



Article

Reveal or Conceal? Signaling Strategies for Building Legitimacy in Cleantech Firms

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Abstract: New entrants in technology-intensive industries are in a race to build legitimacy in order to compete with established players. Legitimacy has been identified as a driver of venture survival and growth; it helps mitigate third-party uncertainty and so facilitates access to resources, engagement with customers and other stakeholders. Nevertheless, we know little about how legitimacy is built and how new entrants build legitimacy in complex technology-intensive industries. In this research we explore how Norwegian cleantech firms use signaling and strategic actions to build legitimacy. We analyze five cases while investigating their actions in different phases of the venture's evolution. The results suggest that, contrary to signaling theory expectations, young clean-tech firms do not always build legitimacy by conveying information on their strengths. Instead, we observe that they use signaling strategies to address the specific concerns of different stakeholders. This is very much contingent upon the evolutionary stage of the venture and the firm's current weaknesses.

Keywords: cleantech firms; signaling; strategies; legitimacy; development stages

1. Introduction

There has been a rapid increase in cleantech firm formation as a result of the further development of the cleantech industry and as a part of the collective effort to mitigate the consequences of climate change and improve environmental sustainability. Research on cleantech firms in the major business research journals has, despite this, been limited. The majority of the few cleantech studies identified in the leading business administration, management, entrepreneurship and innovation journals [1] address the impact of external factors, such as government policies that aim to stimulate the formation of cleantech firms. A small number of studies have also examined firm and individual-level factors that can help characterize the nature of these firms [2]. Such lack of cleantech focused studies is surprising.

The study of cleantech firms is, for a number of reasons, fruitful research. Cleantech firms are firstly important to society. These firms are active agents of environmental innovation and sustainability, as they commercialize eco-innovations enabling the creation of new industries and fostering growth in existing industries [3]. Being part of young and uncertain industry, cleantech firms have limited benefits compared to firms in other more mature technology sectors. For instance, biotech firms may benefit from an existing relationship between firm's R&D potential, the market demand and the wealth generated by the companies [4]. Cleantech firms often exploit new technologies, propose innovative business models, and, hence, depend significantly on especially favorable government policies [4]. Unlike firms using conventional energy technologies, cleantech firms are highly depend on the value placed on reduction of emissions and the sacrifices in terms of durability or reliability [4,5].

Secondly, the cleantech industry offers a unique context for exploring and further developing business and sustainability research, particularly innovation and strategic management theories.

Cleantech firms may therefore also be of interest to entrepreneurship scholars as they combine a strong focus on capital-intensive technological development while addressing the demands of complex industrial markets. They therefore represent an extreme case of technology entrepreneurship, which is useful to the advance of sustainable technology entrepreneurship research.

Cleantech firms, for the above-mentioned reasons, therefore face greater legitimacy challenges when aiming to access external resources than other technology ventures operating in established and legitimized industries [6,7]. The high level of technology innovativeness [8] and the overall uncertainty of the market [9] create additional challenges for firms entering this market. In addition, the clean-tech ventures often represent a new organizational form for which the market does not exist yet, implying that the entrepreneur faces an even greater liability of newness [10]. When the new organizational form diverts from the current dominant organizational forms and industry standards, including regulations, accepted norms, beliefs and values [11,12], an entrepreneur may be especially challenged when obtaining critical resources from existing market actors, as they may view this new organizational form as illegitimate. Hence, an entrepreneur may have to undertake harder efforts in changing existing institutional environment by changing both formal and informal rules that define what is legitimate, in order to access those resources [13,14]. Actions that contribute to the building of legitimacy therefore become a priority, otherwise there is a high risk to fail before completing the technology development [15].

Increased legitimacy enables young firms to access resources, overcome the liability of newness [16] and generate the recognition and approval of stakeholders. Zimmermann and Zeitz [17] introduced the concept of legitimacy thresholds as triggers in the creation of a new venture. Gaining legitimacy is, from the stage-based theory perspective [18], associated with overcoming a threshold and achieving the important milestones necessary for the business to progress. Fisher et al. [19] indicate that firms might, instead of focusing on a single threshold, have to build and sustain legitimacy across stages to overcome multiple legitimacy thresholds, which therefore calls for more research on dynamics.

We in our study therefore address the research gap by asking a main research question: how do cleantech firms build legitimacy across the development phases while entering an industry? We in particular examine how and why cleantech firms engage in signaling to external parties in different stages of new venture development. We address the following research sub-questions: How and why do cleantech firms signal to gain legitimacy? In addition, what type of signaling strategies do they follow in the start-up (early) and growth (late) stages?

Our study contributes in several ways. Firstly, we add to the research on managing cleantech firms by exploring the signaling strategies developed by these types of firms. Secondly, we add to both signaling and technology entrepreneurship theory by describing types and effects of signaling in new entrants' search for legitimacy [20,21]. Formulated as propositions, our study's conclusions explicate signaling actions that entrepreneurs founding clean-tech start-ups undertake as they build companies and establish their legitimacy vis-à-vis resource providers and other actors from the established markets, in both early and late development stages. As such, our study's contribution is to introduce dynamics into signaling theory that has so far suffered from being static [20]. Thirdly, we also add to governance and venture board research by identifying the role of the board of directors in signaling the strategies that cleantech firms pursue. Lastly, we introduce the concepts of "reveal" and "conceal" to explain firms' signaling options for gaining legitimacy in complex environments of multiple stakeholders and rapid technological change. Among all, surprisingly, we did not find that clean-tech start-ups used their environmental signals intentionally (strategically) in their early development stages, as such "concealing" them. However, they did so in later development stages, "revealing" their environmental signals to a greater extent.

The article is structured as follows. Firstly, we outline the theoretical background on legitimacy for new firms. Next, we discuss the research design, study context, data collection and analysis methods. Then we present the study results. Lastly, we discuss the results, conclude, and suggest implications for research and policy.

2. Theoretical Background

2.1. Building Legitimacy in Cleantech Firms

New firms face many liabilities, the liability of newness being the most common [16]. Being new in an industry means that a new firm is often dependent on cooperation with other existing firms, and remains vulnerable to the competition from established players. They are therefore subject to a greater risk of failure. In this context, legitimacy is a resource that enables the founder or manager of a firm to gain external resources and overcome the liability of newness by gaining recognition and approval from other stakeholders [17].

Prior research on cleantech suggests that it is particularly difficult for firms in this industry to build legitimacy. Firstly cleantech firms operate in a relatively new industry and often have limited internal resources, limited access to critical external resources and lower legitimacy compared to firms in more established and thus legitimated industries (for example other types of energy industries). A study of UK firms commercializing technologies in the environmental domain indicates that there are differences regarding the perceived obstacles to firm development between cleantech firms and other firms in this domain [22]. The cleantech firms ranked the obstacles such as making connections with customers and capital costs higher than the other firms in the environmental domain. The study findings suggest that there were at least three reasons behind these perceptions. First, the difficulties to convince potential customers of the dual value (environmental and/or financial) of the technological solution. Second, the minimum scale of demonstration projects to show the viability of the technology. Third, the lack of competitors at the new market. These are hurdles for the early-stage firms with no reputation (lacking track-record) and limited resources [22]. Young cleantech firms offering new renewable energy solutions are therefore subjected to the liability of newness to a larger extent than other early stage technology-based ventures. Zhang and White [2] have collected empirical support for entrepreneurs facing especially higher legitimacy constraints in the context of Chinese solar PV firms. The first start-ups entering industry faced severe lack of legitimacy and had to gain a three-fold legitimacy: (i) as founders, (ii) new firms, and (iii) a new form of competitors (new organizational form) in an industry dominated by multinational incumbents. Later entrepreneurs did not have to expend the efforts to build legitimacy for their organizational form as the early entrants already did this. Consequently, they could acquire resources much more quickly and easier, and as such, develop their firms and enter the market much faster. Secondly, the technology of emerging industries is often under-developed. Technological standards are also emerging or even absent [21]. For example, the cleantech industry covers a wide range of sub-sectors: from solar power that is becoming increasingly legitimized to the wave energy sub-sector that still lacks commonly wide-spread technological standards [23,24]. This implies that there is no common point of reference for industry actors to rely on. Under such circumstances, companies developing technology can build legitimacy and gain recognition and approval from other actors through third-party affiliations. Several studies show that organizations affiliated with reputable or high status partners, e.g., alliance partners, venture capitalists, can experience enhanced performance due to inter-organizational transfers of status or endorsement and/or superior resources transferred to the firm [25–27]. However, emerging industries may lack such reputable or high status actors. Founders must therefore rely on their own experience, endorsement of their parent organizations (e.g., university), or business partners (e.g., established suppliers), even if they are coming from other industries [28].

Third, founders may rely on their prior experience or on their “history”, assets and social ties while assembling resources in the earlier stages of firm development [27]. An emerging industry founder may, however, lack such relevant experience, assets and social contacts due to the newness of the technology-related industry, which adds to the challenges associated with building legitimacy. Indeed, the firms pursuing environmental innovations (or environmental goals) were found to lack funding, technology information, qualified personnel, market information, external knowledge and cooperation with partners [29]. To sum up, prior research points to that cleantech firms operate in a context where signaling strategies can have an impact on legitimacy as well as on the firm’s development.

2.2. Signaling as a Strategy for Building Legitimacy

The premise of signaling theory [30] is that there are certain situations where parties are exposed to information asymmetries and where discrepancies between the information available to parties occurs. If a founder's goal is to acquire investor funding, then the founder should be able to convey the appropriate information about the firm that will allow the firm to secure its legitimacy and economic potential. The founder may also withhold internal information such as on the venture's financial situation or product development, most being invisible or hard for investors to directly obtain. Information asymmetry creates uncertainty for investors, which in turn affects their investment decisions. Information asymmetry may also be present in the relationship between cleantech firm and potential customers [31,32] or strategic partners [33]. One way to reduce information asymmetry is to generate visible signals that convey information on the firm's qualities and its intentions to potential partners [34].

There are four main elements in signaling theory: the signaler, the signal, the receiver and the feedback [20]. A signaler sends a signal which is received and interpreted by a receiver. The receiver, after interpreting the signal, may send feedback back to the signaler. The whole process takes place in a signal environment in which other signalers and receivers also may be active. We, in the following, describe each of these elements in more detail in the context of sustainable entrepreneurship before proceeding with cleantech firms.

Signalers possess two types of information: the one that has unobservable elements related to qualities and another that contains information on signalers' future intentions. The signalers decide which information they wish to convey [35]. Signalers may be entrepreneurs [34], start-up leaders or IPO firm management [36,37] who seek capital. Signaling theory has, so far, primarily focused on the intentional sharing of positive information on qualities to achieve positive outcomes [20]. The quality-information signals that start-ups convey include, for example, technology patents, strategic partners and alliances and the founders' or top management team's (TMT's) experience and human and social capital [38–41]. Alsos and Ljunggren [38] distinguish five types of signals: the entrepreneur, the team, the investor, the venture, and alliances and partners. Giones and Miralles [10] categorized signals into technology, market and social capital signals (see Table 2).

An effective *signal* is determined by two main characteristics: signal cost and observability [20]. Signal cost refers to the assumption that honest signaling of qualities has a higher cost than low-quality signals, or dishonest signals. As a result, high-quality signalers are more prone to a lower signal cost for high quality signals than low-quality signalers [42]. For example, younger cleantech firms pay a higher signal cost than older firms. Young cleantech firms invest time and resources in developing technology, whereas mature companies often have the necessary infrastructure and resources at their disposal. Signal observability explains the extent to which a signal is noticed and understood by the receivers [20].

The *receivers* are investors, private investors [43,44] or public investors [45]. The receiver, to receive the signal, should be observant and looking for specific signals [26,46]. An important assumption is that the receiver seeks to gain from the information obtained from the signal. Investors want, for example, to invest in companies that signal a profitable future [47]. However, some signalers may benefit from sending out falsely positive signals, so tricking the receiver to give positive feedback in return. For example, advertising a product in a way that makes it seem better than it is [48,49].

Feedback, or counter signals, is the response a receiver may choose to return to the signaler. Feedback, assuming information asymmetry in both directions, is usually given to facilitate effective signals or to give otherwise unknown information back to the signaler. This makes it an iterative process [50]. Typical feedback from an investor would be showing a will to invest or the guidance that the signaler should pursue a different direction. Customer feedback might be the customer buying the product and leaving a good review [26].

Few studies have investigated signaling actions in the cleantech context. Examples include Hoenig and Henkel [40] who studied patents, alliances and team experience as signals for obtaining venture capital (VC) financing. They found that team experience was one of the determinants of signal technological quality in cleantech firms. The findings of the study by Loock [51] indicate that cleantech

investors seem to prefer business models proposing best services rather than best technology or best prices. Masini and Menichetti [52] furthermore indicate that cleantech investors are more likely to invest in ventures that signal fast and secure returns rather than long term technology development. Prior research has, however, left the process that precedes the generation of these signals unattended, creating a research gap on how cleantech firms use signaling to gain legitimacy and what type of signals (and to whom) they convey.

2.3. Signaling at the Early and Growth Development Stages

Life-cycle (or stage-based) theory may help explain legitimacy, which is expected to vary with each development stage of a firm [19]. Life-cycle theory builds on development phases, the predefined and organized sets of tasks that a firm has to solve to develop [53]. It assumes that organisational development is imminent i.e., that the present phase influences the departure to the next phase, that development is linear [54] and is invariant across firms [55]. The dominant tasks and resource configurations will however, as the firm moves from the start-up stage towards growth and maturity, undergo change. Kazanjian [56], for example, introduced a stage model for technology-based firms that consists of four stages: (1) conception and development, (2) commercialization, (3) growth and (4) stability. Other researchers have, while also refining the life-cycle theory by acknowledging that the development process represents an iterative and non-linear transition between each stage, arrived at similar categorizations [18]. It has also been proposed that one or a few tasks that a firm works with at each stage, will dominate at that stage [56].

In this paper, and in line with other studies on high-tech firms [51], we adopt previous models describing typical life-cycle stages [7,41]. We simplify these models and adapt them to our research context. Vohora et al's model contains five phases (research, opportunity framing, pre-organization, re-orientation and sustainable return phase). We, however, in our conceptual framework roughly distinguish between early and growth (later) development stages, as represented by the tasks that dominate each stage. For example, the dominant tasks of early stages often relate to securing finance, technology development and strategic positioning in a new market segment. In growth stages they relate to acquisition of additional resources, organization, sales, marketing and administration.

We also integrate the findings of the recent study by Fisher, Kotha and Lahiri [19] into our conceptual framework. The study introduces the concept of multiple thresholds at different legitimacy levels. This study's conceptual framework therefore takes into account the role of legitimacy across development stages, as depicted in Figure 1. There is, however, only one threshold to reduce complexity, and it represents the transition from low to high legitimacy levels.

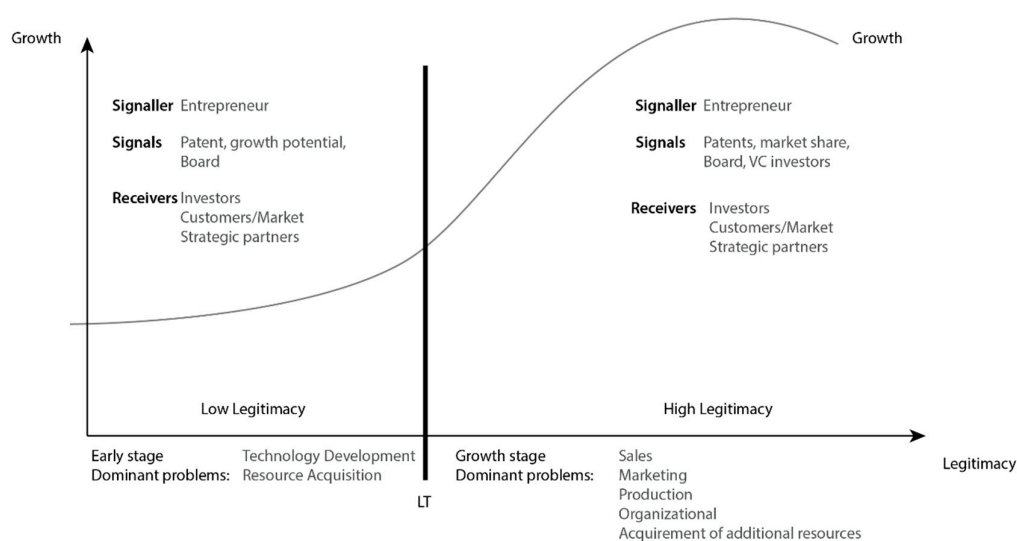


Figure 1. Conceptual framework.

3. Method and Data

Exploring how and why cleantech firms signal to gain legitimacy and the signals they convey in early and late stages, requires insights into the characteristics, events, perceptions, and context that influence signaling strategies. We therefore choose the qualitative research approach as suggested by Miles and Huberman [57], to explore five cases [58] of cleantech firms. Such qualitative approach helps capture and understand the phenomena more fully than other approaches (e.g., survey), as it allows refining/developing theory, e.g., generating propositions, which might be tested in the future research [58].

3.1. Research Context

We select Norway as research context, a country in which the cleantech industry has been emerging in recent decades. Norway plays an important role in the production of renewable energy in Europe, contributing more than 15 percent of Europe's renewable energy production [59]. It has both unique natural resources and competence advantages in the development of clean technology [60]. The Energy21-strategy was published by the Norwegian Oil and Energy Ministry in 2007. The aim of the strategy was to increase the focus on clean energy development and production and includes the ambitious vision that Norway will be "Europe's leading energy and environment nation". The Energy21 program would, to achieve this goal, focus on technology development aimed at value creation and commercialization. One of the challenges of this vision is, however, that the owners of the industry's largest companies are not focused on technology development [60]. This challenge shows that Norwegian cleantech firms that work with technology development and commercialization, play an important role in achieving Norway's ambitious vision.

3.2. Selected Cases

The start point of this study is the 27 cleantech firms in Norway that have participated in research carried out by the Norwegian University of Science and Technology (NTNU) and that are still in operation. These firms were screened and were checked to determine whether they fulfilled the following selection criteria. Firstly, a firm has to have achieved entrepreneurial milestones such as attracting the first investor or first customer. Secondly, a firm can be considered to be a cleantech firm in accordance with the definition We have adopted the definition used by Pernick and Wilder [61]: "A cleantech firm develops any product, service, or process that delivers value using limited or zero nonrenewable resources and/or creates significantly less waste than conventional offerings". Third, firms have to represent different development stages: research, opportunity framing, pre-organization, re-orientation and sustainable return stage [59]. After this initial selection, we examined each firm's background and historical information to better understand their characteristics and stages of development. Available documents on the companies' financial data and their investments i.e., annual reports, accounting data, firm websites and press releases/news articles, were used. We were aware that the variance in the development stage, and technology focus of the firms could be a source of heterogeneity in their signaling strategies [58,62]. Thus, we made a final selection of cases that could capture the different possible variation [63]. As a result, five cleantech firms were selected as cases in our multiple-case study.

A case overview is provided in Table 1. The companies were established between 2000 and 2009. Two were in the early stage (opportunity-framing and pre-organization) with a primary focus on framing the business opportunity, technology and product development, target customers and building the management team. The remaining three cases were in the growth stage (re-orientation and sustainable return) with a major focus on implementing strategic plans, establishing sales and expansion. The number of employees varied from 1 to 38. All cases have passed beyond the research-phase and early thresholds and achieved entrepreneurial milestones such as the first patent application filed, funding received, first prototype developed and first customer attracted, as shown in Table 1.

Table 1. Cases overview.

	WavePower	HydroEnergy	EnergyRecycle	MarineWaste	SunBio
Stage	Early	Early	Growth	Growth	Growth
Incorp. year	2009	2000	2006	2007	2006
No. employees	1	2	11	38	26
Board members	4, all with industry background	4, two VC * investors and two with industry background	4, two VC investors and two with industry background	4, with backgrounds in economics, law and ship brokering	3, with backgrounds in law and business and administration
Key activities	Technology development, searching for funding	Product development, nearly ready for sale	Sales and continuation of growth	Sales and continuation of growth	Sales and expansion to neighboring countries
Key milestones achieved	First patent application in 2007 Soft funding in 2007 First full scale prototype test in 2014	First patent application in 2004 Proof of concept in 2009 Acquired by Investor B in 2014	First patent application in 2004 First full scale prototype in 2011 First sale abroad in 2015	First customer in 2000 IPO in 2014	Product in sale Grown from 100 million to 1 billion in sales during the three last years
Partner firms	-	Investor B	Investor A	-	Customer A
Incorp. year	-	2008	2005	-	2011

* Note: VC—venture capital.

3.3. Data Collection

Our main data collection instrument was semi-structured interviews. Data was collected in the spring of 2016. Respondents were chief executive officers (CEOs) of the cleantech firms and key employees of partner companies. The contact information of relevant strategic partners (signal receivers) was requested during the interviews. Only three partner firms were willing to participate in our study, despite the companies being assured confidentiality and anonymity. Eight in-depth interviews were carried out, each interview lasting on average an hour. Interviews were recorded and conducted in the native language (Norwegian) and later transcribed for data analysis.

We also collected secondary data using the companies' web sites, annual reports, accounting data and press releases found in available databases (e.g., proff. no). This triangulation of data helped improve data reliability and helped correct any information inaccuracy in responses [64]. Triangulation was particularly valuable when experiencing difficulties recalling specific important information. This combination enriched the data. Using different data sources also enriched the construct validity [65]. The use of a multiple-case embedded design allowed both the content of the signals and the signaling process to be examined. All researchers followed the NTNU's ethical principles for conducting research including assuring anonymity and safe data storage.

3.4. Data Analysis

We used QSR NVivo software and followed the qualitative data analysis principles suggested by Miles and Huberman [57]. We followed a stepwise data analysis. Firstly, we familiarized ourselves with the data, looking for the concepts that emerge through open coding for each case. Such concepts helped us develop categories for the coding schemes. Secondly, we used a number of guiding questions from the theory that serves to develop open coding. These questions evolved around signaling strategies for the market, external investors, customers, suppliers or other strategic partners and around the learning processes, e.g., what could be done differently if cleantech firms were given another chance. Thirdly, the antecedents and consequences of the signaling strategies were identified after categories were labeled and coding schemes were structured. An example of protocol coding is provided in Appendix A.

We conducted an in-depth analysis to conceptualize how a combination of different signals conveyed through the signals of clean-tech firms (senders) to receivers (partner firms) and through actions and strategies may lead to the achievement of key entrepreneurial milestones and to increased legitimacy in development stages. An in-depth analysis included a number of steps. The transcripts, records, memos, and notes were first re-read several times. This facilitated the refinement of themes, categories, and concepts. Secondly, thoughts and discussions among the authors facilitated the development and common understandings of the description of concepts and the interrelations between them. Thirdly the authors, to cross-validate each other's observations of the interviews, conducted post-interview discussions, as suggested by Gioia and Thomas [66]. Joint discussions and examination of data unveiled common findings, thus minimizing personal subjective bias. Lastly, within-case and cross-case analysis were conducted to analyze the findings [57].

4. Results and Discussion

This study aims to explore how and why cleantech firms pursue the process of signaling external parties to gain legitimacy in development stages. This section is structured in accordance with our research sub-questions, which are as follows (i) why cleantech firms signal, (ii) what signals they send in the start-up and later stages and (iii) how cleantech firms signal to gain legitimacy.

4.1. Why Do Cleantech Firms Signal?

We have analyzed the data for the underlying motives of each start-up. The motives behind signaling strategies were multiple. Signaling to an investor was, for example, justified by the need

for capital and to increase the firm's evaluation before the investment is made. This is in addition to access to financial networks. An emerging pattern was that *successful companies focus on one or a few signals based on the dominant task*. One or few signaling strategies were aimed at achieving multiple milestones such as obtaining financing, experience, networks, customers and legitimacy. These are described below.

Need for financing and competent investors and directors. One of the dominant problems in the early stages of development is gaining resources such as financial capital for further technology development [56]. The early stage case firms indeed conveyed signals to investors because they needed capital and the additional business competence investors could provide that could aid overcoming legitimacy and credibility issues. As HydroEnergy's CEO stated: *"I was very keen on getting something more than money, we needed an investor who could contribute with something else, that's why we chose investor B. They had the industry experience, and an internal market specifically suited to us, which made it a perfect match."* Choosing an investor with industry experience and one that may provide access to a first market seems to give the right conditions for continued development, for catalyzing the process of overcoming the legitimacy threshold and increasing credibility immediately after first sales have been achieved.

The signaling actions were, in all cases, prompted by the need for financial capital and other additional resources, e.g., industry networks. For example, the CEO of EnergyRecycle described the recruitment of new board members as follows: *"There are two things, one is the contacts and network the person has in the industry, and the other is how he/she can help to obtain financing"*. The example shows that mature cleantech firms are more aware of the use of board directors as a part of their signaling strategies.

Need for customers. Attracting first customer and gaining market share is important in the initial stage. Attracting more customers and increasing market share are among the dominant tasks of growth stages. Our cases aimed, in the early stages, to attract customers for a number of reasons: to test their technology in a real environment, to establish market relationships and to gain references for further market expansion (which is in line with previous findings [18]). For example, the CEO of EnergyRecycle described how they attracted their first pilot customer as follows: *"They chose to be our pilot customer in spite of the risks, which they knew. For us it was not a commercially viable project. However, it was never intended to be commercially viable right from the start. The purpose was to get out there and demonstrate that our technology actually works."* EnergyRecycle therefore chose to engage in a partnership which was not very profitable, but gave them a foothold in the market and the opportunity to test their technology.

Not all approaches to customers however brought the expected results. For example HydroPower, when approaching a potential international customer, experienced that information asymmetry disfavored them when negotiating the terms of their agreement. A moral hazard arose through HydroPower trusting the legitimacy of what they thought would be a paying customer. HydroPower understood, when the customer company did not pay after receiving the finished product, that they have been deceived. An interesting note is that HydroPower had received credible signals from the customer that the Department of Energy of the foreign country had vouched for them. It did eventually become clear that the Department of Energy had failed to carry out a proper due diligence.

Need for legitimacy. Our results confirm that *legitimacy* can be viewed as *a threshold, a milestone and as a mechanism in signaling* [18]. The early stage cases used partnerships and customer references to build legitimacy. As the CEO of HydroEnergy stated: *"we have on several occasions used existing customers as a reference"*. There seems to be a link between why cleantech firms signal and how they perceive their legitimacy. It was very important to HydroEnergy to provide a high level of service to their first customer, so that they would be recommended onwards to new customers and obtain good references. The need for good references indicates that these firms signalize by conveying legitimacy. This, in turn, may contribute to the achievement of important milestones and further increase legitimacy. We, based on the above analysis, propose the following:

Proposition 1a. *Cleantech firms focus on conveying one or a few dominant signals depending on the dominant task of the development stage.*

Proposition 1b. *The signaling strategies of cleantech firms incorporate multiple goals associated with the need for board of directors, financial capital, customers and industry partners and legitimacy in the eyes of these partners.*

4.2. What Signals Do Cleantech Firms Convey?

The pattern of the signals in our cases was similar to that found in the study of ICT firms by Giones and Miralles [10], i.e., signals could be categorized into signals associated with technology, social capital and market. Our analysis revealed one additional signal category the *environment*. This is a renewability and environmental sustainability signal (see Table 2). Figure 2 illustrates major signals, their content, signal channels, other signalers (beyond the cases themselves) and signal receivers. The presentation and discussion of the findings below will follow the categorization. We start by presenting technology, social capital, and market signals and then the environment signal, first in the early stage and then in the growth stage.

Table 2. Signal categories.

Signal Categories	Signal Characteristics
Technology	Technology, patents, product
Social Capital	Team, board, investors, strategic partners, networks
Market	Growth potential, market position, business potential, price, service, long-term cooperation, customer references, history, achievements
Sustainability	Renewability, environmental sustainability

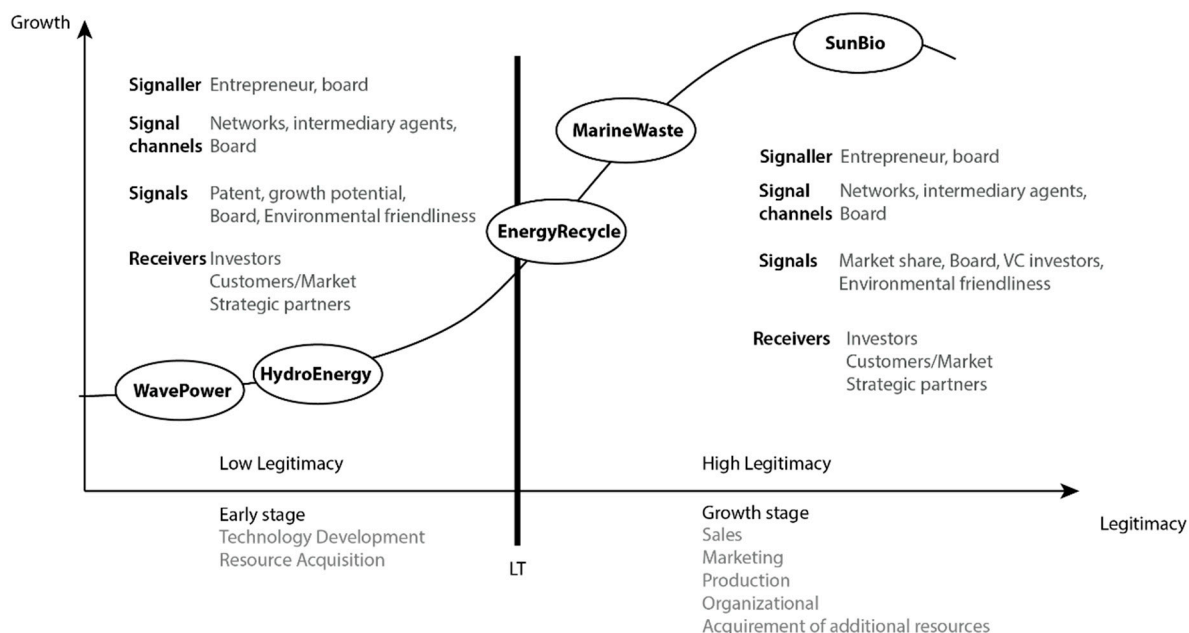


Figure 2. Signal types and other characteristics found in early and growth stages.

Technology, social capital, and market as early stage signals. Findings indicate that technology signals for investors are used to a greater extent in the early stages. A patent as a technology signal was, for example, a trigger event for WavePower: “When we got the patent we were like “king of the hill” and

the investor company got interested" (CEO, WavePower). Signaling the patent demonstrated that their technology was protectable, which led to the first investment in WavePower by a VC investor. This supports the idea that development phases build upon each other [39]. An interesting finding secondly is that one of the most important decision criteria for HydroEnergy's investor was a unique technology. A well-advanced technology as a quality signal may not always, however, generate a positive response. HydroEnergy developed a very complex technology which appeared to be too complicated for their customers. The company had to simplify its technology to achieve better market fit. This finding also illustrates that, in addition to technology signals, it is important for cleantech firms to handle such market signals as customer communication. The different signals are therefore interwoven and tied into each other.

Aldrich [67] suggested that new ventures benefit from their social capital in the demonstration of legitimacy. The early stage cleantech firms were found to rely more on the *social capital* of their connections, their investors and current strategic partners when signaling new customers or potential strategic partners. Leveraging the networks and contacts of their investors appeared to be an effective way of signaling social capital, resulting in "a completely different legitimacy". This, in the case of WavePower, led to a forward connection with a significant strategic partner.

A *market signal*, which seems to be important in achieving entrepreneurial milestones such as investment, is business potential. WavePower was considered to be immature for investment. The company's "billion dollar" business potential however led to the investor deciding to invest. This example illustrates how a perceived, seemingly high, business potential can become a critical market signal for VC investors. We also observe that signals can be interwoven (see 'investors' as a social capital signal and 'business potential' as a market signal in Table 2).

HydroEnergy deliberately signaled to its suppliers the intention of long term cooperation commitment in the following way: "When we were looking for a new supplier, it was important for us to establish a solid and long term cooperation. We signaled therefore clearly that we wanted a long term cooperation with the supplier". Another signal of long-term cooperation intent can be interpreted from providing good service. EnergyRecycle, for example, provides extensive service of their products and annual upgrades of technology far beyond normal warranty limits.

Environmental signals at early stages. EnergyRecycle signaled the environmental benefits of their technology through their unsuccessful attempt to gain government financial support. The CEO explained the reason for this as follows: "The only projects that get support are those that are very deep beneath the water or those that can ten double the number of users within six to twelve months". EnergyRecycle had a different experience when their future pilot customer approached them in the following way: "Our first pilot customer used a different approach, they were somewhat visionary and said that they saw it as part of their social responsibility to contribute to the development of other types of technologies and that the environment was important to them". The technology of EnergyRecycle therefore acted as an *environmental signal*, although, it was not intentionally sent. The focus seems to be on rather gaining technical and market legitimacy at the early stages in our clean-tech cases just as in other high-tech start-ups [10]. This makes the explicit differential nature of cleantech firms as environmental sustainability contributors less visible.

Based on the above analysis, the following proposition is presented:

Proposition 2a. *Signaling strategies in early stage cleantech firms primarily involve technology, social capital, and market signals, but to a lesser extent environmental signals, all being interwoven and conveyed both intentionally and unintentionally.*

Technology, social capital and market signals in the growth stage. Technology signals were conveyed to a much lesser extent in more mature case companies. Later stage signals were found to primarily be market, social capital and environmental signals sent to customers and strategic partners.

Findings indicate that *technology signals* in the subsequent stages are often issued to potential strategic partners such as manufacturers and larger customers, rather than to additional investors, as strategic alliances were deemed necessary to expand business operations. For example MarineWaste, a growth stage firm, used its products as signals to attract suppliers: *“We haven’t searched actively for strategic partners, but we have gained strategic partners because of their interest in our product and the concept we deliver”*, said the CEO. Such signaling was carried out somewhat unintentionally.

This spurs the reflection that cleantech firms that reach the growth stage gain an inertia that generates unintended (but positive) signals on their legitimacy. This results in even greater legitimacy, even though the firms do not seek or need this. We also observe a mix of both unintentional and intentional signals, intentional signals seeming to be used in a more strategic manner than in the early stage firms, decisions being based on prior experience with partnerships.

Social capital was used by start-ups that were already established actors in the market to signal knowledge of sales processes, board experience and network. This was particularly important when agreeing long-term contracts with customers, which is a typical growth stage dominant task [18]. The CEO of MarineWaste explains how the firm used its board as follows: *“On the board we have a lawyer who is responsible for our contract structure and liability, which is important for the type of technology we sell. The legal knowledge has been an important part of our board’s competence”*. Another company, SunBio, states they used social capital signals as follows: *“Personal networks are used deliberately to attract both customers, suppliers and investors”*. Social capital signals were found in these stages, as in earlier stages, to be conveyed to potential investors and customers.

As to *market signals*, the findings indicate that positive references from established customers contribute to attracting more new customers. For example, the CEO of MarineWaste explains: *“You are never better than the last project delivered. So if you deliver a bad project, you may be excluded from future contracts for a long period of time... ..Our success with certain customers has led to us gaining the trust of other customers, which has been very important for us”*. This shows that the development of market credibility is of key importance to achieving growth and sustainable returns. Legitimacy and market signals perceived by signal senders and/or receivers can be viewed as a threshold/milestone in itself and a signaling mechanism for overcoming the legitimacy threshold and allowing the attainment of the next milestone, e.g., attracting new customers.

Environmental signals at growth stages. Environmental signals were found to be primarily sent to investors. SunBio’s CEO explained how environmentally friendly technology was signaled: *“The sustainability and renewability of our concept has been our main selling point. The focus on sustainability and renewability has meant that we now have an American Pension Fund that owns one third of our company”*. The nature of SunBio’s core competence and business model means that the firm does not signal the technological attributes of their products. It instead signals the environmental friendliness it offers beyond that provided by competing products and services. This turned out to be an essential signal for the investor the American Pension Fund that is focused on sustainability and renewability. Signaling environmentally friendly technology is a very important factor that customers look for. SunBio’s CEO states: *“If the price is wrong, then you’re out, these are huge corporations (customers) with public tender processes; then it is important to document the renewability and carbon footprint in all of production”*. SunBio’s customer however did not mention the sustainability signal as important. It instead emphasized the following criteria for partnership establishment: *“delivering reliability, availability, compliance with required industry regulations and desire for a stable and long-term relationship”*. This implies that the signal was not perceived by SunBio’s customers (receivers) as it was intended to be perceived by the firm (signaler).

Another firm, MarineWaste, conveyed to its customers an environmental signal as a quality signal, as the CEO explained: *“In the beginning, we demonstrated to the customers that had faith in us that we were able to deliver new environmental technology with high cleanliness requirements”*. Stringent regulations apply to products in the marine market. These regulations may force firms to signal environmentally friendly technology to a much greater extent than other cleantech sectors.

The regulations also represented new business opportunities: “In 2003, the special waste, on which our core business is based, became classified as hazardous waste and opened up an opportunity where we were able to make money on handling that waste”, as SunBio’s CEO described. Despite this, our analysis indicates that the signals sent by late stage cleantech firms and their receivers differ from those sent by other early stage firms. This is what is described as a combination of reveal and conceal signaling strategies to overcome legitimacy challenges related to development stages. The following is therefore proposed:

Proposition 2b. *Signaling strategies in cleantech firms in growth stage will, to a larger extent, involve environmental signals and all the other signals (market, social capital and to some extent technology) being both intentional and unintentional, interwoven and resulting in higher legitimacy.*

4.3. How Do Cleantech Firms Signal?

The board of directors. WavePower’s CEO stated that; “The whole point of the board was to recruit people who have the networks we require. We completely depend on the board being out there using their network. They use their existing network and create new relationships. Without them we wouldn’t be able to speak to people”. This was particularly important for WavePower, as it was a sole ownership company and the CEO had a limited experience in the energy sector. Finding board members who can provide access to relevant networks is also crucial for early stage cleantech firms. The board can thus be viewed as one of the most important mechanisms for accessing customers, for funding and for partnerships through the director’s industrial and financial networks. MarineWaste’s customers and partners furthermore operate in an extremely consolidated industry where personal contacts and networks seem to be essential for a firm’s survival. Being able to *signal consistency* through a board with strong ties to the central actors in the industry therefore appeared to be one of the most decisive factors for this firm’s success.

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The findings also suggest that all firms leverage the networks and personal relations of their boards to signal legitimacy and other qualities associated with increased legitimacy to important business partners. EnergyRecycle’s CEO commented that: “They (directors) have the contacts in the industry which we operate in, and their networks also contribute when we need financing to obtain the liquidity we need to keep going”. Most directors on EnergyRecycle’s board are VC investors specializing in investing in cleantech. This industry experience greatly helped this firm when shifting focus from product development to reaching out to customers. It enabled EnergyRecycle to convey signals of enhanced legitimacy. SunBio also gave some of its shareholders’ important board positions. The firm used their shareholders’ (who were also directors) broad industry experience when reaching out to external parties. As SunBio’s CEO stated: “We leverage our (board’s) personal network to a high degree when it comes to contacting customers, suppliers and investors”. Board directors are therefore very important actors in signaling benefits and hiding gaps in resources across development phases. We therefore present the following proposition:

Proposition 3. *The board of directors and its networks will be one of the most important signaling mechanisms to enhance legitimacy across all development stages of cleantech firms.*

5. Conclusions

This study seeks to improve our understanding of how, why and what cleantech firms signal to achieve legitimacy. Research on entrepreneurial cleantech firms remains limited despite increasing global climate challenges. In this study, we have addressed the following research questions: how and why do cleantech firms signal to gain legitimacy, and what type of signals do they send across the different development phases?

Our results firstly show that the type of signaling of cleantech firms varies with the firm's development stage and the dominant tasks of the current stage. The nature of the signaling is furthermore related to the multiple and simultaneous needs for financial capital, experience, networks, customers and legitimacy. We found that founders send signals to the external actors who are most relevant for solving a current task. For example, sending a signal to a venture capitalist while trying to acquire financial resources. This shows that the founders seem to act strategically when sending signals to key external actors. Secondly, the results support the findings of previous research that signals relating to the technology, social capital and the market could be distinguished from each other. These findings provide empirical evidence to recent conceptual contributions on how new firms build legitimacy engaging multiple stakeholders [62]. Cleantech firms, as expected, generate environmental signals to potential strategic partners, revealing information on the sustainability impact of their eco-innovations [3]. However, these signals were not explicitly used in the early stages of a firm's development. Sustainability signals were instead used more intensively and more intentionally as the firm evolved. These findings are in line with Ge et al. [6] and Erikson et al. [15] indicating that cleantech firms tend to act somewhat slowly upon their environmental sustainability realizing that this type of signal may provide an additional source of legitimacy. New firms in cleantech industry do not become automatically legitimate despite an institutional pressure that exists to generate solutions that quickly address the sustainability challenges [15]. Interestingly, the constitution of and changes to the board of directors appears to be one of the most important mechanisms for generating legitimacy signaling across all development phases of a new firm. The board of directors has often prior industry experience, networks and legitimacy in the market, all of which make them very important to cleantech firms that often lack these resources.

Our work adds to existing research in different ways. Firstly, we add to the research on managing cleantech firms by shedding light on signaling strategies developed by these types of firms [1]. Our multiple case study design enabled us to explicate specific signaling actions that entrepreneurs founding clean-tech start-ups undertook to establish their legitimacy in the eyes of resource providers and other actors from the established markets. Clean-tech entrepreneurs need to fight for legitimacy justifying new ways of doing business vis-à-vis established industry standards and norms, but may do it differently dependent on whether the firm is at the early or late development stage. Secondly, we add to signaling and sustainable/technology entrepreneurship research. Signaling theory research has so far suffered from being static, and the signals have been treated separately [20,21]. Our study demonstrates signal *dynamics*, *interweavement* and the effects of signaling in the search for legitimacy by young cleantech industry firms. Thirdly, we add to the board and signaling research by showing the role of the board in the signaling strategies pursued by cleantech firms. Fourthly, *we contribute* to signaling theory by observing the evolution of the signaling strategies across the different development stages and *with the concept of reveal or conceal* to describe how firms select (and adjust) possible signals based on what they expect the legitimacy builder for the specific stakeholder audience will be. These findings are in line with recent calls to reexamine the concepts of legitimacy in the context of new technology-based ventures and across development stages [19].

This study is not without limitations. Firstly, the number of cases was limited—five cleantech firms and three partner firms for one country. Although our goal was to contribute to theory development

and conceptual generalizing in the specific area [68], more research should be carried out in order to strengthen the validity and generalizability of this study's findings. Future researchers could try to overcome the challenges associated with the collection of data by following up selected companies representing different countries over time. For instance, institutional factors—e.g., different legislations in different countries, availability of venture capital and incentives [7,69,70]—may lead to differences in the initial team and board composition. This, in turn, may influence the nature and content of the firm's signals. Future researchers are therefore encouraged to investigate whether and how signaling strategies pursued by cleantech firms would be similar or different across multiple institutional contexts. In addition, more research is needed that compares cleantech firms with other technology firms, among all due to that they perceive various obstacles differently throughout firm's development [15,22].

Secondly, future studies should also systematically collect and analyze complementary sources of information such as news articles, press releases, reports, or other information that could be used to communicate with stakeholders, to more completely cover the receiver side of the signaling theory. Capturing the perception of the signal receivers in more depth and the differences across the different types of receivers could further enrich and contrast our findings, thus contributing not only empirically, but also theoretically to signal theory [20]. Third, beyond conceal in early stage and reveal sustainability later pattern, the study did not identify more distinctive characteristics of clean-tech firms. One reason may be heterogeneity in selected cases. Future research studies aiming at uncovering unique characteristics could choose more homogeneous samples, such as clean-tech firms utilizing one specific renewable energy source, e.g., wave and tidal energy [7]. Another reason may be that this study included all types of signal receivers. Future research aiming at uncovering unique features of clean-tech firms could focus on one specific type of signal receivers, e.g., investors or government. For instance, one could expect that clean-tech entrepreneurs act as "institutional entrepreneurs" trying to change established policies and norms in order to defend themselves as viable new organizational forms [2].

This study has a number of implications. Firstly, our results suggest that dynamic perspectives (e.g., stage-based theory) can be fruitfully applied to investigate and better understand signaling in cleantech firms. Next, the identification of different ways of issuing signals, suggests the possibility that not all signals are created in the same way. We would expect that part of the success of a signaling strategy would be related to the ability of the new venture to identify the signals that the audience expects and then explore what type of resources and objective elements can help produce the signal. Such strategies would contradict the signaling theory assumption that relates to the expected advantage of firms with unobservable high quality resources. *Our findings instead suggest that signaling success is related to a firm's ability to understand audience expectations and strike the balance between reveal or conceal signaling.* For cleantech entrepreneurs and other practitioners, this research indicates that signaling activities need planning, managing and orchestrating. Our study highlights the importance of establishing a competent and well-connected board that can contribute to building legitimacy. This is especially important in the absence of reputable external parties, external knowledge or founder's prior history—a situation often inherited by cleantech firms.

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Appendix A. Case Study Codes Describing the Dominant Themes

The coding for the interviews went through several iterations as new codes and combinations emerged. Just the initial codes are represented below, based on the theoretical framework.

(1) EARLY STAGE DOMINANT PROBLEMS

- Technology development
- Resource Acquisition

(2) GROWTH STAGE DOMINANT PROBLEMS

- Sales
- Marketing
- Production
- Organizational
- Acquirement of additional resources

(3) SIGNALS

- Social capital
- Market
- Technology

(4) SIGNALLER

- Entrepreneur
- Network

(5) RECEIVER

- Investor
- Customer
- Market
- Strategic partners

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