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A Review of Key Factors Driving Development of Clean Technology

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Abstract | **Review Article**

The paper explores and investigates key perceptions and definitions of clean technology, historical perspectives associated with the development of clean technology, different categories of clean technology such as energy Efficiency and renewable Energy, key enablers and barriers to the development of clean technology, as well as the impact of clean tech applications. The research is based on reviewing the available literature in the filed as well as inclusion of different academic and professional publications to enhance application, and wider awareness of the development. Findings presented key issues associated with development and adoption of technology that mitigate climate change such as negative externalities of climate change, knowledge spill overs, the scale of adoption, path dependency, principal-agent problems and behavioural change. The growing economy is regarded as an incremental strength of clean tech sector. Furthermore, the impact of clean tech would vary significantly depending on the industry and geographical area. Furthermore, countries should be more focused on giving priority to cleantech sector investment in order to drive the future economic growth.

Keywords: Clean Technology, economic development, policy.

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CLEAN TECHNOLOGY

INTRODUCTION AND BRIEF BACKGROUND

It is a fact that eighty percent of the earth's populations still lacks industrial wealth as we are living in a world of enormous polarisation of wealth and power; thus the need to fulfil a limited market and a very little competition. In the industrial society, quality is still as necessary as a tradition from manual handicraft and this brings about competition evolving from super quality of products and traditional ingenuity and price. However, time factor is more important with competition in terms of production and sale.

Academicians and scholars have described the constarints facing industrial society as:

- Market limitations,
- Raw material problems for energy production,
- Enormous energy dependance, and
- Global environmental pollution

The over exploitation of earth's resourcs or environmental pollution have accounted for waste and environmental problems as a global scale. Despite this, the greatest achievements are believed to be the fundamental changes in respect of the attitude toward environemental policy, waste mangement between government and industries, global effects, as well as limited spatial and ecological sequence.

As the IEA puts it, renewables accounted for 18% of global consumption in 2010, and are growing faster than any other form of energy; thus they are predicted to account for more than 60% of new power-plant investment by year 2035 [1-5].

Historical Perspective: Evolution of Clean Tech

The emergence of Clean Tech was a result of the need to avoid the environmental damage at source. This enables consideration of the life cycle of materials or objectives to provide a service or benefit in order to ensure technology is really clean.

The clean tech came into existence between 2005 and 2006 and was adopted as a choice for description of the asset class and lending credibility to the sector. It is thus a pivotal to delaing with the demand fo growing middle class around the world and resource constraints Clean tech is credited to Ron Pernick and Clint Wilder, who explains it encompasses the umbrella term of investment asset class, technology and business sectors which inclean clean energy,

environmental, and sustainable or green products and services.

Homo Faber (Homo Profusius) – the wasteful man explains the over exploitation of the earth's resources and environmental pollution that are largely ignored; this explains why the earth's population only enoy one-fifth of the fruits of indutrialisation. The issue of Waste and environemntal cobtsrints need to be avoided at source rather than cleanp up at the end of pipes and properly managed instead of being diluted or dispersed into the environment. The enormous efficient production machinery that are created no longer fits into the ecosystem, howevr thee is no substitute at the moment. constraints [6, 2, 4].

Clean teach has established itself as a major long-term opportunity for economic growth and it was estimated to have doubled for global business to $5 trillion by 204. For instance, the New Hampshire Market Report 2014 indicate that clean tech has a substantial and growing economic impact as clean teach accounts for at leat 13,000 job employment in the state , within the Unites States of America.

Clean Tech: Definition

There is no standard definition of Clean Technology, otherwise known as 'Clean Tech. It is defined by various academicians and practitioners based on their notion. For instance [2], defines 'Clean Tech' as cleaner technology used to avoid environmental damage at source; they carefully distinguished clean tech from remediation – repairing damage caused by past human activity or natural disasters – and clean-up tech – reducing environmental damage by retrofitting, modifying or adding 'end-of-pipe- production abatement measures to an established plant or process. To them, clean tech goes beyond clean production. Whilst cleaner production concentrates on product per se, cleaner tech focuses on the functioning of providing a human benefit.

Clean Teach is a relatively new investor-defined term that covers a wide range of applications for the purpose of energ production or provision of solutions to environmental constraints [7, 2, 8].

Categories of Clean Tech

Clean Tech spans a broad range of technology and industries highligts the areas of growth opportunity as:

- Energy Efficiency
- Renewable Energy
- Energy Storage
- Smart Gridand Energy Management Software, and
- Waste Management.

However, [9] extended it and categorised clean technology into eight different forms:

- Renewable Energy
- Energy Storage
- Energy Efficiency
- Transportation
- Air and Pollution
- Clean Industry
- Water
- Agriculture

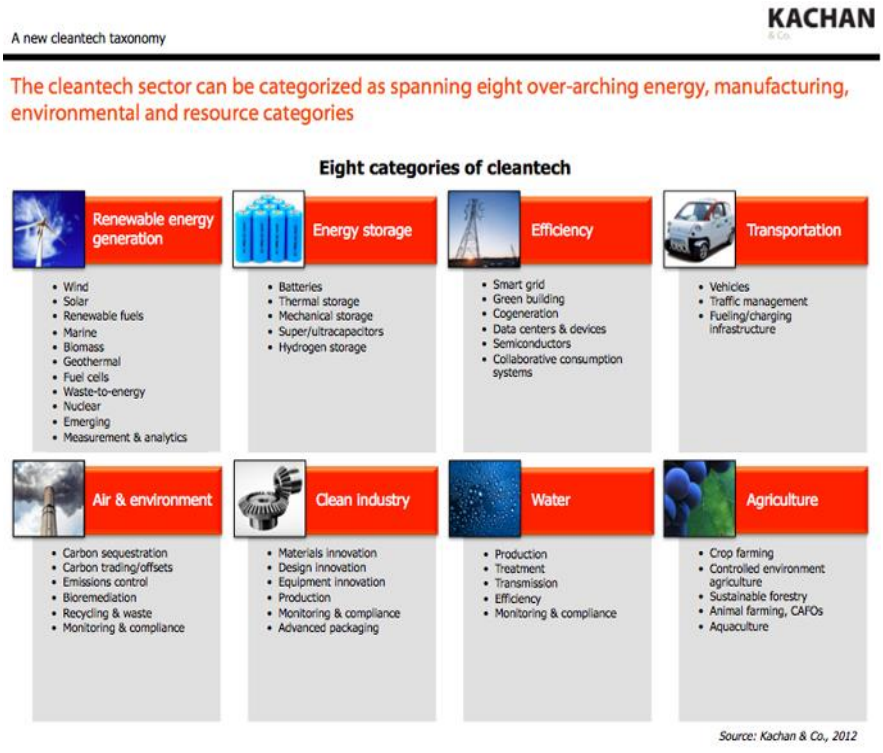

Fig-1: Eight Categories of Cleantech

The above categiories in Figure-1 above show where a clean technology fits as this assist sellers to have an insight into the size of the sector as well as understadning their competitive sets or useful for reports for research and data organisations.

In their own view, the New Hampshire Clean Tech Marker Report 2014 puts the common areas of clean tech as:

- Clean Energy (Bioenergy, Solar Wind, Geothermal and Hydro, and marine)
- Energy Distribution and Efficienc (Samrt Grid, Energy Storage, Buildings, Electric Vehicles and Transportation
- Waste and Pollution (Recycling, Air Pollution and Carbon Capture, and Storage)
- Waste Management (Water Treatment and Water Use Efficiency)
- Clean Product and Services (Chemicals and Advanced Materials, Smart Industrial Production, Clean Web, Agriculture and Professional Services

The top areas of business activities have been earmarked as:

- Energy Efficiency
- Water and Waste Water
- Biofuels and Biochemical
- Smart Grid, and
- Energy Storage [2, 9, 10]

Concepts and Principles of Clean Tech

Concepts

With the fundamental changes as a result of environmental considerations, there have been two conceptual possibilities:

- Thermodynamic sense – the closed industrial system that exchanges only energy and no material, with nature and all material flow are confined to one sytem
- The development of industrial product system completely compactaible with nature, otherwise known as 'soft technology' using renewable raw materials and biodegradable product.

The first concept relates to incorporating recycling strategy at the design stage of different products to recylce the products, it brings about positive impacts on the quality of the product. The problem with recycling however is the use of sophisticated technologies and products that increase the unconventional use use of materials such as toxicty. More so, the mnufacture and design valune tend to be higher than material content value. This is an inefficient strategy to be used when dealing with waste since value is based on ordr, and not on quality.

Cleantech is a diverse concept, some have enormous potential and could well succeed whilst others could be distructive to incumbent industries e.g. advanced building technology, food life cycle optimisatioon, grid analysis and solar PVs (photovoltaics). The limited access to capital decreasing subsidies often scale down clean tech investments. However, clean tech far exceeds expectation in some areas where technological innovation and manufacturing improvement have driven down the price. The shift is taking place in less payment areas such as water re-use, waste separation, and aerobic digestion.

The concept of clean tech provide additional opportunities for improvement and the trends can accelerate, slow down or even reverse. This explains why academicians and practitioners being is has come to stay regardless of the nature of the business and the varied progress of business. It is beilieved that some companioes may eventually cosed down due to some technologis that would not make the cut [1, 4].

Key Principles

The guiding principles for evolution of species in nature is the optimisation of resource management. Fr instance, ectotherms do not generate their own body heat, so they require less food (energy) per unit of body weight than edotherms. Optimal resource management is a central issue for future mankind. During the oli crisis of 1970s threat was a threat to industrialised world and fear of environmental pollution [1].

The key to clean tech advancing are based on three areas:

- Increased sophistication of business models,
- Financing, and
- Management principles`.

Business model innovations are all over the cleantech map. The include water-treatment, car-sharing services to reduce carbon use of waste product from one industry as feedback for another, and other initiatives to increase the profis and reduce the carbon emissions. Management practices would help green businesses to benefit from them.

There is the need for partnerships to help get offering to market in a quicker way, and giving access to lower-cost captial to the sammler firms. This explains why successful cleantech companies focus mainly on competitive offerings to ensure excellence in operation, marketing, sales and distribution.

Clean tech enables manufacturing businesses, as a principle in terms of compliance, to reduce their procurement costs and improve their productivity through lean manufacturing. The practices of clean tech

are based on customer segmentation, channel access and pricing [1, 9, 4].

Clean Tech Drivers and Barriers

Drivers

According to Pernik and Wilder, there are several main drivers of clean tech., as follows:

- The current cost of conventional technology
- The capital being invested in research and development (R&D) by large corporations
- A competitive global marketplace
- A change in customer attitude which has brought environmental concerns with the mainstream
- The growing middleclass in China, which is forcing the Chinese government to invest heavily

Hastings-Simon, S *et al.*, [4] have suggested four critical elements that are necessary to create cleantech business:

- Cost
- Access to capital
- Go-to-market approach, and
- Regulations. They affirmed that regulator's support is a key component of successful clean tech.

O'Donnell, T [11] classified the traditional cleantech drivers as follows:

- Environmental
  - Compliance
  - Bio-diversity mgt
  - Emissions to air
  - Water/chemical discharges
- Societal
  - Diversity
  - Human rights
  - Equal opportunity
  - Outreach programmes
- Economic
  - Consistent, profitable growth
  - Total shareholder return
  - Risk management
- Eco-Economic
  - Resource efficiency
  - Energy efficiency
  - Global climate / energy issues

Clean tech has been observed to be a catalyst for increased in job opportunities and economic activity. It also provides additional economic benefit by creating energy savings. There is often a focus on new tech to enhance productivity in clean tech [12].

Barriers

The major challlenge countries face is how to quickly develop energy alternatives that will create domestic jobs while freeing the country from spending excess daily on importing other products or services from unstable areas of the world. The USA for instance alleged that 'streamlining balky government permit processes or convoluted global supply chains are just some of the challenges in the "Valley of Death" faced by fledgling clean energy firm. Poor quality communication is limiting adoption of cleantech products and services in the UK [13, 14].

Cleantech innovation in not easy these days as it often requires economy, skills, the right entrepreneurs and finite resources in incubator; the biggest waste of your resources are those SMEs that don't evolve into successful businesses.

The global pressure on businesses leads to the following barriers:

- Environmental constraints Climate Changing (Water Scarcity; Environmental Diversity Declining; and Finite Natural Resources – Peak Everything)
- Increasing Societal Responsibilities (Global and Local Legislation; P2P Politics / Active NGOs; Employee & consumer aspirations; and Supply chain pressures)
- New Economic Realities (Global Population – estimated to be 9 billion 2050; Economic Power Shifting; Growing Demand - Cars, Phones, Food; Expanding Middle Class in BRICs; and Resource Pressures – Pricing & Security) [11].

Impact of Clean Tech Applications

Over the years, cleantech purchasers, both product and services, such as renewable energy, hybrid electric vehicles, energy efficiency, and high performance buildings, have experienced massive growth in sales. For instance, the sale of electric vehicle has been ten times higher, as at May 2015 whilst LED lightening installation has been growing annually over 400% rate in the USA.

Similarly, solar photovoltaic (PV) has continued to experience significant growth and opportunities. This accounts for the reason why 75% of all new electric generating capacity in the USA as the megawatts (mvv) of solar PV installed in the first quarter of 2013 had gone up by over 81% by the end of first quarter in 2014 to 1,330 megawatts.

The impacts of clean tech vary significantly depending on the industry type and the geographical area. A major effect is transforming market. Where products such as the light-emitting diode (LED) is now used for lighting. Further, the penetration rates are lower, which impacts on industry structure and market

dynamics. For instance, the United States electric utilities adopt the traditional business models that rely on putting capital in the ground.

Another impact is the installation of solar panel on roofs, and this adds new capacity whilst the demand for utilities would increase more slowly. Clean tech also allows some regulators to include investments in energy efficiency and renewable in their rate base.

The Unite States, for instance have lowered the wholesale price of power due to the large volume of share gas – which makes up approximately 40% of their gas production. This is at the expense of the coal-fired generation.

With clean tech bringing competition, regulation has become less relevant. For instance, in 2013, LED light sources produced large sales in high manufacturing even in markets where incandescent bulbs are still widely use; it was however predicted that this figure would rise to 80% in 2015. Solar power impacts on the regulations because its benefits and constraints have evidenced the re-need for continued regulation since solar is still growing in countries like Germany where renewables are deployed [1, 4].

The global solar installations have risen to 57% a year since 2006; whilst regulation has been helpful to relaunch cleantech, it no longer remains crucial in many situations as the use of renewables continue to grow.

Economists have also determined that knowledge spill overs act as a bridge between private and social rates of return to R&D; this often impact on to key issues – market failure constraints and the complication in evaluating the effect of environmental innovation [1, 15, 16, 4].

The Implications for Cleantech Incubators are: Environmental, Societal and Economic

The questions to be addressed are:

- Do SME Innovators Understand This Change?
- Do SME Propositions Maximise This Opportunity?
- Are SMEs Aligned with their best markets and clients?
- How will you improve the return on your Innovation € / £ s?
- How will Incubators measure success? [11].

Clean Tech Policy Discussions

Based on the need for clean tech, there are policy considerations that are driven by available resources:

- Emphasise Innovation
- Maintain Stability
- Utilise Competition and Market-driven Mechanism
- Focus on Key Sectors, and
- Focus on Key Technologies

Emphasise Innovation

There is the need for focus on innovation policies that would strengthen the cleantech sector as well as support research and development (R&D), commercialisation of academic research and investment in technology to increase business performance and efficiency. In relative, it strengthens clean tech patents per capita and broadens human capital measurements, as well as reflecting a healthy environment of academic R&D.

Maintain Stability

In order to deal with the current political and regulatory climate often characterised with uncertainty and reduction in private investment, organisations would benefit from applying for proposals, both in the siting and regulatory environment. This type of policy would provide reasonable certainty for clean tech demand by incentivising cleantech-based organisations to enable them invest in capital equipment and employment.

Utilise Competition and Market-driven Mechanism

Market-driven mechanism or policies enable price to be formed in order to bring about competition and to value environmentally desirable aspect of energy system that are extremely efficient as public policy. These mechanisms would no doubt support clean tech and economic growth. Typical examples are the Renewable Greenhouse Gas Initiatives (RGGI), Renewable Portfolio Standard (RPS) and a new group metering law.

Focus on Key Sector

There is a call for concentration on manufacturing that is key component for the next wave of cleantech growth, specifically on electronics and sensors. This includes cleantech applications that relates to technologies such as renewable energy, energy efficiency and smart metering.

Focus on Key Technologies

Other key technologies such as renewable energy, smart grid and energy efficiency are useful in creating employment in other sectors such as construction. Solar also has positive impact and opportunity for employment in construction and professional services sectors whereas renewable energy and energy efficiency can support local economy by reduction of cost and saving of energy as well as diversifying energy.

Practitioners and researchers must also consider the huge impact of efficiency on economic pay-off i.e. Energy use management (a program that allows organisations to benefit from energy efficiency

that is most cost-effective and reduces fuel consumption) [16, 10, 12].

SUMMARY AND CONCLUSIONS

According to [17], clean technology consists of a diverse reange of innovative products and services that enhance the use of natural resources as wellm as reduce the adverse effect of the environment whilse creating value through costs reduction, efficiency improvement and provision of high quality performance. The key issues associated with development and adoption of technology that mitigate climate change include: negative externalities of climate change, knowledge spillovers, the scale of adoption, path dependency, principal-agent problems and behavioural change. The growing economy is regarded as an incremental strength of clean tech sector. This tend to enable organisations to provide more employment than higher way pay and saves money from both consumers and organisational view point. Thus there is the need for benchmarking of clean tech leadership and business intnsity.

The impact of clean tech would vary significantly depending on the industry and geographical area, some of which include: tranforming maeket, lower penetration rate, impact of solar panel on roofs and regulators investment on energy efficiencies and renewables. The level of global patenting has been increasd by threefold in the solar, wind and marine technological areas by comparing the periods in the late 1990s to the late 2000s. However with cleantech footing competition, regulation is increasingly becoming less relevant and may no longer be necessary in some sectors. Despite this, syetms such as solar still needs continued regulation for its grwoth in developed countries like Germany for deploying renewable. This explains why solar installation has increased globally to approx 57% annually since 2006.

Just like most other countries, the UK must be very determined in giving priority to cleantech sector investment in order to drive the future economic growth. With transformational policy interventions as well as sustainable policy framework, the impediments caused by policy, capital and infrastructure would be eliminated and private sectors would also be fully committed to investing at large [18, 17, 19, 20].

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