

SUSTAINABLE DEVELOPMENT BY BUSINESSES BASED ON CLEAN TECHNOLOGIES: CHARACTERISTICS AND TRENDS

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Abstract

The general framework for improving human-environment relation is established through the concept of sustainable development. Achieving this necessitates major changes that should reach every aspect of the social and economic life. Such task is overwhelming even for the most advanced states that also recognize the effectiveness of entrepreneurial approaches for other issues of public concern. Involving businesses in delivering sustainable development is necessary and possible and clean technology based businesses could be an important engine in this respect. The characteristics of these are sought for by considering previous results, but also a sample of successful companies. It was found that such businesses are capital intensive, fast evolving, concentrated in North America and in clean tech segments such as energy efficiency, solar energy, transportation, agriculture and food, and biofuels and biochemical.

Keywords:

Sustainable development, clean-tech, investment, energy, transportation

Introduction

The continuous and dynamic path of population growth and the increasing consumption experienced by billions of inhabitants living in emerging economies, which is also desired by other billions living in least developed countries, were considered predictors of an unbearable pressure on the natural environment that proved to be fragile enough in its confrontation with phenomena like pollution and resource exhaustion.

The way out of from these clashing trends was outlined in many approaches and continues being discussed by scholars, but also by forward looking policy makers and businessmen. Between the limits established by the return to the status of picker and hunter and the replacement of nature's role by technological solutions there are very many visions of how humans could have a safe and lasting natural environment (Bran et al., 2013). Despite this variety, only one model gained a broad enough support to be promoted at global level. This is sustainable development, which acknowledges the possibility of having a large human population, living a decent life, benefiting from both a healthy natural environment and a rewarding work.

Initially, steering toward sustainable development was made by introducing new rules that restricted certain activities with proven harmful effects. Further, these rules envisaged not only the actions, but especially their framework by creating incentives and disincentives that correct market failures. Altogether, it is expected a major change in how businesses are conducted that should become sustainable by delivering economic, social, and environmental value (Radulescu et al., 2015). The roadmap is to have clean technologies that allow successful businesses to develop (Bellia and Pilato, 2014; Iovițu and Călin, 2014; Petrescu-Mag and Petrescu, 2010).

Clean technologies are a fertile ground for new business models and attract a large amount of investment money (Marcus et al., 2013). Nonetheless, the current path is considered too

slow for reaching the goals of equitable chances and for preventing irreversible environmental losses (Doganova and Kamoe, 2015).

It is of increasing importance to know the characteristics of clean tech based businesses, since sustainable development should harness the creativity and effectiveness of business approaches. These characteristics were scouted by a thorough analysis of literature and investment media. Further, the analysis approached a sample of successful businesses that aimed to provide valuable insights on the size of capital that is needed, number of companies that managed to succeed, clean tech segment, investment geographies and other aspects. The results could become useful premises for designing supportive policy measures that improve resilience of sustainable businesses, especially within the highly competitive context of the globalized economy.

The first part of the paper provides a rationale for the pursuit of sustainable development through businesses. This is followed by an analysis of the existing literature of sustainable business start-ups based on clean tech investment and also of the state of these investments for a sample of successful companies. The concluding section highlights the characteristics of clean tech based businesses and discuss their implications for policy making.

1. Sustainable development by businesses

Achieving sustainable development necessitates an economic activity that is performing, meanwhile being more equitable in distributing the benefits and less harmful for the environment. Accomplishing such goals supposes important changes in the economic framework in order to reduce the external costs. This could be reached by enforcing new rules, but also by changing the incentives through market based mechanisms. Altogether, the initiative and responsibility rest at public authorities that design the policy and the tools for their implementation. The outcome should be an economic framework in that businesses are reducing their social and environmental impact by reacting to the new incentives.

It becomes increasingly clear that by these means the changes needed for sustainable development might arrive far too late than it is needed, meaning that it is necessary to have a more dynamic transformation.

Sharing responsibility with businesses in both designing and implementing policies is acknowledged as necessary and possible for accomplishing sustainable development because public institutions are lacking the capacity needed for a meaningful and timely change; many companies own the power and financial resources for steering the social change; and businesses are outperforming public institutions in creating jobs, wellbeing and innovation that improve environmental performance.

In many states it is recognized that sustainable development is an overwhelming task that exceeds the capacity of public institutions and that a more entrepreneurial approach is needed. This trend is stemming in Germany, Great Britain, and USA where it was recognized that businesses are more efficient than institutions in delivering public services. Other benefits include faster dissemination of good practices and more flexibility in adapting to the changing economic context. These assumptions are not always confirmed by empirical results, but the process is ongoing and an increasing number of companies are building their businesses in services traditionally performed by public authorities.

Regarding the power and resources of companies it should be emphasized that this is comparable if not exceeding public authorities. Thus, out of 100 largest economies of the world, 51 are companies and only 49 are national economies (Shah, 2002; Roach, 2007). How large the impact of companies might be is a question answered also by the number of people that consume their product and the amount of money earned by these companies. Indeed, large companies impact on the lives of billions of people. For instance, Unilever's products are used by more than 300 million people, being present in 7 out of 10 families

from more than 190 countries (Unilever, 2015). The turnover of the company is 53.3 billion euro, amount that is larger than the GDP of 114 countries out of 191 (Statistic Times). Since businesses proved to be more effective than governmental problems it is expected that companies recognize their responsibility in promoting sustainable development. Consequently, companies should involve actively in finding the possibilities of fostering change. Nonetheless, the benefits of business driven sustainability could be harnessed only by having a strong business case. In this respect, many studies highlighted the most important reasons for that companies should be interested in sustainability. These include, but are not limited to the followings: cost savings obtained mainly by improving eco-efficiency; consumer demand that slowly changes due to increased environmental awareness; mitigation of risks born in energy cost volatility and scarcity of raw material supplies; leadership that will allow companies to play an active role in policy design; tax incentives that are enforced in more and more states or regions; employee retention since the most valuable labour is interested working in companies having a strong sustainability culture; brand reputation and publicity will foster positive relations with customers and consumers; increasing competitiveness because sustainability slowly, but surely becomes a feature of a competitive company; new opportunities for making revenues by accessing new markets, such as the carbon market, the market of environmental monitoring services, organic products, renewable energy etc. (Willard, 2012; Revell and Blackburn, 2007; Salzmann et al., 2005).

2. The perspective of clean tech investment analysts

United by the characteristic of their impact, namely the lower environmental impact, clean technologies (clean tech, cleantech or greentech for short) comprise a variety of technological solutions obtained by innovation. Clean tech is defined as a range of products, services, and processes that lower costs, reduce or eliminate negative ecological impact by a more efficient use of natural resources (Migendt et al., 2014).

The complex nature of environmental degradation is mirrored by the wide range of technological solutions. That is why the notion of clean tech covers many types of technologies from different economic sectors. Nonetheless the notion itself is considered as corresponding to an emerging economic sector, as it is the case for investment analysis, especially for venture capital (Caprotti, 2016). Table 1 summarises the broad categories outlined by several organizations specialized in clean tech analysis.

Table 1 Clean tech taxonomies outlined by analysts

Clean Tech Capital Advisors	Cleantech Group	PwC	Kachan&Co
Green ICT	Transportation	Agriculture and bioproducts	Clean energy (wind, solar, renewable fuels, marine, biomass, geothermal, fuel cells etc.)
AgTech	Agriculture and food	Energy efficiency	Energy storage (batteries, thermal, mechanical etc.)
Green Materials and Chemicals	Energy efficiency	Smart grid and energy storage	Efficiency (smart grid, green building, cogeneration etc.)
Wind supply chain	Recycling and waste	Solar energy	Transportation (vehicles, traffic management, charging)

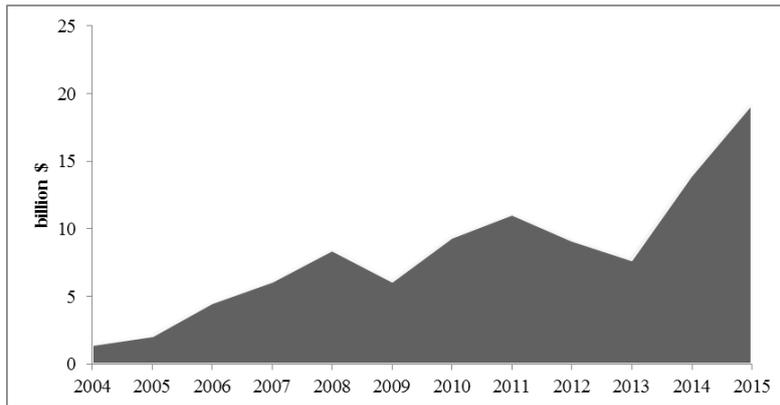
Clean Tech Capital Advisors	Cleantech Group	PwC	Kachan&Co
Smart grid	Solar	Transportation	Air & environment (carbon sequestration, carbon trading, emission control, bioremediation etc.)
Marine energy	Fuel cells	Water and waste management	Clean industry (materials, design, equipment, production etc.)
Bioenergy and energy from waste	Water and wastewater	Wind and geothermal	Water (production, treatment, transmission, efficiency etc.)
PV (photovoltaic) products	Advanced materials	Other renewables	Agriculture (crop farming, controlled environment agriculture, sustainable forestry, animal farming etc.)
PV equipment and materials	Energy storage		
Energy storage	Air		
Energy efficiency			
Sustainable transport			
Water technology			

Source: Clean Tech Capital Advisors, Cleantech Group, PwC, Kachan&Co

Clean tech is the result of innovation process. It is often fostered by the establishment of specialized organizations know as innovation hubs, clean tech incubators or accelerators. As in case of any innovation, the most important challenge is to pass from ideas of great potential to successful businesses.

This process needs major financial resources that differ in size and patterns for the different stages. Some of these stages are financed by venture capitals, the importance of which for the success of clean tech based businesses being demonstrated by Bocken (2015). He also found that in order to succeed in attracting venture capital, clean tech companies should demonstrate creativity in the design of business model, but also strong business cases that hold even outside the sustainability interested investors. On the other hand, venture capitalists should enable collaboration and provide guidance for the triple bottom line business management. The main barriers are the short-termism of investors, but also the existence of a strong incumbent industry.

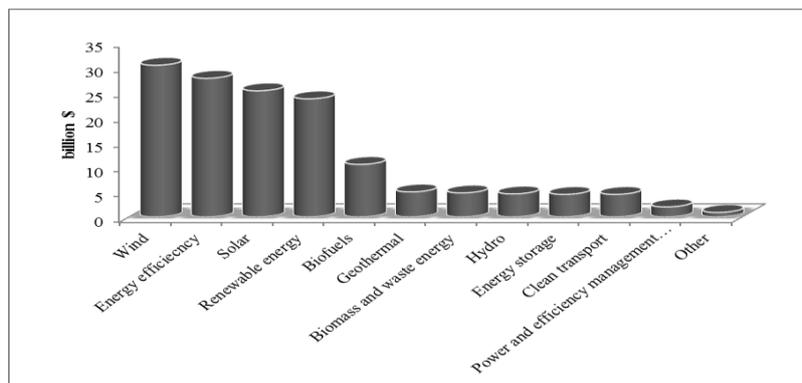
Investigating clean tech venture capital at a global scale, Cumming et al. (2016) reveal some of its characteristics, namely: clean tech is very capital intensive, requiring large amounts to be mobilized; the technological risk of clean tech is larger than the one for other technologies; scalability and exit is more difficult; benefits provided by the business could be only partly captured by the investors because some of them are in fact positive externalities. It was also found that the most important factor that influences investment in clean tech, at least in stages that this consists in venture capital, is the price of the oil. Other influential factors are stakeholder attention and the impact of formal and informal institutions.



Source: Cleantech Group data

Fig. 1 Global clean tech investment

Clean tech investment is a recently emerged category for capital markets. Caprotti (2016) and Mendt et al. (2014) provide a thorough analysis of this process, using data for both discourse and investment. The category is used as such since 2003 or 2004, although the data (number of deals, amount invested) shows that only after 2006 the sector defined itself. The clean tech sector attracted increasing volumes of money from the capital market, although across years there were also periods then the amounts have fallen significantly, namely in 2009 and 2013 (fig. 1).



Source: Sarazen (2012) data

Fig. 2 Market capitalization of energy clean tech by segment

By segment or sector of clean tech, the latest trends indicate solar energy and energy storage and smart grid as being favoured by investors (PwC, 2015). Other rising sectors are energy efficiency, internet and software, basic materials, electronic components and agriculture and food (CBInsights, 2015) and the expected growth for electric vehicles (McGreevey, 2015). Compared with the situation pictured in 2012 by an analysis focusing on energy (fig. 2), it could be stated that there are shifts in the types of clean energy, but also new opportunities in additional services such as storage.

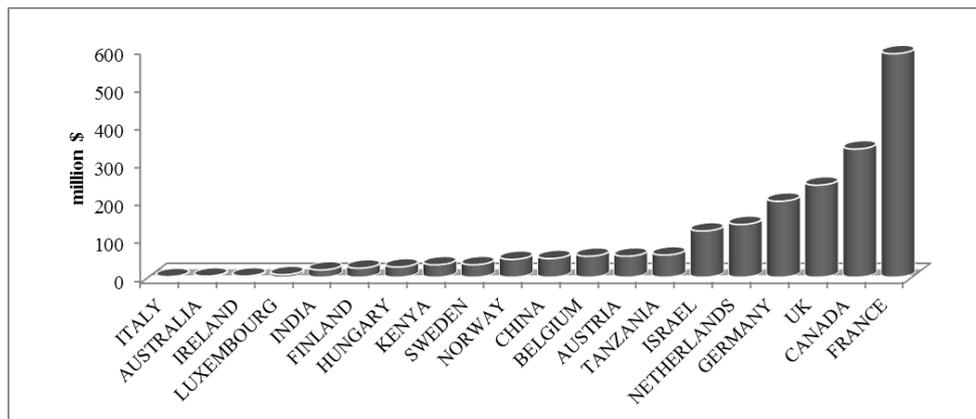
Another major trend is the integration of clean tech in all sectors of the economy. This will occur by process innovations that enhance efficiency using ITC for smart applications in mobility, parking, buildings, design, a lot of them falling in the broad and fast growing category of Internet of Things (IoT) (Vlacheas et al., 2013).

3. Patterns and trends of clean tech businesses

For capturing the patterns and trends of clean tech investments we also analyzed a sample of clean tech companies. The sample comprises 159 companies selected by Cleantech Group for the top 100, as upcoming and under the radar in 2015. The selection base used by the Cleantech Group comprises more than 2000 companies. The analysis considers the capital invested, location, clean tech segment, and age of company.

Total investment accounted for almost 11 billion \$, representing more than half of the global clean tech investment of 19.2 billion \$ made in 2015. The size of the average investment was found to be of 48.6 million \$, but it ranged between 0.4 and 237 million \$. Most of the investments are in fact smaller, since the median of the sample is only 27.61 million \$.

More than 80% of the clean tech investment was made in USA, totalling 9 billion \$. The rest of investments were made in 20 countries, with larger amounts attracted in France (586 million \$), Canada (336 million \$), UK (241 million \$), Germany (199 million \$), Netherlands (138 million \$), and Israel (121 million \$) (fig. 3).



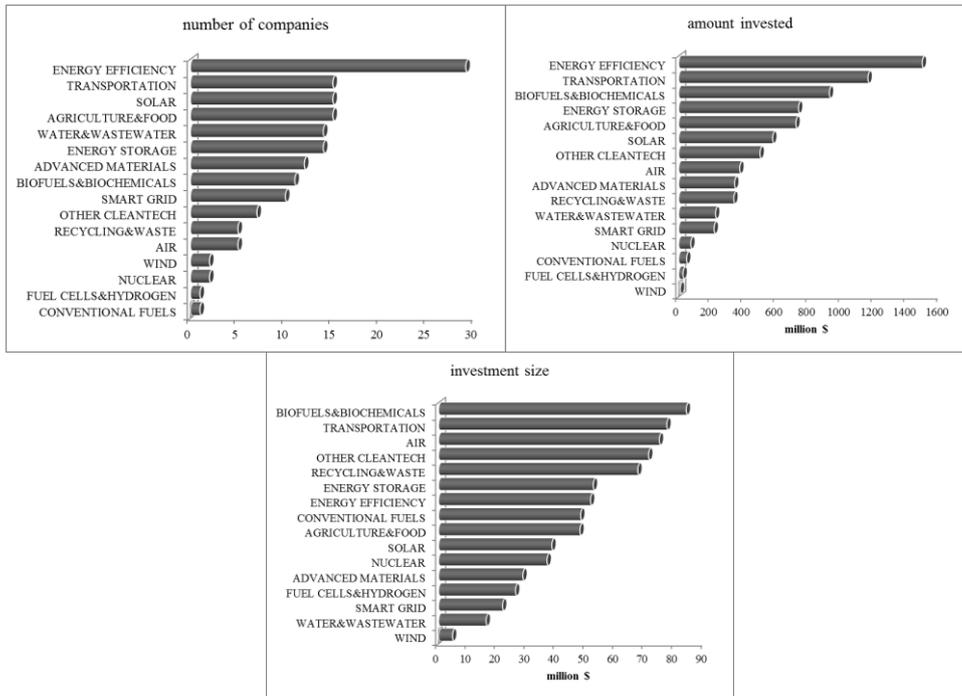
Source: Cleantech Group data

Fig. 3 Clean tech investment by countries

The analysis of the sample regarding clean tech segment or sector considered the number of companies, the total amount that was invested and the average size of the investment (fig. 4).

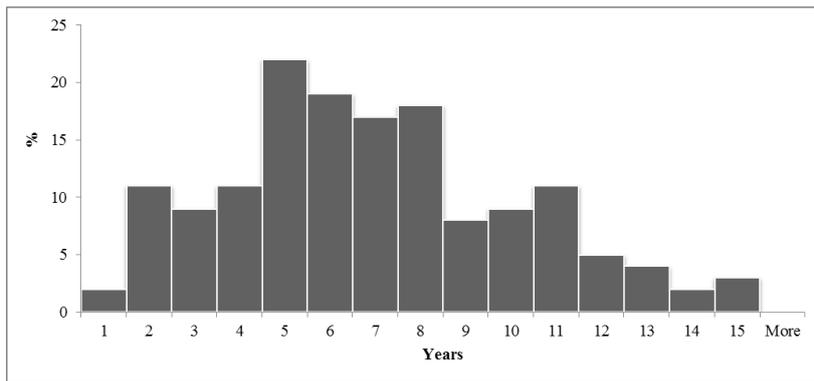
Most of the companies developed their business by providing solutions for energy efficiency. They represent 18.2% of the total and account almost for the same proportion of the total investment (19.2%). For this segment, the average size of investment was of 51.3 million \$, ranking seventh compared with other segments.

The second segment, as number of companies and total investment, were made up by companies with businesses in transportation. They represent 9.5% of the sample and account for 15% of the capital, having the second largest size per company (77.1 million \$).



Source: Cleantech Group data

Fig. 4 Clean tech companies by segment



Source: Cleantech Group data

Fig. 5 Histogram of companies by their age

Solar, agriculture and food, and energy storage are other sectors that attract large amounts, also allowing the development of many businesses. The largest capital needed was found for the segment of biofuels and biochemical, while the smallest ones were found for wind, water and wastewater and smart grid.

Other clean tech included companies basing their businesses on ITC, both software and hardware, financial engineering, and robotics. This category comprised the company with the largest capital (3.2 billion \$), Airbnb, one of the most successful business start-ups in the last years. It enables accommodation by a community market place promising unique travel experiences.

The sample comprised companies founded before 2000, but most of them were established after that moment. The histogram in fig.5 shows that the largest proportion is made up by companies founded in 2010, followed by the ones established in 2007. Companies founded between 2007 and 2010 represent around half of the sample. The size of the capital is not correlated with the age of the company.

Conclusions

A great part of the environmental challenge society is confronted with today is born in the disruptive impact of industries developed on the basis of technological innovation. The same process is also responsible for a significant improvement of the quality of life. The bubbling question if innovation could also provide technologies that are less harmful for the environment received an affirmative answer decades ago. Nonetheless, the so called clean tech sector emerged only recently and it is currently confronted with the restraints of business approaches. The paper aimed strengthening the rationale for involving businesses in the pursuit of sustainable development and finding bold characteristics of clean tech based businesses the acknowledgment of that could be helpful in policy making and business administration.

Businesses contribution toward sustainable development is necessary because public authorities cannot manage the overwhelming task of changing every aspect of the social and economic life, companies are holding power and financial resources that exceed many national economies, and businesses are more effective in accomplishing specific tasks, including environmental protection.

Clean tech is covering a range of technological solutions for reducing the environmental impact. Although on the capital market it represents a clearly defined sector, it comprises companies from a broad variety of industries. According to business reviews, energy related clean tech (solar power, energy storage, and energy efficiency), software and hardware, agriculture and food are the most attractive for investors. The sample analysis confirmed some of these trends. Thus energy efficiency and transportation were found to be the segment for the largest number of companies accounting for almost one third of the capital. Further, the sample analysis revealed that US is home for 56% of the clean tech companies that account for most of the capital (8.95 billion \$). The rest of the capital is unevenly spread in twenty countries, with more in France, UK, and Germany. These results picture a different image than the one resulting from the country index calculation. Here the US rank only third after Israel and Finland (Cleantech Group, 2014).

Most of the sample companies are 5-8 years old, although this characteristic is not related with the size of their capital. The average capital of a clean tech company is 48.6 million \$, confirming the pattern of capital intensiveness found by Cumming et al. (2016).

Europe should found an effective catching up strategy that mirrors its leadership in sustainability. Although there are many policy measures that already foster this sector, efforts should be enhanced and management improved. Energy will continue to be one of the most important clean tech segments although the focus tends to fall on processes that are optimized by smart applications. Companies to be successful need several years, period during that support by various means could be helpful. Further research should consider the role of innovation hubs, more comprehensive samples, comparisons among countries, but also case study based exploratory approaches focusing on business model innovation of clean tech companies.

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