a successful 5G trial, peak speed could reach over 70 Gbps. For this reason, Huawei is confident in becoming a leader in setting the global 5G standard, which is crucial in licensing and IP protection . There are also examples of where Chinese companies are reaching advanced levels of competitiveness with regards to innovation. DJI, the Shenzhen-based drone maker, has captured the largest share of the global consumer drone market, and is releasing advanced drone products that boast artificial intelligence technology [39].

Increasing Investments in Sustainable Technology in China

China has already overtaken the EU in terms of clean energy investment. In 2015, total investment in clean energy reached $101.2 billion. China has strategically planned for the deployment of clean energy and electric vehicles. From 2015 to 2020, new investment in renewable energy will reach RMB 2.3 trillion [40]. Furthermore, China will invest $368 billion in ultra-high voltage grids, smart grids and distribution grids in the next 5 years; this is necessary infrastructure for dealing with power generation from solar/wind energy. By 2020, China plans to increase electric vehicle sales to 5 million, a tenfold increase compared to 2015. The increased amounts of investments in sustainable technology areas have greatly increased China’s competitiveness in the low carbon market, and it could soon overtake the European Union [36].

Figure 15
China has already overtaken the EU in clean energy investment

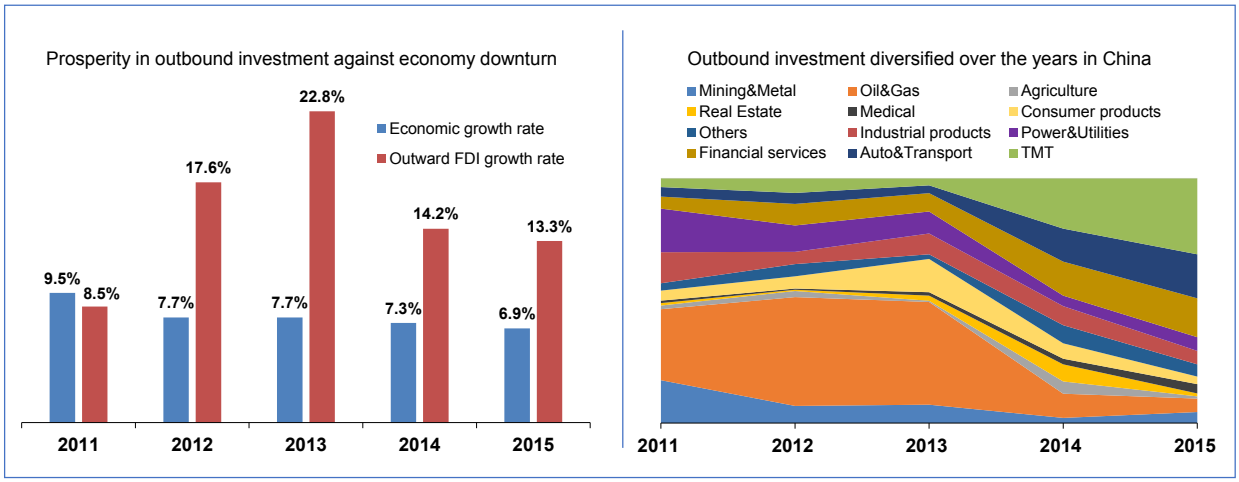


Sources: BNEF; Xinhuanet

On the other hand, China's outbound investment in the sustainable technology area increased to a new phase driven by favorable policies. For the past 10 years, China's outward FDI has grown by more than 500 percent, from 21.2 billion USD in 2006 to 139.5 billion USD in 2015 [34]. Moreover, the focus area of investment has diversified throughout the years as well, with a large expansion in sustainable areas, such as smart-tech. For example, in the past five years, mining and conventional energy in China's total overseas M&A dropped from 47% to 10.5% [35], bringing more room for the development of sustainable technologies.

In general, although China's economic growth has slowed down, the economy's structure is shifting to a more diverse, low-carbon, and innovative growth model.

Figure 16
China outbound investment has increased and diversified



Source: Ernst&Young, 2016 China Outbound Investment Outlook

The Road Towards Sustainability Calls for Disruptive Innovation

Tsing Capital believes that the road towards sustainability requires the application of exciting new tools from outside the traditional Cleantech sectors. Such tools may include new technologies and business models that did not necessarily originate in the Cleantech sector.

Chapter 3 provides insights on how such tools can enhance sustainability practice across a variety of industries. Regarding technological tools, we examine: sensors, machine learning, AR/VR, Blockchain, 3D printing, and advanced materials. Business tools evaluated include recent business model innovation (related to hardware, software, products, services, etc.), the sharing economy, and innovative financing.

Technology Innovation

Tsing Capital follows innovative technology mega-trends that are shaping industries around the world. Such trends have high potential to affect the Cleantech sector at each step of the value chain; this makes understanding these trends crucial to successful Cleantech investments.

A recent McKinsey report identified 12 technologies with great potential to drive economic impact by 2025. The 12 technologies and their potential economic impact (including consumer surplus) are summarized below [41].

Table 3

Tech	Description	Developed Countries	Less Developed Countries
Mobile Internet	Increasingly inexpensive and capable mobile computing devices/internet connectivity could make an economic impact of between $3.7 and $10.8 trillion annually by 2025	50% of market. High value applications, e.g. worker productivity.	50% of market. Bulk of new mobile users.
Automation of knowledge work	(including artificial intelligence) Intelligent software systems capable of performing knowledge work tasks involving unstructured commands and subtle judgements could make an economic impact of between $5.2 and $6.7 trillion annually by 2025.	80% of market. Higher impact of increasing labor productivity.	20% of market. Large numbers of knowledge workers.
The Internet of Things	Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization could make an economic impact of between $2.7 and $6.2 trillion annually by 2025.	70% of market. Major applications enabled by advanced technology infrastructure, e.g. advanced supply chain systems.	30% of market. Majority of new adoption.

Cloud technology	Use of computer hardware and software resources delivered over a network or the Internet, often as a service, could make an economic impact of between $1.7 and $6.2 trillion annually by 2025.	30% of market. High surplus per user.	70% of market. Majority of new adoption.
Advanced robotics	Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans could make an economic impact of between $1.7 and $4.5 trillion annually by 2025.	80% of market. Greater ability to pay for surgical robots and prosthetics; high savings from automation.	20% of market. Many manufacturing workers but lower savings from automation.
Autonomous and near-autonomous vehicles	Vehicles that can navigate and operate with reduced or no human intervention could make an economic impact of between $0.2 and $1.9 trillion annually by 2025.	80% early adoption in high-end vehicles.	20% of market. Many vehicles but smaller percentage of high-end vehicles and low cost of hiring drivers.
Next-generation genomics	Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology ("writing" DNA) could make an economic impact of between $0.7 and $1.6 trillion annually by 2025.	80% of market. Greater early adoption of genomic technologies and treatments.	20% of market. Lower initial adoption, particularly of new treatments.
Energy storage	Devices or systems that store energy for later use, including batteries could make an economic impact of between $0.1 and $0.6 trillion annually by 2025.	60% of market. Many new vehicles with potentially higher adoption of electric and hybrid models.	40% of market. Many vehicles but potentially smaller percentage of new electric and hybrid models.
3D printing	Additive manufacturing techniques to create objects by printing layers of material based on digital models could make an economic impact of between $0.2 and $0.6 trillion annually by 2025.	60% of market. Potential for earlier adoption in manufacturing and by consumers.	40% of the market. Large manufacturing base and many consumers, but lower initial adoption.
Advanced materials	Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality could make an economic impact of between $0.2 and $0.3 trillion annually by 2025.	90% of market. Greater early adoption of new nano-based treatments due to more advanced health-care systems.	Lower initial adoption for new nano-based treatments and substances.
Advanced oil and gas exploration and recovery	Exploration and recovery techniques that make extraction of unconventional oil and gas economical could make an economic impact of between $0.1 and $0.5 trillion annually by 2025.	80% of market. North America leads in shale gas and light tight oil production.	20% of market. Significant investments being made but could require years to catch up.
Renewable energy	Generation of electricity from renewable sources with reduced harmful climate impact could make an economic impact of between $0.2 and $0.3 trillion annually by 2025.	20% of market. Larger existing renewables base (especially wind) with moderate growth.	Large renewables capacity development, e.g., in China

Outside of traditional Cleantech technologies, Tsing Capital has identified two "mega" technology categories: The Internet of Things and Artificial Intelligence. Both of these categories include a number of more specific technologies which can have a high impact on the Cleantech sector. Before addressing these specific technologies, we first examine the "mega" technology categories below.

Mega-Trend: Internet of Things

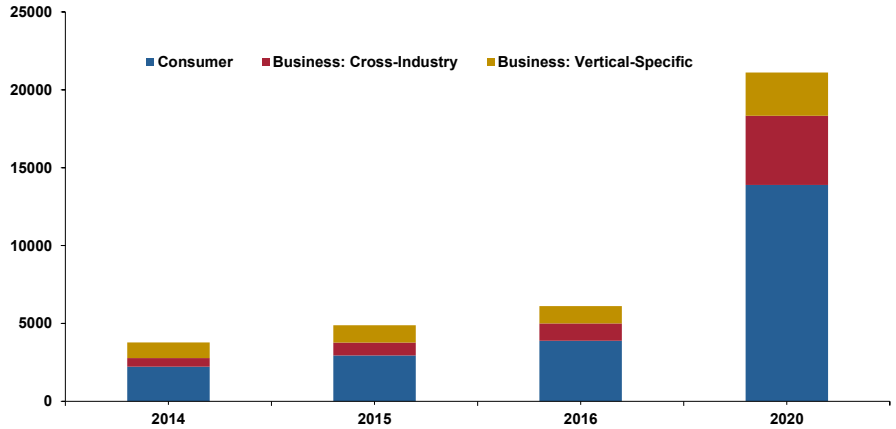
IoT Can Raise Efficiency and Productivity

The Internet of Things (IoT) is a network of equipment, vehicles, devices, and other physical objects that allows for the collection, transmission, and exchange of data via the internet. IoT can potentially improve the quality of life for consumers and the productivity of businesses while also cutting costs.

As will become clear, IoT can enhance sustainability by connecting networks of “things” across a wide range of applications in order to make data-driven decisions, which can enhance the efficiency and resource productivity in a variety of processes. IBM’s IoT solutions are based on the trend that “IoT and cognitive computing are powerful new tools that can make our businesses and our environment greener.” [42] IBM states that “IoT can help you conserve precious resources and eliminate waste to achieve these goals. It starts by making sense of the ocean of raw data produced every minute by the thousands of connected things that make up your business, supply chain and products. When you understand your physical world, you can see opportunities to improve resource efficiency, reduce pollution, and stimulate new thinking and innovation.” For instance, IoT is helping the city of Rotterdam implement efficient waste management systems thanks to IoT-based optimization [43].

“The volume and services value of IoT applications are growing rapidly. According to Gartner, 6.4 billion “connected things” will be in use worldwide in 2016, up 30% from 2015, and will reach 20.8 billion by 2020. In 2016, 5.5 million things will get connected every day. There are three main segments where IoT penetration is growing quickly: the consumer segment (hardware, cars, etc.); the cross-industry business segment (generic devices used in multiple industries such as lights bulbs and HVAC systems); and the vertical-specific business segment (industry specific devices such as specialized equipment used in hospitals or container ships). Figure 17 shows the projected installed base of IoT devices across these segments [44].

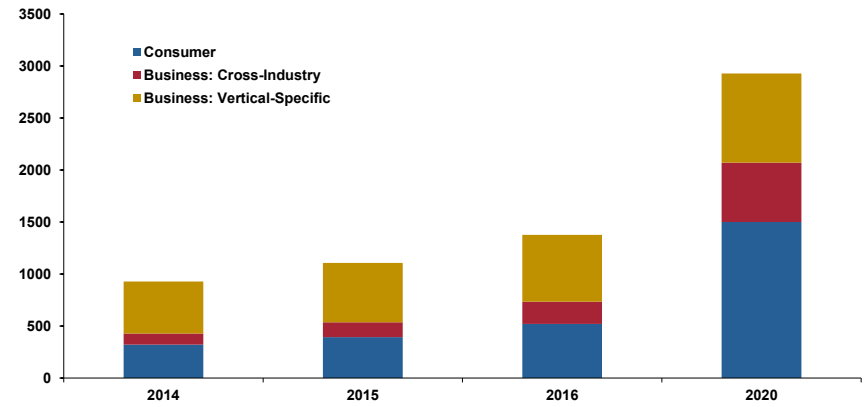
Figure 17
IoT units installed by category (# of units in millions)



Source: Gartner, 2016

Moreover, Gartner estimates that IoT will support total services spending of $235 billion in 2016, up 22 percent from 2015. One analyst claims that “IoT services are the real driver of value in IoT, and increasing attention is being focused on new services by end-user organizations and vendors”. Endpoint spending related to IoT could reach $3 trillion by 2020. Figure 18 shows projected IoT endpoint spending

Figure 18
IoT endpoint spending by category ($, billions)



Source: Gartner, 2016

Although the volume of vertical-specific IoT devices is currently larger than the volume of cross-industry IoT devices, cross-industry IoT devices will dominate by 2020 as generic devices become more common.

Investment in IoT

The rapid growth in IoT penetration in recent years has come with significant investments by major international companies in recent years. For instance, Google acquired Nest Labs (a manufacturer of smart home IoT appliances) for $3.2 billion in 2014. In addition, Intel acquired Altera Corporation (producer of microprocessors primarily used in networking equipment) for $16.7 billion in 2015. In 2015, IBM invested $3 billion to build an internal IoT division. The following Table 4 shows some major recent M&A activity in the IoT space

Table 4 Recent M&A Activities in the IoT Field

Year	Acquirer	Target	Application	Acquisition Price	Revenues	Price/ Revenue
2016	Nokia	Withings S.A	Connected Health - Wearables	$191M		
2016	Microsoft	Solair	Manufacturing, Retail, Food & Beverage, Transportation	Undisclosed	$1.5M (2015)	
2016	Cypress Semiconductor	Broadcom (IoT business)	Analog & Digital Semiconductor Connectivity Solutions	$550M	$189M (2015)	2.9
2016	Sony	Altair Semiconductor	Modern Chip Technology & Related Software for LTE	$212M		
2016	Cisco Systems	Jasper	Cloud based IoT Service Platform	$1.4B		
2016	Intel	Yogitech	Semiconductor Functional Safety and Related Standards	Undisclosed		
2016	Qorvo	GreenPeak Technologies	Smart Home	Undisclosed		
2016	ARM	Apical	Embedded Computer Vision Technology	$350M	$18.5M (2015)	18.9
2016	Mars Petcare	Whistle	Smart Dog Collars	$117M		
2015	Qualcomm	Cambridge Silicon Radio	Platform solutions for BT, GPS, FM broadcast, Wi-Fi, etc.	$2.4B	$774.8M (2014)	3.1
2015	HP	Aruba Networks	Wired & WLAN Networks	$3B	$728.9M (2014)	4.1
2015	ARM	Sansa Security	IoT Security Platform	$85M		
2015	NXP	Freescale	Semiconductor Design, Research, & Development	$11.86B	$4.6B (2014)	2.6
2015	Amazon	2lementary	Big Data Services	Undisclosed		
2015	BlackBerry Ltd.	Good Technology	Mobile Security Provider	$425M	$211.9M (2014)	2.0
2015	Intel	Altera	FPGA, SoC, & CPLD Solutions	$16.7B	$1.9B (2014)	8.7
2014	Samsung	SmartThings	Smart Home	$200M		
2014	Amazon	Twitch	Video Game Streaming Service	$970M		
2014	Google Inc.	Nest Labs	Smart Home Products	$3.2B		

Source: Fundamental Research Corp, 2016

Mega-Trend: Artificial Intelligence

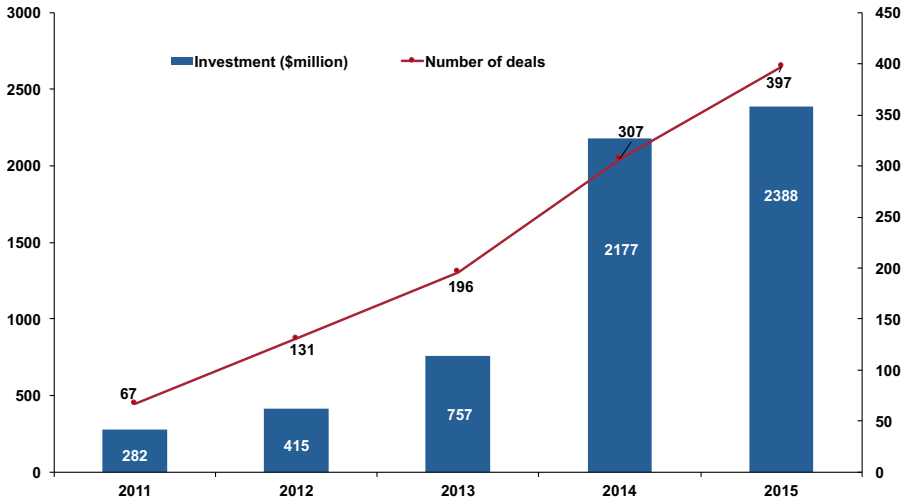
Broad Coverage of AI

Today, AI refers to a broad range of applications, including computers playing games against humans, computers capable of understanding human languages, virtual personal assistants, and robots which can "see", "hear", and react to other sensory stimuli. AI companies can broadly be segmented into two types: AI infrastructure companies and AI application companies [45] [46].

AI infrastructure companies refer to companies that develop (1) machine intelligence systems (including machine learning, deep learning, and cognitive systems); (2) natural language processing algorithm (including speech recognition and text/speech analysis); and (3) visual recognition technology; and (4) enabling hardware or software.

AI application companies develop applications that target (1) enterprise (business intelligence, security & surveillance, sales, marketing, customer service, human resources, customer success, productivity); (2) industry (advertising, pharma/ healthcare, transport, financial services, agriculture, education, retail/e-commerce, legal); and (3) consumer (virtual assistants, intelligent robots).

Figure 19
Increase in investments and deals – a new high in 2015 in Ai startups

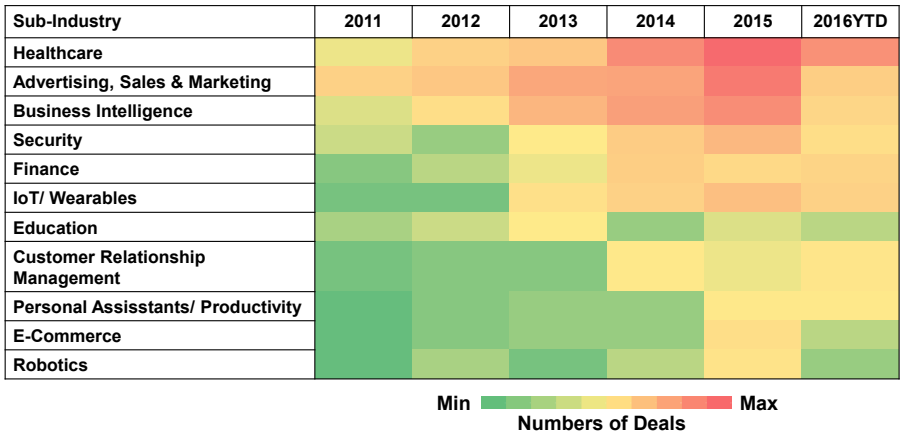


Source: Lux Research, 2015

It is estimated that the global economic impacts associated with the development, adoption and use of AI over the next decade ranges from $1.49 trillion to $2.95 trillion. Moreover, as shown in Figure 19 above, there has been a dramatic increase in investments and deals in recent years, with equity funding for AI startups reaching $2.34 billion in 2015, up from $282 million in 2011, a 747% increase in just 5 years [45] [46]. Corporate investors have been highly active in the recent surge in investment. Corporations invested $926 million in 88 startups across 88 deals in 2015; the most active corporate investors included Intel Capital, Google Ventures, GE Ventures, Samsung Ventures, and Bloomberg Beta [45].

As shown in Figure 20 below, the top 3 segments in 2015 in terms of deal-making were healthcare, advertising/sales/marketing and business intelligence. The 3 lowest-performing segments in deals were education, e-commerce, and robotics.

Figure 20
Sub-industry heat map: AI 2011-2016



Source: CBInsights, 2016

An increasing amount of companies in China are becoming involved in the AI space. Baidu for instance, has directed a significant amount of R&D expenditure towards three research labs which may serve as a growth driver for Baidu in the coming years. There are currently three labs under its research umbrella [46], including (1) the Big Data Lab (involved in developing the potential of big data for marketable applications and also to help the company optimize and manage their current business operations. (2) The Baidu Institute of Deep Learning (focuses on machine learning technologies to develop next generation products) and (3) the Silicon Valley AI Lab (developed to unlock the potential of AI by exploring the newest deep learning algorithms and conduct research into associated hardware and software technology).

AI is also making breakthrough impacts with regards to sustainability. For instance, the World Resources Institute and big data technology startup Orbital Insight are using AI to identify the factors that could be predictive indicators of threats to forests around the world. This partnership comes at an opportune moment when global corporations such as McDonalds are taking initiatives to end deforestation [47]. More examples on sustainability applications are provided later in the subsequent sections.

Disruptive Technology I: The World's "Things" are Becoming Increasingly Inter-Connected Through Sensors

Sensor Technology Adopted in Monitoring and Data Collection

IoT sensor technology is poised to play a key role in enhancing sustainability with regards to energy efficiency, water resources, and transportation, to name a few. Since the applications in China are still at early development stage, some specific US-based examples are given below [48]

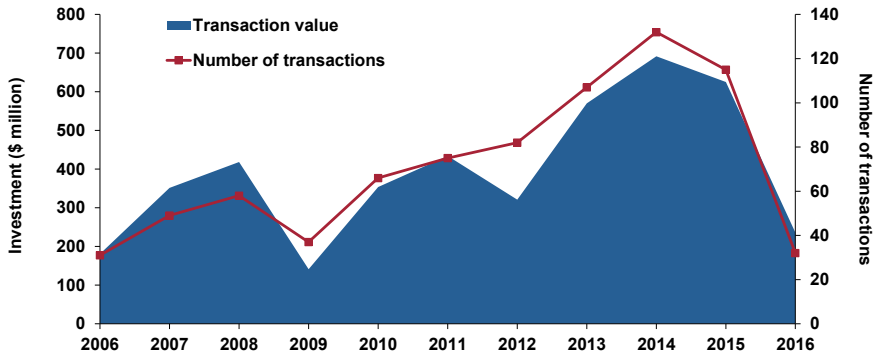
- Buildings: Sensor technology can be used in buildings in conjunction with energy management software systems to assess and control energy use. Some examples include products from companies like IntelliCommand, Retroficiency, Enlightened, EnOcean, Lutron, and Philips Hue [49].

- Transportation Infrastructure: Connected IoT devices and sensors placed within transportation infrastructure enables real-time data collection of vehicle movement through fixed points. One example of this is the Mobile Millennium and Connected Corridors projects to test innovative systems-level traffic management [50].
- Smart Water Pipes: New IoT technologies allow cities to make their water pipe systems "smart" by installing remote sensors to monitor flow and prevent leakage. Companies like AquamatiX have developed sensors that regulate water pumping by monitoring water flow and minimizing the amount of water in the pipes, reducing leakage and energy consumption [51].
- Smart Meters: As of July 2014, 50 million residential smart meters were installed in the US, covering 43% of homes, and their growth continues. The potential sustainability benefits of smart meters are realized from the more detailed consumption data provided than automatic meter reading (AMR) systems, allowing for more immediate changes in consumption by occupants and more nimble management by utilities. The Visdom platform is one such example [52].

Investment in Sensor Applications Covers Multiple Sectors

IoT sensor technologies have attracted major investment in the past decade. Since 2006, sensor developers with unique technology have globally attracted $4.3 billion over 780 transactions. Investments grew from $180 million in 2006 to $625 million in 2015, a CAGR of more than 13%. In the first four months of 2016, $236 million has already been invested, representing 38% of the total investment amount in 2015. On a regional level, out of the total $4.3 billion investment since 2006, 80% ($3.4 billion) was invested in 340 companies in the Americas (primarily North America) [53].

Figure 21
Total VC investments 2006-2016

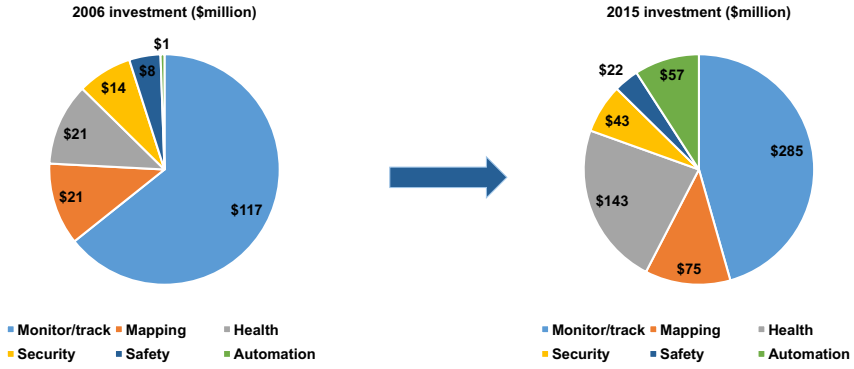


Source: Lux Research, 2016

The investor pool in sensor technology is wide, and includes VC/PE firms, investment banks, government entities and large corporations. VCs alone have invested about 47% of the total investments in sensor companies since 2006, or about $2 billion. Corporate investors have invested almost $545 million since 2006. Some of the most committed corporate investors include Samsung (currently investing $13 billion towards development of sensors and sensor system software); Sony (currently raising $4 billion to ramp up sensor production), Panasonic (investing $780 million to build capacity for image sensors) and IBM (investing $3 billion in sensor data) [53] [54].

Across sensor applications, monitoring/tracking applications have attracted 50% ($2 billion) of total cumulative investments since 2006. The second highest investment went towards health-related applications ($1 billion). The next-largest applications in terms of investment attracted are mapping ($700 million), safety ($220 million), automation ($240 million) and security ($150 million). It is worth noting that the share of automation within overall investment amounts increased significantly between 2006 and 2015, since automation has strong implications for sustainability.

Figure 22
Investment breakdown of sensor application



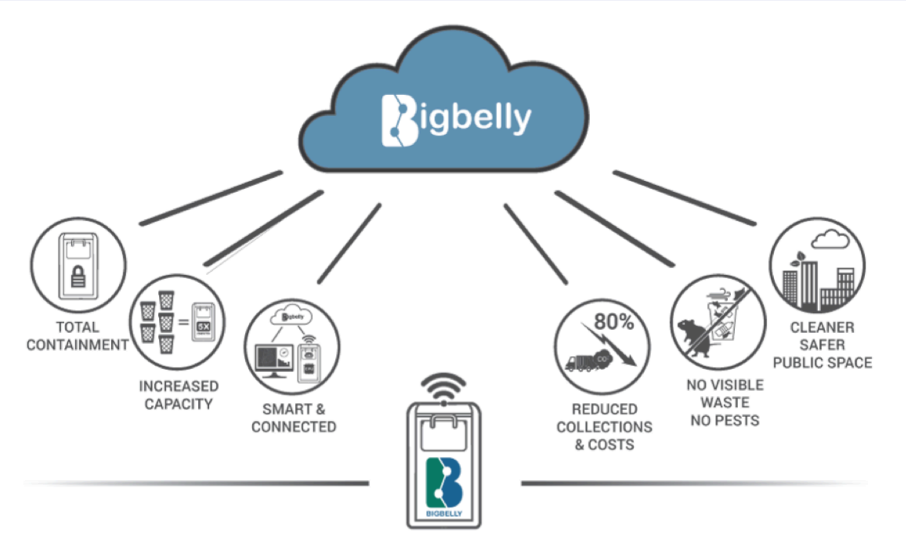
Source: Lux Research, 2016

Case Study: IoT Sensors Used in Waste Collection Bins to Optimize Waste Collection

Big Belly is a US-based company that offers a smart, connected waste management system. The company's flagship solution is a "smart" garbage bin deployed in cities worldwide. The solution has several components based on IoT sensor technology:

The Big Belly smart garbage bin is a solar-powered garbage bin which has sensors that monitor how full the garbage bin is. For example, sensors send an alert back to a centralized system when a bin hits a certain percentage of capacity so that it can be emptied rapidly. The bin also features solar-powered compaction, so that more waste can fit into the bins.

The real-time data from these sensors is sent to Big Belly's CLEAN management console. This is a dashboard that captures data on bin fullness and waste volume, which allows waste management companies to decide which locations need waste to be collected quickly, and which do not. Location-specific data enables waste collection route optimization. Moreover, historical data analysis allows the waste operator to reduce collection frequency/costs and allocate resources elsewhere [55].



Source: Big Belly website

Big Belly's solution was recognized as the Top Smart City Application in the 2014/2015 Internet of Things Awards. Moreover, the company's IoT-based waste management products/services are currently available in 47 countries around the world. In Melbourne, Australia, for instance, the city government spends AUD$9.8 million per year on waste management, and has recently purchased several Big Belly bins to reduce "overflowing" garbage bins around the city [56].

Case Study: Using Sensors Achieve Optimal Hydroponic Growing Conditions for Plants

In China, a company called Alesca Life is turning unused shipping containers into "highly automated hydroponic mini-farms". The company grows plants under LED lights in shipping containers, where automation and control systems monitor plants through sensors, collecting data on plant health and growth rate and adjusting the environment/nutrient supply accordingly to reach optimal growing conditions.

The company is a representative example how urban agriculture companies can use cloud-based data analytics in conjunction with sensors to apply software/hardware automation to enable convenient nutrient replacement, pH monitoring, temperature, lighting, humidity and other factors necessary for plant growth.

Alesca Life's mini-farms require no more than two hours of labor per week, since IoT-based software takes care of most of the maintenance [57] [58].

Disruptive Technology II: Machine Learning is Transforming How Society Understands the Exploding Volume of Data Being Collected

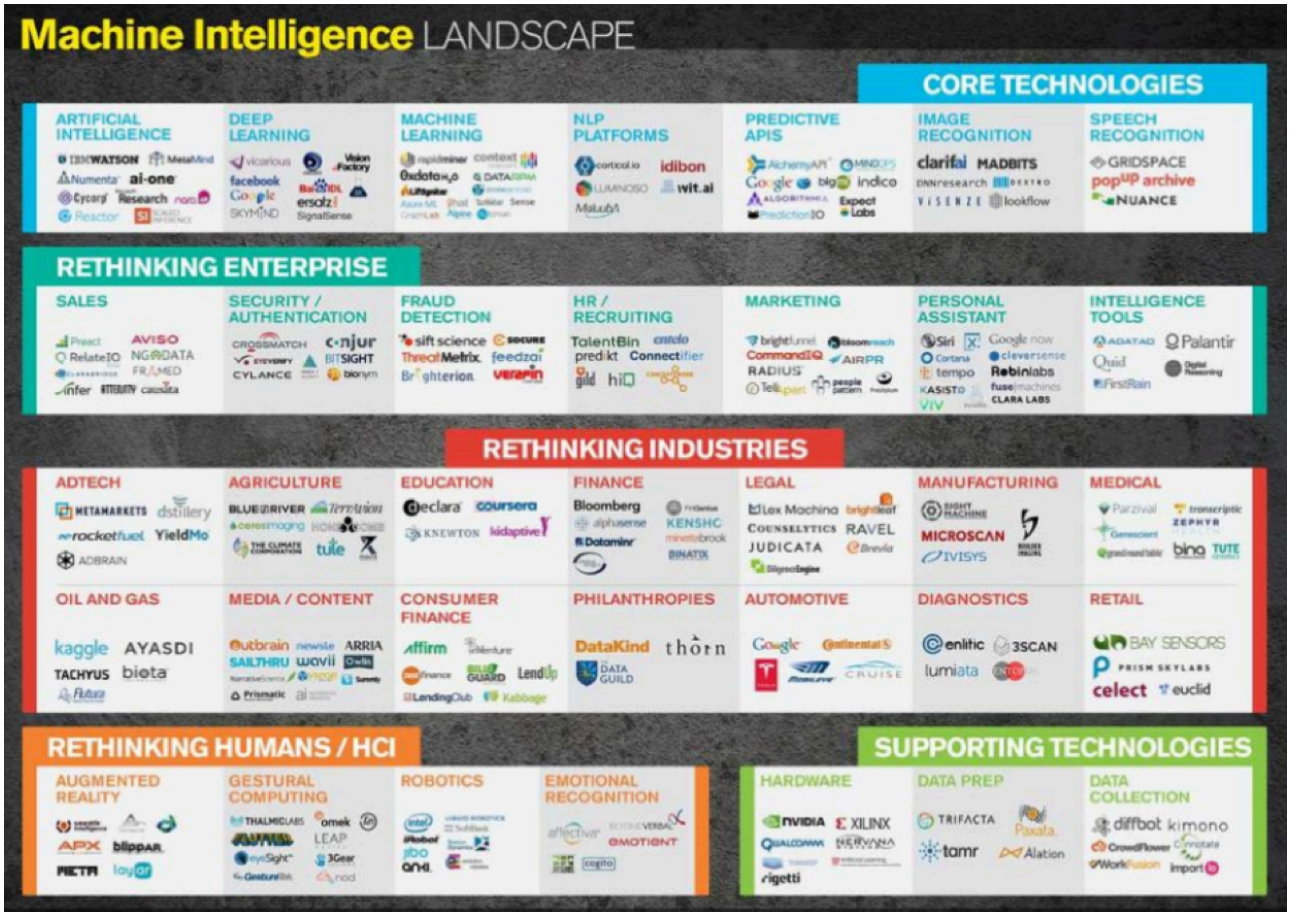
Machine Learning Makes Better Use of Big Data

"Big Data is the headache; deep learning is the solution," according to venture capitalist Steve Jurvetson, a partner at Draper Fisher Jurvetson and an early investor in multiple billion-dollar companies including SolarCity, Tesla Motors and Twitter. As millions of sensors connect "things" in the sustainability sector (and other sectors), there is an increasing demand to go beyond simply finding patterns in big data towards applying predictive/evolutionary algorithms to the staggering amounts of data being collected [59].

There are numerous examples of endeavors that are combining machine learning with sustainability. One example is Stanford University's sustainability and artificial intelligence lab which is working on (1) combining satellite imagery and machine learning to predict poverty and (2) modelling crop yields using computational methods to increase productivity and enhance food security [60].

The Market is Growing Rapidly at a CAGR of *38%*

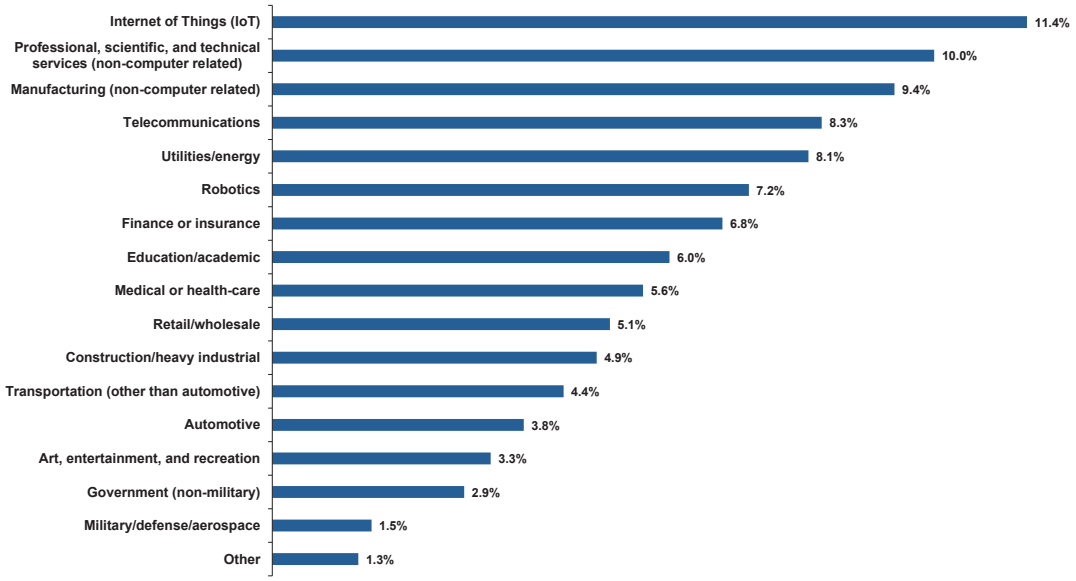
Machine learning, also described as "cognitive computing" is a fast growing market. The global cognitive computing market is expected to reach $12 billion in 2019, up from $2.5 billion in 2014, a CAGR of 38%. Machine learning is often confused with many other technologies, but it can be thought of as part of the "Machine Intelligence Landscape", as proposed by Shivon Zilis, an investor at BloombergBETA in San Francisco [61].



Source: Bloomberg

Machine learning is able to handle huge volumes of data, accelerating end-user access to the insights. With cognitive computing, the business can also see improved productivity and streamlined operations. IT teams, too, enjoy seeing some of the more mundane tasks automated so that resources can be directed instead to technology innovation and business growth. According to a report by Forbes in 2016, the top industries focusing on applying machine learning include Internet of Things (IoT), professional/scientific/technical services (non-computer related), manufacturing, telecommunications and utilities/energy [62].

Figure 23
Industries targeted by machine learning application developers, as of 2016



Source: Forbes, 2016

Case Study: Machine Learning to Facilitate Decision Making for Electric Grid Operators

EWeLiNE is a machine learning program that could work as an early-warning system for grid-operators to help them calculate renewable energy output over the next 48 hours.

This technology is vital for enhanced efficiency in the German power sector, because one-third of electricity in the country comes from renewables. As a result, Germany sometimes faces insufficient power supply on cloudy days and power overflows on sunny days. Inability to deal with such power fluctuation results in higher costs, as operators have to pay fees to coal/gas-powered utilities to adjust their power output to deal with this fluctuation [63].

To operate the grid more efficiently, operators need to be able to expect how much output renewables will produce at a given time. EWeLiNE is capable of collecting data from sensors on wind turbines and solar panels. This data is then combined with atmospheric observations collected by radar, satellites, and ground-weather stations, where the machine learning program predicts the renewable energy output over the next two days [64].

Case Study: Machine Learning to Predict Air Quality in Chinese Megacities

IBM's team in Beijing is using complex computer models and machine learning to calculate how pollution will spread across the city. They believe that AI will be a crucial factor in managing China's chronic pollution problem more successfully. The modelling system, which is called Green Horizon, is able to produce pollution forecasts with a resolution of one square kilometer up to 10 days in advance. These predictions have exceptionally high value for the municipal government, who can act to avoid worst-case scenarios, for instance by shutting down certain factories or reducing the number of cars on the road. IBM also models the economic impact

that such decisions would entail.

Green Horizon operates based on data captured from pollution sensors around the city. The system then uses complex modelling of both specific point-source pollution, weather patterns, and air movement to predict how bad pollution will be in certain neighborhoods. Previous data is then used to refine predictions using machine learning approaches [65] [66].

Disruptive Technology III: AR/VR Technology Development is at an Early Stage but Shows Strong Development Potential

AR/VR Helps to Make Intelligent Decisions

Virtual Reality and Augmented Reality (AR/VR) technology has shown signs of potential to enhance global sustainability, both directly and indirectly. A few examples are illustrated below:

- The Stanford Virtual Human Interaction Lab has shown how putting people in virtual reality can encourage them to act in ways that are more environmentally friendly. One study conducted involved subjects being shown a tree being cut down in a virtual world. The experience caused them to use 20% less paper in the real world on the day of the study, compared to those who only read about cutting down a tree. Moreover, their changes in attitude persisted a week later [67].
- QUT university in Australia has launched research on how VR and AR can lead to better quantitative decision making tools for environmental conservation. The research will combine VR, with other techniques to create improved quantitative decision-making tools for conservation, and will be underpinned by two real-world showcases: conservation of jaguars in the Peruvian Amazon and conservation of Australia's Great Barrier Reef [68].
- AR applications are also affecting supply chain management. SAP, for example, has crafted warehouse operations systems that use smart glasses from Vuzix to provide real-time data about products and materials. The high-level motivation is efficiency, but the software could be used to keep tabs on whether suppliers are conforming with sustainable sourcing guidelines. European logistics company DHL, along with another software company, Ubimax, began experimenting with this concept in January 2015 [69].
- VR can be used in planning greener cities. Virtual Oresund (VO) is a VR platform for sustainable city planning and design. The company's mission is to provide a VR Infrastructure-as-a-Service (IaaS) with open APIs for VR, augmented reality and data analytics tools so cities, architects, engineers, construction (AEC) and others can build virtual sustainable cities [70].

Entertainment is the Main Application

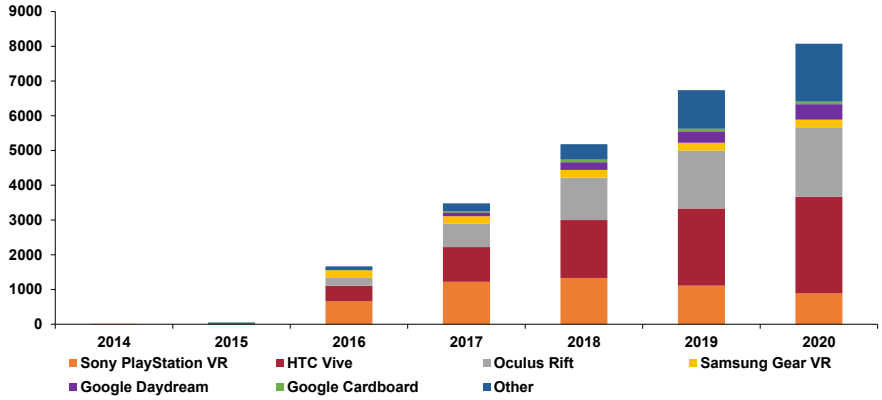
$828 million has been invested by VCs in VR since 2005, with especially fast growth since 2013. Smartphone VR currently dominates the share of addressable headsets in 2016, with an installed base of almost 16 million units and 87% of the addressable market. By 2020, this share is projected to decrease to 53% as other VR platforms find traction, but smartphone VR platforms will still represent the biggest addressable market for VR content. Consumer spending on VR entertainment content will reach $310 million in 2016 and is forecast to grow to $3.3 billion by 2020. The US will remain the largest market for VR entertainment content, reaching $1.2 billion by 2020. China is expected to have a relatively small VR entertainment market, at $200 million by 2020.

Although gamers are the earliest adopters of VR, some research firms believe that

the technology has the potential to transform business processes in a wide range of industries. There is potential for annual unit shipments of 10 million in 3-5 years and 50 million in 5-10 years. Currently, however, gaming is the main application. For instance, out of the 280 apps uploaded to OculusShare.com by developers, approximately 70% are gaming-related. Non-gaming uses included casual, educational, 360 video and horror [71].

The key players with a promising future on mobile VR are Facebook and Alphabet; these companies both have greater than 1bn active monthly users and several platforms, which could drive monetization opportunities for these firms. Google's Daydream will become the dominant smartphone platform by 2019 in terms of installed base of headsets reaching 14 million units that year. The Google VR platform could directly impact sales of Android-based phones [72] [73].

Figure 24
World VR headset sales value by headset brand ($, million)



Source: IHS, 2016

Possible Solutions for Current Constraints

According to Jefferies equity research, VR in China still remains at an early stage. Most products, even from domestic leaders such as Baofeng Mojing, have poor quality, low resolution, and only work with smartphones. Potential customers for such products are likely not sophisticated VR users and merely want to gain some VR experience. Useful VR applications such as education and online shopping are still under development to figure out the best solutions. Software and algorithms appear to be the most important sources of differentiation in products on the market. According to Shenzhen VRTRID Technology, an early mover in China's VR market, full immersion, high resolution and low dizziness are key success factors. These factors are achieved by solid software and algorithm development, rather than just combining high-end components such as powerful graphics processors [74].

Despite the uncertainty regarding VR market developments, major players are starting to apply the technology. Baidu, for example, recently unveiled an AR platform called DuSee that will allow China's mobile users to test smartphone augmented reality on their existing devices. While this technology is not as advanced as Google's Tango, it has the ability to bring AR to millions of users who are already using Baidu's mobile apps. Integrating the AR experience with

Baidu's apps can change the way consumers use these apps, paving a new way for advertisers to reach their audiences thus providing Baidu with a huge competitive edge [75].

Case Study: Proof-of-Concept of Using AR for Construction Work

Martin Bros. created their own on-site BIM CAVE (Computer Aided Virtual Environment), which allowed the company's VDC BIM Manager, Cody Nowak, to spend the past couple of years developing VR (Virtual Reality) and AR (Augmented Reality) solutions for the firm. The research and development recently culminated in the pinnacle of his team's research—yielding quite possibly one of the most exciting innovations to hit the AEC tech sector in the past decade.

With the HoloLens superimposing the augmented reality pod design on the top and bottom of a frame, a builder followed the scaled 3D projection seen through his HoloLens headset to complete physical construction. Among other exciting aspects, this process involved direct interaction between the AR world and the real world, delivering fascinating, tangible results [76].

Disruptive Technology IV: Blockchain has shed negative perceptions but is still at an early stage in terms of application

From a sustainability perspective, blockchain can create a distributed and connected energy future. The MIT Media Lab recently hosted an inaugural event on this topic. A key takeaway was that blockchain can enable the tokenization of energy – this means that in a local energy trading market, the actual monetary value of energy traded may not be as valuable as the fact that the energy was generated from a renewable source in a certain neighborhood. This means that any revenue transferred will return to the local economy.

Blockchain is Gaining Traction

In addition, the United Nations (UN) has recently explored how blockchain might contribute to achieving the UN's sustainable development goals. The idea that blockchain technology could yield new solutions in finance and beyond has gained attention within the UN, especially due to its potential to drive change in governance and identity [77].

What is Blockchain?

A blockchain is a public ledger of all Bitcoin transactions that have ever been executed. It is constantly growing as 'completed' blocks which are added to it with a new set of recordings. The blocks are added to the blockchain in a linear, chronological order. Each node (computer connected to the Bitcoin network using a client that performs the task of validating and relaying transactions) gets a copy of the blockchain, which gets downloaded automatically upon joining the Bitcoin network. The blockchain has complete information about the addresses and their balances right from the genesis block to the most recently completed block.

In short, blockchain is a type of "distributed ledger" that enables the creation of easily updateable, secure, immutable, flexible and universally accessible digital records of asset ownership. And 2015 was the year that it rose to prominence, as investors began to wake up to its wide-ranging utilities beyond the world of cryptocurrencies [78].

One of most interesting features of blockchain's rise in 2015 was the type of businesses touting its potential. Traditionally focused on payments infrastructure, startups are emerging presenting a wide variety of use-cases in diverse sectors

such as trade finance, increasingly seeking to demonstrate its potential to disintermediate and decentralize established institutions and services by developing streamlined processes that undercut incumbents' roles at the heart of the consumer experience [79].

Blockchain is increasingly seeing new payment applications across a range of sectors. These include (1) digital content, document storage and delivery; (2) authentication and authorization; (3) digital identity; (4) marketplace; (5) smart contracts; (6) real estate; (7) precious stones/metals; (8) internet of things; (9) app development; (10) network structure and APIs; (11) currency exchange and remittance; (12) P2P transfer; (13) ride sharing; (14) data storage; (15) trading platforms; and (16) gaming. Investor sentiment is particular strong for remittance, trading platforms, P2P transfer, smart contracts, precious stones/metals and IoT applications [80].

Despite the increasing interest in blockchain, challenges remain. The technology is not yet scalable, few use cases have been properly developed and cost savings haven't yet been sized. But the ambition is high: if blockchain technology can be widely adopted it could lead to fundamental changes for the various market participants, and could revamp large parts of the industry value chain [81].

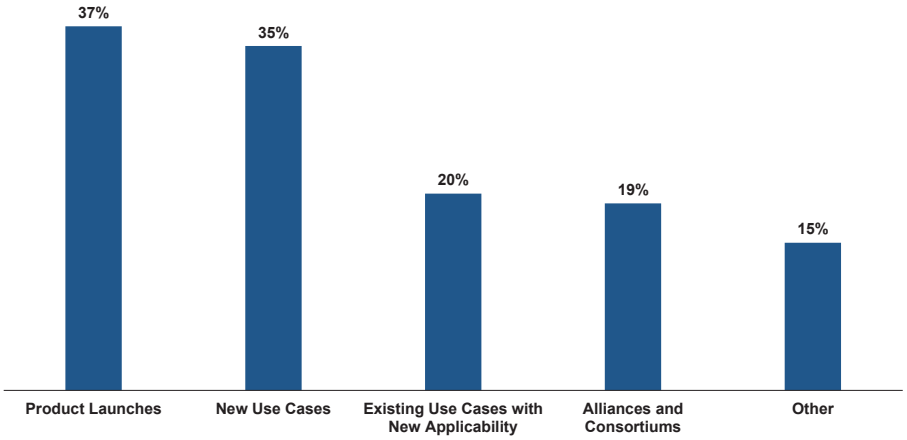
Market Growth at a High CAGR of *61.5%*

The blockchain technology market is estimated to grow from $210.2 million in 2016 to $2.3 billion by 2021, at a CAGR of 61.5%. The blockchain technology market is segmented into various segments, out of which the Banking, Financial Services, and Insurance (BFSI) sector is expected to dominate the market with the largest market share. This has strong implications for sustainability as shown in the case study below, as new financial tools can incentive renewable energy generation [82].

North America is expected to hold the largest share of the blockchain technology market in 2016 due to the technological advancements and early adoption of blockchain technology in the region. The market in APAC is expected to grow at the highest CAGR between 2016 and 2021 due to huge opportunities across industry verticals in APAC countries, especially China, India, and Australia [83].

Although the future of blockchain is uncertain, 2015 was a pivotal year for the technology. Skepticism surrounding the technology gradually eroded, and better understanding of its potential increased. Deloitte surveyed an important cryptocurrency community on the question "what do you think will be the biggest breakthrough in the blockchain space in 2016?". Figure 26 below shows the responses; most respondents believed that product launches and new use cases would be the main breakthroughs. New use cases may have particular sustainability relevance as demonstrated below with the case of SolarCoin [84].

Figure 25
What do you think will be the biggest breakthrough in the blockchain space in 2016?



Source: Deloitte, 2016

Case Study: Blockchain Technology Can Encourage Renewable Energy Generation

Blockchain and bitcoin technology are inspiring the development of new digital currencies which can have positive impacts on sustainability. For instance, SolarCoin, launched in 2014, is a digital currency which is coupled to solar energy and rewards solar energy producers. Each MWh of solar electricity produced by a PV installation awards one SolarCoin, incentivizing the implementation of solar power worldwide. Transactions using SolarCoin are recorded and validated by a peer to peer network of computers, similar to blockchain/bitcoin technology.

More than 70,000 SolarCoins have already been granted to owners of solar power projects. This is still a small fraction of the remaining amount to be granted, given that 240GWp of solar panels were already installed globally by the end of 2015. This capacity represents 240 million solar coins to be potentially granted. The International Energy Agency estimates that installed capacity could reach 900GWp by 2030. 98.5 BillionSolarCoins were created and set aside to reward solar energy producers. [85] [86]

Disruptive Technology V: 3D printing has enormous potential, but sustainability impact will be defined by how it is applied across sectors

3DP Can Reduce Resource Intensity in Manufacturing

3DP has the potential to decrease resource-intensity in manufacturing. Traditionally, in order to build a product, it is necessary to remove pieces from a larger object until you get the desired shape. It is also possible to inject material into a mold. However, these processes require significant resources and produce excess amounts of waste, which is avoided with 3DP technology. In addition, 3D printers can also provide strong environmental benefits from a green materials perspective, as shown by a research team at UC Berkeley which conducted a life cycle analysis of 3D printing technology. 3D printers can use an alternative plastic called polylactic acid (PLA) which biodegrades. Due to its advantages, PLA is becoming a standard 3D printing material [87].

In the long term, however, how society chooses to use 3D printers will be the crucial factor in whether the technology can aid in lowering emissions. For instance, researchers in The Netherlands found that 3D printing contains the potential to reduce costs by $170-$593 billion, the total primary energy supply by 2.54–9.30 EJ and CO_2 emissions by 130.5–525.5 Mt by 2025 (the great range within the saving potentials can be explained with the immature state of the technology and the associated uncertainties of predicting market and technology developments). The energy and CO_2 emission intensities of industrial manufacturing are reducible by maximally 5% through 3D printing by 2025, as it remains a niche technology. If, however, 3D printing was applicable to larger production volumes in consumer products or automotive manufacturing, it contains the (theoretical) potential to absolutely decouple energy and CO_2 emission from economic activity [88].

Increasing Interest in 3DP From Large Corporations

Corporations around the world have recognized the potential of 3D printing to save time and money in the design and manufacturing process. 3DP is defined as "the additive manufacturing of objects by depositing and patterning successive layers of material". Currently, 3DP's largest applications are for making prototypes, but direct production of end-use parts is beginning to grow in industries like aerospace, medical, automotive, consumer products, architecture and electronics.

For example, General Electric recently announced plans to invest $1.4 billion in acquiring two European 3DP companies, and expects its 3DP business to grow to $1 billion by 2020 [89]. In addition, Daimler, the world's largest truck manufacturer, will use 3DP to produce spare parts such as spring caps and cable ducts. Volkswagen and BMW are engaging in similar initiatives. By printing new parts, automakers can save logistics and warehouse storage costs and produce complex components at low volumes.

The 3DP Market Will Reach $12 bn in 2025

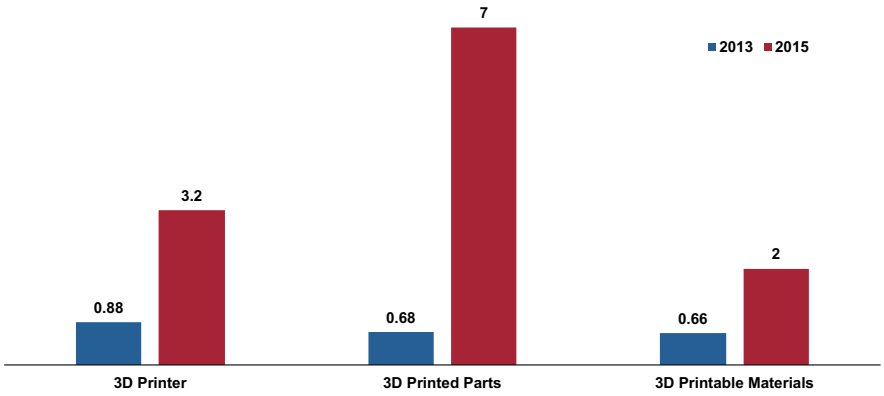
The total market for 3DP could range between $7 billion to $22.8 billion by 2025, with the most likely market size being $12 billion. The overall 3DP market can be segmented into three further categories: (1) 3D-printable materials; (2) 3D printers; and (3) 3D printed parts [90].

3D printable materials include low grade plastics (PLA, ABS, polyolefins, wax, etc.); mid-range plastics (nylon, PET, acrylic, styrene etc.); high-end plastics (PEEK, PEKK, PEI) low-end metals (stainless steel, aluminum alloys, magnesium etc.); high-end metals (titanium, cobalt-chrome, nickel super-alloys) and other materials (ceramics, precious metals, living cells, carbon nanomaterial composites etc.). The printable materials market is forecast to reach $2 billion in 2025, up from $661 million in 2013, a 9% CAGR.

3D printers include desktop printers (all printers under $5,000); industrial polymers (larger polymer printers used for large-scale prototypes and production of final parts); metal printers (all-metal printers), and other printers (ceramics printers, hybrid technologies, novel printing methods). The market for 3D printers will reach $3.2 billion in 2025, up from $857 million in 2013, a 12% CAGR.

3D printed part types include prototypes (direct printing of aesthetic/functional prototypes); molds and tooling (objects for use in manufacturing production lines to produce prototypes and end parts); and production parts (end-use parts for sale or internal use across all industries). The 3D printed part market is estimated to reach $7.0 billion by 2025, up from $684 million in 2013, a 21% CAGR.

Figure 26
Total market for 3D printers, printable materials and printed parts ($, billion)



Source: Lux Research, 2016

Market Leaders

The leading publicly traded 3D printer producers include 3D Systems, Stratasys, EOS and ExOne. According to Wohlers Associates, Stratasys' $750 million in 2014 revenue from printers, materials and services makes it the 3DP technology industry's largest player, with an 18% market share, followed by 3D Systems with an estimated 15% market share [91].

Case Study: Stratasys is Making 3D Printing Available in a Range of Industries

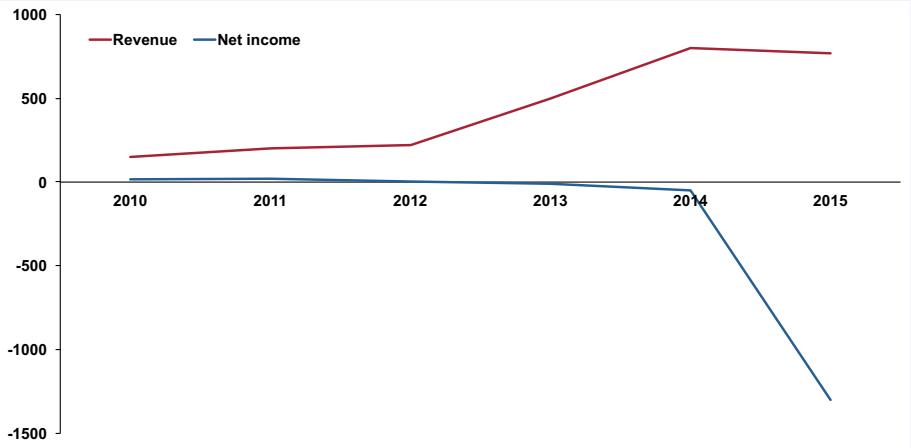
Stratasys, which was founded in 1998, is a provider of three dimensional (3D) printing and additive manufacturing (AM) solutions for the creation of parts used in the processes of designing and manufacturing products and for the direct manufacture of end parts. The company currently has 2,700 employees. The company's solutions include products ranging from entry-level desktop 3D printers to systems for rapid prototyping (RP) and production systems for direct digital manufacturing (DDM). The company also develops, manufactures and sells materials for use with its systems and provides related services offerings. Stratasys' products and services are used in different applications by customers in a range of industries, including aerospace, automotive, consumer electronics, consumer goods, medical processes and medical devices, education, dental, jewelry and others.

The company competes with 3D Systems Corporation, EOS GmbH, XYZ Printing, Ultimaker, Tiertime and EnvisionTEC GmbH.

Financials and forecast performance

Stratasys' revenues have been growing at a CAGR of 43% since 2010 to $696 million, while net income plummeted to -$1.37 billion in the 2015 FY, indicating a period of accelerated M&A. Morningstar research estimates that over a 10-year forecast horizon, average annual revenue growth will be in the 12% range (versus 15% previously), reflecting organic growth supplemented by niche acquisitions. Moreover, long-run average gross margins will be in the low- to mid-40% range, reflecting moderating gross margins on hardware sales balanced by a rising contribution from high-margin consumables and services.

Figure 27
Stratasys revenue & income, 2010 - 2015



Source: Thomson Reuters Database, 2016

SSYS seeks to assemble an expanding "ecosystem" of printers, materials, software, consulting services, and service bureaus to provide customer-centric solutions and one-stop shopping for professional and industrial customers. The company's recently expanded and strengthened Stratasys Direct Manufacturing service bureau and its GrabCAD software unit will be helpful in assessing customer needs, and demonstrating the value of its products in use.

The 3D printing marketplace is transitioning quickly beyond its early-adoption and general consumer experimentation phase toward one driven more by industry-specific solutions and applications. Stratasys is steadily repositioning to focus on rapid prototyping for engineering and design and a greater emphasis on finished-parts production [92].

Disruptive Technology VI: Advanced Materials Have Strong Potential Linkages in Cleantech

Sustainable Materials are Blend of Advanced Material Technologies

Advanced materials have strong linkages to sustainability. "Sustainable materials" are those used throughout the consumer/industrial economy that can be produced in required volumes without depleting non-renewable resources. Such materials vary enormously and may range from bio-based polymers derived from polysaccharides, or highly recyclable materials such as glass that can be reprocessed an indefinite number of times without requiring additional mineral resources [93].

Building and construction activities worldwide consume about 40 percent of total global use annually. Using green building materials and products can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these building industry source materials [94]. For example, in the pre-fabricated housing industry, there is a growing interest in the use of composite wall systems due to lower environmental impact, light weight, and lower energy consumption [95]. Moreover, in materials science research, with increased development of high-tech insulation products, the use of natural materials with low environmental impact has been growing over time. One research study commented that a promising future direction is "the production of environmental friendly insulating materials by combining bio-based

materials with nanotechnology using a low-tech/high-tech approach." [96].

One example of a company engaging in circular economy principles to the materials production process is Morgan Advanced Materials, a global leader in the development and application of advanced material technologies. One circular economy initiative resulted in a 50% reduction in chlorine use at one of its sites, a 23% saving in natural gas usage at a site, and a 7 percent global reduction of energy intensity across the group [97].

Lastly, advanced materials can affect the efficiency of power devices. For example, material performance determines efficiency of batteries and solar PV. The same holds true in most electronic chips: efficiency of semi-conductor materials affect the energy efficiency of many electronic devices. One example for the power device case is DuPont, which is developing advanced materials that can enhance the efficiency of solar panels through higher fine line capacity, processing latitude and reliability [98].

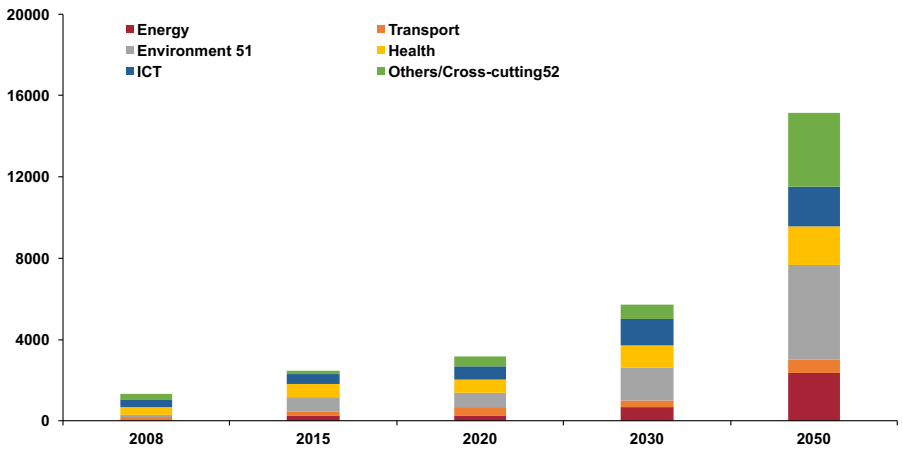
The Market is Broad and Highly Segmented

The advanced materials space covers a broad spectrum of technologies. The main branches of advanced materials can be divided into three main categories: (1) Surfaces: coating and surface treatment technologies that impart/enhance material properties; (2) Structures: Materials used to form the bulk composition of parts, and key advances in the process technologies used to produce and process them; and (3) Future material platforms: Novel, emerging material technologies that offer high long term disruptive potential by increasing the range of what properties future materials can offer [99].

Advanced materials differ from traditional materials such as steel and aluminum. They have high strength and multi-functionality, and can be lightweight, fire and chemical resistant. Advanced materials include materials such as biocompatible materials, fibers, resins, specialty resins and formulations, composites, hybrid materials, superconducting materials and nanomaterials, high performance ceramics, glass fiber and carbon fiber.

The European Commission projected the size of markets where value added materials (VAMs –defined as materials which are knowledge-intensive, multi-functional, and beneficial to competitive advantage) are applied to 2050. They estimated the size of potential end markets in 2015 at about $2.6 trillion, with a translating into a direct opportunity for material providers of $166 billion [100] [101].

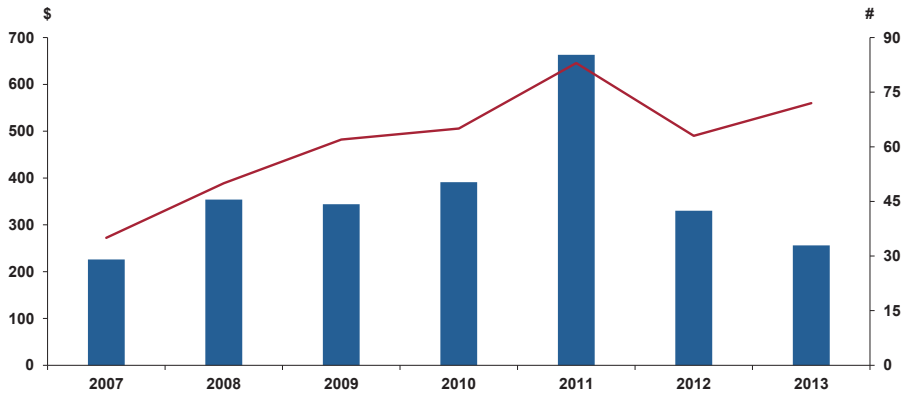
Figure 28
Size of identified markets where VAMs are applied (€, billion)



Source: Oxford Research

In addition to a large projected market size, advanced materials companies have attracted $4.9 billion in investment over the 13 years prior to 2013, $3.5 billion of which came from venture capital investments. Between 2007 and 2012, the sector consistently attracted about five percent of total Cleantech venture capital. Compared to other Cleantech sectors, advanced materials attracts a wider range of funding types, from corporate investment to government grants [102].

Figure 29
Global VC investment in advanced materials



Source: Cleantech Group

There has been strong activity with regards to medium-sized funding rounds in the past few years in the advanced materials sector. For instance, Beneq, the finish developer of spray nanotechnology used to add solar control properties to soda-lime-silica glass, received 25 million EUR in growth equity from RUSNANO to set up a facility in Russia [103]. Covaron Advanced Materials produces a two-part ceramic formulation for producing thermal barrier coatings, foams, molds and toolings, and raised $550,000 in Series A seed funding in 2013 [104]. Polyera, as US-based supplier of materials for the printed and flexible electronics industries, received $24.5 million Series C financing from Chengwei Capital, Solvay Ventures and Tsing Capital to invest in expanding Asia operations [105].

Case Study: Physee is Using Advanced Materials for Energy Generation on Windows

PHYSEE

Physee is a company that produces luminescent coating for windows to convert light into electricity, called “PowerWindows”. These are transparent, double-paned windows that convert light into electricity. While conventional glass reflects about 30% of the incoming light, Physee’s coating transports light through the glass and converts it into electricity. The company’s product comes at a time when EU regulations have stipulated that commercial and governmental building construction or renovation has to be energy neutral by 2020. Commercial real estate developers are currently confronted with this challenge [106]. The product is shown in Figure 30.

The company was founded in 2014 by two Dutch Physics students, Physee received between $600,000 to $1.2 million in seed funding from TU Delft and the Dutch government. The company is looking for further funding of $2 million in 2017 for research and development (R&D), product development, and sales.

Physee's PowerWindow has an electrical conversion efficiency of roughly 2%, allowing 20W/m^2 of power output. The coating contains a host crystal with a 3% concentration of Tm^{2+} doped inorganic luminescent material. It is produced by a magnetron sputtering method which is standard in the glass industry. The coating is colorless, and its luminescent material does not degrade over time. The PowerWindow has an estimated life expectancy of 15 years to 20 years, and it will work with any type of transparent surface including plastic, triple pane or curved glass [107].

Figure 30
Physee's PowerWindow

Source: Lux Research, 2016

Business Model Innovations

In sectors related to sustainability, numerous innovative business models have been developed in the last few years. It is increasingly crucial for companies in this area to determine the business model that gives them the best revenue position. There are usually a few options these companies face as explained below:

Hardware vs. Software

Several example of business model innovation with regards to hardware and software can be found in the solar power sector. Some companies focus on manufacturing specialized components, such as companies including First Solar, JA Solar, Kyocera and more. Other companies, on the other hand, are developing software that focus on system monitoring and proprietary algorithms to optimize design and engineering. Notable examples include HST Solar [108] and SolarWinds [109].

Product vs. Services

China's solar PV landscape has a large fraction of solar product manufacturers and providers. However, an example of a Chinese company engaged in platform solutions is Seeder, a Shanghai-based startup. Using their strong network, Seeder provides a platform and rigorous methodology to identify the quality-proven suppliers for clients based on company profile, project requirements, and geographic location.

Another typical example is drones with applications in agriculture. Manufacturing agriculture-specified drones may not be as profitable as providing pesticide/ fertilizer spraying services. For instance, companies can provide drone-based imaging services to reduce the amount of herbicide required on crops [110].

Vertical Solution Provider vs. Platform

Another example of business model innovation in sustainability is companies designing vertical solutions or platform solutions. In the European water treatment and biogas industries, one example of a successful vertical solution provider is the Swedish company Malmberg [111] which builds and maintains comprehensive turnkey treatment facility solutions for clients across the globe based on in-house technology and expertise. On the other hand, in the solar industry, platform providers such as SolarCity is a provider of platform energy services. The company designs, finances and installs solar power systems, but does not have complete vertical integration.

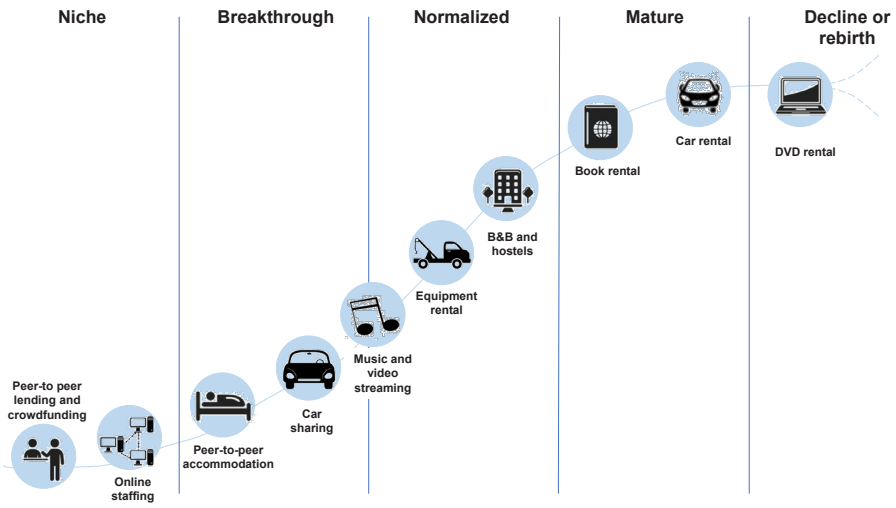
Ecosystem Integration

A high profile "green" company engaged in ecosystem building strategy is Tesla. The company, in addition to its core business of manufacturing electric vehicles, has recently unveiled products wall-mounted battery packs for homes, businesses and utilities in a bid to expand its ecosystem offering [112]. The company's recent announcement regarding solar roof tiles continue this ecosystem-building trend [113].

Sharing Economy

In the last few years, the sharing economy has drawn the world's attention through rapid development and fundraising of a few star companies, including Uber, AirBnB, Didi Chuxing, etc. The sharing economy can be described as "the result of long-term megatrends colliding together, driven mainly by advances in technology, resource scarcity and social change [114]." According to PwC, total revenues for five prominent sharing economy sectors – P2P finance, P2P accommodation, online staffing, car sharing, music/video streaming – could hit $335 billion by 2025, up from $15 billion in 2014. Figure 31 shows the potential S-curve pattern that these sectors may exhibit [115].

Figure 31
The sharing economy life cycle



Source: PwC, 2014

The growing sharing economy revenue trend reflects how the sharing economy is becoming an essential feature of modern society. Currently, 44% of US consumers are familiar with the sharing economy and 19% of consumers have engaged in sharing economy transactions [116].

Beijing MoBike Technology Co., founded in 2015, is a self-service bike-sharing system based on a mobile app. The company is backed by Chinese internet giant Tencent Holdings among others, and closed a $100 million funding round in October 2016. Its main competitor is ofo, a similar bike rental app. Both companies have tweaked the Vélib' bike-sharing pioneered in Paris 10 years ago by integrating bicycles with stand-alone locks that activate with a mobile payment. Find a bike nearby, ride where you want, then ditch it wherever for the next user. The bikes are installed with electronic chips, GPS and sensors in order to make it easy for people to locate them [117] [118].

To use the system, users simply download the MoBike app and supply their national identity number. Users must have just 299 yuan as a deposit to use the bikes. Nearby available bikes are located via GPS and their QR codes must be scanned, after which they are unlocked and ready to ride [119].

Investors hope the model is globally scalable to more developed countries where rental rates are higher. MoBikes, for example, rent for just $0.15 per half-hour in Shanghai, which at an average of 6 half-hour rides a day would generate less than $1 daily. In New York, Citi Bike charges $12 for a day pass [120].

TaskRabbit is an online and mobile marketplace that matches freelance labour with local demand, allowing people to outsource tasks and errands such as cleaning, moving, delivery and handyman work. The company was founded by Leah Busque in 2008, and has received $37.7 million in funding so far, although it has yet to become profitable [121].

Financing Innovation

In recent years, there have been several business model innovations in financing. One such innovation was mentioned earlier in this chapter, the example of SolarCoin. Another, more high-profile innovation in financing in recent years is crowdfunding, which refers to the practice of funding a project or venture by raising funds from a large number of individual investors. Some of the most popular crowdfunding platforms in recent years include Kickstarter and Indiegogo, the world's largest crowdfunding site [122]. The total global crowdfunding industry's estimated fundraising volume in 2015 was about $34 billion [123].

One recent example of how crowdfunding has been applied to sustainability is Solar Mosaic Inc., the leading residential solar lending platform in the US. Mosaic is a platform that acts as an online marketplace for investors of solar power projects. Its platform connects investors to solar projects in need of financing; and allows them to generate revenue and interest on their projects by selling the produced electricity to solar customers. The company's platform also enables users to apply home solar loans online to purchase solar installations. Solar Mosaic, Inc. was founded in 2009 and is based in Oakland, California [124]. The company has already raised a total of $285.17 million in 6 rounds from 13 investors, with the most recent funding in August 2016 of $40 million [125].

The company is currently the US' top loan provider for residential solar installations, and the average loan amount is $30,000. The loans can be paid back over 10,15 or 20 years, with interest rates between 2.49 percent and 7.99 percent. Mosaic aims to originate $1 billion in home solar loans in the next year [126].

Defining the Future of Sustainable Technology Investment

Sustainability investment is seeing robust growth, continuing the trend witnessed in the past 17 years. Tsing Capital, as a pioneer in this investment space, has experienced the market-shaping disruptions that have driven the sustainability sector in recent history.

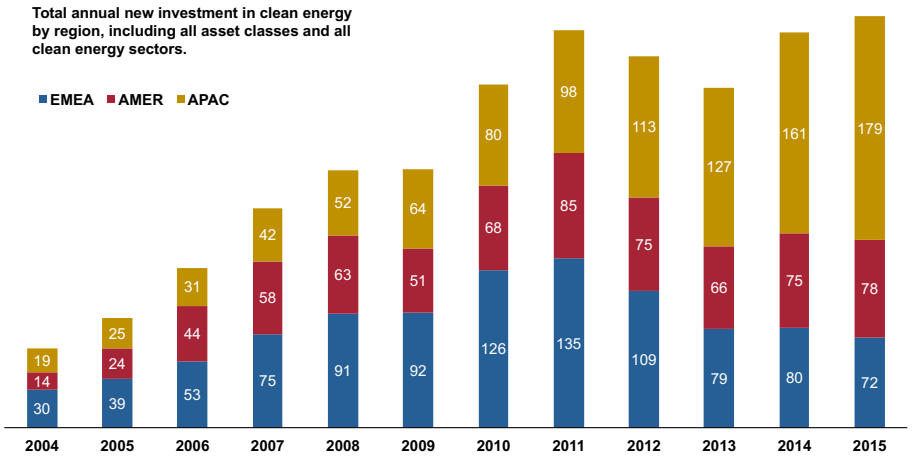
Chapter 4 provides insights to our partners regarding the current era of sustainability investment that we find ourselves in. In the past 17 years, the sustainability market has gone through three phases. The first phase is coined the "Envirotech" phase, which was policy driven, CAPEX-intensive, and reliant on scaling-up capability. The second "Cleantech" phase was CAPEX-efficient, but commercialization bottlenecks plagued the industry. Based on Tsing Capital's analysis, we are currently in the "Sustaintech" phase, which is characterized as demand-driven, innovative in terms of technology and business models, intelligent, and has a high degree of internet-integration.

Chapter 4 provides case studies that demonstrate the potential of disruptions to shape sustainability, including sustainable mobility and the Energy Internet. Lastly, the chapter concludes with an in-depth look at Tsing Capital's recent investment focus and investment approaches/ criteria.

Booming Sustainability Investment

Investment in sustainability globally has been constantly increasing over the past 17 years. According to Bloomberg New Energy Finance, global new investment in sustainability has reached a historical high at $329 billion [127]. This total investment includes venture capital/private equity investment, government R&D grants, corporate R&D grants, and asset finance. The Asia Pacific region was an especially significant contributor to global sustainability investment. With strong government policy support, China has experienced a rapid increase in sustainability investment over the years. By 2015, total sustainability investment in China has reached a record of $101.2 billion [128].

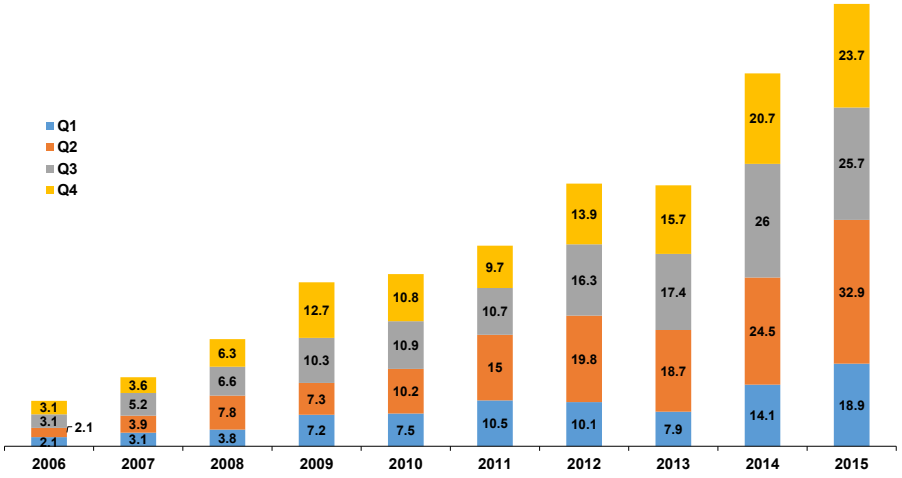
Figure 32
Global sustainability investment reached historical new high at $329 billion in 2015 ($, billion)



Note: The investment in 2015 includes corporate and government R&D and spending for digital energy and energy storage projects.

Source: Bloomberg, 2016

Figure 33
The total amount of sustainability investment in China has reached a historical high at $101.2 billion in 2015 ($, billion)



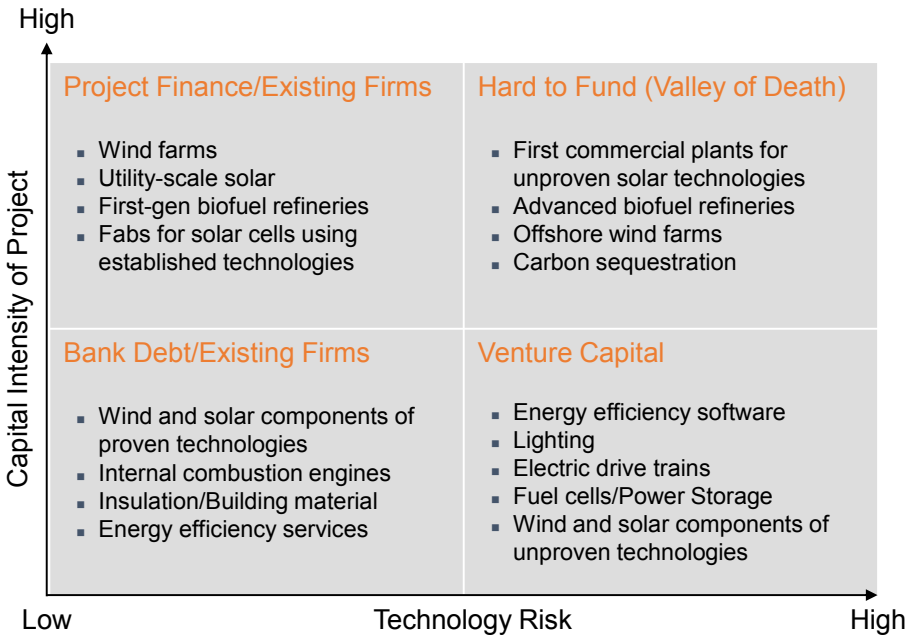
Note: The investment amount in 2015 includes undisclosed deals; excludes corporate and government R&D, and spending for digital energy and energy storage projects.

Source: McKinsey, 2016

Sources of sustainability technology investments depend on the level of technology risk and the CAPEX level. Project finance and bank financing can provide financing solutions for high CAPEX sustainability projects with low technology risk. Relatively mature sustainability technologies like solar and wind farms fall into this category.

Capital-intensive companies with high technology risks can easily fall into a "Valley of Death" stage, and generally find it difficult to secure funding. Energy Breakthrough Coalition, which has a higher tolerance for technology risk, was established to fund companies at that stage. Venture capital firms in general are in the best position to invest in low CAPEX and high technology risk areas [129].

Figure 34
The investment landscape for sustainability industry



Source: Harvard Business School, 2010

- Government

  The current 21 Mission Innovation countries together have invested about $15 billion per year on sustainability R&D investment. It is projected that R&D investment will reach $29.5 billion by 2021 [130].

- Project Finance

  In the past 17 years, certain sustainability technologies have become more mature, which has greatly encouraged debt investors to invest large sums of money to scale up such technology. Despite the challenging global capital market between 2007 and 2009, project finance of mature technologies, such as solar and wind farms, accounted for over 50 percent of the $500 billion in new investments [129].

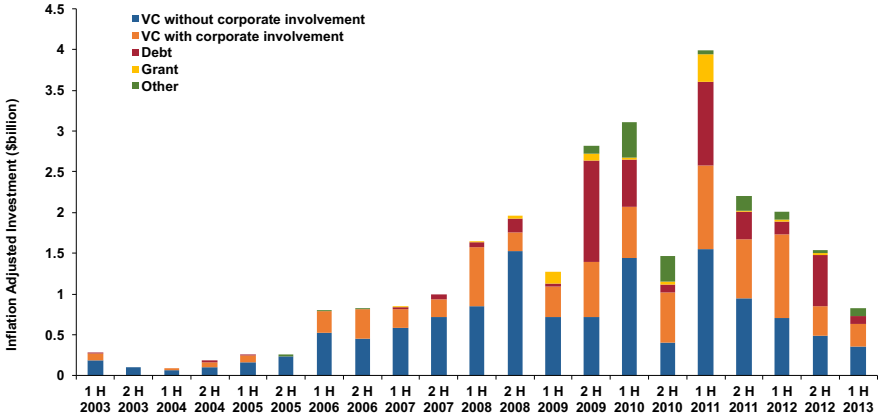
- Venture Capital

  Venture capital firms (e.g. Tsing Capital, Emerald, Khosla Ventures, etc.) or corporate VCs (e.g. General Electric, ABB, BASF, Bosch, etc.) are generally more interested in CAPEX efficient companies. Moreover, they have higher tolerance for technology and business uncertainty [127]. The sustainability industry is challenging for venture capital investment due to four reasons: (1) Typically, companies take a longer time to establish and scale-up their business, sometimes

even longer than a venture capital fund's lifetime; (2) Technology based companies require a large amount of funding to continuously support R&D, which can be challenging if the company has not made stable revenue yet and is purely backed by venture capital funding; (3) For companies relying on scaling-up of mature technologies, there is usually a small margin for error to compete in commodity markets; (4) It is comparatively difficult for VCs to exit through M&A, as utilities and industrial giants are unlikely to acquire risky start-ups and are averse to paying a premium for future growth prospects. According to a report by the MIT Energy Initiative, on average, sustainability start-ups in materials, processes, chemicals and hardware integration only returned a sixth of invested capital and 5 cents on the dollar respectively [127]. Therefore, it is crucial for VCs to have competence in identifying companies with promising technologies, determining the best timing for investment, and securing strategic partnerships or follow-up funding for the companies.

Despite challenges in sustainability investment, venture capital funds play a unique and vital role because they can tolerate the high risks related to immature technology, management expertise or commercialization capabilities. Even though venture capital investments have fluctuated in recent years, companies still receive the largest portion of early and growth stage investments from venture capital firms [129]. California, one of world's most advanced sustainable technology bases, represents how the investment landscape has evolved during the past 10 years. VC firms, independent or corporate, compose a significant percentage of total sustainability companies' financing, while grants and debt are also becoming prevalent in the sustainability industry. California alone received two thirds of total U.S. venture capital investments in the sustainability field. In 2012 alone, VC investments accounted for 74.8% of total sustainability company financing [131].

Figure 35
Independent or corporate VC played a vital role in accelerating California's sustainability industry.



Source: Next 10.org, 2013

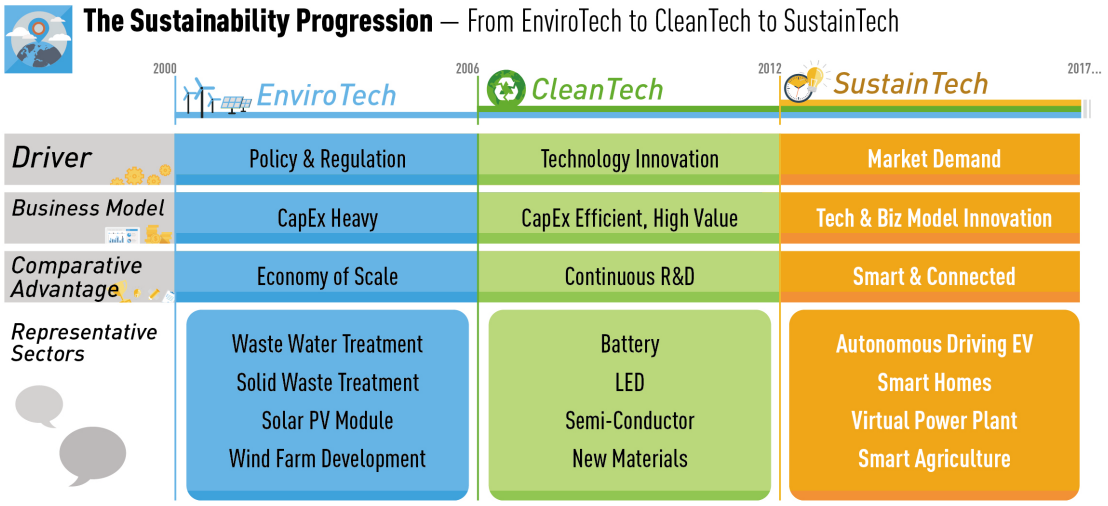
Tsing Capital has witnessed and experienced the oscillations in sustainability

investment in the past 17 years. It pays close attention to developments in the sustainability industry. These experiences give Tsing Capital unparalleled expertise in identifying promising companies for investment deals, and avoiding future weaknesses in sustainability investment.

Evolution of the Sustainability Technology Market Over the Past 17 Years

The sustainability technology market has undergone significant evolution over the past 17 years. There have been three main stages of development. The first stage of sustainability saw companies focusing on environmental protection (Envirotech), which is policy-driven, CAPEX-intensive and relies on rapid growth to achieve better economies of scale. The second stage is when innovation took over as a driver of the sustainability industry, producing a wave of high value and CAPEX- efficient companies (Cleantech). The third and current stage of sustainability is demand-driven, with disruptive innovation in both the technology and business model spheres (Sustaintech). Intelligent technology, internet connection and innovative business models have disrupted the traditional Cleantech landscape and opened up tremendous new opportunities in the sustainability industry.

Figure 36
The Evolution of Envirotech, Cleantech and Sustaintech



Source: Tsing Capital Strategy&Research Center, 2016

Envirotech: Policy-Driven, CAPEX Intensive, and Reliant on Scaling-up Capability

The first stage of environmental technology (Envirotech) at the beginning of the 21st century mainly addressed traditional environmental issues, such as solid waste treatment and water treatment issues. Renewable energy such as wind and solar were picking up pace as well. Tsing Capital initiated the first China Environment Fund in 2000 in response to these trends. In this era, the environmental industry was CAPEX-intensive, heavily influenced by government policy, and dependent on scaling up for competitive advantage.

Cleantech: Innovation-Driven, CAPEX-Efficient, Longer Time to Commercialize

After Envirotech, the sustainability industry encountered a turning point, where innovation became a key driver. Cleantech became the new buzzword to describe this new trend in the sustainability industry, and new technologies were constantly being developed. Numerous Cleantech technologies saw rapid cost reductions during this period and became more mature. Solar photovoltaics, for example, has undergone multiple rounds of innovation and seen rapid cost reductions.

New industries also emerged in this field. For instance, electric vehicle related technology, LEDs, batteries, semiconductors, and energy efficiency-related fields became increasingly important areas that have seen breakthroughs in technology. Certain sustainability technologies, after a long research and development period, established high technical barriers for competitors to enter and realized strong revenue growth, but may however take longer to commercialize.

Sustaintech: Demand-Driven, Technology + Business Model, Intelligent + Internet + Integrated

The latest evolution of sustainability companies, defined as the Sustaintech phase, applies digital tools and business models to accelerate the removal of environmental, energy and resource constraints. A shift towards less capital-intensive and more digitally-enabled sustainable technology was a result of the proliferation of digital technologies and the commoditization of the first generation of Cleantech. Applications could include the acceleration of renewable technologies by improving customer engagement, using big data to optimize energy efficiency, and utilizing social media to encourage sustainable technology adoption. The digital revolution has led to the betterment of existing clean technologies. For example, the "hard costs" in photovoltaic panels have dropped significantly over the past decades, and resulting "soft costs" related to financing, sales, marketing, permitting and installation etc. became the larger portion of solar installation expenses, since digital technologies can reduce hard-cost expenditure. Digital technologies are also being widely used in other sustainability technology companies, for example in firms that optimize building energy performance or seek charging stations for electric vehicles. The proliferation of web and cloud based technologies have accelerated this trend even further [132].

Increasing numbers of investors have recognized this trend and invested significant amounts of capital. Despite relatively lower returns on traditional Cleantech companies, Sustaintech companies that embraced the digital revolution, such as Nest, on average returned about three-and-a-half times the capital of A-round VC investment [3]. For the past several years, VCs have successfully funded a few Sustaintech startups that engaged in IPOs or M&A, and which applied disruptive digital technologies or business model innovation. Existing successful Sustaintech companies that went public or acquired/embraced the digital revolution include Opower, Nest, Solarcity and Tesla. These firms have pointed the industry in exciting new directions. Traditional software giants have also joined the Sustaintech movement. For example, Opower went public in 2014 and was acquired by Oracle with a transaction valued at $532 million in 2016. Google acquired Nest for $3.2 billion in 2014.

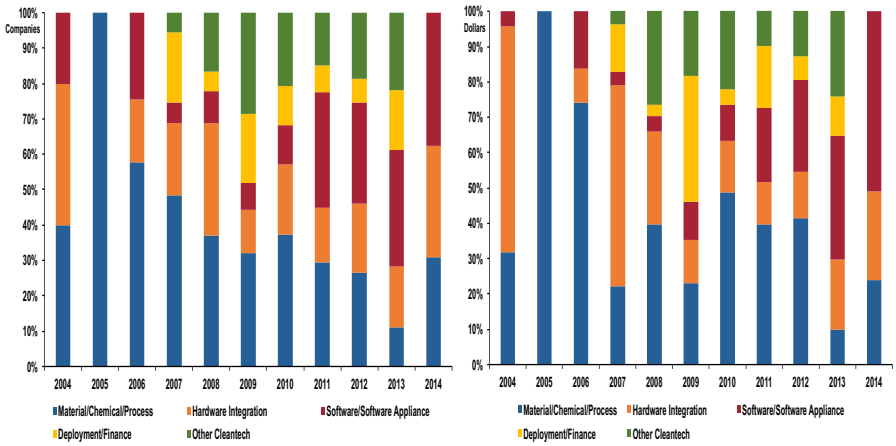
Table 5
Selected Sustaintech companies that were acquired or went public

Company Name	Business	Digital Technologies	Exit
Nest	Smart thermostat and home energy management company	IoT, big data, machine learning	Acquired by Google for $3.2 billion in 2014
Opower	Utility energy-efficiency program. Provide utility bills to customers to encourage behavioral changes in energy	SaaS company, Big data	Went public in 2014 and was acquired by Oracle with a transaction valued at $532 million in 2016
Tesla Solarcity (merged into Tesla)	Tesla: Electric vehicles, energy storage Solarcity: Financing and installing distributed generation	Tesla: Self-driving, machine learning, IoT, big data Solarcity: solar as a service (business model innovation)	Went public. Tesla is capped at $29.4 billion by Oct.31, 2016

In the United States, there are new venture capital firms and accelerators being formed just to focus on Sustaintech. Powerhouse, the world's first solar-focused accelerator located in Oakland, California, focuses on empowering entrepreneurs to find solutions to reduce soft costs in the solar industry. Another example of the trend is the annual Suncode hackathon hosted by Powerhouse, which aims to find software solutions to reduce soft costs in solar industry [133]. The former CEO of Cleantech Group, Sheeraz Daniel Haji, recently founded Zipdragon Ventures to invest in Software as a Service (SaaS) companies in energy, water, environmental protection and more [134]. New York City also hosted a series of Cleanweb hackathons since 2012 to bring together developers, designers, industry experts and business people to create innovative sustainability solutions using software and data [6]. Other sustainability VC firms, such as Khosla Ventures, Chrysalix and Rockport have all observed the trend in Sustaintech and invested in this field.

Based on a study by the MIT Energy Initiative, the trend has become increasingly clear that related sustainability companies applying software and business model innovation have attracted more venture capital attention, while the portion of capital for pure materials/chemicals/processes and hardware integration focused companies has been decreasing [135].

Figure 37
Increasing amount of venture investment in software and deployment related sustainability companies.



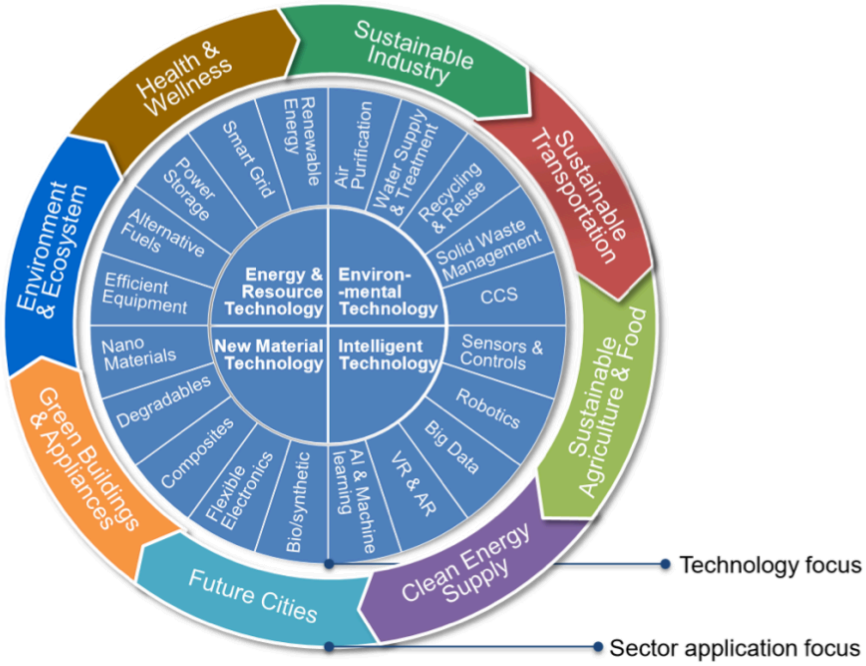
Source: MIT Energy Initiative, 2016

Tsing Capital's Investment Focus

Through years of experience, Tsing Capital has recognized that sustainability is a theme not exclusive to a limited amount of sectors. We realize that sustainability is not contained within common perceptions of renewable energy, energy efficiency, and environmental protection, for instance. Rather, intelligent technologies have played an increasingly important role in accelerating sustainable development across other industries too, leading to important advances in the development and deployment of sustainability solutions.

During the past 17 years of investment, Tsing Capital has carefully evaluated the sustainability performance of each deal company in terms of environmental impact, clean energy generation/energy efficiency, and better resource utilization.

Figure 38
Tsing Capital's investment landscape.



Source: Tsing Capital Strategy&Research Center, 2016

Tsing Capital invests in companies with sustainability applications in the areas of: sustainable transportation, food/agriculture, clean energy supply, future cities, green buildings/appliances, environment/ecosystem and health/wellness. These sustainability applications are enabled by four technology areas: energy resources (e.g. renewable, energy efficiency), environment (e.g. water and solid waste treatments), new materials (e.g. solar photovoltaic materials) and intelligent technology (e.g. IoT, machine learning, robotics, AR/VR, blockchain). Emerging Sustaintech companies enabled by intelligent technologies are continuously unlocking enormous sustainability potential and creating a better future for humanity.

Disruptive Innovation and Investment Opportunities

Sustainable Mobility

Our future will be more intelligent, connected and environmentally sustainable. This trend will transform lives in multiple ways. Tsing Capital predicts that sustainable mobility and the Energy Internet will be two sectors with early adoption of Sustaintech. Disruptive technologies and business models are emerging in both fields, creating tremendous investment opportunities.

Mobility Will Be Shaped by Driverless Vehicles

In the future, mobility will be highly influenced by the development of driverless vehicles. A future where shared autonomous vehicles are widespread is desirable. Such a scenario would reduce car ownership, reduce life-cycle emissions, improve resource efficiency, and create social benefits. Moreover, such a future would be enabled by the wide deployment of electric vehicles, technological innovation in the autonomous vehicle space, and business model innovation. It is estimated that by 2035, nearly 76 million autonomous vehicles will be sold globally, while 21 million will be sold in 2035 [136]. The four major areas driving these trends are shown below:

- Connected vehicles

  Autonomous vehicles and infrastructure communicates through a digital cloud to enable hands-free calling, navigation, emergency response, and concierge services.

- Coordinated vehicles

  Internet streaming enables real-time data optimization for tariff flow and parking.

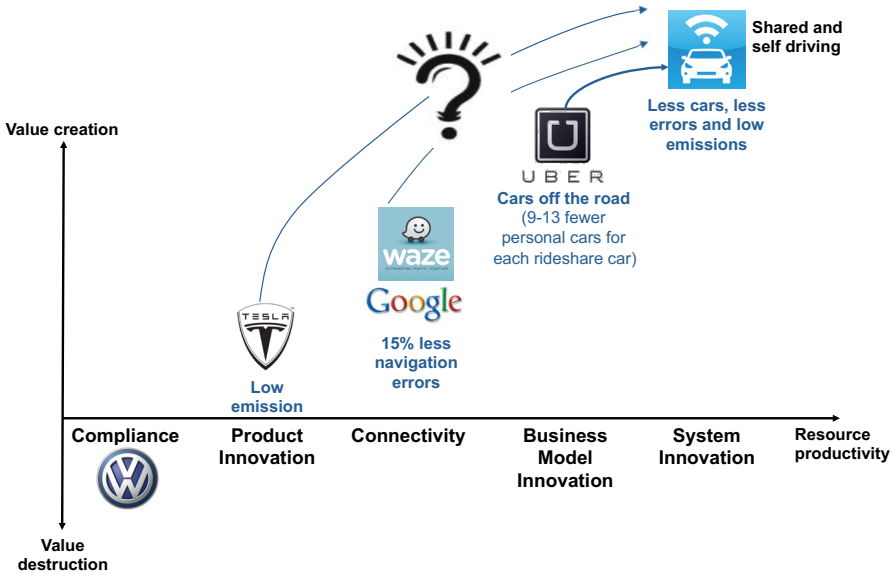
- Shared vehicles

  More than 25 shared vehicle companies have already entered the market. Research at UC Berkeley has estimated that vehicle-sharing revenue will exceed $3 billion in North America.

- Driverless vehicles

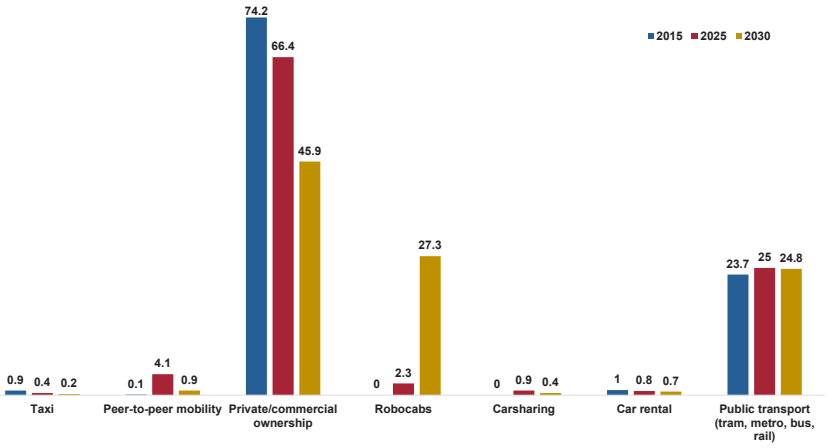
  Companies like Google, Tesla, Daimler, Volvo, GM, Toyota, Volkswagen, BMW, Bosch, Continental and Delphi claim to have working autonomous driving technology by 2020 or sooner.

Figure 39
The future of mobility is moving towards sharing and self-driving [137].



Source: Lux Research, 2016

Figure 40
By 2030, “Robocabs” (autonomous taxis) will take a significant share of the market worldwide and reduce car ownership [138].



Source: Presseportal, 2016

Large Scale Deployment of Electric Vehicles

Disruptive Technology: Focus on EV and Autonomous Driving

Battery costs are keeping the overall cost of electric vehicles high; this is a key barrier for large-scale electric vehicle deployment. Electric vehicle performance is now comparable with that of gasoline vehicles. If battery costs fall to the $100 per kWh level, then battery costs for electric vehicles with a range of 200 miles could cost as low as $5000. The fast development of battery technology could make this feasible by 2023, by which time EVs would become more economical to purchase than gasoline-based vehicles [139]. According to Bloomberg, global sales of electric

vehicles will hit 41 million by 2040, representing 35 percent of new light duty vehicle sales [140].

The wide deployment of electric vehicles will lay the foundations for greater adoption of autonomous vehicles, since it is much easier to integrate autonomous features with electric vehicles. Lux Research listed several major reasons for this [141]:

- **It is easier to implement autonomous features on EVs**

  ICE engines still largely use 12 V electrical systems, running off a single lead-acid battery; the higher voltages and energy stored in an EV battery pack allows much more design freedom when it comes to self-driving hardware and software implementations.

- **Wireless charging integrates seamlessly with autonomy**

  An autonomous vehicle can self-charge using wireless charging.

- **Self-driving extends range, addressing a key weakness of electric vehicles**

  Autonomy could extend EV driving range by 5%-10%.

- **Both electric vehicle and autonomous driving technologies will mature at around the same time**

  Lux research estimates that both technologies will mature around 2030 – that is, when plug-ins will become the mainstream drivetrain type, and when full autonomy will be achieved.

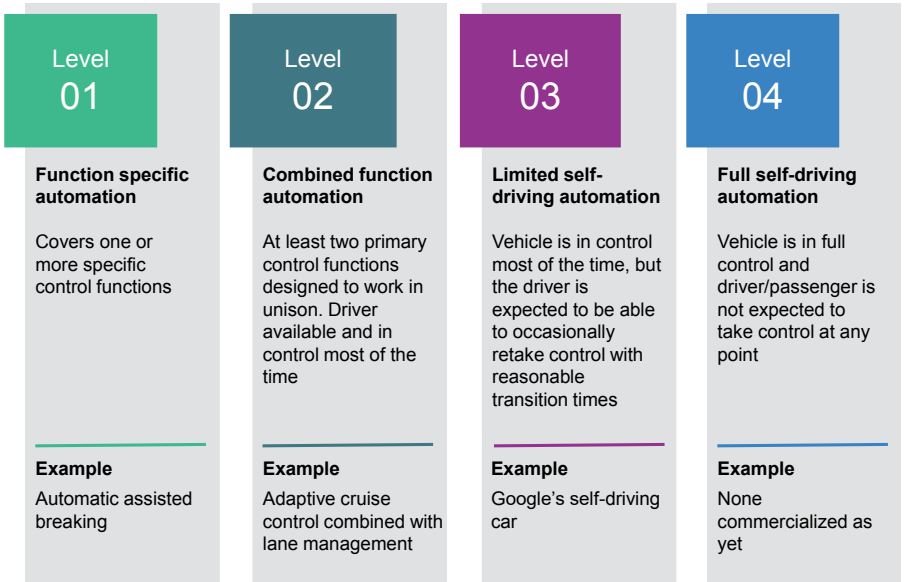
- **Higher end electric vehicle manufacturers are some of the earliest and most enthusiastic developers of autonomous technology**

  Integrating autonomous driving features could distinguish such manufacturers from those who make gasoline vehicles in a similar price range.

Technology is a Key Enabler of Autonomous Vehicles

The road towards autonomous vehicles will enable numerous technology innovations and new businesses. The National Highway Traffic Safety Administration (NHTSA) defined four levels of autonomous driving, as shown in Figure 41.

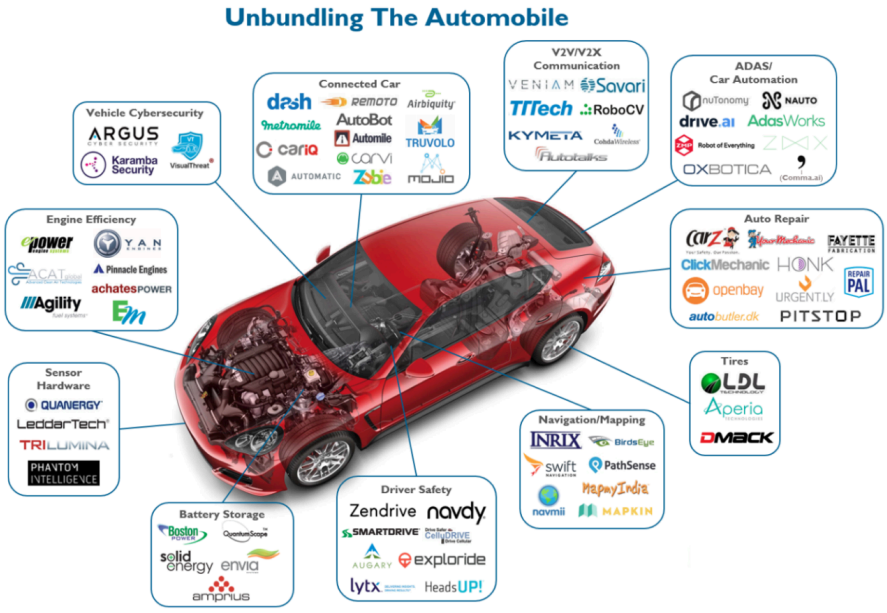
Figure 41
Level of autonomy defined by National Highway Traffic Safety Administration [142]



Source: McKinsey, 2016

Autonomous driving is a complex system that enables technology breakthrough in numerous areas and creates tremendous business opportunities. To achieve full autonomy, innovation is required in areas such as ADAS/car automation, engine efficiency, vehicle cyber security, connected cars, V2V/V2X communication, auto-repair, tires, navigation/mapping, driver safety, battery storage and sensor hardware, as summarized in Figure 42. Tremendous amounts of big data analyses will also be an important enabler of self-driving technology. Google's self-driving car currently gathers more than 1GB of data per second. As sensor costs drop, the amount of data collected will increase exponentially. Such data can be used for various purposes in an autonomous driving system [139].

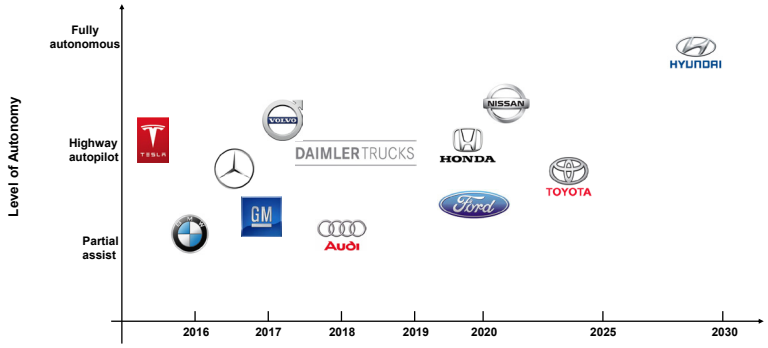
Figure 42
Technology areas and current startups of self-driving cars and autonomous vehicles [143]



Source: CB Insights, 2016

The cost of autonomous technology is also rapidly decreasing. LIDAR technology is a key navigation technology in autonomous systems, and it currently represents half of Google's self-driving car's cost. For autonomous vehicles to drop in price, the LIDAR price must drop as a prerequisite. The rate of LIDAR technology improvement in the past has been comparable to Moore's Law. If that trend continues, LIDAR technology will drop from $70,000 in 2012 to $4,481 in 2020, significantly reducing the cost of autonomous systems and leading to large-scale adoption [139].

Figure 43
Timeline of existing car manufacturers and their road-maps for autonomous driving



Source: Lux Research, 2016

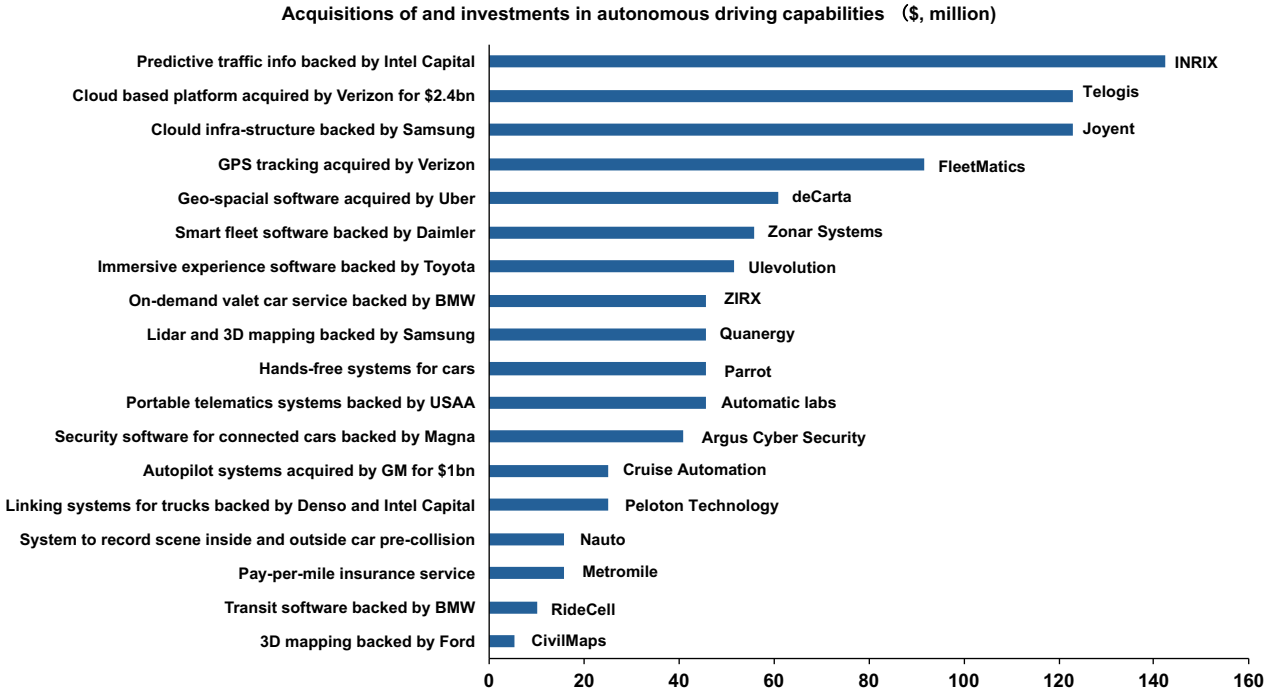
Figure 44
Existing companies and new startups tapping into the autonomous driving market

Source: I.S. World, 2016

Autonomous driving is a hot area attracting strong investment

Autonomous driving technology has created many innovative startups. The market size of autonomous driving has already reached $3.6 billion in 2015 [144]. In addition to traditional car manufacturers, existing software giants are also showing strong interest in autonomous driving (e.g. disruptive technology players like Google, Apple, and Baidu) [145]. Investments in autonomous vehicles are growing, and multiple startups focused on autonomous driving technologies have been successfully acquired.

Figure 45
Active acquisitions of AV firms and investments in the AV market



Source: Bloomberg, 2016

Business Innovation: Focus on Car Sharing and *Car as a Service* (CaaS)

Car Sharing is Becoming More Common

Following the birth of Uber, a leader in the mobile platform business model, car sharing has started to become common in people's everyday lives, especially in urban areas. Similar businesses are starting to take root around the world. Lyft is now a major competitor for Uber in the United States. In China, Didi acquired Uber China in August 2016, becoming the on-demand car sharing giant in the China market with a market size of $35 billion [146]. The trend of car sharing had actually started much earlier than when Uber became popular. Zipcar, an hourly basis car rental service, was the pioneer in car sharing. Today, Zipcar already has 1 million members by today [147]. Other car services, such as GetAround.com, also allow people to rent out their idle, unused cars in order to increase the utilization of existing cars and decrease car ownership. Investments into ride-hailing companies topped $11 billion in 2015, and totaled $21 billion in mid-2016 [142]. Car sharing services in the past have created a decreased demand for cars on behalf of consumers, creating a foundation for large-scale adoption of driverless cars.

Under ideal scenarios, people would not need to own their own cars. Autonomous vehicles can arrive on demand, drop off passengers, and head to the next car-hailing request. It is therefore a natural choice for car sharing companies to tap into the autonomous driving market. Existing car sharing company Lyft, for example, just announced its ambitious self-driving taxi development plan with General Motors, which aims to bring fully autonomous vehicles to market by 2021 [148].

The Car as a Service Business Model is Most Likely for Autonomous Vehicles

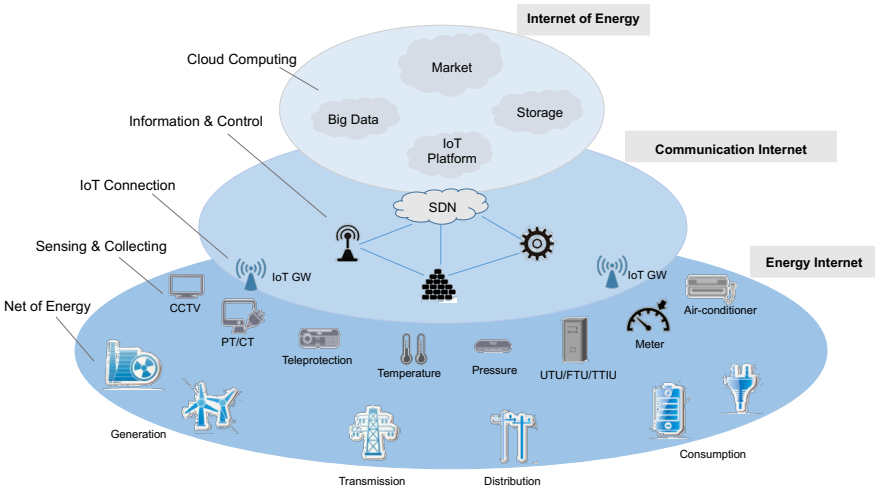
The autonomous vehicle sector is currently inclined towards the Car as a Service busine ss model. Cars may no longer be just personal belongings, but may instead become revenue generators. Zipcar has calculated that every shared car on the road could replace 15 cars owned. People often do not desire car ownership due to maintenance/operation costs, time wasted driving, and safety concerns. Autonomous vehicles can successfully avoid these flaws and utilize cars as part of a more comprehensive service. Electric vehicles are the natural platform for autonomous driving, enabling the Car as a Service business model [139].

Energy Internet

Foundations of the Energy Internet System

Internet technology is transforming existing energy and grid systems and making them more advanced and intelligent. The key foundations of energy systems in the internet era are more open-source, distributed, flat, software-based systems. The Energy Internet has resulted in commercialization of software platforms for decentralized scheduling of energy producing or consuming assets on the electricity grid [149]. Software solutions help customers to optimize storage, generation and consumption assets in their area of operation. Energy Internet is enabled by advanced technology solutions including cloud computing, information and control systems, Internet of things (IoT), sensing, and connected grid technologies.

Figure 46
Foundation of The Energy Internet



Source: Cindasc, 2015

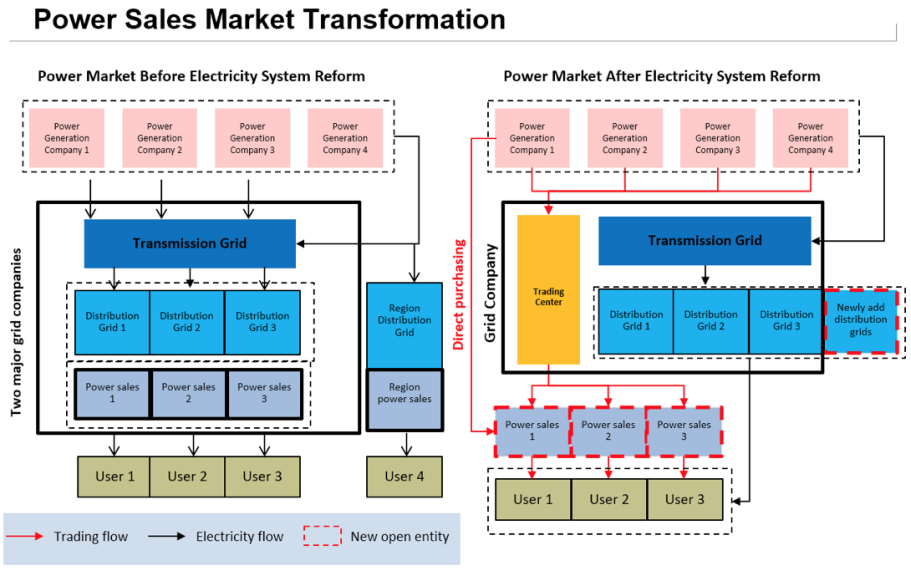
Smart grids are a good example of the Energy Internet. Grids are getting smarter with the increased penetration of smart meters, meter data management apps, the availability of demand response mechanisms, and storage mechanisms. Smart grid innovation today is mostly centered on the Internet of Things (IoT), which can help to integrate renewables, storage, microgrids, and flexible demand considerations. Investments have been made into successful companies such as Silver Spring

Networks, Trilliant and eMeter. The electricity grid has attracted many industrial IoT companies today and has resulted in the birth of exciting startups such as Sigfox, Mocana, Ayla Networks and C3 IoT [150].

China's power system reform provides business opportunities in the Energy Internet space

In the past, China's power system was centralized and highly regulated. It also lacked the necessary institutional infrastructure for startups in the Energy Internet field to enter the market. The on-going power market transformation is deregulating the current electricity system and separating electricity transmission and distribution. Power market reforms are also transforming trading mechanisms, electricity prices and providing business opportunities for electricity retailers. All these reforms are transforming the current Chinese electricity system into an electricity market similar to the model in the United States.

Figure 47
How China's power market would transform under a deregulated market

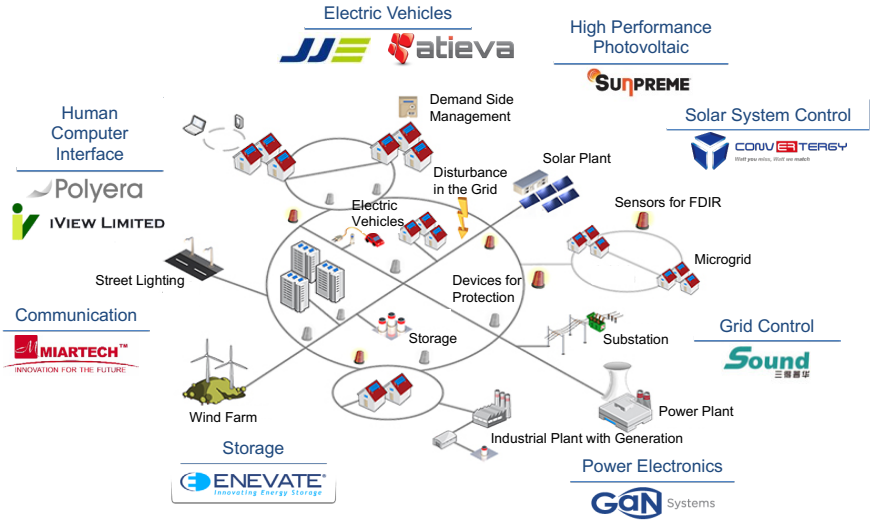


Source: Tsing Capital Strategy&Research Center, 2016

Electricity market reform in China provides tremendous business opportunities in the field. Tsing Capital is focusing on various areas in the Energy Internet field, including:

- Electric vehicles
- High performance solar systems
- Solar system control systems
- Grid control
- Efficient equipment
- Energy storage
- Communication
- Human-computer interface

Figure 48
Areas in the Energy Internet space that Tsing Capital monitors closely



Source: Tsing Capital Strategy&Research Center, 2016

Based on a study by Martec [151], Energy Internet will go through three major stages of development in China.

Stage 1 (2015-2020): Internet of things and intelligent hardware

- Distributed renewable energy systems, distributed storage, energy routers

  The prevalence of a distributed energy system, distributed storage system, smart meters, charging stations, and intelligent inverters will form the foundations of Energy Internet.

Stage 2 (2017-2023): Innovative business models

- Demand side management and services (2017-2023)

  Numerous entities will enter the area of electricity sales. Electricity trading market mechanisms will be established .

- Microgrid and virtual power grid (2020-2025)

  Grid distribution infrastructure will become more intelligent and open due to maturation of the electricity trading market and increased fluctuation of energy generation.

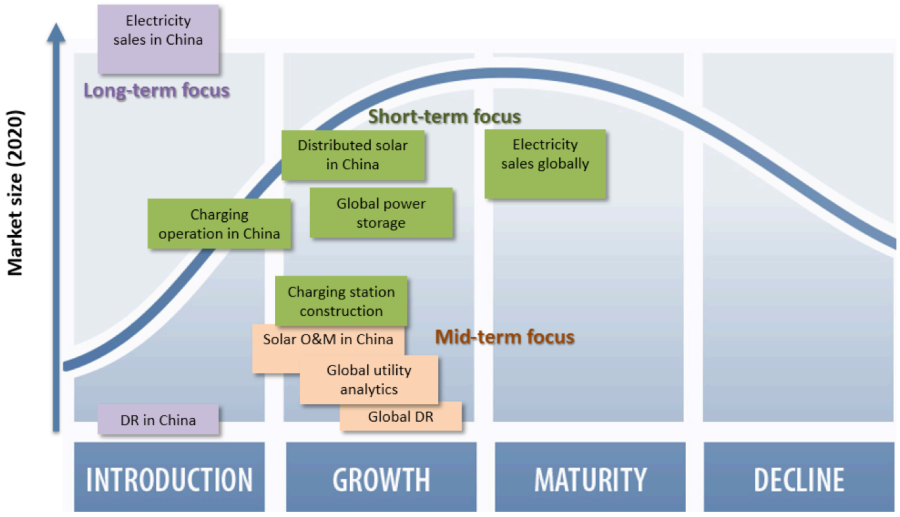
Stage 3 (2025-2030): Big data and cloud computing

- Energy Internet becomes more mature

  From more flexible dispatch systems to intelligent grid connection, Energy Internet will become more mature with applications including advanced big data tools, machine learning, and artificial intelligence. The grid will have self-recovery and learning/adaptive capabilities.

Based on this prediction, Tsing Capital will focus on specific areas in the short, medium and long term, and identify promising startup companies in the aforementioned fields.

Figure 49
Tsing Capital's investment focus in recent years

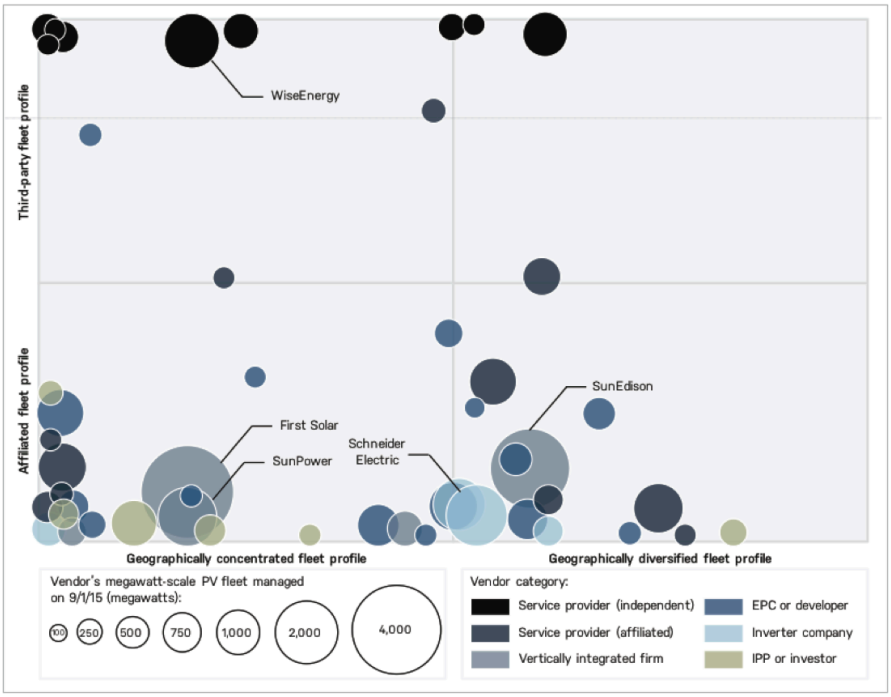


Source: Tsing Capital Strategy&Research Center, 2016

Case Study: Solar System Asset Management

The global market for megawatt-scale operation & maintenance (O&M) and asset management (AM) surpassed 133 GW by the end of 2015. This number will triple by 2020 and exceed 488 GW worldwide, mostly in China, the U.S., India and Japan. Investors and vendors are turning their attention towards on-going PV management, both financially (asset management) and technically (operations & maintenance) [152].

Figure 50
Existing solar operation & maintenance (O&M) and Asset Management (AM) markets

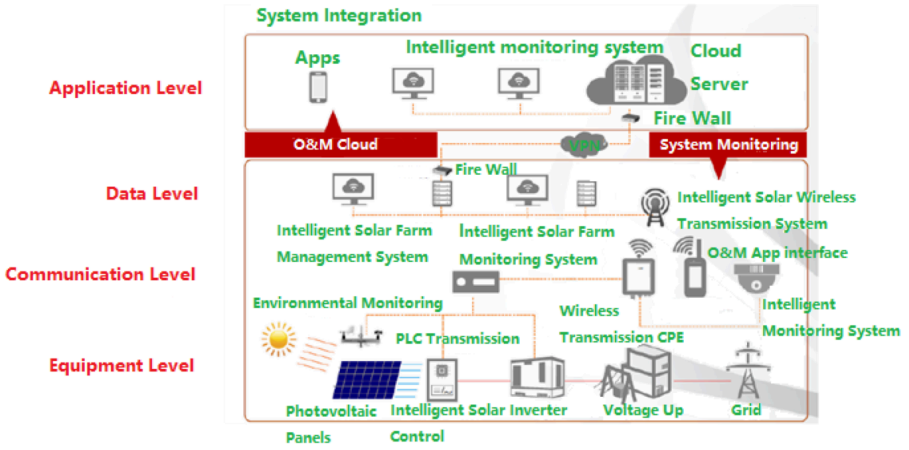


Source: Greentech Media, 2015

According to the latest 13th Five Year plan, by 2020, total solar installed capacity will reach 100 GW [153]. Tsing Capital predicts that the solar operation and maintenance market is projected to increase by 1 billion RMB/year in the next five years.

Solar asset management systems consist of four levels: the equipment level, the communication level, the data level and the application level. These four levels have software and hardware integrated together, providing a complete solar asset management solution. The software segment is comprised of desk top monitoring and analysis systems, cloud services for data storage and desktop/mobile apps. Software integrates well with communication hardware, solar photovoltaic panels, and solar control panels. In this eco-system of solar asset management, innovation and startup activity could occur in any of the software or hardware components of the system.

Figure 51
Solar asset management system



Source: Cindasc, 2015

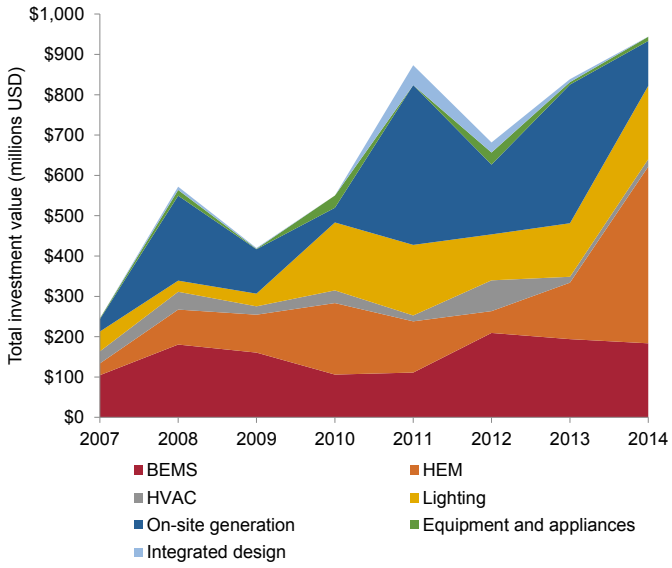
In general, existing solar asset management companies have four approaches to bringing down solar soft costs:

1. Choosing the right rooftops for cost reduction and output optimization.
2. Providing professional services for efficient and economical operations.
3. Optimal financing channels to reduce financing cost
4. Rating and insurance according to sunlight hours, equipment quality and system efficiency

Case Study: Smart Homes

Smart homes have come a long way since the utility-driven energy management in the mid-2000s. Smart home innovation started with home energy management (HEM) systems. From 2005 to 2014, HEM has attracted a total of $550 million in venture capital investment. Notable investment activity includes Google's acquisition of Nest and Dropcam in 2014. Samsung acquired SmartThings in 2014. Flextronics acquired Wink in late 2015 [154].

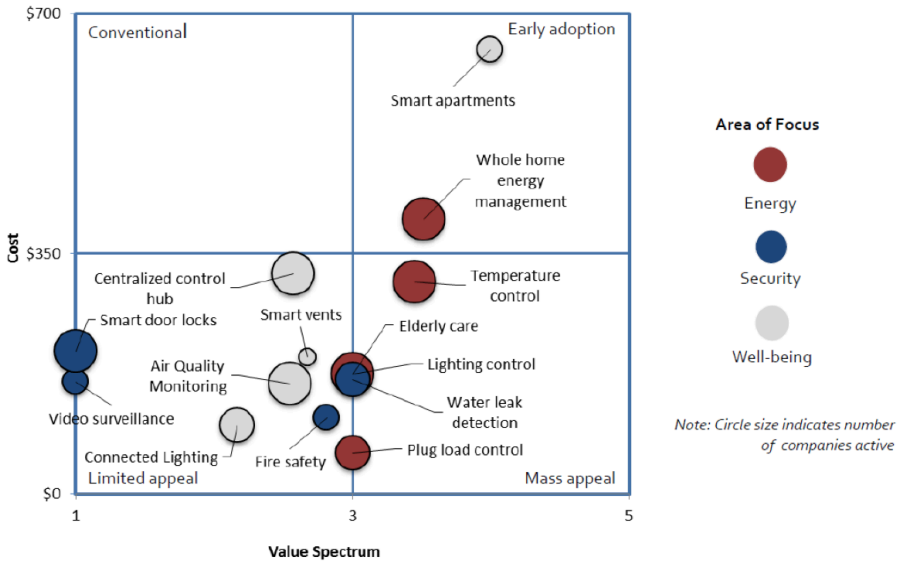
Figure 52
The HEM sector is a strong driver of the smart home market



Source: Lux Research, 2015

The construction of smart homes involves a multitude of advanced technologies. Subcategories in each related area of energy, security and well-being have attracted existing companies and start-ups to enter. Companies that offer temperature controls, including smart thermostats, are in the most crowded smart home market segment. This area is diverse and involves both Businesses to Business (B2B) and Business to Business to Consumer (B2B2C) models, as well as direct consumer models (Business to Consumer, B2C). The cost of smart thermostats varies greatly, from $250 to $420. With a 12 to 30 percent energy saving rate, the economics of such technology is reliable and proven [154]. Smart thermostats not only provide energy saving for consumers but also create possibilities for demand side management for utilities. Other areas in the HEM market to tap into include whole-building energy management system and plug load controls.

Figure 53
Existing smart home market landscapes



Source: Lux Research, 2015

Developments in the HEM field represented the beginning of the smart home market. Today, smart homes provide connectivity to manage household energy consumption, provide physical security, and ensure indoor environmental quality. Nest was a pioneer in the area of smart thermostats, and successfully brought people's attention to smart homes. Other existing companies have also joined the HEM era, such as Lutron, which controls lighting systems in residential and public spaces. Facing competition from Nest, Honeywell, the traditional thermostat giant has also developed its own smart thermostat.

Table 6
Companies and products in home energy saving

Focus Area	Function	Cost Range	Startups	Large Companies
Energy	Temperature control	$250 - $420	Tado, Ecobee, PassivSystems, Sunnovations	Nest, Honeywell, Emerson, Johnson Controls
	Lighting control	$45 - $90	Plum, Think Automatic	Lutron, Leviton
	Plug load control	$50 - $70	2D2C, Zuli	Belkin, iHome, D-Link
	Whole home energy management	$280 - $540	Ambient Devices, Green Energy Options, weMonitor, Wattio, BeNext, Rockethome	Honeywell, eQ-3, Schneider Electric, Xiaomi

Source: Lux Research, 2015

The security space is another relevant area in smart homes. Electronic locks are becoming popular not only in resident's homes but also in short-term rentals, where home owners can provide electronic codes for customers to enter the premises. Companies like Nest are tapping into the security area as next steps in expanding the smart home eco-system.

Table 7
Companies and products in security

Focus Area	Function	Cost Range	Startups	Large Companies
Security	Fire safety	$100 - $120	Leeo, Birdi	Nest, Kidde, First Alert, Honeywell
	Video surveillance	$190 - $200	MyFox, Homeboy, Canary, Netatmo, Withings	Honeywell, Nest, D-Link
	Water leak detection	$100 - $300	Notion, Water Hero, SNUPI, Technologies, Fibaro	D-Link, Insteon
	Smart door locks	$100 - $325	August, Lockitron, Goji	Kwikset, Yale, Schlage

Source: Lux Research, 2015

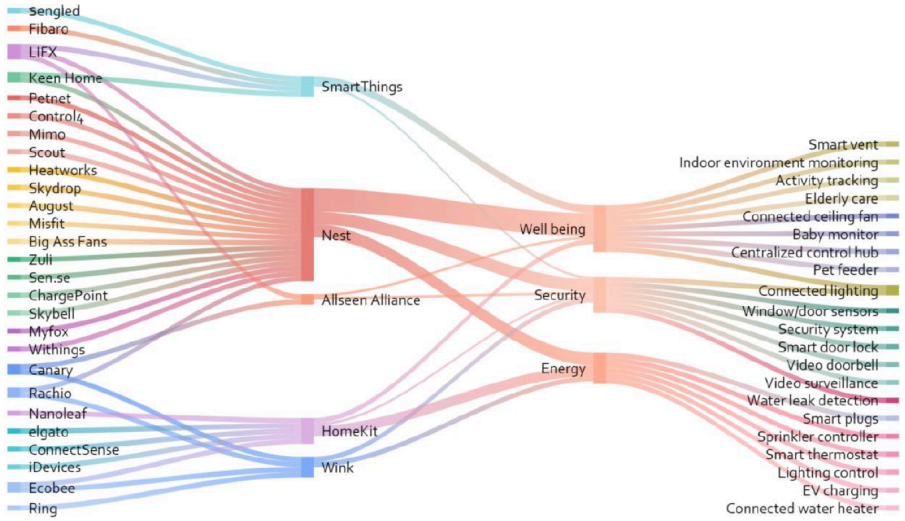
Indoor environmental quality is another area that existing companies and startups are tapping into. Relevant areas include air quality monitoring, thermal comfort, connected lighting, centralized control hubs, smart apartments and elderly care.

Table 8
Companies and products in well-being

Focus Area	Function	Cost Range	Startups	Large Companies
Well-being	Air quality monitoring	$40 - $200	Airviz, Airboxlab, Bitfinder, Beagle, Netatmo	Dylos
	Thermal comfort	$100 - $300	KeenHome, Ecovent	Emerson
	Connected lighting	$30 - $100	Sengled, LIFX, SmartFX	Philips, Cree, GE
	Centralized control hub	$90 - $565	Zipato, Fibaro, Viva Labs, nCube, Cozify, Zonoff, Wink	Samsung, Lowe's, Google
	Smart apartments	$420 - $900	Dwelo, Embue, Lotas	
	Elderly care	$40 - $310	Sen.se, Lively, Silverline	

Source: Lux Research, 2015

Figure 54
Significant numbers of startups have appeared in the smart home industry



Source: Lux Research, 2015

Investment perspective of smart homes

Smart homes are an attractive field for investors. So far, smart homes have attracted $550 million in venture investment from 2005-2014, and we have already seen the first wave of sizeable exits [154].

Based on Tsing Capital's observations, devices are the key foundations for smart homes. Devices like smart thermostats and webcams currently represent the largest portion of the total $6,700 smart home cost budget. It is still too early to say whether the data-centric nature of smart home platforms will prove to be useful. The difference between a mediocre and a high-level smart home lies primarily within the functions enabled by these devices.

Sustaintech Investment Strategy

At Tsing Capital, we continually refine our investment approach, and have chosen to focus on “5C” dimensions: Capex efficiency, Consumer-facing, Connected approaches, Cross-border technology transfer, and Collaborative investment. As more companies, as well as the public, recognize the importance of sustainable development, we have been centering our investments on three themes: Cleaner Energy, Pollution Reduction, and Resource Efficiency. Driven by these dimensions and themes, we have assessed areas of the market that are ripe for investment in commercialization or R&D, as well as sectors we should watch for growth in the near future. As the market continues to evolve, we will continue to adapt our predictions.

Our Investment Approaches

For the past several years, we have been continuously revising our investment approaches and improving as the market evolves. In addition to our original investment themes, we have added the following 5C dimensions to better seize emerging opportunities.

- Capex efficiency

Our team has learned from global mistakes during Envirotech. To avoid traps and mishaps of traditional sustainability investment, we are making a conscious decision to pay more attention to the capex requirements, time-to-market, cost curve and risks of scaling up.

- Consumer-facing

The nexus of consumer-oriented products may provide more explosive opportunities than traditional Cleantech investment, and accelerate the maturity of innovative sustainable technologies. The key factors for consideration in consumer-oriented Sustaintech investment are technology platforms, business models and timing.

- Connected approaches

Technology advancement enables collaborative platforms that provide new ways of doing things in businesses, homes, public services and government administration. For example, data and artificial intelligence will play vital roles in unleashing vast market potential. Re-imagination has transformed production, logistics, commerce, and financing. Our interest in these platforms lies in the fact that they bring more effective and efficient use of resources and energy, and less waste and pollution.

- Cross-border technology transfer

Chinese companies continue to look overseas for innovative and cost-effective technologies. Foreign technology companies also continue to view China as the biggest market. Therefore, there is still great need for cross-border technology transfer. Tsing Capital is expanding our target areas from the U.S. to Israel, Canada and Scandinavia.

- Collaborative investment

Working in cooperation with strategic investors, public companies and other companies that offer supply chain synergies has proven to be an effective strategy. Strategic co-investors bring much-needed expertise for commercialization. Supply chain and marketing platforms provide faster time-to-market, rapid cost-reduction and market intelligence. Listed companies, who are poised to acquire technologies to enhance their market competitiveness, are potential exit channels. Going forward, we will enhance our collaboration with these players.

Tsing Capital will continuously monitor market trends, and update our strategy and investment summary every year.

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Authors

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Contact us

Beijing

B23-B, UBP,
No.10 Jiuxianqiao Rd,
Beijing, 100015
Tel: +86 10 5975 6601
Fax:+86 10 5975 6635

Shanghai

B-2102, Dawning Center,
500 Hongbaoshi Rd,
Shanghai, 201103
Tel: +86 21 6090 7180
Fax:+86 21 6090 7181

Hong Kong

Unit 2002-3, New World Tower 1
16-18 Queen's Rd, Central,
Central Hong Kong
Tel: +852 3628 3859
Fax:+852 3753 1266

Silicon Valley

2725 Sand Hill Road,
Menlo Park, CA94025

www.tsingcapital.com