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Annu Kotiranta
The Research Institute of the Finnish Economy
Helsinki, Finland

Antti-Jussi Tahvanainen
The Research Institute of the Finnish Economy
Helsinki, Finland

Maria Ritola
DEMOS
Helsinki, Finland

Peter Adriaens
Stephen M. Ross School of Business
University of Michigan

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Annu Kotiranta[1], Antti-Jussi Tahvanainen[1], Maria Ritola[2], and Peter Adriaens[1,3]

[1]The Research Institute of the Finnish Economy, Helsinki, Finland; [2]DEMOS Helsinki, Finland; [3]University of Michigan - Ross School of Business, Ann Arbor, Michigan USA

Abstract

Cleantech has made a respectable comeback onto the global agenda of firms, investors and economic developers alike, evolving with a constantly proliferating range of cleantech companies and business models. In the midst of the resurgence, Finnish CleanTech has been recognized globally. Indeed, recent rankings placed Finland in the top-3 of global leaders in cleantech, along with Israel and the US.

This paper takes a closer look at the Finnish commercial cleantech space and scrutinizes it in light of select indicators such as degree of specialization into cleantech, type of industrial activity, generation of value added, financial performance as well as type and volume of intellectual property generated.

The results are thought-provoking. Of the many insights, three stand out: First, the Finnish cleantech space is dominated by manufacturing-driven businesses. Second, consumer-oriented technical innovations seem to be rare. And third, the engine of industrial renewal – the small and medium-sized firms – appears to struggle with financial sustainability.

The ability to shift gears from manufacturing- to service-driven businesses may be compromised if the low financial viability of small and medium sized companies turns out to be more than a statistical anomaly. These firms have the capacity to transition conventional industry boundaries to develop novel business models and open new markets, and poor financial performance would indeed be bad news for the long-term development of the cleantech space in Finland.

In the gold rush era of digitalization, our findings beg the question whether the seemingly dominant focus on manufacturing, engineering and technology could become the ball-and-chain to the growth of Finnish cleantech. Digitalization is currently revolutionizing service businesses and providing opportunities to harness vast consumer markets for rapid, scalable growth – particularly in the area of resource efficiency – via new, often disruptive business models. In recent years these opportunities have been widely discussed in several contexts including cleanweb, smart cities, internet of things, and consumer cleantech.

Given the central role of information technology in cleantech 3.0 businesses, there is a clear opportunity to leverage the innovative capacity of the Finnish ICT industry to: (a) accelerate the adoption of green solutions, (b) drive economic growth, and (c) render cleantech companies not only profitable, but also attractive investments.

Keywords: Cleantech, cleanweb, industrial renewal, digitalization, Finnish economy

JEL: L16, O12, O14, O52

From policy fad to respectable economic activity

In the past decade, cleantech has evolved from a policy-driven economy to a perceptible, economic megatrend with considerable industrial and financial momentum. Only as recently as 2008 did the Economist[1] proclaim the “downturn of clean technology” under the “gathering clouds” of the global economic slowdown. Today, Chrysalix EVC[2], one of the longest standing venture capital firms in the cleantech space, estimates that the total addressable market in cleantech will grow to a size anywhere between three and four trillion USD by 2020; an eight-fold increase since 2005. In 2013, global investments into green energy alone exceeded $200Bn, a figure that is expected to triple until 2030[3]. To put the numbers into perspective, current investments into fossil-fuel-based power generation top out at $270Bn.

The market performance of select vanguard names in cleantech provides further support for the sector’s long-awaited success story that many are still rather cautious to buy into. According to CapitalIQ and Bloomberg, the present-market-capitalization-over-IPO-value multipliers of companies such as Cree, Tesla and Solar City are on par with those of eBay, Google, Linkedin and Facebook. Certainly, one cannot ignore the growing body of economic and financial evidence speaking in favor of Case Cleantech. Nonetheless, the agnostic will still want to know what is driving this surge in cleantech. What are the incentives? Where are the growth opportunities? How have business models shifted? Why is cleantech back on the agenda?

Threats are effective drivers for the greening of economies

As an incentive, the stick is often mightier than the carrot. In the context of cleantech, the stick comes in the form of increasing resource scarcity and global warming (WEF, 2014[4]; PWC, 2014[5]; KPMG, 2014[6]). Already, decision makers in business and politics alike are starting to feel the pain brought on by the foreseeable negative impacts of environmental and social sustainability trends, if neglected:

1. Rapid growth in the planet’s population and the gentrification of developing economies exacerbates the competition for resources as pressures to increase the production of food, energy and minerals rise. According to the UN, the demand for food will increase by 30 percent until 2030; and by a staggering 50 percent until 2050. In parallel, crop yield in agriculture grows at an ever slowing rate of only 1 percent annually. Four decades ago the rate still was twice as high. With demand outpacing production, prices are bound to soar and weaken the purchasing power of consumers.
2. In the wakes of Fukushima’s nuclear tragedy and Ukraine’s political conflict, businesses and governments are redirecting emphasis on energy security. Strategies in the energy space focus on diversifying risk by increasing the number of producers and suppliers as well as by accelerating the integration of renewables in the energy mix. The uncertainties in this space are reflected in increasing energy prices that, depending on the sector, already make out 5-20 percent of businesses’ total costs.

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[1] The Economist (2010)
[2] Wal van Lierop (2014)
[3] Bloomberg New Energy Finance
[4] WEF (2014)
[5] PWC (2014)
[6] KPMG (2014)

3. According to the newest findings by the International Energy Agency (IEA), the cost impact of global warming will exceed 3.2 percent of global GDP by 2030, if attempts at curbing emissions-related increases in the global temperature should fail. Current estimates value present costs at $1200Bn (DARA, 2010[7]). To de-risk potential consequences of climate change on society and the economy, governments are setting in place regulatory measures that drive sustainable production and consumption. These regulations set new strategic and operative boundaries for businesses, challenge incumbent business models, and provide ample opportunities for new, innovative businesses and incumbents that seek to renew their business practices. Even behemoths such as Exxonmobile, Microsoft and General Electric already forge strategies that are compatible with business environments subject to carbon tax –like regulatory innovations (New York Times, 2013[8]).
4. Regulatory schemes – the governmental armory of sticks – are complemented by more direct measures such as the withdrawal of current subsidies. The International Institute for Sustainable Development (IISD) estimates that governments around the world subsidize the production and use of fossil fuels with a compound $600Bn annually. About $100Bn thereof are said to go to the oil producers directly. As outlined by the Global Subsidies Initiative in 2010[9], decision makers at the G-20 Pittsburgh Summit proclaimed that "inefficient fossil-fuel subsidies encourage wasteful consumption, distort markets, impede investment in clean energy sources and undermine efforts to deal with climate change." The Summit's yield was a joint decision to phase out inefficient fossil-fuel subsidies that encourage dissipative consumption. When and how a phase-out will hit producers, investors, industry, business and other central stakeholders such as consumers is not known, but the impact will be felt widely with great certainty.
5. In many countries, governments and NGOs take on more aggressive roles in the promotion of cleantech related sectors. In Finland, for instance, the Ministry for Employment and the Economy has launched a "Government Strategy to Promote Cleantech Business in Finland"[10]. By 2020 the strategy aims (i) to raise the compound turnover of Finnish cleantech companies to €50Bn, of which exports would account for over 75%, (ii) to double the Finnish cleantech home market to about €20Bn, (iii) to raise the number of cleantech companies from 2000 to about 3000, and (iv) to create at least 40,000 jobs in clean technology in Finland. To name a few action points of the strategy, the "Ministry of Finance is to annually provide €30M in investment subsidies for cleantech demonstration and reference projects, which are to catalyze €150M in investments into Finland." Prize money for companies winning in international cleantech -related business plan competitions is set to €1M. Furthermore, the "Ministry for Foreign Affairs is to name shared cleantech envoys to more than 100 countries by 2015." In the NGO space, the Global Cleantech Cluster Association (GCCA), a meta-cluster with the vision "to drive sustainable regional economic development on a global scale", has grown in only four years of its existence to encompass 50 clusters from across the world, representing 10,000 cleantech companies. The GCCA is collaborating with the P80 Group Foundation and Club de Madrid to support the Global Technology Deployment Initiative.
6. In parallel with the corporations and governments, the financial markets are bracing for the impact that regulations and changes in consumption will have on the valuation of companies that produce and refine fossil fuels (Carbon Tracker Initiative, 2011[11]). The rise of ESG (Environmental-Social-

[7] DARA Group and Climate Vulnerability Monitor (2010)
[8] New York Times (2013)
[9] GSI (2010)
[10] TEM (2014)
[11] Carbon Tracker Initiative (2011)

> Governance) –indexed funds, impact investing, and responsible investing reflect growing concerns about a shift in the valuation of business models and practices. Pension funds that are by far the largest investors in fossils-based businesses are especially exposed to carbon risk, because of the annual dividends paid out by oil and gas companies. The question is when do pension funds start repositioning their vast resources towards a green (or better, carbon-free) economy? And where are those funds to be placed? A recent Environmental Finance workshop in London indicated that part of the problem is the dearth of green assets for allocation. The challenge is, pension funds do not like thematic investments. To them themes are policy-driven fads subject to political volatility[12].

In summary, commitment to and opportunities in cleantech seem to finally materialize in tangible form. Hype is being replaced by a growing concern about the sustainability of not only the environment but that of societies. Food, housing and transportation costs are on the rise as resource scarcity is becoming more imminent in a world with a fast growing population but finite assets. Fortunately, driven by this concern, governments, businesses and consumers alike seem to share a common view of the necessity to green the world's economies.

That being said, governments can do only so much. While setting the incentives, they do not produce the solutions. The question then is how well is the corporate space positioned to take advantage of cleantech and drive change? What is the state of cleantech as a business today? How do cleantech companies need to restructure their business models to enable scale of adoption and profitability?

What is cleantech?

To provide some empirical answers to the questions, this report takes a close-up look at the commercial cleantech space in Finland. The picture is drawn using numeric, categorized distributions of central economic indicators such as turnover, number of employees, profit margin, and return on investments.

Before diving into the numbers, we need a taxonomic description of this investment domain. Given the strong sentiments different stakeholder groups have developed towards cleantech in the past two decades, one is inclined to think that by now it is a well-defined, manifest concept.

The truth is somewhat disappointing. Anyone randomly searching for a definition among literature or on-line sources soon finds that it is everything but well-defined. Existing definitions are extremely vague and ambiguous. They are either too narrow or describe technological, industrial and strategic spaces so vast they lose all functionality as a definition. It is a researcher's nightmare: one cannot measure what one cannot define. For the reader's convenience and to provide her with the possibility to assess the gravity of the issue independently, a small sample of existing definitions for cleantech is given below:

"Clean technology (cleantech) is the installation or a part of an installation that has been adapted in order to generate less or no pollution. In clean as opposed to end-of-pipe technology, the environmental equipment is integrated into the production process." – OECD/UN[13].

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[12] The Atlantic (2013)
[13] UN (1997)

"Cleantech refers to products, services and processes, which promote the sustainable use of natural resources while reducing emissions. Cleantech is not an industrial sector of its own but the markets for the products and services are found in all industrial sectors, especially from technology, energy and construction sectors." – Ministry for Employment and the Economy, Finland.

"In brief, Cleantech refers to technology, products and services which generate superior commercial benefits to customers while addressing significant environmental concerns such as global warming, sustainability of natural resources and energy security." – ecoConnect, UK

"A broad base of processes, practices and tools, in any industry that supports a sustainable business approach, including but not limited to: pollution control, resource reduction and management, end of life strategy, waste reduction, energy efficiency, carbon mitigation and profitability." - Clean Technology Trade Alliance

"Cleantech, also referred to as clean technology, and often used interchangeably with the term greentech, has emerged as an umbrella term encompassing the investment asset class, technology, and business sectors which include clean energy, environmental, and sustainable or green, products and services." - Neal Dikeman, Jane Capital Partners LLC

"A shortened form of "clean technologies", a term used to describe an investment philosophy used by investors seeking to profit from environmentally friendly companies. Cleantech firms seek to increase performance, productivity and efficiency by minimizing negative effects on the environment." - Investopedia

"Cleantech is any product or service that improves operational performance, productivity, or efficiency while reducing costs, inputs, energy consumption, waste, or environmental pollution. Its origin is the increased consumer, regulatory, and industry interest in clean forms of energy generation—specifically, perhaps, the rise in awareness of global warming, climate change, and the impact on the natural environment from the burning of fossil fuels." - Wikipedia

Despite their ambiguity, the above definitions converge on a number of issues: First, cleantech is not an industry in its own right. It is an amalgam of technologies, products, services, processes, practices and investment classes that promote the sustainable development and greening of incumbent and emerging industries, as well as societies. Second, through efficiency gains or entirely novel alternatives it reduces the unsustainable exploitation of natural and societal resources in industry, business and consumption. Third, it provides industries, businesses and consumers with superior value propositions when compared to conventional solutions.

The definitions do not contradict each other and provide three loose criteria that cleantech should match to be recognized as such. Again, one might be inclined to think that, in the absence of more definite parameters, one would at least be able to spot a cleantech company on sight. After all, we know that entire US Supreme Court cases have been decided based on the famous "I know it when I see it"-heuristic[14].

Example 1: Renewable energy generation. The use of fossil fuels for energy production and transportation has been viewed as the number one driver of global warming and climate change. If using wind, solar, wave or hydro power helps to curtail the threats and costs of natural disasters, food shortage, disease, environmental degradation, loss of property and social turmoil then the average person will agree that

[14] Gewirtz (1996)

renewable power generation indeed meets the above criteria of cleantech. And so agrees the researcher. Other equally unchallenging examples can be found in the areas of waste water treatment, electric vehicles, recycling of materials and many others. This was somewhat trivial.

Example 2: Resource sharing services. Here the problem becomes more complex already. Take a car sharing service provider such as Zipcar or car-pooling service companies the likes of kyyti.net. Sharing the right to use a vehicle or offering redundant seat space to travelers headed towards the same destination can very well be argued to fulfill the three criteria:

(i) the activity is clearly not a traditional industry of its own, but a service that provides information for the coordination of the efficient exploitation of *existing, redundant* assets and is built on top of existing industrial infrastructure such as telecom and IT networks, cars, etc.,

(ii) it generates both natural and societal resource efficiencies as it substitutes for new car manufacturing and related resource consumption up the value chain, decreases traffic congestions and pollution, and reduces overall fossil fuel consumption, and

(iii) it provides new value added to users in the form of (a) foregone insurance, parking and maintenance payments, (b) access to a car for low-income or low-use individuals who could not otherwise afford it, and (c) the convenience of on-demand transportation without the burdens of ownership such as the daily search for a parking, which has been argued to make up a forth of the total time spent in a car in metropolitan areas.

Apparently, calling car sharing services cleantech seems not to be too farfetched. But then again, transportation and its connection to cleantech are still fairly easy to grasp for most of us; the links between their use and its detrimental impacts to the environment and (personal) economy are very direct.

What about more indirect links, then? Who, for instance, would say that Airbnb is a cleantech company; a company that competes with the hotel business by facilitating the temporary renting of private homes on-line? We could run the company through the three criteria and show with ease that both the environment and users gain from the use of the service. For example, according to Pure Energy Partners, a room booked via Airbnb boasts a 66% reduction in carbon emissions per night over a hotel room[15]. Many would still argue that "clean" is just a serendipitous by-product that the providers of the service have skillfully harnessed for marketing purposes.

Example 3: Data analytics services. Let us go even further and claim that Google is a cleantech company. Consider the following: In many cleantech sectors, especially those that are considered "smart" (e.g., smart grid, smart mobility, smart cities), the entire business model and technology is built on and around increasingly growing masses of user data. In smart grid, for instance, power utilities want to anticipate peaks in electricity consumption well in advance to avoid the very unprofitable use of emergency generation capacity. A growing installed base of smart meters in homes and industrial facilities enables utilities to tap into the power consumption patterns of their customers in real time. The hook is that

[15] Bunting (2014)

utilities are not very efficient at interpreting Big Data. Patterns are challenging to identify if you do not know how and what to look for.

Specialized analytics companies such as Enernoc can provide utilities and other industries that turn data into smart action points. Specialized companies are in no way the only ones hungry for a sizable chunk of these fast growing analytics market. Google is one of the most aggressive contestants in the field. So is Amazon. If former search engines and on-line retail outlets are soon-to-be core players in cleantech, where is the line drawn? Enter the *cleanweb* opportunity: The emergence of new types of companies that take advantage of advancements in information technology.

Analytical Approach

The difficulties to provide an explicit definition for cleantech are inherent in its own cross-industrial and cross-technological nature that transcends existing demarcations of traditional industries and technologies. In the case of dedicated pure-players, the task is easier but the more diverse and numerous a company's portfolio of business lines is, the harder it is to identify it as a representative of the cleantech space.

To add to the difficulty, dedicated and specialized cleantech companies – designated "pure players" in this report – lean heavily on an entire ecosystem of stakeholders that would not explicitly identify themselves as cleantech organizations. Google, as a big data generalist, would probably not qualify as a cleantech company; nor would a sub-component producer for smart meters. And yet, they are indispensable players in the cleantech ecosystem due to their central roles in the value chains of pure players.

We concede that an airtight definition eliminating all room for interpretation is next to unattainable. Hence, the issue of definition has been addressed in this report by reverting to a *de facto* approach: We merged lists of Finnish cleantech companies compiled for internal development purposes and in use by central governmental and non-governmental economic development organizations such as Cleantech Finland, Confederation of Finnish Industries, Ministry for Employment and the Economy, the Finnish Funding Agency for Innovation, Centre for Environment and Energy, and Lahti Region Development. While not necessarily a highly academic solution, it is an empirical, practice-proven approximation of the Finnish corporate cleantech space as established by some of the most influential economic development organizations in the country. In the remainder of the report, we refer to the list of companies and the pool of their respective data points collected from a number of public and private databases as 'the data'.

Data Categorization

The original, unedited data consist of financial and other descriptive information on more than 1,800 Finnish companies active in the cleantech space. After the elimination of recently deactivated ones, the remaining 1600 companies were manually examined and (i) categorized into *thematic cleantech sectors* such as *smart grid*, *recycling and waste management*, or *biofuels and biochemicals*, and (ii) classified according to their *degree of specialization* to cleantech – or their *cleantech intensity*, as referred to in the remainder of the paper (see Box 2.1).

Box 2.1 Cleantech intensity

To bring companies with a strong focus on cleantech into the spotlight, all companies in the data were classified according to their *cleantech intensity*. The classification was based on publicly available information, mostly companies' websites.

The Cleantech intensity scale:

1 = Peripheral role in the cleantech ecosystem
2 = Support role in the cleantech ecosystem
3 = Potential dedicated activity in cleantech
4 = Clear dedicated activity, but not core business
5 = Dedicated pure player in cleantech

Box 2.2 Company examples for different cleantech intensities

Example 1 ----------

Case: A **gardening store** that sells new fertilizers for home-farmers, developed from the leftovers of the food industry.
Intensity: 1
Argument: Selling a cleantech product does not make the retailer a cleantech company. It has a supporting role in the ecosystem, however.

Example 2 ----------

Case: A **developer of embedded software, hardware and device solutions** for wireless products and services in different industries.
Intensity: 3
Argument: While the company's main markets are conventional industries such as automotive and telecommunication, its expertise in wireless solutions has great potential in the industrial internet space that drives many cleantech sectors such as smart grid or e-mobility.

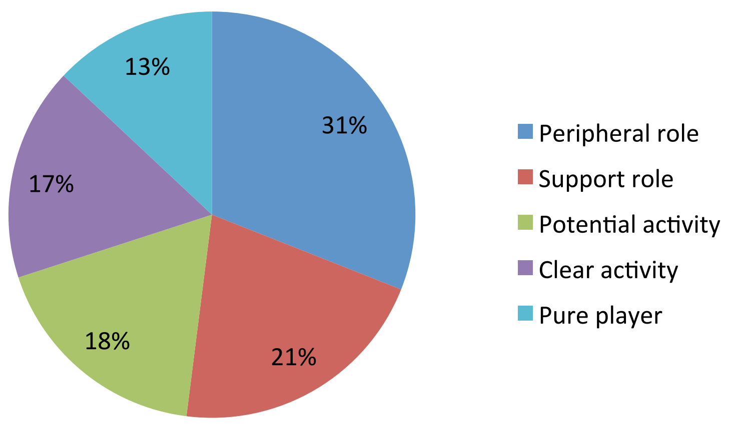
Example 3 ----------

Case: A company that designs, develops and manufactures **automated material handling systems.** Consumers dispose of recyclable waste such as empty beverage tins, empty batteries and broken light bulbs at these machines.
Intensity: 5
Argument: The company is an active driver in the recycling sector, the sole objective of which is to reduce waste in the environment. It manufactures and develops essential solutions to the glass, aluminum and plastic recycling system. It has no other lines of business; it is a pure player.

One of the key objectives of the paper is to highlight those features of the cleantech space that sets it apart from other industrial spaces. To drive the objective, the *intensity measure* was applied to the data as a *filter*: companies that operate on the fringes of the dedicated cleantech space in a supporting role to the *cleantech ecosystem* – i.e. obtained *intensity scores* of 1 or 2 – were excluded from the analyses. The exclusion resulted in a final dataset of 762 companies representing 21 different *thematic sectors*. For simplicity's sake, these companies are referred to as *cleantech companies* in the paper.

Figure 1 breaks down the *original*, *unedited* and *unfiltered* data by the *cleantech intensity* of companies. Almost a third of the company population failed to provide tangible evidence of specialized cleantech activity, and another 20 percent sent only weak or ambiguous signals thereof. As said, the important supporting role of *infrastructure construction companies*, *technology-* and *business consultancies*, *financiers*, *generic component manufacturers*, *retailers* and other stakeholders with very *low intensity scores* must be acknowledged from an ecosystem-wide perspective, but were discarded from further analyses in this report. The remaining 48 percent of the company population split fairly evenly across intensity values 3 to 5. Pure players, obtaining an intensity value of 5, accounted for 13 percent of the population.

Figure 1 Share of companies by cleantech intensity



Results

1. Manufacturing companies dominate Finnish cleantech

Since the cleantech space intrinsically defies any single industrial or technological definition, a constructive approach to the depiction of the space is to break it down by conventional industry classifications such as the *European industrial activity classification* (NACE) used by European statistics authorities.

As Figure 2 reveals, the Finnish cleantech space does not mirror the structure of the Finnish economy as a whole; it is a lot more *manufacturing*-centric. According to the data, more than a third of all cleantech companies in Finland operate in the *manufacturing* sector. The equivalent figure for the general economy is a mere seven percent. The importance of *manufacturing* in the cleantech space is even more dramatic when looking at the breakdown by *turnover* or *number of employees*. Over 60 percent of the *turnover* generated in the cleantech sector is generated in *manufacturing*. Similarly, more than half of the jobs in the cleantech space are offered by companies active in the *manufacturing* sector.

1) The Finnish cleantech space is *manufacturing* driven. A focus on the development of *physical technology* rather than *software* and *services* is the result of the relative dominance of manufacturing engineering companies in the population.

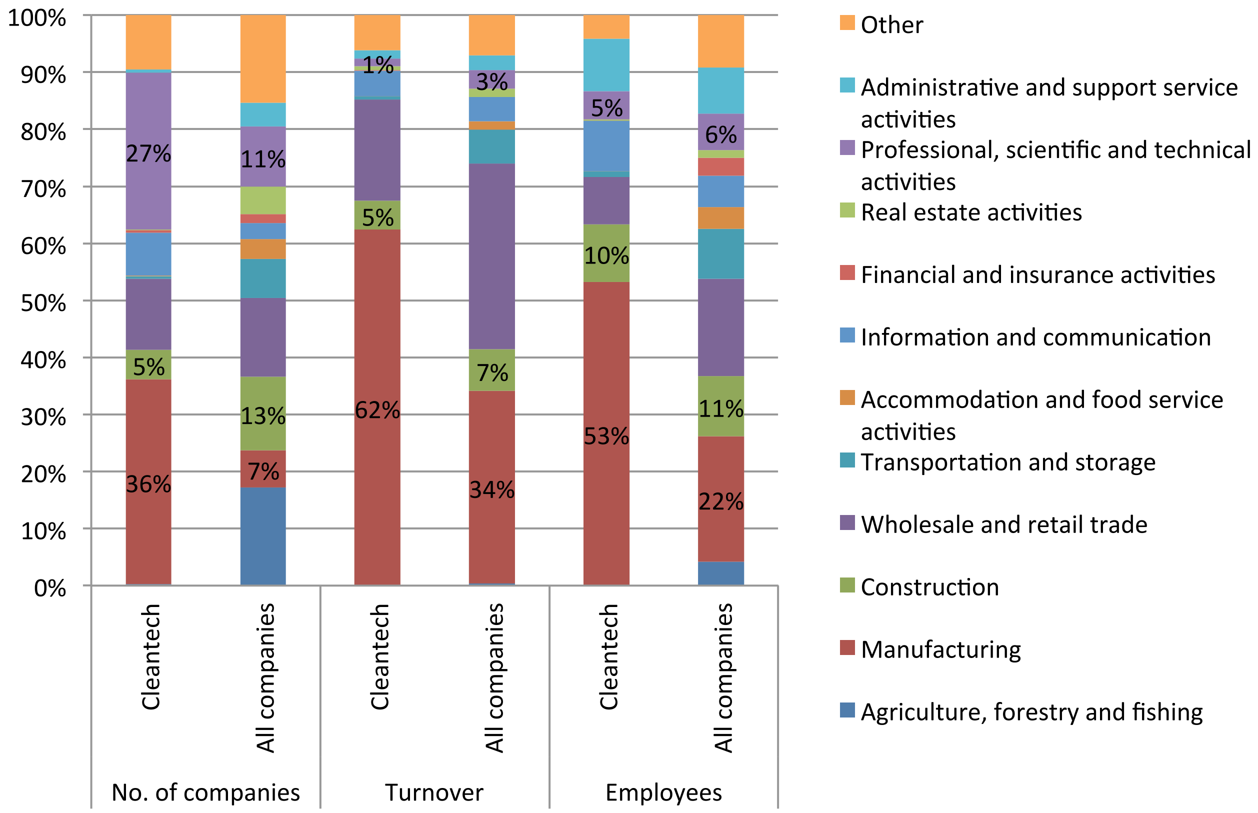
2) Cleantech in Finland is largely understood and narrowly defined as a manufacturing-related activity, largely set forth by economic developers with a focus on job creation (see the definition put forth by the OECD, for instance).

3) The data only encompass companies with high cleantech intensity scores, which may have biased the results. By nature, software developers and service providers are more frequently generalists than manufacturing companies and, therefore, might have obtained lower intensity scores.

4) On average, manufacturing companies are larger than companies in other sectors. Therefore, the importance of the manufacturing sector tends to be over-emphasized when looking at the data by volume-based indices such as turnover and number of employees.

The share of companies in the sector pursuing *professional, scientific and technical activities* – e.g. *legal and accounting activities*, *scientific research and development*, *technical testing and analysis*, *engineering activities* or *advertising and market research* – is equally higher in the cleantech space (27%) than in the overall economy (11%). *Turnover and employment* –based comparisons yield less drastic differences as the *average size* of cleantech companies active in this sector is relatively small.

Figure 2 Breakdown of data by NACE industry classification

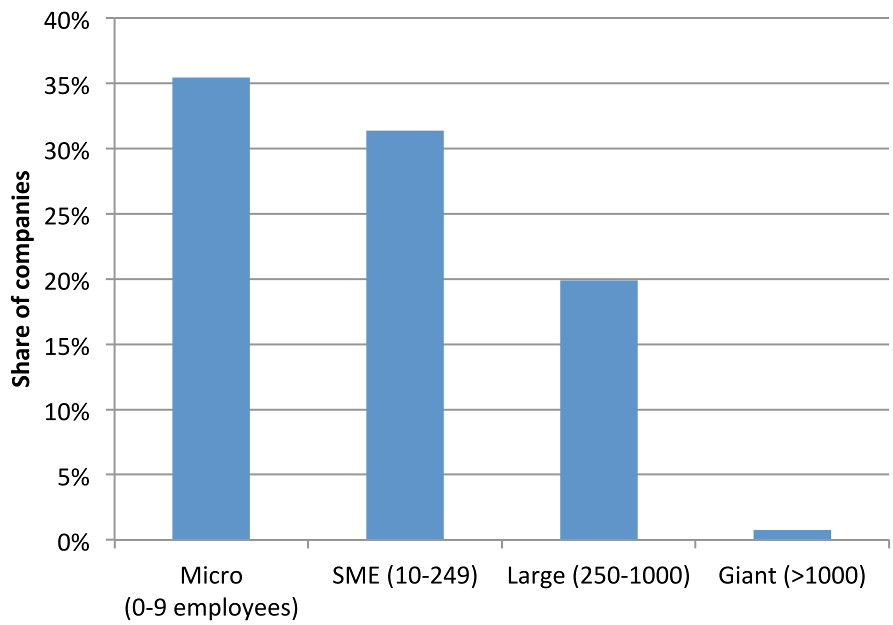


The *commerce* as well as *information and communication* sectors obtain shares comparable to the Finnish industry in general, while the *agriculture and forestry* as well as *construction* sectors seem to be clearly underrepresented in the cleantech space.

2. <u>Finnish cleantech companies are comparatively large</u>

The population of Finnish cleantech companies employs a total of 83,360 individuals. As Figure 3 shows, the majority of Finnish cleantech companies, nearly 70 %, are either *micro enterprises* or *small and medium -sized enterprises* (SMEs), employing less than 250 employees. Constituting more than a third of the population, *micro enterprises* that employ less than 10 individuals are particularly frequent. *SMEs* comprise 30% of the companies, while *large enterprises* that employ more than 250 individuals make up another 20%. Companies designated *giants* occupy a separate category. The reasoning behind this classification is a very practical one: a *giant*, employing more than 1000 individuals and generating annual *revenue* in excess of 1 billion euros, can significantly distort the descriptive statistics in a small population – especially when subsections of the data are to be examined. For instance, out of the 13 000 patents held by the cleantech companies, more than 9 700 are owned by Nokia. For this reason, the giants were treated as a separate sample and excluded from the reports analyses and averages presented hereafter.

Figure 3 Cleantech company population by size



We identified six giants in the data, all of which operate in the manufacturing sector: Wärtsilä Oyj, Neste Oil Oyj, Nokia Oyj, UPM-Kymmene Oyj, Stora Enso Oyj and non-listed ABB Oy. These six companies account for roughly 80 % of the turnover of all cleantech companies in the *manufacturing* sector and more than 65 % of the *entire* Finnish cleantech space.

Interestingly, the proportion of *large* and *giant* companies is notably *larger* in the cleantech space than in the Finnish industry as a whole. In 2012 Finland's total company population mainly consisted of *micro -sized* companies: more than 90 % of the population were *micro enterprises*, of which more than 60 % employed only one person[16]. These *one-person companies* often operate in the *services sector*, such as *education*, *personnel services*, as well as *beauty-*, *social-* and *healthcare services*. Comparatively, the 35 % of cleantech companies that employed less than 10 individuals seems a rather small share.

3. <u>Foreign-owned firms are characterized by higher revenue</u>

The Finnish cleantech sector consists mainly of *privately owned*, *domestic* companies: Roughly 83 % of the cleantech companies are *private* and in *domestic* ownership. Finnish *municipalities* own three percent and the *government* one percent of the companies. 12% are in *foreign* ownership.

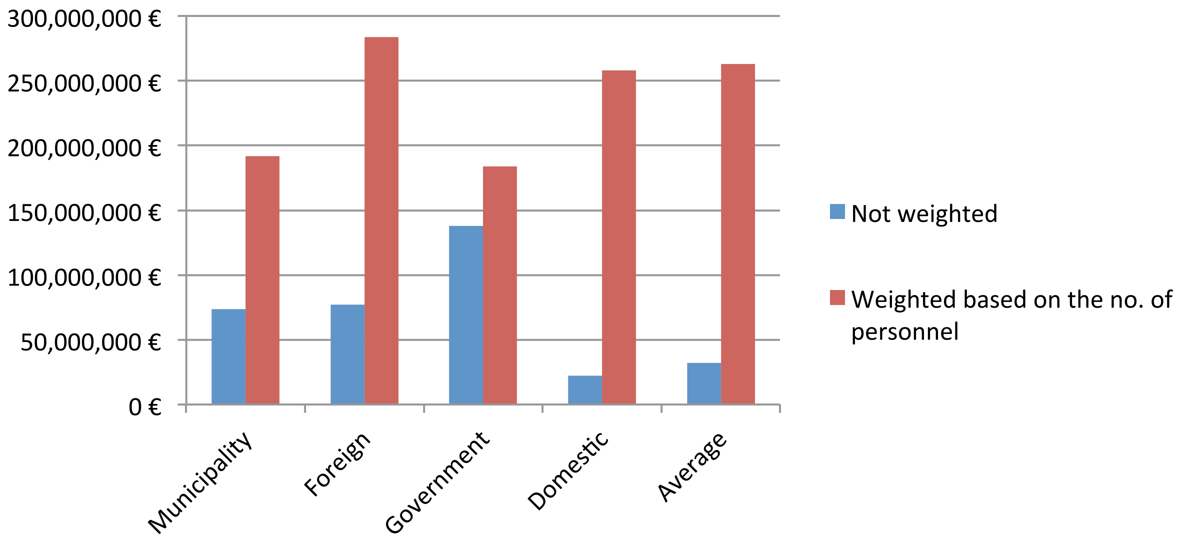
To add depth to the examination, we can break down the *revenue volumes* by *ownership type*, for instance, and ask how domestic companies fare in comparison to their foreign-owned counterparts. Figure 4 reveals

[16] Source: Statistics Finland

interesting results: On average, a *foreign-owned* company generates *higher revenues* than a private, domestically owned cleantech company. This is true for both un-weighted and weighted results[17].

There are multiple factors that can play into the finding, ranging from a *stronger market position* and *superior business models* to more *direct access to global markets* through the foreign parent organizations' established channels. Regrettably, the data do not provide enough evidence to validate these reasons empirically. One explanation that can be grounded in the data, however, is *size differential*. The *average size* of *foreign-owned* companies is significantly larger (284 employees) than that of *private domestic* companies (95 employees). *Government-owned* companies are the *largest*. They employ 493 individuals on average.

Figure 4 Average turnover by ownership type (giants excluded)



4. <u>Renewable energy, water treatment, and biofuels are dominant cleantech sub-sectors</u>

Traditional industry classifications do not disclose information on a company's activities in the cleantech space, as they are agnostic to most technology-based paradigms such as *biotechnology*, *nanotechnology* or *clean technology*. To make things even more difficult, cleantech today permeates through most of the conventional industry sectors, a phenomenon which renders the respective conventional classifications an even poorer indicator.

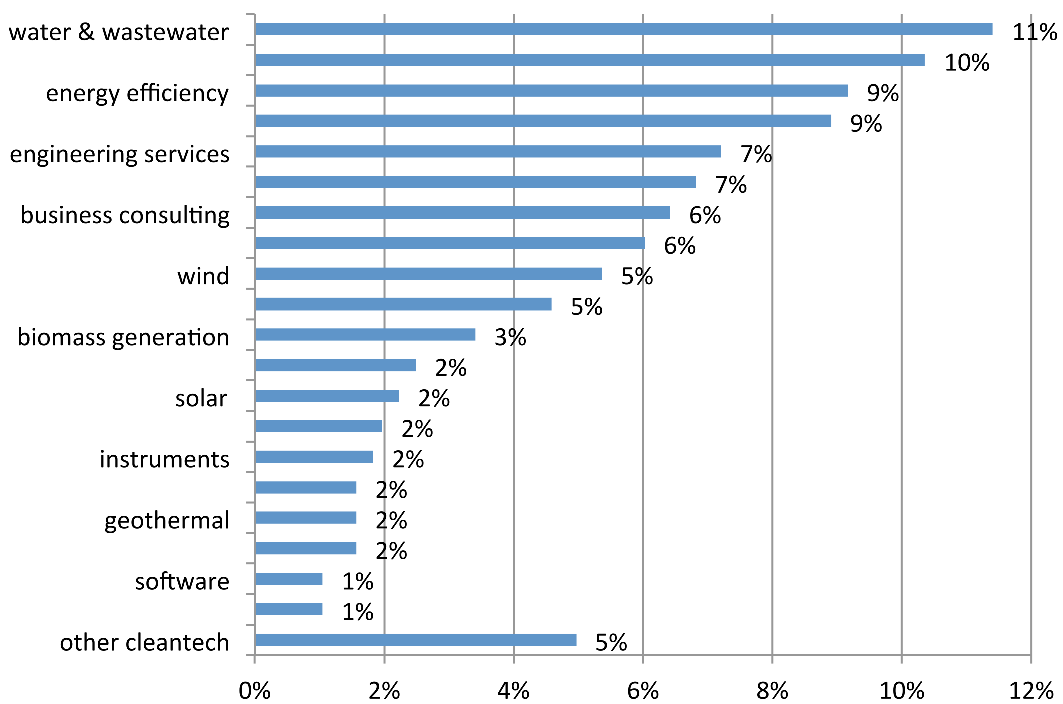
To exemplify, for instance, how are *telecommunications providers* or local *power utilities* engaged in cleantech? Their conventional industry classifications – *telecommunications* and *electricity supply*, respectively – do not indicate specific cleantech activities. A *telco operator* might play an important role in a regional *smart grid network* or provide the *telecommunications infrastructure* for a city's *e-mobility platform*. Similarly, a *power utility* might focus on *renewable energy* sources or apply cutting-edge *demand-response technology* in its generation control to stay ahead in the race towards sustainability.

[17] To correct the presented averages for distorting size effects of a very uneven size distribution of companies, the results have been weighted based on each company's number of employees.

To shed light on the veil of conventional industry classifications, the cleantech companies were manually analyzed and classified into *thematic cleantech sectors*, such as *wastewater treatment*, *advanced materials*, *biofuels*, *recycling systems* and *solar power generation*. The classification yielded 34 different cleantech sectors or sub-domains.

The results presented in Figure 5 show that the sectors *water and wastewater treatment* (11%), *biofuels and bio-chemicals* (10%), *energy efficiency* (9%), as well as *recycling and waste treatment* (9%) are the most abundant in Finland.[18] It is important to highlight that *renewable energy generation* – combining *solar*, *wind*, *biomass*, *hydro* and *geothermal power generation* – would account for 12% of the cleantech companies and therefore represent the largest single cleantech sector. To avoid compromising the level of granularity, the sectors are maintained separate. *Other cleantech* includes sectors such as *mining*, *hydro and marine power*, *fuel cells and hydrogen*, *metals*, *electronics* and *environmental services*. The complete list of sectors and the respective company frequencies is available in Table A1 in the appendix.

Figure 5 Distribution of companies by cleantech sectors



5. Smart grid, biofuels and energy efficiency sectors contribute most to the economy

To gauge the real impact that industrial activities have on a country's economy company frequencies are insufficient. The foremost indicator economists pay attention to is the *value added*, because it positively correlates with employment, one of the key metrics keenly monitored by economic developers. "The value added measures the total value added produced by the various factors of production in an establishment's [here the companies'] actual operating activities."[19] In more operational terms, the *value added* is calculated as the sum of *labor costs*, *depreciation and amortization*, *rents*, and *profits*. Alternatively, one

[18] The classification is based on the authors' views and is therefore subjective. In the case that a company operates in more than one cleantech sector, the most focal sector was chosen.
[19] Source: Statistics Finland

can subtract the cost of all *factors of production* that have been produced outside the company – i.e. *procurements* – from a company's *revenue*. The *value added* can be calculated for entire sectors by adding those of companies that comprise it, and quantifies the net volume of local, regional, or national production.

Figure 6 Value added by cleantech sector

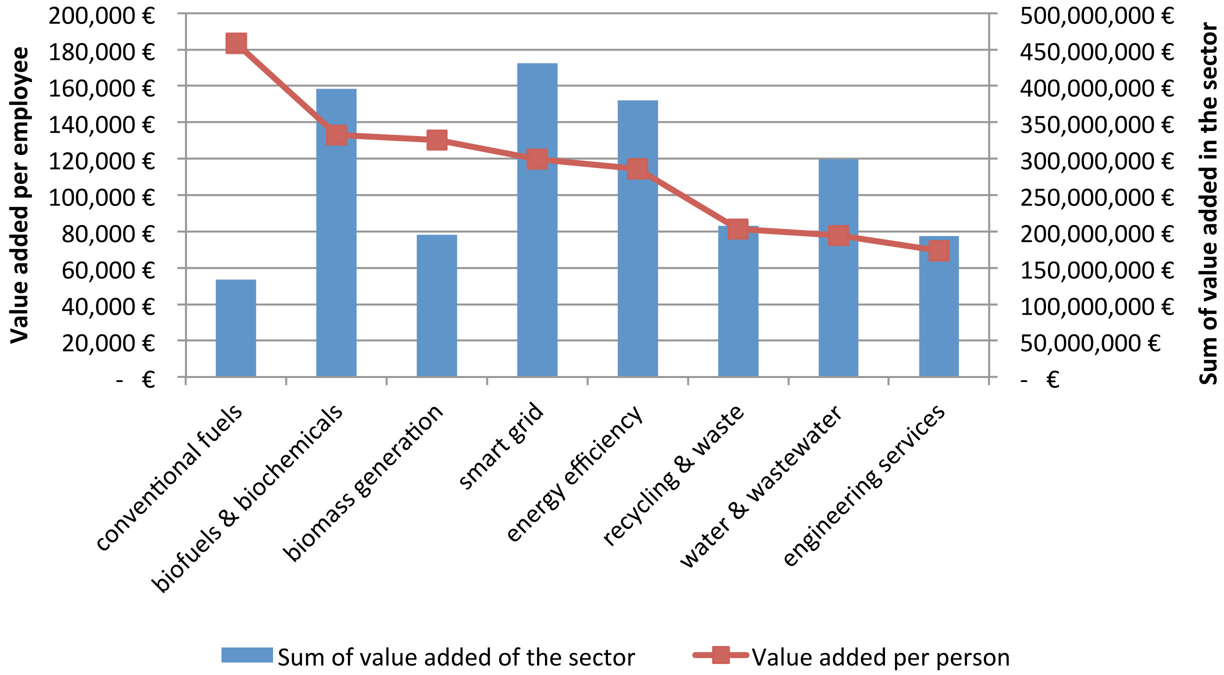


Figure 6 reveals that, in absolute volumes, the *smart grid* (€431M), *biofuels and biochemicals* (€396M) as well as *energy efficiency* (€380M) -sectors generate the most value added in the Finnish cleantech space. The eight sectors depicted in the figure produce nearly 75% of the value added of the whole cleantech space captured by the data. The giant class of companies has been excluded from the analysis. Note that *renewable energy generation* would rank second with a total value added of €429M if it were treated as an integrated sector in the report. A more detailed breakdown of value added by sector is available in appendix A.3.

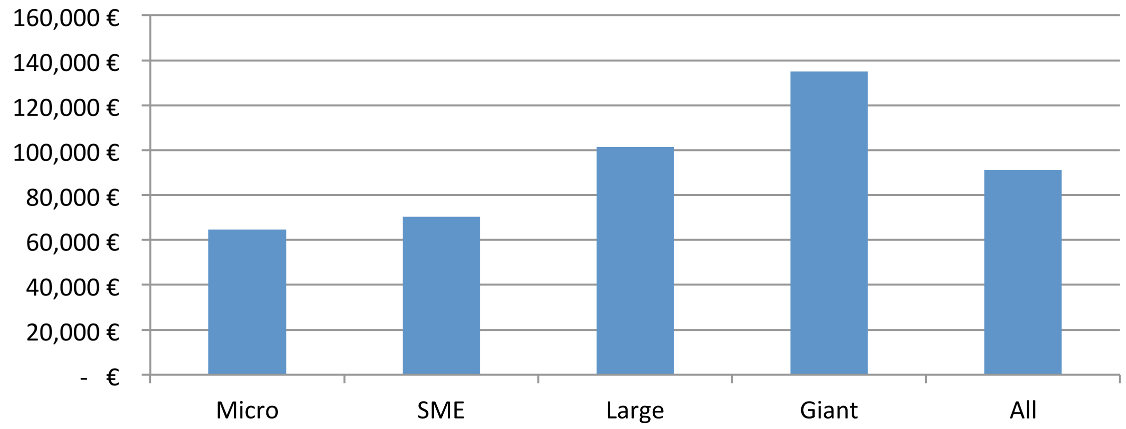
It is interesting to see that sectors such as *water and wastewater treatment* as well as *recycling and waste* do not generate value added in proportion to the company frequencies. This can be a function of many factors such as comparatively lower revenues, smaller average company size or a higher share of factors of production procured from outside the sectors.

The value added can be also harnessed to determine the productivity of employment – i.e. the value added per employee[20] – within sectors. Figure 6 demonstrates that absolute value added does not necessarily always coincide with the average value added per employee. Productivity seems to be especially high in the

[20] As already noted earlier, the productivity index for the different sectors used here is weighted by the companies' number of employees.

conventional fuels -sector, which as a sector produces comparatively little value added. The average value added per person in the sector is over €180,000, more than twice as much as in the *recycling and waste* as well as *the water and wastewater treatment* -sectors. *Biomass generation* is another highly productive sector when compared to its absolute value added. A breakdown of the average value added per employee by company size is shown in Figure 7.

Figure 7 Average value added per employee by company size



While value added is a convenient indicator for illustrating the ability of sectors to create value and assessing their importance to the overall economy, it is important to keep in mind that it is also volatile and susceptible to manipulation. For instance, multinational companies are able to undertake international transactions to register profits and costs in countries other than their origin. These transactions, typically executed for the purposes of tax minimization, can influence the total value added in sectors with large numbers of multinational companies.

6. <u>SMEs struggle with profitability</u>

The financial performance[21] of companies can be measured using a number of indicators. Here, we employ four: *return on assets* (ROA), *return on equity* (ROE), *earnings before interests and taxes* (EBIT), and the *profit margin*.

Breaking down the data by company size, Figure 8 clearly shows that, on average, small companies in particular struggle with profitability. While the strongly negative results for *micro-sized businesses* can still be argued to reflect expected patterns for businesses in the *pre-revenue phase*[22], the figures for *SMEs* are somewhat alarming.

[21] The outliers have been treated by using a winsoring method; 2,5% of the extreme values are set to the value of the 97,5th percentile. The averages are weighted using the number of personnel.
[22] In the data, there is significant positive correlation (95% significance level) between company age and size.

Given that *SMEs* in general are considered the backbone of economic stability as well as the engine for *economic renewal* and *job creation*[23], the long-term financial health of *SMEs* is essential for the buildup of a viable and thriving cleantech ecosystem in Finland. While investors, in theory, still have been able to achieve decent average returns (12% ROE), the *financial sustainability* of *SMEs* in the cleantech space is of concern. An average operating margin of -7% could indicate financial distress if it is not the random result of normal temporal variation that can occur in cross-sectional, single-year (2012) data used in this paper.

The fact that the indicator has been constructed as a *weighted average* value of *all SMEs* in the sample, however, clearly argues against this possible explanation. Averages are much less prone to suffer from variation-related effects as the aggregate results tend to converge towards the mean. Also, when benchmarked against the excluded cohort of companies with low *intensity scores* (1 and 2), cleantech-intensive companies indeed fare far worse. This is another argument in support of the robustness of the overall finding. On a more optimistic note, large companies fare much better which, on the other hand, is quite intuitive given the universal *survivor bias* that grows with the average age of businesses in statistical datasets: only profitable companies survive in the long-term.

While profitability is seemingly low in the cleantech space, the data should be interpreted in proper economic context. According to Statistics Finland, the average *Return on Assets* (ROA) percentage of the Finnish industry in 2012 was 5.4 %; for *SMEs* the figure was 4.4 %. The corresponding figures for the cleantech space are 6.9 % and 8.3 %. The figures for ROE are even higher. While the returns have been smaller, they have been generated with lower *assets* and *capital inputs*.

These ROA and ROE data can be interpreted in many ways. The cleantech space may be *undercapitalized* but is characterized by capital-efficient companies. The intrinsically efficient companies generate smaller profits because they have been unable to tap into large enough pools of resources or are unwilling to invest into growth. Reasons can be manifold, ranging from the inability to raise financing and the size of targeted markets, to a reluctance to grow. Alternatively, the explanation is a statistical one. As shown earlier, the companies in the cleantech space are significantly larger in terms of revenue and personnel when compared to Finnish companies in general. In addition, the differences in other dimensions such as industry distribution may play a role in the observed profitability indicators.

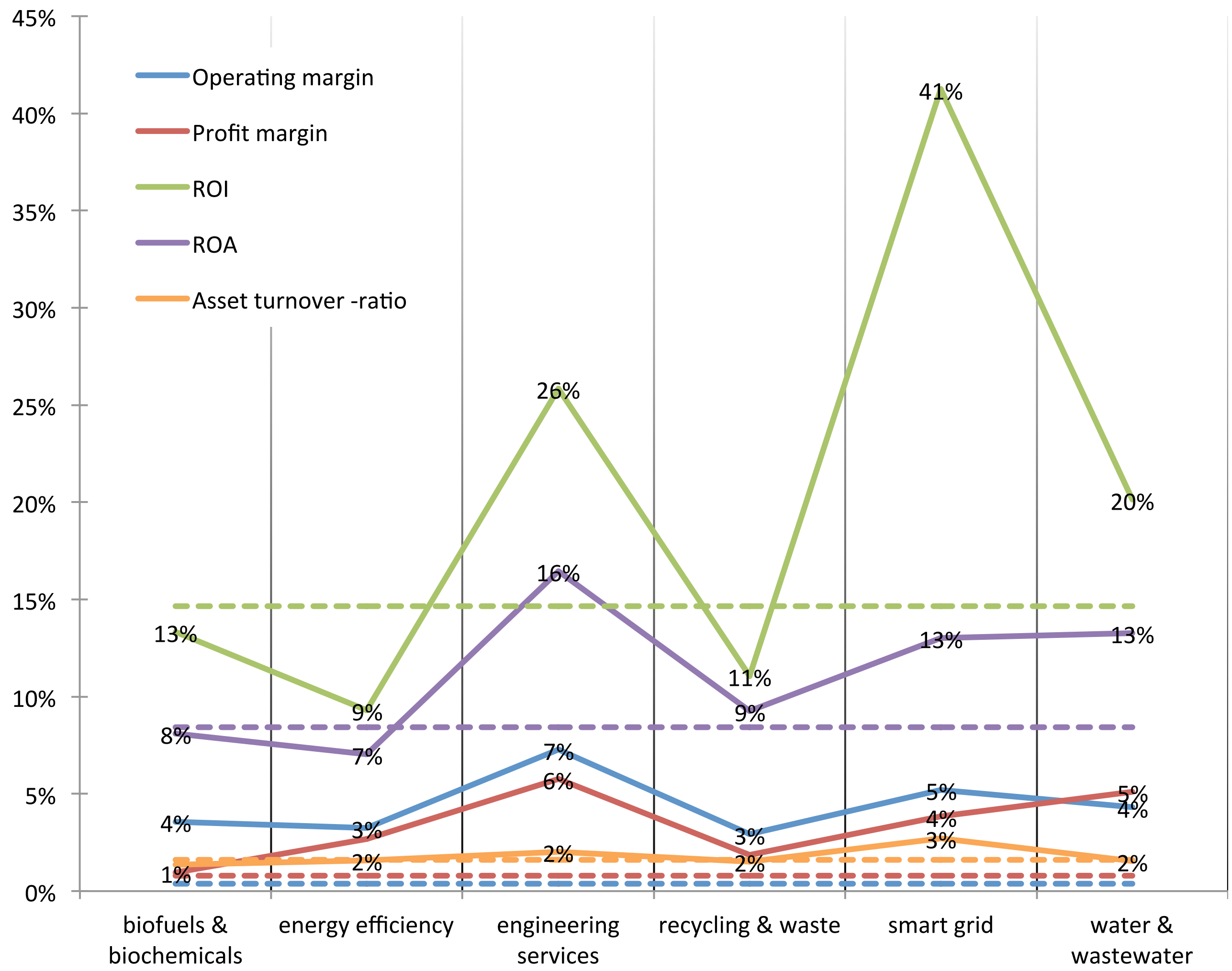
Figure 8 Financial performance by company size

	Micro	SME	Large	Giant	All cleantech
Operating margin	-42 %	-7 %	4 %	2 %	0 %
Profit margin	-46 %	-10 %	5 %	6 %	1 %
ROI	0 %	12 %	16 %	16 %	14 %
ROA	1 %	7 %	9 %	9 %	8 %
Asset turnover ratio	2 %	2 %	2 %	1 %	2 %

[23] 66,5% of European jobs were provided by SMEs in 2012 (European Commission, 2013).

To provide further granularity to these data, the financial performance of cleantech companies was examined *by sector*. Figure 9 reveals that the companies in the six larges sectors financially outperform the rest of the cleantech population on average[24] (population averages shown in dashed lines). With a six and five percent profit margin, respectively, the *engineering services* and *water and wastewater* -sectors generate the highest profits. Both are still below the average general industry benchmark of seven percent. The *smart grid* and *energy efficiency* -sectors trail in third and fourth places with four and three percent margins, respectively. The lowest profit margins are found in the *agriculture and forestry* (-151%), *hydro and marine power* (-88%), *solar power* (-47%) and *nuclear power* (-34%) -sectors (see Table A3 in the Appendix). Note that some of the latter sectors such as *agriculture and forestry* (6 companies) and *hydro and marine power* (6 companies) have very low company frequencies.

Figure 9 Financial performance by cleantech sector



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[24] Outliers have been subjected to 90% Winsorization: indicator values below the 5th percentile have been set to the 5th percentile, and values above the 95th percentile have been set to the 95th percentile. In addition, the averages are weighted using the number of personnel. Giants are excluded from the analysis.

The investment-related performance indicators show (Figure 9) that some of the cleantech sectors clearly outperform the general Finnish industry, which on average returns 14 % on investments. Smart grid (41% ROI), engineering services (26% ROI and 16% ROA) and water and wastewater treatment (20% ROI) are the most notable examples. Again, the *agriculture and forestry* (-35%) as well as *solar power* (-12%) are the poorest performing sectors.

7. Do patents uncover a deficiency in consumer-oriented solutions?

Intellectual property rights are used for a plethora of purposes in research. Ranging from a measure of innovativeness to a tangible support in tracking technological evolution, patent data in particular are a widely used resource to probe the inherently fuzzy and ambiguous dimension of innovation. Patent data surely have their flaws. Patents are only one form of intellectual property protection, and many times companies revert to other methods such as secrecy or lead-time. Hence, patents are in no way an exhaustive, all-encompassing measure. Patenting practices also differ from industrial sector to the other, making comparisons challenging.

Here, patents are used to describe the technological space of Finnish cleantech. What specific technological fields does Finnish cleantech comprise of? It should be noted that especially *software*, *data* and *service-based* businesses are strongly underrepresented in the following analyses since these enabling technologies or methods are not patentable in the European context; another flaw of patent data as a statistical proxy for innovation and technology.

Given those limitations, 192 out of the 760 cleantech companies in the data – one quarter of the population – hold at least one patent. For an allegedly technology-driven industry, it is not an exceptionally high share. It seems that many of the businesses in the cleantech space are not necessarily built around proprietary technology. In total, the companies hold roughly 13 000 patents, of which more than 9700 are owned by Nokia. The majority of other patent holders in the data hold only a few patents: less than 20 % boast more than 10. In the following analyses the giants, including Nokia, are excluded.

To help in a structured analysis, the patents are categorized according to a patent classification. The classification used in this report is developed by Mancusi[25] and encompasses six broad technological fields: *electronics*, *instruments*, *chemicals and pharmaceuticals*, *processes*, *machinery* as well as *consumer goods and civil engineering technologies*. These six categories are further divided into 30 technologies.

As Figure 10 reveals, the majority of the patents[26] reside in the categories *mechanical*, *process*, or *electrical engineering*. To no surprise, actively patenting companies operate most frequently in the manufacturing industry: out of the 174 companies that have at least one patent, more than 100 are in the manufacturing industry. Consumer-oriented technologies are clearly underrepresented; a result, which gives rise to a very interesting discussion on the dangers of Finnish cleantech companies missing out on the massive growth opportunities that consumer markets currently offer.

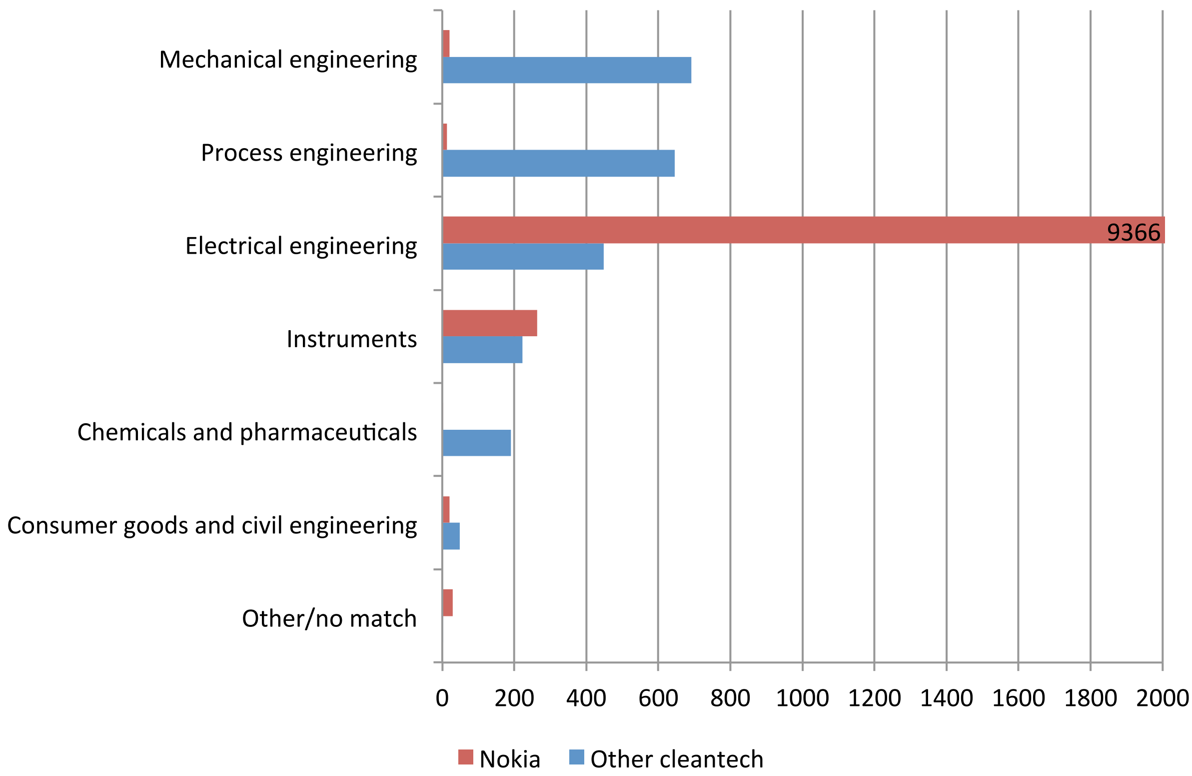
Three sectors, in particular, put a major strain on the sustainability of consumption of planetary resources today: *Transportation*, *food and feeds*, and *housing*. In all three sectors it is consumers that drive the overall consumption. Hence, many companies around the globe that could be branded cleantech are developing

[25] Mancusi (2003)
[26] The patents of the "giants" are excluded from the analysis.

solutions geared towards motivating consumers to adopt more resource-efficient practices (Uber, Airbnb, Revolv, SmartThings). According to a rule of thumb, one unit saved in consumption translates into three units saved in production. The combined effect on resource consumption can be exponential.

A large share of these solutions is service and software -based and will not show up in the patent statistics presented here because they are not patentable in Europe. Hence, a lack of patents in consumer-related technology is not necessarily alarming, but many of these services encompass a technological component in the form of sensors, transmitters, receivers, terminals etc. that might involve opportunities for developing proprietary technological solutions. These should show up as patenting activity. In the US, the types of patents addressing the consumer markets through "*cleanweb*" products encompass mobile device applications, place-based (e.g. GPS) tracking and decision support systems, logistics, and driver or product rating strategies. However, the US Supreme Court narrowed the type of inventions that are eligible for patents, such as methods that are merely computer- or cloud-based applications of familiar ideas, such as financial transactions or price-based models[27].

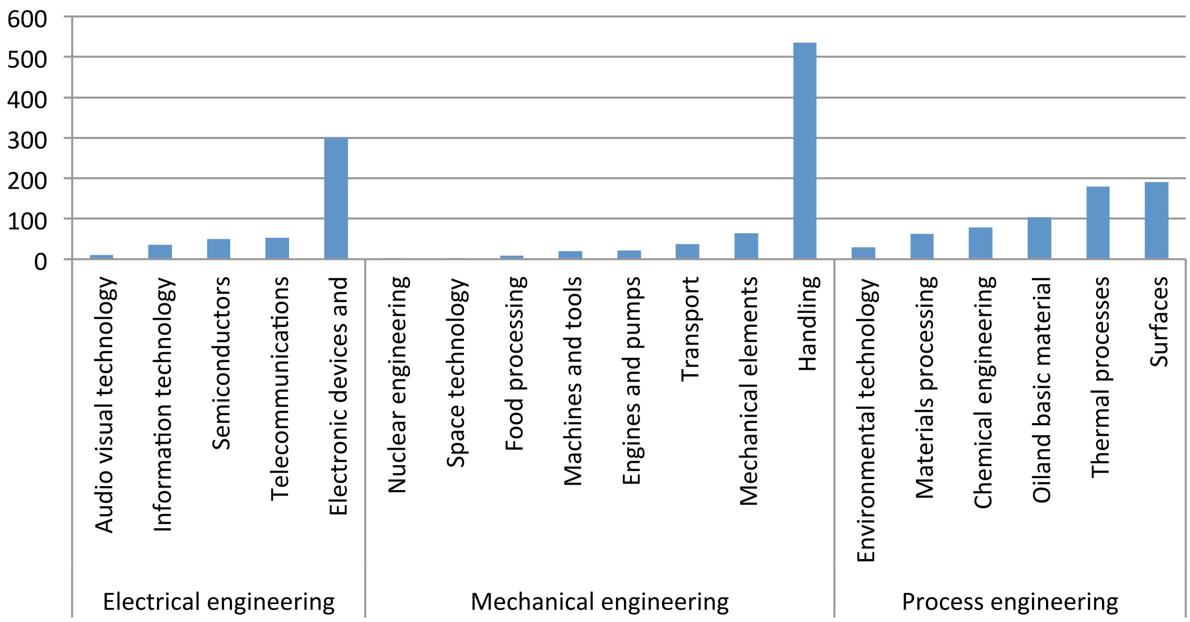
Figure 10 Breakdown of cleantech patents by technological field



A closer look at the three engineering patent categories reveals that *electronic devices and electrical engineering* (electrical engineering), as well as *handling and printing* (mechanical engineering) are clearly the two single most important technology categories that Finnish cleantech companies patent (see Figure 11). To clarify, the category *handling* includes patents on packing, storing, lifting, and hauling technologies. *Surface technologies* and *thermal processes* (process engineering) are the next most frequent categories.

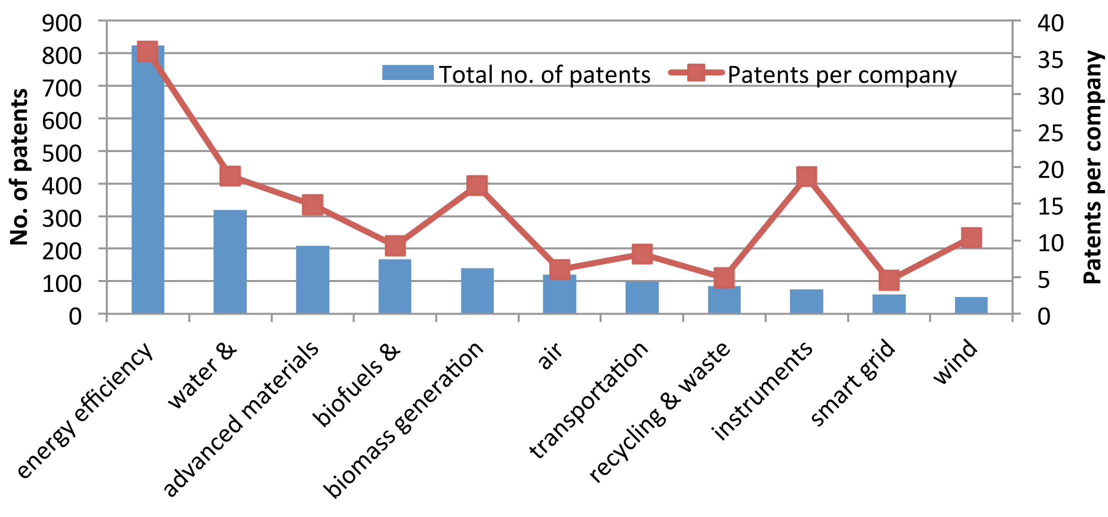
[27] [http://www.supremecourt.gov/opinions/13pdf/13-298_7lh8.pdf; Alice Corporation PTY. LTD. v. CLS Bank International et al.; October 2013]

Figure 11 Breakdown of engineering patents by subcategory



Breaking down patenting frequencies by cleantech sector, in turn, shows that sectors with large numbers of companies also tend to have the most patents (Figure 12). More than one third of all patents are held by companies that operate in the sector *energy efficiency*. The result is intuitive, since *energy efficiency* is a very loosely demarcated sector that covers manufacturers and developers of products and services that are exploited across other cleantech sectors. The interpretation finds support in the division of the *energy efficiency* companies across conventional industry classes: while companies in the cleantech sectors *cables*, *metals*, and *electronics* all operate in the *manufacturing* industry, *energy efficiency* is a lot more diverse. It comprises companies that operate in the *manufacturing*, *construction*, *wholesale and trade*, *ICT* and *R&D* industries. To avoid misleading interpretations of the result, we should emphasize that the finding is partly explained by the bigger size of the companies in the *energy efficiency* sector.

Figure 12 Total number of patents and patents per company by cleantech sector



Conclusions

Since its break with an agrarian base, the growth of the Finnish economy has been spearheaded by high-profile, engineering- and manufacturing-driven companies such as Outokumpu, Wärtsilä, Metso, Kone, Nokia, Rautaruukki, and UPM. Hand in hand, the reverence of manufacturing engineering skills and education has shaped the perceptions of the professional hierarchy in the country. It is quite descriptive that, in the aftermath of the latest economic crisis in Europe, the Finnish public started discussing the threats of mass unemployment only after the unemployment rate of engineers, thought untouchable, soared to an all-time high of 4.5% in 2014[28].

Our results strongly reflect this legacy. Manufacturing businesses are the clear center of gravity in the cleantech space, even more so than in the Finnish industry in general. It is fairly irrelevant whether this is because of a perspective economic developers in Finland have adopted or because the majority of Finnish cleantech companies are engineering-driven. What matters is that, in the gold rush era of digitalization, a heavily manufacturing- and engineering focused company base can quickly become the ball and chain to the mid-to-long-term growth of the industry.

The ongoing shift of the transportation industry, and the response of the Ford Motor Company to this shift, is telling. In light of recent developments in digitalization, big and open data, and the diminishing interest in owning vehicles amongst the younger generations, it is estimated that in ten years 80 percent of the value of the car will reside *outside* the car. The vehicle is at risk to turn into a commoditized sensor platform, gathering data on the vehicle's environment and the behavior of its passengers, only to be picked up by third party service providers. While the car is turning into a moving hardware platform for the mobile office, entertainment center and shopping mall, it is the data analytics businesses, on-line retail brands, insurance companies and other service providers who will reap the profits generated with new business models. Hence, Ford is asking itself the strategic question whether it should actually move up the vertical and horizontal value chains to position itself as a technology company, as its CEO recently did at the Consumer Electronics Show in Las Vegas. Hanging on to the legacy seems to come with the risk of being pushed to the proverbial periphery of the new, emerging e-mobility ecosystem[29].

Similar stories could be told about the emerging smart grid ecosystem, where telecommunications and data analytics companies currently fight for dominance of the demand-response space, an area in which power utilities *should* (or used to) reign superior.

That being said, where are all the service businesses in the Finnish cleantech space? Where are the Finnish equivalents to Lyft, EnerNOC, Stem, Uber, Airbnb, etc.? Even for a scholar of industrial renewal, these businesses are extremely hard to find. Many of the companies are still in the start-up phase. Peloton Club, an accelerator focusing on consumer cleantech solutions for Finnish efficiency companies and run by DEMOS Helsinki, caters to the needs of young companies that develop new consumer solutions for more sustainable energy usage: Peer-to-peer courier service provider PiggyBaggy; Fourdeg, an intelligent thermostat company; Weegos, a service that turns city-owned vehicles into a car fleet in joint use; Sharetribe, a sharing-economy platform enabling peer-to-peer exchanges; Moralguard, an application to help consumers shop according to their values; and Re-Pack, packaging system for online retailers and shoppers whereby delivery packages can be returned. These companies are heralds of growing service-

[28] TEK (2015)
[29] Crothers (2015)

based activity in the Finnish cleantech space, which clearly needs urgent redefinition to accommodate more businesses outside the manufacturing engineering domain.

These companies have earned the honorary title of pioneer for yet another reason: their offering is mainly geared towards consumer markets. As demonstrated earlier, preliminary evidence shows a deficiency in Finnish innovations in the consumer domain. Consumer markets should not be neglected in the development of Finnish cleantech. Among the four fastest growing businesses[30] in the world, three *consumer brands* have wedged themselves a position: Apple, Google and Microsoft. With the proliferation and mass adoption of *smart consumer technologies* as well as global trends such as the *quantified self* – movement, *open data, smart city* and the rise of the *internet of things*, the opportunity for wide-reaching improvements to overall economic, social and ecological sustainability in the very near future is nascent.

To ride the cleantech wave as a global forerunner necessitates catching and harnessing the riptide of change in the consumer domain. In a best possible scenario, it will be an integral part of a Finnish cleantech ecosystem that complements the already existing skeleton of manufacturing-driven company base. What the sector now requires is an engagement of economic developers, existing industries and the government for opening their technology platforms and databases for new growth-oriented businesses which pioneer consumer markets with service-based smart solutions.

A more urgent challenge that needs to be tended to is the poor financial performance of small and medium sized businesses in the cleantech space. Our results are merely descriptive and do not provide information on the reasons behind the lackluster performance of the most crucial drivers of industrial renewal. In-depth research is needed to unveil whether the result is a statistical aberration related to sampling, or whether there should be real concern about the long-term survival of Finnish cleantech SMEs. Is the problem traceable to the current European-wide economic downturn? Are investors overly cautious because of it? Or are cleantech SMEs in Finland either too young to or still in the process of defining their business models to become profitable?

Redefining the Finnish CleanTech Opportunity in the Age of Digitalization

Since 2003, when the term CleanTech first came in vogue, it was defined along verticals that relate to physical infrastructure systems and legacy industries, such as energy utilities (e.g. wind power, solar power), water utilities (e.g. water treatment, membranes), and specialty electronics companies (e.g. solar lighting, LED). The *make-and-sell* business model, the stalwart of the *traditional CleanTech economy* is slowly being eroded by service models with recurring revenue streams and low capital intensity.

To exemplify, consider how Bloom Energy, a company that makes utility-scale fuel cell energy storage systems, replaced its revenue and business model from sales transactions, to lease and power purchase agreements, which allowed it to scale its turnover and profit margins. Compare First Energy, a solar panel manufacturer, and Solar City, a solar energy provider through brokerage and long term power purchase agreements. In terms of all financial metrics, Solar City comes out on top: capital efficiency, revenue growth, margins.

[30] PriceWaterhouseCoopers (2014)

CleanTech 3.0 has been defined by business models that have been *built on top of legacy infrastructure*, and has given rise to the *cleanweb*. The *cleanweb* reflects the *convergence* of several technology megatrends, including: The *explosive growth of data* from sensors and networked devices; Increasing *connectivity* and *automation* among devices; The *falling price of computing power* and rise of "big data" *analytical capabilities*; The growth of *smartphone ownership*; The emergence of *new consumer behavior* on social networks and other platforms. Since *Cleanweb* companies sit at the nexus of traditionally disparate industries and functions, they have affected the collapse and cross-integration of value chains. They by-pass traditional market channels and no longer depend on governments for subsidies or tax breaks. Rather, government and patenting policies are playing a catch up game in terms of regulation and customer privacy protection.

As stated earlier, Finland has service businesses, but they are all startups and not much on the radar of economic developers. The redefinition that needs to happen is the transition from make-and-sell to *digitalized service* business models – shifting the cost structure of doing business. ICT and network-based technologies are at the core of the transition from cleantech to cleanweb. The convergence between ICT and cleantech holds the key to scale and profitability. Given the pre-eminence of Finnish companies in this area, and a rich industry value system in this space, there is clearly an opportunity to be tapped and assets to be leveraged, as a survey administered to Finnish SMEs in early 2015 reveals[31].

[31] The Federation of Finnish Enterprises (2015)

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Appendix

Table A1

Cleantech category	Number of companies	Company size: SME	Micro	Large	Giant	Ownership: Municipality	Foreign	Government	Private domestic
advanced materials	19	50 %	22 %	28 %	0 %	0 %	18 %	0 %	82 %
agriculture & forestry	6	0 %	83 %	17 %	0 %	0 %	17 %	0 %	83 %
air	35	44 %	47 %	9 %	0 %	0 %	6 %	0 %	94 %
biofuels & biochemicals	79	36 %	39 %	24 %	4 %	3 %	15 %	0 %	82 %
biomass generation	26	27 %	46 %	27 %	0 %	8 %	8 %	4 %	79 %
business consulting	49	16 %	67 %	16 %	0 %	5 %	0 %	0 %	95 %
cables	2	0 %	0 %	100 %	0 %	0 %	50 %	0 %	50 %
chemicals	2	100 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %
construction	8	25 %	63 %	13 %	0 %	0 %	0 %	0 %	100 %
conventional fuels	12	33 %	25 %	42 %	0 %	8 %	0 %	8 %	83 %
electronics	2	0 %	0 %	100 %	0 %	0 %	0 %	0 %	100 %
energy efficiency	70	44 %	28 %	28 %	2 %	2 %	14 %	0 %	84 %
energy storage	15	43 %	50 %	7 %	0 %	0 %	0 %	0 %	100 %
engineering services	55	25 %	56 %	19 %	0 %	4 %	13 %	2 %	81 %
environmental services	2	0 %	100 %	0 %	0 %	0 %	0 %	0 %	100 %
finance	2	0 %	100 %	0 %	0 %	0 %	0 %	0 %	100 %
fuel cells & hydrogen	2	0 %	0 %	100 %	0 %	.	.	.	.
furniture	1	0 %	100 %	0 %	0 %	0 %	0 %	0 %	100 %
geothermal	12	60 %	20 %	20 %	0 %	0 %	30 %	0 %	70 %
hydro & marine power	6	33 %	33 %	33 %	0 %	17 %	0 %	0 %	83 %
instruments	14	58 %	25 %	17 %	0 %	0 %	17 %	0 %	83 %
machinery	12	73 %	9 %	18 %	0 %	0 %	18 %	0 %	82 %
metals	2	50 %	0 %	50 %	0 %	0 %	0 %	0 %	100 %
mining	1	0 %	0 %	100 %	0 %	0 %	0 %	0 %	100 %
nuclear	4	50 %	0 %	50 %	0 %	0 %	0 %	0 %	100 %
recycling & waste	68	32 %	46 %	22 %	0 %	5 %	3 %	2 %	90 %
smart grid	52	43 %	35 %	22 %	2 %	2 %	22 %	2 %	73 %
software	8	13 %	50 %	38 %	0 %	0 %	14 %	0 %	86 %
solar	17	38 %	38 %	23 %	0 %	0 %	0 %	0 %	100 %
transportation	46	43 %	40 %	17 %	2 %	0 %	17 %	0 %	83 %
water & wastewater	87	41 %	37 %	22 %	0 %	3 %	20 %	1 %	76 %
wholesale	5	20 %	40 %	40 %	0 %	0 %	40 %	0 %	60 %
wind	41	31 %	42 %	28 %	0 %	12 %	12 %	3 %	74 %
Total	762	36 %	41 %	23 %		3 %	12 %	1 %	83 %

Table A2

Cleantech category	Importer/exporter			Share of ltd. companies	Company age (yrs)	Number of employees
	Importer	Import and export	Exporter			
advanced materials	15 %	85 %	0 %	94 %	9,6	65,6
agriculture & forestry	50 %	50 %	0 %	100 %	12,2	10,3
air	9 %	83 %	9 %	94 %	14,8	25,0
biofuels & biochemicals	39 %	52 %	9 %	91 %	14,8	67,5
biomass generation	9 %	73 %	18 %	92 %	16,4	67,2
business consulting	100 %	0 %	0 %	88 %	8,9	7,1
cables	0 %	100 %	0 %	100 %	10,5	254,0
chemicals	0 %	100 %	0 %	100 %	47,5	88,0
construction	0 %	100 %	0 %	75 %	4,0	11,0
conventional fuels	50 %	50 %	0 %	100 %	20,1	63,8
electronics	0 %	100 %	0 %	100 %	34,0	200,4
energy efficiency	24 %	74 %	2 %	98 %	11,5	141,7
energy storage	11 %	67 %	22 %	93 %	17,1	18,2
engineering services	56 %	44 %	0 %	88 %	15,4	58,3
environmental services	.	.	.	100 %	6,5	2,9
finance	.	.	.	100 %	6,5	2,2
fuel cells & hydrogen	.	.	.	.	.	
furniture	100 %	0 %	0 %	100 %	5,0	1,0
geothermal	43 %	57 %	0 %	100 %	13,6	107,5
hydro & marine power	75 %	25 %	0 %	100 %	14,7	9,6
instruments	0 %	100 %	0 %	100 %	17,8	82,0
machinery	10 %	90 %	0 %	100 %	17,2	78,4
metals	0 %	100 %	0 %	100 %	12,5	161,0
mining	0 %	100 %	0 %	100 %	10,0	486,0
nuclear	100 %	0 %	0 %	100 %	16,5	242,0
recycling & waste	30 %	53 %	18 %	97 %	14,9	147,7
smart grid	21 %	75 %	4 %	96 %	13,2	93,3
software	50 %	0 %	50 %	88 %	10,7	468,7
solar	25 %	75 %	0 %	69 %	14,0	11,1
transportation	30 %	60 %	10 %	93 %	12,8	43,1
water & wastewater	26 %	74 %	0 %	92 %	18,4	59,6
wholesale	33 %	67 %	0 %	60 %	8,0	4,5
wind	55 %	32 %	14 %	94 %	13,8	54,9
Total	29 %	65 %	7 %	93 %	14,3	77,6

Table A3

Cleantech category	Return on assets (%)*	Net profit (%)*	Profit margin (%)*	Return on investment (%) *	Asset turnover ratio**	Tangible assets (1000 €)*	Value added per person*
advanced materials	6,1	-2,3	-4,6	7,4	1,4	108 000 €	95 002 €
agriculture & forestry	-31,3	-144,1	-151,0	-34,7	0,7	738 €	- 7 188 €
air	4,4	-16,4	-13,2	12,3	1,5	21 800 €	53 856 €
biofuels & biochemicals	8,1	3,6	1,0	13,3	1,3	356 000 €	126 397 €
biomass generation	8,5	2,3	0,4	23,7	1,3	350 000 €	130 220 €
business consulting	16,9	-4,5	-6,7	25,6	2,8	2 282 €	68 843 €
cables	6,6	3,4	2,1	10,1	2,0	75 300 €	72 991 €
chemicals	5,4	8,9	7,7	7,0	0,6	70 100 €	97 163 €
construction	38,1	11,7	11,6	61,0	4,6	2 696 €	100 805 €
conventional fuels	6,9	2,1	-0,7	10,8	2,0	173 000 €	183 354 €
electronics	11,9	12,0	9,2	14,4	0,9	82 000 €	.
energy efficiency	7,0	3,3	2,7	9,3	1,6	558 000 €	100 151 €
energy storage	2,5	-9,8	-12,5	2,2	1,6	4 552 €	51 568 €
engineering services	16,5	7,3	5,8	25,8	2,0	32 400 €	69 418 €
environmental services	10,1	1,1	-0,1	19,6	2,7	200 €	65 345 €
finance	31,5	14,3	13,4	42,0	2,1	170 €	103 035 €
fuel cells & hydrogen							
furniture	-34,3	-76,0	-80,8	-37,6	1,0	125 €	-17 000 €
geothermal	10,6	3,7	3,1	21,9	2,7	39 000 €	55 872 €
hydro & marine power	0,4	-79,2	-88,3	1,8	1,4	7 951 €	53 926 €
instruments	13,2	9,9	9,6	17,3	1,1	171 000 €	82 202 €
machinery	0,9	1,4	-0,4	0,2	1,5	20 400 €	63 658 €
metals	1,7	1,0	0,4	2,3	1,5	25 100 €	42 018 €
mining	5,1	-6,9	3,9	6,5	0,6	236 000 €	.
nuclear	-0,4	-28,4	-33,6	- 1,0	0,1	4 820 000 €	129 752 €
recycling & waste	9,3	2,9	1,9	11,1	1,5	283 000 €	81 302 €
smart grid	13,0	5,2	3,8	41,2	2,7	163 000 €	102 235 €
software	0,7	-0,1	-0,1	1,3	1,3	304 000 €	53 623 €
solar	-9,3	-34,7	-46,6	-12,3	1,1	21 300 €	33 955 €
transportation	2,1	-5,5	-5,9	6,0	1,6	40 500 €	69 337 €
water & wastewater	13,3	4,3	5,1	20,1	1,5	402 000 €	77 975 €
wholesale	31,8	6,6	5,2	50,3	4,7	1 013 €	88 808 €
wind	6,2	-31,1	2,0	9,3	1,1	3 480 000 €	91 120 €
Total	8,4	0,4	0,8	14,6	1,6	89 900 €	91 211 €

*) Weighted by the no. of personnel and winsored by 2,5%
**) Tangible assets, weighted by the no. of personnel and winsored by 2,5%

Table A4

Cleantech category	**No. of patents**	**Patents/ 1000 € turnover**	**Patetents across patent categories**					
			Chemicals and pharmaceuticals	Cons. goods & civil engin.	Electrical engin.	Instruments	Mechanic. engin.	Process engineering
advanced materials	14,9	5,7	3,5	0,8	3,1	2,1	0,9	4,5
agriculture & forestry	2,0	16,0	0,3		0,7		1,0	
air	6,1	74,4	0,2	0,1	0,3	2,1	0,3	3,3
biofuels & biochemicals	9,3	2,9	0,4		0,1	0,2	2,1	6,4
biomass generation	17,5	58,5	1,5			0,6	1,3	14,1
business consulting								
cables								
chemicals	11,0	3,3	2,0					9,0
construction								
conventional fuels	2,0	0,1						2,0
electronics	11,0	0,1	1,0		5,0			5,0
energy efficiency	35,8	26,1	0,8	0,8	7,2	0,8	23,3	2,8
energy storage	4,5	23,3		0,5	3,5		0,5	
engineering services	3,3	1,3			2,0	1,0		0,3
environmental services								
finance								
fuel cells & hydrogen								
furniture	1,0	8,0					1,0	
geothermal	1,5	0,4		0,5			1,0	
hydro & marine power	6,0	194,4					5,5	0,5
instruments	18,8	0,9			4,3	14,3		0,3
machinery	3,3	1,0	0,7				0,7	2,0
metals								
mining	9,0	0,1	3,0		1,0	1,0		4,0
nuclear								
recycling & waste	4,9	38,0	0,3	0,1	1,0		2,2	1,4
smart grid	4,5	0,7			3,3	0,8	0,4	0,1
software								
solar	4,3	3,3	0,3		1,7			2,3
transportation	8,2	3,6		0,1	5,0	2,8	0,2	0,2
water & wastewater	18,8	5,1	4,5	0,8	3,7	0,9	1,2	7,6
wholesale								
wind	10,4	0,7	1,6		1,0	0,4	1,0	6,4