How Can a Sustainability Entrepreneur Facilitate a Transition from Brown to Green Energy?
The Renewable Energy Island of Samsø

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Abstract

How do we deal with sustainability issues at the local level? The island of Samsø in Denmark and its rapid introduction of renewable energy demonstrates that it is possible to facilitate a transition from brown to green energy when the right "sustainability entrepreneur" (SE) is present. Theoretically, we consider four entrepreneurial skills, where at least two skills must be present for the SE to succeed. Three of these skills are identified as being present in the Samsø case, and a main result is that it is crucial to convince non-green local people about the economic profitability of the project rather than its potential green components.

Keywords: Local participation; entrepreneurship; information; coordination; sustainability; Samsø; renewable energy.

1. Introduction

The island of Samsø is located in the middle of Denmark in Scandinavia and constituted an important meeting place in the Viking age. Today, Samsø has become a meeting place for energy specialists from all over the world. They want to see how such a small community has been able to make a shift from being energy consumers to energy producers. Earlier on Samsø was entirely dependent on oil and coal, both of which are imported from the mainland. In 1997, however, the Samsingers joined forces bottom-up due to local entrepreneurship and started a rapid transition to renewable energy, especially by erecting wind turbines. Eight years later they produced more renewable energy than they were able to consume and thus became climate neutral. Remarkably, Samsø only comprises 22 villages and 4,000 residents. As the Egyptian ambassador put it on a visit to Samsø: "[T]he number of people living on Samsø could fit into three apartment buildings in Cairo!" (Höges, 2009).

Before this transition began, Samsø had no conventional energy resources of its own. All fossil fuel had to be transported by tankers, and electricity was secured by connecting to the mainland grids (Energychange, 2013). Local green initiatives, such as the one observed on Samsø, are needed to make the world more sustainable, as described in the ENEP green economy initiative (UN, 2011, 2012a, 2012b). Among other things, this covers investments and innovation in natural capital (agriculture, fisheries, water, and forests) and in energy and resource efficiency (renewable energy, manufacturing, waste, buildings, transport, tourism, and cities).[1] Likewise, numerous books that sound dire warnings of environmental disaster often end on an optimistic note, concluding that civilization's salvation rests upon the shoulders of heroic social and environmental entrepreneurs (Hall et al., 2010). In particular, entrepreneurship combines an understanding of social and technical expertise with the experience of non-profit and for-profit projects to improve the practice of sustainable design and development (Sustaineship, 2012).

Hall et al. (2009, 2010) finds a gap in the existing literature: It remains an open question to what extent entrepreneurs have the potential for creating sustainable economies, how they are motivated

[1] This is an application of the so-called "Hardwick's rule": In order to sustain a non-declining consumption path over time in the presence of non-renewable resources, it is necessary to invest all resource rent into productive capital to keep the total capital stock (natural and manmade) non-declining (also known as the weak sustainability hypothesis) (see Perman et al., 2011).

and incentivized, whether there are structural barriers to the capture of economic rents for sustainable ventures, and whether sustainability-oriented entrepreneurs differ from traditional entrepreneurs. We try to fill this gap by considering a situation where the SE may have the required knowledge and coordination skills. The issue of optimal group size in relation to the sustainability issue is addressed in Brandt and Svendsen (2013), who find that implementation of local Agenda 21 is problematic if consensus in a given group is needed. Compared to their analysis, this paper, by including the sustainability entrepreneur, presents a more positive view on the probability of successful sustainability initiatives at the local level.

Thus, based on the empirical puzzle of Samsø, our main research question is:

How can an SE facilitate a transition from brown to green energy?

The answer is given by using a model that explores the conditions under which the SE can overcome informational shortcomings and coordinate collective action.

The skills we identify include: 1) the ability to secure high private economic performance of the project and, at the same time, deliver a sufficiently high green component (a high-performing SE); 2) coordination skills (the ability to bring people together and convince them about the values of the project and thus foster willingness to corporate) (a unifying SE); 3) the power to persuade those who initially only derive value from the private income of the project about the value of the collective benefit (sustainability part) of the project (a persuasive SE); and 4) the SE needs to be trustworthy; that is, the potential participants should trust that the SE is in fact able to deliver a project that is profitable for all participants (a trustworthy SE). In the theoretical model we describe circumstances where a combination of these skills is necessary and examine a situation where the SE needs to be both high-performing, unifying, persuasive, and trustworthy to being able to initiate the project.

Finally, we link these findings to the Samsø case, and analyzing this case we conclude that the SE (Søren Hermansen) needed at least two of the mentioned skills to initiate the transformation. In particular, by acting as a first-mover he became a trustworthy SE. On the other hand, he did not need to be a persuasive SE, since the project yielded a high level of personal income.

Our conclusion is that this SE is an idealistic rationalist, and his project succeeded not because of its green components, but because he convinced "ordinary" people with no specific preferences for sustainability to join the project – a result also found in Sandler (1997), who points to the necessity of creating policies that are both sustainable and profitable.

Section two of this paper first discusses how entrepreneurship made sustainable energy production work on Samsø. Next, section three develops the model and presents the potential skills of the SE along with three versions of the model, which require different skills to initiate the project. Section four introduces asymmetric information, where, for example, the people involved from the outset do not know the type of SE and project they will be facing. We identify ways for a high-performing SE to signal its true type and be perceived as a trustworthy SE, who can deliver a high-performing project. Section five concludes on the findings.

2. The Renewable Energy Island of Samsø

Søren Hermansen, a local farmer, was the SE who organized this small miracle on Samsø. He says: "It's important to negotiate, but then they have to go home and do something." And: "We don't wake up every morning thinking about how we're going to save the polar bears. No, people think about themselves. But this isn't a problem according to Hermansen, it's the solution!" (cited from Höges, 2009).

At first Hermansen had difficulties convincing local investors that the renewable energy project would be profitable, and he spent months going to community meetings and talking up renewables. He went from house to house to promote the plan. Then he bought a cider press, because almost everyone on Samsø has apple trees. Offering them fresh apple juice was one way to get them to listen. His main drive was how people could continue to live on Samsø after the "Great Depression", that is, the closing of the slaughterhouse, which would put many people out of work. He argued that the new project was more profitable than the slaughterhouse, and soon his arguments and the information he carried began to have the desired effect (Höges, 2009, DAC, 2013).

The key, according to Hermansen, was to convince Samsingers to actively participate in the project, and that it was not just another hippie bureaucracy project sent out by some smart Copenhagen top-down politicians and consultants. His job was then to tear these presumptions apart and break it down to daily things that related to everyone in one way or another. He coined a term, "commonity" – a combination of community and commons – which he referred to in his discussions with the locals, trying to persuade them to get on board with the idea of becoming investors in local renewable energy resources. Also, Hermansen sent an important signal by personally investing in the project (Guevara-Stone, 2013, Jakobsen, 2010).

So, basically Hermansen convinced local investors that there was money in it: "The reason you invest differs from who you are, but in the end it is about money, and the fact that when we show that if we do it like this we save on the import of oil. Everyone knows that price for oil fluctuates and is therefore interested in doing something else" (cited from Jakobsen, 2010, 55). Furthermore, a green development would bring new jobs, new businesses, and increased business from more visitors to the island. Today the island's tourism website, "Visit Samsø", includes a major section on Samsø as a renewable energy island.

The economic argument by Hermansen was based on a report made by an engineer from the city of Aarhus (situated just across the water from Samsø). This engineer won a contest in 1997 announced by the Danish Ministry of Energy, where it was calculated that it would pay to introduce renewable energy on Samsø (Höges, 2009, Guevara-Stone, 2013). As it turned out, the calculations proved to be correct.

Today the weather on Samsø is always good – at least in terms of renewable energy production: When the wind blows, the rotors turn. When it rains, the straw for the heat generators grows. And when the sun shines, the solar panels get to work. The overall pattern here is that this rapid eight-year transformation to renewable energy was made possible by the presence of an SE, embodied by Søren Hermansen. He acted as a multiskilled entrepreneur and came from a population that was big enough to foster him. He was elected bottom-up, carried the needed information, and through face-to-face negotiations convinced the local investor group on Samsø that it was in their own economic interest to make these relatively big investments, as they would prosper in the longer run from their shares in making the island climate neutral (Jakobsen, 2009).

3. The Model

In this section we set up a theoretical framework and introduce another SE before elaborating on which skills an SE needs to be equipped with to overcome the coordination and knowledge problems that may prevent a group of people to voluntarily produce a particular type of project.

Focus is on projects that generate both private benefit, for example, power or biogas (valued either for its saleability on the market or its opportunity costs from the members' own use of the produced power or biogas), and non-market values like less pollution, more sustainable use of resources, but also public goods such as cleaner air, more tourists, etc., which may also directly or indirectly benefit non-members.

We restrict our attention to situations where many local investors are needed to actualize the project. We define $I = \{1,2,\cdots,n\}$ as the number of participants, with $(i \in I)$ denoting individual participants. Many local investors are needed in situations where each potential participant has a budget constraint, b^i, assuming that the person will use his budget constraint to participate in a good project, but also that the individual budget is small compared to the fixed costs of the project.

An important characteristic of the "good project" we consider is that the development of the private and collective benefit increases with the project size. The vital assumption here is that for each added participant the capacity of the project increases in such a way that the economic return for all participants remains constant. Similarly, the collective benefit of the project increases when the size of the project increases: The more participants, the larger the public goods component of the project.

A secondary characteristic of this type of project is that it exhibits economics of scale in the form of particular network externalities and knowledge and infrastructure sharing. For example, building the first wind turbine requires a lot of infrastructure, like roads and power grid connections, and negotiating contracts in order to sell the power. The cost per capacity installed diminishes for the following turbines, as some of the required infrastructure already exists.

More formally, the total costs of the project will be described as $C^{Total}(n)$. Since the project size increases with the number of participants, the total costs are a function of n. Thus, $C^{Total}(n)/(n)$ is

the average costs of the project and $AC(n) = C^{Total}(n)/(n)$. For a given n (probably up to a certain n size) adding another participant will lead to a decrease in the project's $AC(n)$, so that $AC(n) > AC(n+1)$.

To make the analysis simpler we will look only at equal cost sharing arrangements. This implies that for any group of n people that accept the project, each will pay $C^{Total}(n)/n$ of the total costs. (This is not an important assumption, since other sharing rules could also have been used, but the equal sharing rule remains a focal point).

Second, the private benefit provided by the project is also shared equally. Let the total revenues of the project be $R^{Total}(n)$. Since, as the project size increases with the number of participants, the total revenue is also a function of n. Let $AR(n) = R^{Total}(n)/(n)$ be the average revenue of the project. (We assume that this is constant and not depending on *n*). The collective benefit is non-market in type and is valued according to individual preferences. Let $G(n)$ be the size of the collective good, so that $G(n+1) > G(n)$.

We here try to replicate how a population can be described by its preferences toward sustainability. We will assume that a (relatively small) fraction of the population values sustainability, but that the majority is only interested in the private benefit, and that these peoples' decision is not affected by whether or not the product/process contains a sustainability component. Even though this is a very simple partition we believe our assumption captures the essence of a normal population.

Therefore, we will now consider two types of participants: One group that does not value the sustainability part of the project, but only cares about the private stream of income they gain from the project. We call this type of participant the E-type (E for economy or economic man). The second type is the G-type (G for green). This group also cares about (derives utility from) the public goods (sustainability) component of the project. Since we are considering relatively local (or small-scale) projects, let there be a limit of potential participants of n^{G+E}. All participants are equipped with the following quasi-linear utility function:

$$u_i^t(n) = u_i^t\big(G(n)\big) + AR(n) - AC(n), \;\; t = G, E \qquad (1)$$

The distinguishing factor between the two types is:

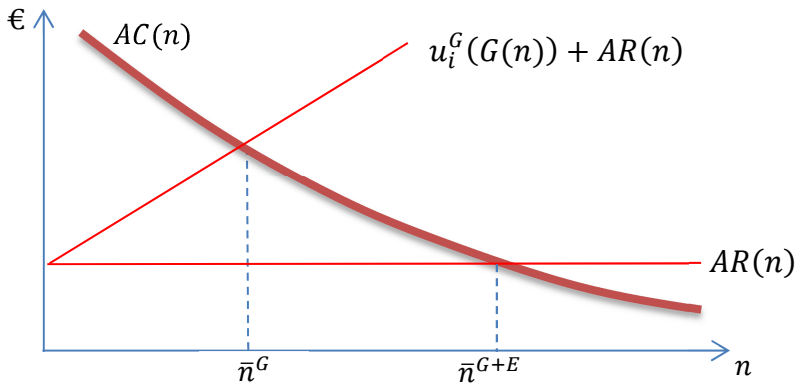
$$u_i^G(G(n)) > 0 \text{ for } G(n) > 0, u_i^E(G(n)) = 0 \text{ for } \forall G(n) \qquad (2)$$

Another important distinguishing factor between the two groups of participants is that the G-types will not participate unless it involves a significant sustainability provision, whereas the E-types will participate if they receive a positive net benefit from participating. This leads us to two relevant types of participation constraints:

Economic participation constraint (PCE): $u_i^t(n) \geq 0$
Green participation constraint (PCG): $G(n) \geq \bar{G}$.

In order for a G-type to participate, both the PCE and PCG must be satisfied, whereas for the E-type only the PCE needs to be satisfied. Note that this implies that the G-type can accept lower net revenue from the project, provided that the G-component is large. We summarize the model in Figure 1.

Figure 1: *The basic structure of the model*



In the Figure $\bar{n}^G$ represents the number of G-types needed for that group to collectively provide the good, given that $G \geq \bar{G}$. A formal definition is: $\bar{n}^G = \arg\{u_i^G(n-1) < 0 < u_i^G(n) \wedge G \geq \bar{G}\}$. Moreover, $\bar{n}^{G+E}$ is the number of participants, including both G-types and E-types, needed for that group to be willing to provide the good. Here is the formal definition: $\bar{n}^{G+E} = \arg\{u_i^t(n-1) < 0 < u_i^t(n) \wedge G \geq \bar{G}\}$, $t = G, E$.

The consequence hereof is that if, for example, the number of potential participants n^{G+P} is smaller than $\bar{n}^{G+E}$, then the participation constraints will not be satisfied.

Given this structure, what are the reasons that the project may not be implemented by the local community (without help from an SE)? We point to two main reasons. First, there is a need for knowledge about the project. Opportunities need to be identified and potentials quantified into benefits and costs. Second, there is a great need for coordination. Due to the falling AC, such projects involve many participants, and therefore someone needs to be the first mover who gathers people, initiates meetings, information sharing, etc.

This leads naturally to a discussion of the skills that an SE could or should be equipped with. As already described in the introduction, an SE is a person who possesses extraordinary skills and abilities, which he/she can utilize to get a group of people to provide or produce a good with a sustainability component, a good that, without the presence of the SE, would not have been provided.

First, what are the objectives of the SE? Since we denote him/her a sustainability entrepreneur, it is reasonable to assume that the objective of the SE is to maximize the size of the project or the green component hereof. Therefore, the SE acts as an idealistic realist, as he/she, in order to meet his/her objective, also needs to consider how he/she can involve people who do not have a preference for the green part of the project.

So, how can an SE turn an otherwise non-realized project into a success? Let us look more formally at which skills the SE needs, depending on the type of situation. We point to four distinct abilities which may all be relevant depending on the specific details of the above set-up.

1) Ability to make the project generate sufficiently high net benefits.
2) Communication and coordination skills.
3) Ability to influence non-green participants, making them care about the green component.
4) Trustworthiness.

1) The SE may have better knowledge than the locals about which types of investments are the most relevant for their specific location and, through personal networks, the ability to identify the necessary production facilities and facilitate the transformation needed to create the project that yields the highest net benefit or the highest level of sustainability. 2) The second skill is rooted in the personality of the SE and his/her ability to coordinate. The SE needs to have a sufficiently dedicated personality, making him/her a natural leader and driving force. 3) Under certain circumstances (to be explained below) a given project can only be realized if some E-types are transformed into G-types. Here the SE needs to have persuasive powers to generate awareness of and interest in the non-personal benefits of the project. Finally, 4) the SE needs to be trustworthy; that is, the local people who invest in the project must to a sufficient extent believe that the SE can in fact realize a profitable project.

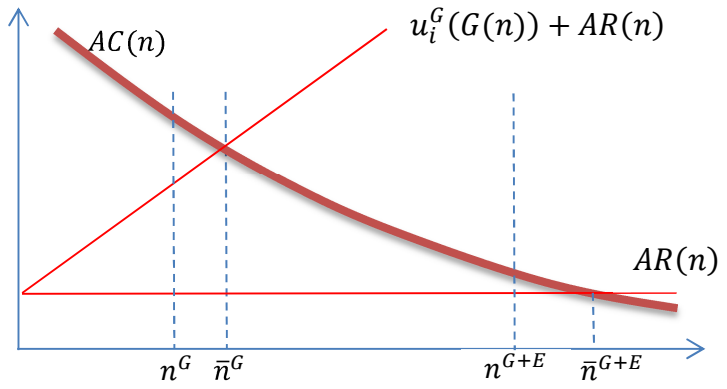
Now we will identify situations in which the skills of the SE are needed to implement the project. These situations represent three versions of the set-up described above. (There are of course many more possibilities, but the situations presented here show that the finer details of the problem define which types of skills the SE must posses).

In this section we focus exclusively on the case of full information, and here the skill of "trustworthiness" is not relevant. We will devote section four to the asymmetric case. Full information implies that the SE always presents the true costs and benefits of the project.

VERSION 1 is defined as a situation where $n^G < \bar{n}^G$ and $n^G + n^P < \bar{n}^{G+E}$. In this version neither of the participation constraints are satisfied. This might be caused by 1) high costs, which only fall slowly when n is increased, 2) relatively low benefits resulting from too few potential participants, or 3) a limited project size which leads to capacity constraints. In any case this is the most complicated situation for the SE to initiate a full-scale project. An illustration of version one is given in Figure 2.

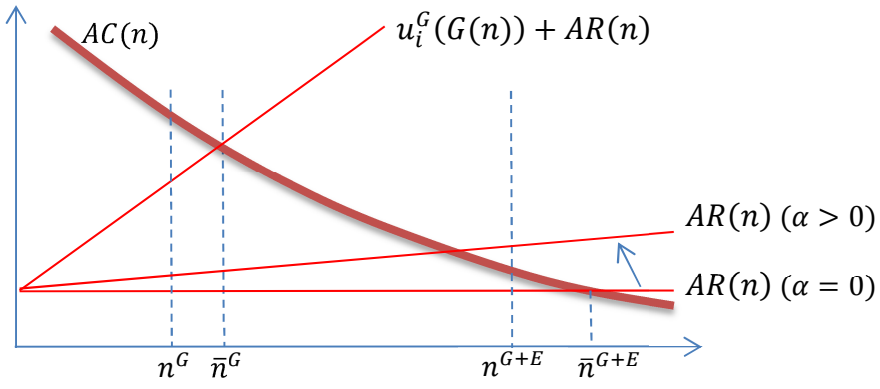
Here, the SE needs to have skills 2 and 3 in order to create a project where everyone participates. In particular, in this situation the only way to build such a project, is if the SE can "transform" some of the E-types to G-types. We refer to this sort of SE as a persuasive SE, since he/she in this case must be able to persuade a sufficiently large number of E-types to also value the G-benefits.

Figure 2: *A situation where the SE needs a lot of skills to succeed.*



One way to model this is to redefine the utility function of the E-type as follows: $u_i^E(n) = \alpha \cdot u_i^E(G(n)) + AR(n) - AC(n)$. Initially, the parameter $\alpha = 0$. A persuasive SE then has the ability to increase α above zero. (For simplicity we here assume that all E-types have the same α). This situation is specified in Figure 3. For a sufficiently high α, it is now possible for the group to realize the project, if they are faced with a persuasive and multi-skilled SE.

Figure 3: *The SE influences E-type preferences to also value sustainability.*



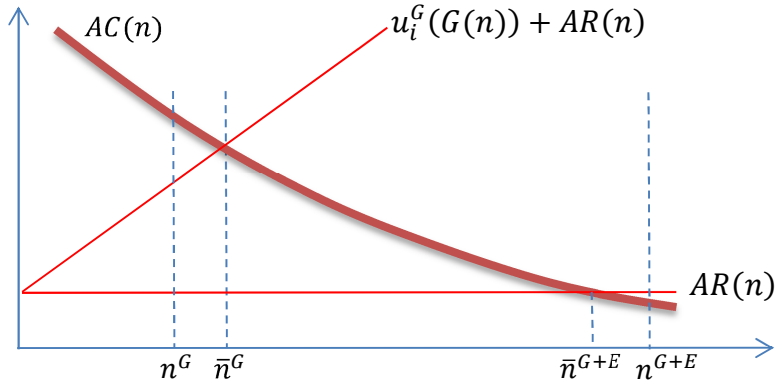
There are several studies that discuss how behavioral choices can be initiated. Within environmental education Finger (1994) provides the following chain of links to show how information provision can foster behavioral changes: More information → more knowledge → larger concerns → higher awareness → changes in values → changes in attitudes → changes in behavior. See also James

(2010). Some studies reveal that persuasion can have an impact on peoples' behavior (see, for example, Kraemer and Mosler, 2010).

VERSION 2: Consider a less demanding situation (compared to version 1) where $n^G < \bar{n}^G$, but $n^G + n^P > \bar{n}^{G+E}$. This implies that even if all the G-types go together, they are unable to realize the project; however, if all the participants, G- and E-types, go together, then the individual rationality constraint is satisfied for all players. An example of this is shown in Figure 4.

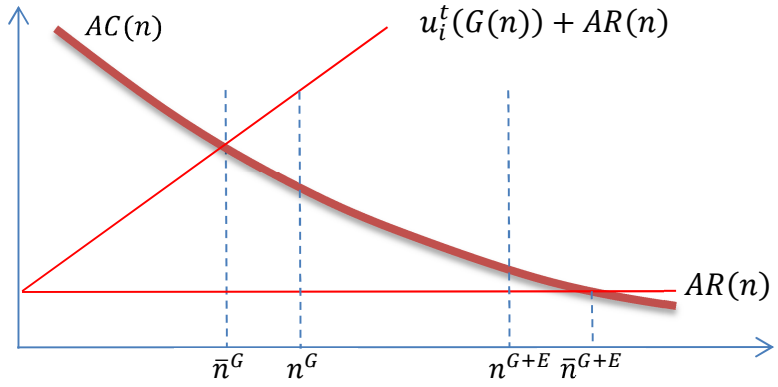
Here, in principle the SE does not need to change the preferences of the E-types and can instead focus on coordinating and communicating information about the benefits and costs of the project. We can call this type of SE a unifying SE, in that he/she needs to be able to combine the economic potentials of the project with its sustainability potentials and, in so doing, get all the G-types and E-types to joint forces.

Figure 4: *A situation where the SE needs coordination skills to succeed.*



Version 3: Here we have a situation where $n^G > \bar{n}^G$, but $n^G + n^P < \bar{n}^{G+E}$. See Figure 5. Due to the definition of $\bar{n}^G$, the G-types as a group will be able to create a project of the size n^G. In this case an SE who is able to provide the G-component is sufficient; he/she does not need any additional skills (assuming that the G-types can coordinate themselves).

Figure 5: *A situation where the SE has different options.*



However, if we introduce the pervasive SE there is also another possibility; if he/she is pervasive enough this SE can produce a larger project of the size $\bar{n}^{G+E}$. To sum up, here the SE only needs skill 2 or skill 3.

So far we have assumed that any SE can produce the same costs and benefits for the project. However, skill 1, the ability to provide a high net benefit, is an important skill. In the next section we assume that there are different types of SEs – a type of SE who can deliver a high performance project and a type of SE who cannot. Furthermore, we assume that the potential participants to begin with are unable to identify which type of SE they are facing.

4. Asymmetric information and signaling of high performance

Because such investments are made up-front, the participants need to know what type of SE they are facing – does the SE have the needed skills?

So far we have only looked at which skills the SE needs if full information is provided. Consider now a situation where the potential participants do not know what type of project they are supposed to be part of. If, for example, the SE claims that version one prevails and the SE has the necessary skills (2 and 3), and if everyone chooses to participate, the project will be profitable for everyone. But what if the SE overstates the green and/or economic components of the project and in reality wants to force the project through for his/her own sake? The presence of a potentially bad SE, who does not possess skill 1, will challenge a god SE, who can truthfully deliver the necessary green and economic potentials.

Consider a situation where there are two possible G-components, G_L and G_H, and where $G_H > G_L$. There are also two possible E-components, E_L and E_H, where $E_H > E_L$. We link this to the SE by

defining four possible SE types: SE_{HH}, an SE who both provides G_H and E_H; SE_{HL}, who both provides G_H and E_L; SE_{LH}, who both provides G_L and E_H; and finally SE_{LL}, who both provides G_L and E_L. The incentives are now so that an L-type SE also exists, who untruthfully announces the green and economic potentials of the project and, consequently, fails to make the project profitable for the participants, even though he/she has promised to do so.

To make this interesting, imagine a situation with an information structure where the participants initially do not know which skills the SE is equipped with. Instead they have certain beliefs about the given type of project (and the given type of SE). Such prior belief depends largely on the history (record/reputation) of the SE. Past successes increase the potential participants faith that the SE will also create a successful project this time. Let $\rho^{G_o} = prob(G = G_H)$ be the (common) prior belief that the SE can provide a high green performance. Similarity, let $\rho^{E_o} = prob(G = G_E)$ be the (common) prior belief that the SE can provide a high economic performance. We assume that beliefs differ between types, but are identical between members in a group. Moreover, ρ^{G_o} and ρ^{E_o} are assumed uncorrelated.

Let the people be able to form expectation and calculate the expected utility. The expected utility function is therefore:

$$E_{\{\rho^G;\rho^E\}}u_i^t(G,E;n) = \rho^G u_i^t(G_H(n);n) + (1-\rho^G)u_i^t(G_L(n);n) + \rho^E AR(E_H;n) \\ +(1-\rho^E)AR(E_L;n) - AC(n), \quad t = G,E \qquad (4)$$

An interesting case is when the potential participants refuse to participate due to prior beliefs, but where everyone would in fact profit from participating if the SE turns out to be an H-type SE. In this case, the SE must try to convince the participants that he/she represents an H-type SE.

Due to their objectives, all types of SEs want to realize the project, and they therefore want people to believe that they possess certain skills. We assume, however, that there exists no costless verification technology by which the SE can reveal his/her type. In order to change the beliefs of the group the SE thus needs to act or send a signal that will make it more likely that the SE is a "skilled" SE who is able to produce a high green and/or economic performance.

We will not set up a formal signaling game model, but instead use the logic of such a framework. A skilled SE needs to act in a way that would not be in the interest of (or feasible for) an unskilled SE, even if it would increase people's beliefs that the SE indeed is skilled. The characteristics of such an action could, for example, be that it is either easier (cheaper) for the skilled SE to produce, or that it can be produced in a larger amount.

A signaling device carries with it information about the type of sender that might have sent the signal For example, if an SE invests his/her own resources into the project, he/she would be signaling that the project is profitable. Formally, let a^j be the signal device j. Assuming that the range of a^j is discrete (and finite), $a^j \in \{a_1^j, a_2^j, \cdots a_k^j\}$.

Formally, write $SE_{G_\theta,E_\theta}, \theta = \{L, H\}$ and define $p\left(a_l^J | SE_{G_\theta,E_H}\right)$ as the conditional probability of SE_{G_θ,E_H} , given observing a_l^J. Let the Bayesian updating, after observing a_l^J, be:

$$\rho\left(SE_{G_\theta,E_H} | a_l^J\right) = \frac{p\left(a_l^J | SE_{G_\theta,E_H}\right) \cdot \rho^{E_o}}{p\left(a_i | SE_{G_\theta,E_H}\right) \cdot \rho^{E_o} + p\left(a_i | SE_{G_\theta,E_L}\right) \cdot (1 - \rho^{E_o})} \qquad (5)$$

$\rho\left(SE_{G_\theta,E_H} | a_l^J\right)$ is called the posterior belief.

An example of this is a situation where a^I is the income that the SE invests, and $a^I \in \{a_{low}^I, a_{high}^I\}$. Upon observing a_{high}^I, it is more likely to see this among high E-types than among low E-types. Furthermore, $\rho^{E_o} = 0.5$, $p\left(a_{high}^I | SE_{G_\theta,E_H}\right) = 0.9$ and $p\left(a_{high}^I | SE_{G_\theta,E_L}\right) = 0.2$. Upon observing a_{high}^I, the participants update their prior beliefs according to:

$$\rho\left(E_H | a_{high}^I\right) = \frac{0.9 \cdot 0.5}{0.9 \cdot 0.5 + 0.2 \cdot 0.5} = 0.82 \qquad (6)$$

Given the priors, it is equally likely that the SE is of a low E-type or of a high E-type. Upon observing the action $a^I = a_{high}^I$, it is much more likely that this action is produced by a high E-type than a low E-type, and if yes is observed, the group members will update their prior probability according to a posterior belief of 0.82. One reason why beliefs are not equal to 1 is that it is not completely unlikely that the SE has so high preferences for the green component that he/she would

be willing to sacrifice a considerable personal income for the sake of a project that will not generate high private benefit.

We can imagine various verification technologies (signaling devices), which a (high-performing) SE may employ to convince the group members that the project is a good investment. We focus here on cases where the SE, through certain actions, can increase the probability that he/she is a high-performing type of SE.

Such actions (signals) can be grouped as follows:

1) Signaling high performance by first moving and making a "real" costly investment in the project: willingness to engage (invest) in the project.
2) Signaling by providing convincing (trustworthy) information about costs and benefits, for example through reliable external expert information.

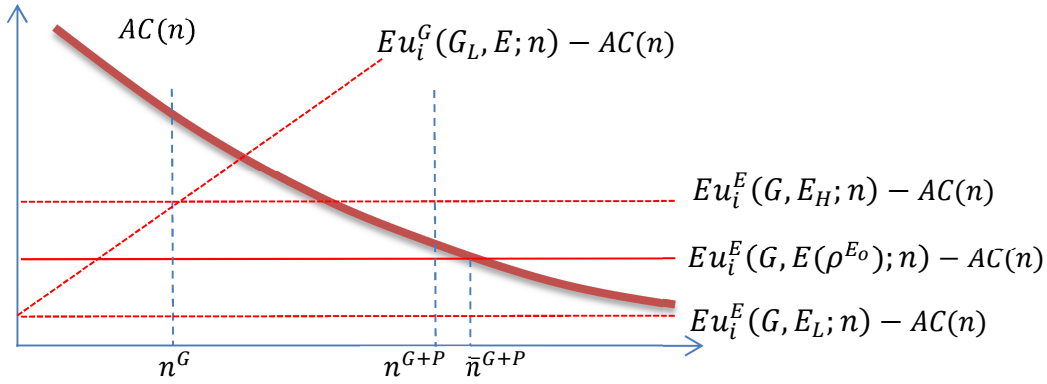
Note that an SE who talks a lot, but rarely acts and who provides limited documentation, will not be perceived as trustworthy and will not be able to convince people to engage in the project.

Now it is possible to combine the signaling approach with the model from section three. We will look at three situations: 1) a situation where the SE needs to signal a high economic performance to implement the project, 2) a situation where the SE needs to signal high green potential to get the project implemented, and finally, 3) a situation that combines the previous two, that is, where the SE needs to signal high performance in both domains to implement the project.

The first situation is structured as follows: Consider that an L-type SE represents version one (that is, the SE cannot for the given number of potential participants provide a project that satisfies PCE). However, an H-type SE represents version two. Moreover, prior beliefs support version one. This is a situation where $Eu_i^E(G, E_H; n) > 0$, where $Eu_i^E(G, E_L; n) < 0$, but where $Eu_i^E(G, E(\rho^{E_o}); n) < 0$ for n^{G+P}. This is illustrated in Figure 6. Prior belief for E_H is so low that no project is created, whereas prior belief for ρ^{G_o} is so high that if the E-types choose to participate, the G-types will joint them.

Note first the possibility of ncreasing α and increasing beliefs of being a high E-type. Here an SE who can increase α sufficiently, but not alter prior beliefs can be successful, as can an SE who cannot increase α, but who can instead increase the probability sufficiently.

Figure 6: *The mechanism for successfully signaling a skilled E-type.*



Here $Eu_i^E(G, E(\rho^{E_o}); n)$ is the expected utility for the E-type given prior beliefs.

However, in any case the increase in beliefs will help the SE implement the project. For $\alpha = 0$, in this case, an SE needs to be able to increase the group's belief that he/she is an $SE_{\theta_{G,H}}$ type. Define $\bar{\rho}^E = \arg\{AR(n^{G+E}) = AC(n^{G+E})\}$ as the threshold value of the probability that the SE is of a high E-type such that the value is high enough to ensure that the project will be produced.

From the updated formula, and letting $p^E(\boldsymbol{a})$ be the posterior belief that the SE in a high E-type after observing signals $\boldsymbol{a}$, **t**he ability of the high-skilled SE to change the beliefs sufficiently such that $p^E(\boldsymbol{a}) > \bar{\rho}^E$, is easier:

1) The more effective the signaling device (measured by $p(a_i|SE_{\theta_{G,H}})/p(a_i|SE_{\theta_{G,L}})$).
2) The smaller needed change in probability (measured by $\bar{\rho}^E - \rho^{E_o}$).
3) The larger the number of possible signaling devices.

As noted above, if $\alpha > 0$ the SE needs to do less in terms of signaling to change the PCE into a positive one.

Now consider a case where ρ^{E_o} entails that the project will be initiated if only the G-types choose to participate. However, the G-types will not participate for ρ^{G_o}, but they will if $1 > \rho^G(\boldsymbol{a}) \geq \bar{\rho}^G > \rho^{G_o}$. Here, $\bar{\rho}^G$ is defined in the same way as $\bar{\rho}^E$.

Compared to the above case, the SE can now only hope to implement the project if he/she can increase the probability that he/she is a green H-type SE. In this case the task of a truly high green SE is to signal his/her true type and thus increase $\rho^G(\boldsymbol{a}) \geq \bar{\rho}^G$. This could, for example, be done by initiating a small production that produces green energy or is truly organic.

As before, the more effective the signal, the larger the number of signals available, and/or the smaller the needed increase in probability, the more likely it is that the high G-type will succeed.

In the final case, ρ^{G_o} and ρ^{E_o} entail that unless posterior beliefs are sufficiently increased for both dimensions, the project will not be initiated. In this case the SE needs to signal a high type in both the G and E dimensions, that is combining the signaling proposals from the two cases above – $\rho^G(\boldsymbol{a}) \geq \bar{\rho}^G$ and $\rho^E(\boldsymbol{a}) \geq \bar{\rho}^E$. In this case only a truly multiskilled SE (representing a high E and G type) can implement this type of project. Note for this case one important complication, where a signal increasing belief in one dimension reduces belief in another dimension. That is, signaling high green performance might, for example, reduce beliefs that high economic performance is also feasible.

5. Conclusion

Motivated by the puzzle of the renewable energy island of Samsø, the main research question was how a sustainability entrepreneur (SE) can facilitate a transition from brown to green energy. Our theoretical model suggested that the SE could posses four skills, namely 1) the ability to make a project both profitable and sufficiently sustainable; 2) communication and coordination skills; 3) the ability to convince non-green actors of the value of the green component; and 4) trustworthiness, i.e., trust that the SE carries reliable information. We then demonstrated how different versions of the model needed two or more of the four skills for the project to be realized.

In the case of Samsø Søren Hermansen acted as a multiskilled SE who used three of the four skills outlined. First, he convinced the local people about the profitability and sustainability of the project (skill 1). Second, he acted as a communicator and coordinator of the green energy project (skill 2). Third, he failed to convince non-green actors of the value of the green component (skill 3). Fourth, he built a good reputation by investing in the project and was known among the locals as a reliable and trustworthy person (skill 4). Thus, three of the four skills were used by the SE – and this was sufficient for realizing the project. Overall, the main result of our theoretical model can help explain the success of entrepreneurs such as Hermansen. In perspective, the theory and the case show that the crucial element is the ability of the SE to convince non-green people that the project is "more profitable than green".

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References

Brandt, U.S., Svendsen, G.T., 2013. Is local participation always optimal for sustainable action? The costs of consensus-building in Local Agenda 21. J. Environ. Manage. 129, 266–273.

DAC, 2013. Samsoe: A role model in self-sufficiency. http://www.dac.dk/en/dac-cities/sustainable-cities/all-cases/energy/samsoe-a-role-model-in-self-sufficiency/?bbredirect=true/ (Access date 16-09-15).

Energychange, 2013. Case Study 18: Samsø - renewable energy island. Commission of European Union, Brussels. http://www.energychange.info/casestudies/175-samso-renewable-energy-island/ (Access date 16-09-15).

Finger, M., 1994. From knowledge to action? Exploring the relationships between environmental experiences, learning, and behavior. J. Soc. Issues. 50, 141–160.

Guevara-Stone, L., 2013. Introducing Samsø: A 100% wind-powered island. http://cleantechnica.com/2013/10/29/introducing-samso-100-wind-powered-island/ (Access date 16-09-15).

Hall, J.K., Daneke, G.A., Lenox, M.J., 2009. Sustainable development and entrepreneurship: Past contribution and future directions. J. Bus. Venturing. 25, 439-448.

Höges, C.**,** 2009. An ecotopia for climate protection: Samso iosland is face of danish green **r**evolution. Spiegel Online October 22, 2009, http://www.spiegel.de/international/europe/an-ecotopia-for-climate-protection-samso-island-is-face-of-danish-green-revolution-a-656325.html/ (Access date: 16-09-15).

Jakobsen, I., 2010. The road to renewables: A case study of wind energy, local ownership and social acceptance at Samsø. https://www.duo.uio.no/handle/10852/17867/ (Access date: 16-09-15).

James, R., 2010. Promoting sustainable actions: A guide to successful communication. http://sustainability.berkeley.edu/sites/default/files/Promoting_Sustain_Behavior_Primer.pdf/ (Access date: 16-09-2015)

Kraemer S.M., Mosler, H.-J., 2010. Persuasion factors influencing the decision to use sustainable household water treatment. Int. J. Environ. Heal. R. 20, 61-79.

Perman, R., Ma, Y., McGilvray, J., Common, M., 2011. Natural Resources and Environmental Economics, fourth ed. Pearson, London.

Sandler, T., 1997. Global Challenges: An Approach to Environment, Political, and Economic Problems, Cambridge. Cambridge University Press, Cambridge.

Sustaineship, 2012. Sustainability & Environment. http://sustaineship.sts.rpi.edu/ (Access date 16-09-15).

UN, 2011. Objective & themes, Rio+20 - United Nations Conference on Sustainable Development. http://rio20.ch/en/about-rio-20/objectives-and-themes/ (Access date: 16-09-15).

UN, 2012a. Green economy in the context of sustainable development and poverty eradication. Rio+20 - United Nations Conference on Sustainable Development. http://www.uncsd2012.org/greeneconomy.html/ (Access date: 16-09-15).

UN, 2012b. The transition to a green economy: Benefits, challenges and risks form a sustainable development perspective. http://www.unep.org/greeneconomy/Portals/88/documents/research_products/UN-DESA,%20UNCTAD%20Transition%20GE.pdf / (Access date 16-09-15).