Upscaling of integrally sustainable animal production systems: The dynamic of anchoring processes

Boelie Elzen[1], Bram Bos[2], Bart Bremmer[3] and Barbara van Mierlo[4]

[1] *University of Twente, Enschede, the Netherlands. b.elzen@utwente.nl*

[2] *Wageningen UR Livestock Research, the Netherlands.*

[3] *Self-employed innovation sociologist, Renkum, the Netherlands.*

[4] *Wageningen University Research, Knowledge, Technology and Innovation, the Netherlands.*

Keywords: anchoring, niche-regime interaction, system Innovation, sustainable agriculture, animal production, reflexive interactive design

Abstract

This paper analyses the combination of a method to design new sustainable animal husbandry systems by the name of RIO with efforts to stimulate the uptake of these new designs in practice. Over the past 15 years, this approach has been applied in a variety of animal production sectors in the Netherlands, two of which will be analysed here, one for broilers (chickens for meat) and one for pigs. To analyse the uptake process we build on the concept of anchoring that describes how a novelty becomes newly connected, connected in a new way, or connected more firmly to a niche or a regime. In the literature, three forms of anchoring are distinguished, notably technological, network and institutional anchoring. In this paper we seek to develop this general conceptualisation further to understand the dynamics of anchoring processes. On the basis of the cases analysed we conclude that to make technological anchoring more robust, a process takes place that we have called the 'specification of technology'. Furthermore, we distinguish two patterns in institutional anchoring, one in which the technology adapts to existing institutions and one in which new institutions are adapted to fit the developing novelty. This latter process seems to be key in transition processes to develop 'integrally sustainable' solutions.

1. Introduction

In traditional innovation studies, the issue of *upscaling* (which is the central topic at this workshop of the 2016 IFSA symposium) is conceptualised as the 'diffusion of innovations' (Rogers 1962). More recent work on transitions has shown, however, that innovation is a much more complex process, especially when looking at 'radical' innovations or 'system innovations' (Geels 2002, 2004, Elzen and Wieczorek 2006). The widely used multi-level perspective (MLP; Geels 2002) sees innovation as the interplay between the three levels of niches, regimes and landscapes. A regime denotes an existing socio-technical system which may be under external pressure from a socio-technical landscape to change. Thus, the agricultural regime is under large landscape pressure to become more sustainable. The reaction of regime to such pressures typically is to transform via a path of incremental innovation.

Next to that, various actors may be tinkering with radical alternatives in 'technological niches'. In a niche, these alternatives (novelties) are protected from market forces via a variety of protection mechanisms and the niches thus provide a space for the actors involved to develop the novelty further and learn about how to make it work in practice. A novelty not only concerns technical aspects, but also social aspects like how it is to be used, a network of actors to sustain it, etc.

One key issue in transition studies is how niches can link up to regimes and start a process that may lead to a transformation of the regime (Smith 2007). This linking is a first key step in a process of upscaling. In this paper we will address this linking issue by building on the concept of 'anchoring'. We will apply this to two cases from the RIO projects that the authors have been involved in over the past decade. The next chapter will describe the general RIO approach and the anchoring concept. Subsequently we describe the two cases and end with some conclusions.

2. Reflexive Interactive Design and Anchoring

Around the year 2000, Wageningen UR Livestock Research (WLR),[1] was assigned the task to tackle the sustainability challenges associated with large scale animal production in the Netherlands. This led to the development of the RIO approach, a Dutch acronym for "Reflexive Interactive Design." The authors of this paper have applied this approach in several projects targeting various animal sectors and developed it further, taking into account what was learned in previous applications

Details of the RIO approach have been described elsewhere (Bos et al., 2011, Bos and Groot Koerkamp, 2009, Bos et al., 2009). Here we only describe its main features. RIO starts with a design phase that builds on the approach of *Structured Design* (Cross, 2008, Siers, 2004, Van den Kroonenberg and Siers, 1998), in an interactive fashion. The design groups consisted of various types of agricultural stakeholders (including farmers, farming equipment suppliers, policy representatives, NGOs) to ensure the incorporation of practical and tacit knowledge, and prevent a research bias with respect to the values underlying the design.

To study the uptake of the results from the RIO design sessions, we build on the concept of anchoring, which was developed in the context of system innovation programmes (Loeber 2003, Grin & Van Staveren 2007). In a study of the uptake of radical energy novelties in glasshouse horticulture, the concept was defined more specifically as follows:

> "Anchoring is the process in which a novelty becomes newly connected, connected in a new way, or connected more firmly to a niche or a regime. The further the process of anchoring progresses, meaning that more new connections supporting the novelty develop, the larger the chances are that anchoring will eventually develop into durable links." (Elzen et al., 2012a, p.3)

Building on a distinction between three constituent components of a regime, notably technical, network and institutional components (Geels, 2004), the authors distinguish three forms of anchoring. These are technological anchoring, network anchoring and institutional anchoring (Elzen et al., 2012a, p.4-6). *Technological anchoring* takes place when the technical characteristics of a novelty (e.g. new technical concepts) become defined by the actors involved and, hence, become more specific to them. *Network anchoring* means that the network of actors that support the novelty changes, e.g. by enrolling new producers, users or developers. *Institutional anchoring* relates to the institutional characteristics of the novelty, i.e. the new rules that govern its further development and uptake. Institutional anchoring implies that developments within a niche or regime become translated into adapted or new rules that govern, at least temporarily, the activities of both niche and regime actors.

Elzen et al. (2012a) have described anchoring in rather general terms, providing evidence that the distinction of three forms of anchoring can help to understand how novelties are picked up in niches and regimes and can start a transformation process. The next step is to analyse in further detail how the dynamic of anchoring progresses. In this paper, we will analyse how the results of two RIO projects, one on broilers (chickens for meat) and one on pigs, were taken up and what we can learn from these on the dynamics of anchoring processes.

Concerning the research methodology, all authors have been involved to some extent in the projects described. Most of the empirical material is based on our own presence in various meetings and interactions with relevant actors. A secondary analysis of this material allowed us to give a detailed account of the anchoring of the core radical concepts in the two RIO cases. We

[1] In 2000, WLR had a different name (ID Lelystad) but for simplicity reasons we use the name WLR for the whole period.

use them in this paper (1) to illustrate and refine the concept of three forms of anchoring; (2) to show the dynamic of these forms of anchoring; (3) to answer the question whether we can deliberately anticipate and stimulate anchoring.

3. Windstreek case

3.1 Introduction

The formal origin of the Windstreek henhouse can be traced back to a government funded RIO project that started in 2009. Farmer Robert Nijkamp (together with two other farmers) became involved in the second half of 2010, during the first round of interactive design sessions.

One of the authors of this paper (Bram Bos) was involved as project leader in 2010, and played an active role in the follow-up of the *Broilers with Taste*-project, after its end in 2011 (Janssen et al., 2011). The follow-up was spurred by a special policy instrument (*Small Business Innovation Research* or SBIR) used to elicit societally desired innovations from private enterprise by means of a tender, in which competition is firstly based on quality and business prospects, and only secondarily on price. Eventually, a consortium of five private parties around the concept of *Windstreek* was the big winner of the SBIR-tender "Sustainable barns in the landscape" that ran from 2011-2015. Helped by the considerable amount of financial support from SBIR (about 500k€), the consortium was able to further develop and establish the first pilot barn of Windstreek, at the farm of Nijkamp.

The consortium consisted of a poultry slaughterhouse (Interchicken), a climate technology firm (Sommen), a landscape architectural bureau (Vista), farmer Nijkamp himself and Wageningen UR Livestock Research. Engineering MSc-student Hendrik Kemp was firmly associated. Later, Interchicken was substituted by the largest Dutch slaughterhouse Plukon after a takeover, while Vista was replaced by the bureau Circular Landscapes.

This led to the development of Windstreek, opened late 2015, a henhouse very unlike the traditional ones in the Netherlands. Its iconic, asymmetrical form (cf. figure 1) is noticed from almost a kilometre away. Its 11 meter high transparent front on the north side can be opened across the full 95 meter of its length, both in the upper as well as the lower 2 meters. As a result, the animals live by the natural rhythm of day and night. The air inside is refreshed by natural ventilation. The very young chickens (that enter the barn as one-day old chickens or as eggs) are kept warm in a special isolated 'mini-barn' - the brooding hood - that captures their own warmth and can be heated additionally by PV powered infrared panels. The higher parts of Windstreek are used as living space, both on the ground, as well as on long stretching tables that can be reached via straw bales. Special mats under the brooding hoods can be used to remove the litter (with manure) from the barn, to prevent the emission of ammonia and fine dust. Trees on the outside, facing the high open front, capture part of the remaining fine dust before it is emitted to the environment. As a result, the Windstreek housing system is claimed to be very animal friendly, to have a very low energy consumption that can be renewably supplied by solar panels, to have low emissions, while the working environment is more healthy than in regular systems.

As the system differs in so many respects from traditional housing systems, and is under a much bigger influence from weather conditions, testing of these and other claims will take at least a year. The economic prospects of the system, and thus its ability to scale up to a larger number of barns without subsidies, still have to be established.

Figure 1 presents a timeline of the history of Windstreek since the start of Broilers with Taste in 2009. Below the timeline, the visual and technical evolution of three central concepts are depicted, notably the barn system as a whole, the concept of the brooding hood and the concept of regular litter removal.

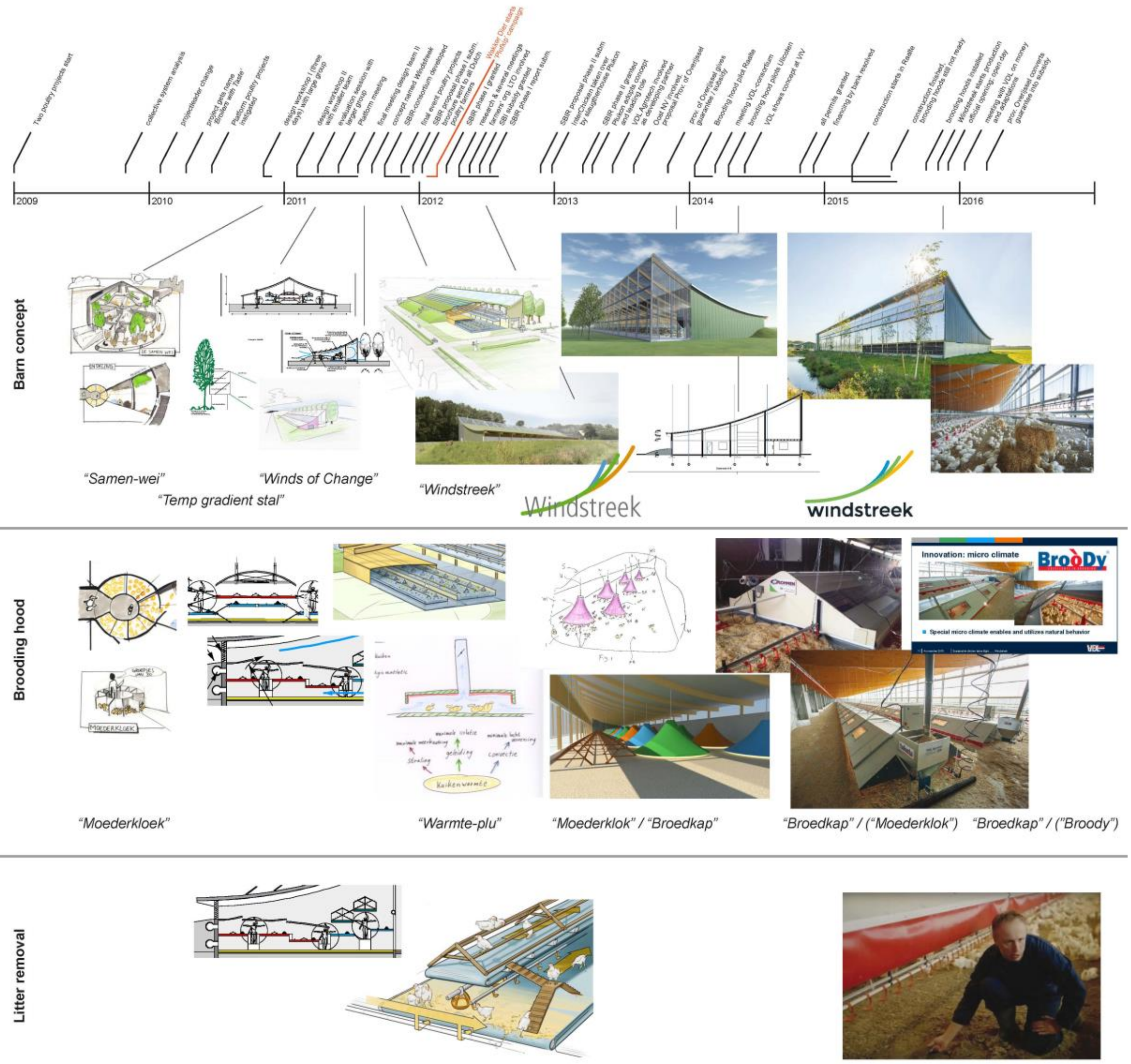

Fig.1: Timeline of Windstreek development for the overall concept and two 'partial innovations'

3.2 Anchoring of the Windstreek concept as a whole

As can be seen from figure 1 (Barn concept), these features were already present in one of the designs (de 'Samen-wei') from the first interactive design session. During the second, extended design round, these ideas got different shapes, but were maintained as core elements. Added were the use of the third dimension to enlarge the living area and the radical 'halving' of the architectural form and curving the remaining slope. This curved slope was originally conceived as (technically) functional to natural ventilation, but appeared not to be critical to achieve this. But it was kept, even though it increased building costs, to become part of the Windstreek 'logo', and it was registered by the consortium as a trademark together with the name itself. Thus, although the technical reasons for the curved slope weakened, it became firmly anchored in the network for aesthetical reasons. This was the distinctive feature that made immediately clear to an outsider that this broiler barn was very different from any other in the country.

Landscape quality was an important provision under the SBIR-tender and a landscape architecture firm (Vista) developed the initial shape of a 'barn' into a concept that moulded with the landscape. This helped the local government to bypass institutional barriers (building aesthetics regulations) that initially prohibited both height and form of Windstreek. These and other distinctive features helped to get Windstreek through the local and regional regulative systems. Early visuals by Vista from 2012 were not only used in the SBIR tender phase II, but also in an NGO publication on sustainable food.

The application of natural ventilation throughout the system became technologically anchored in the existing network via the involvement of a climate systems enterprise (by the name of Sommen), with whom Nijkamp had worked before. Contrary to many similar firms, their specific business model turned out to fit working with natural ventilation, since Sommen did not primarily depend on the sales of mechanical ventilation systems, but on the sales of computer systems and software for climate regulation in livestock production. Part of the SBIR-grant was used by Sommen to completely redesign its climate software.

3.3 Anchoring of the Brooding hood

Enlarging the living space for broilers as they grow older was originally meant to decrease costs. This was combined with the concept of a ‘mini-barn’ to save energy and create a special climate for very young broiler chickens, as well as brooded eggs. Important institutional barriers were Dutch and EU-regulations that prohibited limiting the space per chicken, even very small ones. Thus, the 2011 Windstreek-concept, that featured a smaller inner barn for young chickens, faced an important hurdle that was unlikely to change.[2] It was one of the reasons that the concept of a mini-barn morphed into the brooding hood.

Regular broiler chickens live for approximately 42 days, while slower growing varieties in more animal-friendly market-concepts live two weeks longer. In the first two weeks of their life, broiler chickens cannot maintain their own body temperature. For this reason, traditional barns are heated these weeks to a temperature of about 32-38 degrees Celcius, which consumes much (fossil) energy in the Dutch climate. The mini-barn in the original Windstreek design of 2011 was intended to solve this, by reducing the volume to be heated.

In the first phase of SBIR tender (spring 2012), the technical people from the Windstreek consortium developed an alternative to this mini-barn: they calculated that the warmth emitted by a large group of very young broiler chickens might be enough to keep an insulated enclosure warm, provided ventilation is reduced a minimum. The concept was called “warmte-plu” (heat umbrella) and was developed further into a churchbell shaped device. On the basis of this it was renamed ‘moederklok’ (mother bell), a word play with ‘moederkloek’ (a broody hen in Dutch) and its churchbell form (‘klok’ in Dutch). Later it was renamed ‘brooding hood’. In a subsequent visualization by Vista, the whole Windstreek barn was equipped with over sixty bells with different bright colours, each to be used by about 500 young chickens. Since these brooding hoods hover 10-20 cm above the floor, the young chickens can move freely throughout the whole barn, thus circumventing EU and Dutch regulations. But chickens are likely to stay underneath the warm hoods most of the time because it fits their thermal requirements and natural behaviour.

Shortly after the consortium won the second phase of the SBIR tender,[3] climate systems firm Sommen got in touch with VDL Agrotech, an industrial supplier of agricultural equipment, and part of one of the largest Dutch industrial conglomerates (VDL). Sommen saw a chance to enroll a partner that could develop and mass produce the brooding hood, a vital part of Windstreek, that would be needed in considerable numbers. Furthermore, the director of Sommen saw an important general business opportunity to collaborate with VDL Agrotech.

[2] Parallel to the first phase of the SBIR-tender, project leader BB was involved in a similar case of a farmer who invented an inflatable wall to decrease the volume of his traditional barn in the first weeks of a round to save on energy. This farmer approached BB after the publication of the brochure of *Broilers with Taste* that was sent to all poultry meat farmers in the Netherlands. After some backing and forthing with, among others, the Dutch Animal Protection Society (Dierenbescherming), it became clear that there was no short term sight on institutional changes, that forbid this temporary decrease in living surface, despite the fact that there was evidently no animal welfare issue *per se*.

[3] The first phase is a feasibility study; the second phase a pilot, proof of concept or full scale implementation, aiming to show the commercial relevance.

The new partner was reluctantly welcomed by the consortium. Initial contacts suggested a lukewarm and sceptical reception of the brooding hood concept by VDL. Especially the non-manufacturing partners in the consortium (Nijkamp, WLR, Vista) feared that a distinctive feature of Windstreek, with the most commercial potential, would be gradually appropriated by an outside partner and sold to anyone, as the brooding hood would also be applicable in standard broiler barns. Without exclusivity, the upscaling potential of the Windstreek concept as a whole might be in danger. Partners Plukon and Sommen, however, stressed the inevitability: the consortium would not be able to develop the brooding hood by itself, and more importantly, lacked the capabilities needed to produce them in large numbers at an affordable price.

Sommen and VDL started a series of small scale pilot experiments with the brooding hood. First in Nijkamp's open cow barn during winter, later in a covered alley way between two poultry barns of a farmer near Sommen headquarters in Ulicoten. These pilots involved a few hundred chickens and hand-made constructions of metal and plastic. Both mechanical and natural ventilation were tested. Heating was supplied by a warm water heating device.

After a few months of experimenting, VDL Agrotech decided to prominently present the brooding hood, as well as Windstreek, at the VIV-fair 2014 in Utrecht, an annual fair for the global equipment industry for intensive livestock production. This again sparked the doubts of the non-manufacturing partners on concept ownership.

At this point in time, for ease of construction reasons, VDL played with the idea of connecting a number of brooding hoods to a large tunnel, but farmer Nijkamp objected to this. Furthermore, Sommen and VDL were about to conclude that, for control reasons, the brooding hood should be mechanically ventilated. Nijkamp opposed this vehemently, since he wanted a robust system that would be as independent as possible from fallible technology. Additionally, he wanted to experiment with infrared heating, instead of warm water heating, since this could be powered by solar panels which would save the costs of a separate gas connection to the new barn.

Infrared heating and natural ventilation were implemented reluctantly by Sommen and VDL in the subsequent pilot experiments. Both features reduced the controllability of the brooding hood with traditional sensors, and required new ways of thinking. As they proceeded, however, they became more and more convinced that these features were possible and an important characteristic of the brooding hood concept.

While the construction of the Windstreek barn commenced in March 2015, pilot experiments in Ulicoten were still under way. VDL had a contract with Nijkamp to deliver and install *sixty* brooding hoods in Windstreek. When the construction of Windstreek was almost finished, VDL told Nijkamp that, for construction reasons, the sixty brooding hoods would be fused into six large tunnel-like brooding hoods. Since Nijkamp planned to start production in July 2015, he had no option but agree. Production in Windstreek eventually started in November 2015.

3.4 Anchoring of the regular litter removal

The concept of regular litter removal (by means of belts) was a central idea from the start of the design process. Yet, the actual implementation in Windstreek has been half-hearted. An important reason seems is that it is a solution for a problem that is not perceived to be urgent by anyone except the researchers of WLR and the former project leader: the emission of fine dust. Since Windstreek is naturally ventilated with large volumes of air, fine dust is not seen as a problem inside the barn, nor in the rural surroundings of the village of Raalte. Additionally, some partners believe emissions will be low *because* of the slow air velocities associated with natural ventilation. On this basis, expensive dust reducing belts were replaced by cheap composting mats. Attempts to get a machine for removing and cleaning these mats failed because of high costs and lack of motivation from third-party enterprises to innovate on this. Thus, the network anchoring of this concept was limited to WLR people only and it never took off.

The risk, however, is that emissions of fine dust may be higher than desired. This will pose institutional obstacles (regulations on fine dust emissions) that limit the applicability of the

Windstreek concept elsewhere in the Netherlands. Moreover, since regular litter removal is also meant to limit the emission of ammonia, Windstreek also might not be able to comply with the regulations in this respect, especially if the barn were used with higher stocking densities.

4. Vair Varkenshuis case

In 2009, pig farmer Marijke Koenen joined a multi-day interactive design session that was part of WLR-led RIO project by the name of Porc Opportunities. She fattened pigs on an outdated pig farm in the south of the Netherlands and wanted to renew her business. But she did not want to proceed fattening pigs as she had done before as she was dissatisfied with the current production system and had been looking for alternatives for several years. Most important to her was to become an autonomous entrepreneur and disentangle from the straitjacket of production efficiency. She wanted to be proud of her farm again, and to be able to show the general public how she kept pigs without having to be afraid of disgust. As possible alternatives, she had looked into systems by the name of “ecological production” and “Canadian bedding”, but in her view these limited the autonomy of the farmer too much.

By joining Porc Opportunities, Koenen hoped to find an alternative that would satisfy her objectives. She took part in a design workshop in which the participants designed new pig production systems on the basis of requirements and functions that this production system should fulfil. By thinking in terms of requirements and functions, without directly jumping to solutions, the solution space was enlarged, so that problems in the current production system could be solved in new ways via radically different designs.

In Porc Opportunities there were several design sessions. In the first session only pig farmers and researchers participated. They worked together on three designs for radically new ways of keeping pigs. In the second design session, researchers only acted as facilitators. The actual design process was carried out by participating pig farmers, builders of housing systems, agricultural advisors and a municipal and a provincial policy maker. Another difference between the first and the second design session was that in the first session participants worked on generic designs, while the second design session put the needs of pig farmers in the centre of the design process. They designed their own potential future farm. To further stimulate the practice-orientation, the participants were informed of the possibility to participate in an SBIR tender with their new design to finance realization of their plans. Here the foundation was laid for “Vair Varkenshuis” (meaning Fair Pig Home).

One of the core elements of Vair Varkenshuis is the ‘pig toilet’, that uses the rather clean excretory behaviour of the pigs to improve animal welfare, reduce ammonia emissions and raise the quality of manure. Following the second design session, not only Koenen started working with it, also a national pig innovation centre, VIC-Sterksel, applied it in a pilot farm.

Her involvement in Porc Opportunities did not only provide Koenen with a draft design for her farm, but also with a small network of parties who were enthusiastic about various concepts that were embedded in the Vair Varkenshuis, and who were willing to join her in developing an SBIR proposal. She was joined by another pig farmer and three service suppliers/system builders.

On the basis of the promising results from the SBIR feasibility study, the consortium wrote a proposal for the second phase of SBIR (to build a pilot barn), which was granted. Supported by a 500k€ grant, a first pilot barn was built and several experiments were carried out. At the end of the SBIR trajectory this pilot barn was improved and expanded to finally form Vair Varkenshuis.

This was not a smooth process, however. Although all parties were eager to make it a success, they clearly had differing interests and objectives. Koenen’s ultimate aim was to create a new market concept for pork while the service suppliers/system builders were only interested in the technical aspects. This resulted in several discussions on what to put on the agenda and how to spend the SBIR grant. This resulted in a process of continuous negotiation within the network to specify the various technological details.

The SBIR grant was an important resource to make this process possible. The provisions of the grant determined to a considerable extent what could happen, in terms of content as well as in terms of the network. On content, SBIR specified that the concept should be integrally sustainable, i.e. combine several sustainability aspects. Furthermore, the concept should be scalable and have a good market perspective. On the network, SBIR provided specifications for the participating consortium. To be eligible, the consortium should at least consist of farmers and service suppliers/system builders. SBIR ensured a certain commitment and continuity by not only providing money, but also a 'project' infrastructure with outsiders monitoring the process and the outcomes. Without SBIR, the network would possibly split up at an earlier moment in time.

Thus, SBIR also offered a degree of robustness. For Koenen, this implied that the SBIR trajectory gained a rather technological focus. The system builders focused on perfecting the technical features and develop them in such a way, that pig farmers could implement them in their existing barn. Although this was not very successful in the end, it meant that there was very little attention for the marketing and communication aspects of Vair Varkenshuis. Thus, Koenen had to work on these aspects separate from the SBIR consortium and largely after the realization of the barn.

In terms of anchoring, due to the provisions of SBIR and the objectives of the majority of the consortium, there was a focus on technological anchoring. By contrast, institutional anchoring (economic, but also influencing and connect to world views/problem definitions of other farmers of consumers) received minimal attention.

To pay attention to these aspects as well, Koenen teamed up with a marketer, who supported her in building the story of Vair for the consumer. Furthermore, she involved product developers and advisors to work on the meat products and worked on developing sales channels. She first entered into dialogue with supermarkets, but when they refused to satisfy her requirements, i.e. give compensation for improved sustainable production, she turned towards a combination of house selling, internet marketing, market sales and other regional marketing solutions.

Although Koenen reached her goal - she created a radically different pig farm that provided her with autonomy and pride - anchoring to prelude upscaling is ongoing and continuing along two routes. Firstly, Koenen is constantly trying to find new ways to consolidate what she obtained and pursue new opportunities. She started her own crowdfunding initiative (*institutional and network anchoring*), continues to explore new sales channels (*institutional anchoring*) and tries to encourage colleague pig farmers farmers to adopt Vair Varkenshuis (*network, technological and institutional anchoring*). Secondly, other innovation trajectories have started: system builders try to sell the technology they developed in the SBIR trajectory, various farmers appear to be inspired by the technological features of Vair Varkenshuis, and various stakeholders see potential in the way product development and marketing of Vair is being shaped.

Concerning upscaling, several pig farmers built a variation of the farrowing pen from Vair Varkenshuis, and various pig farmers started to consider adopting the pig toilet or other elements of Vair Varkenshuis. This offers an interesting dilemma from the perspective of system innovation. Adoption of a sustainable farrowing pen, without changes in the rest of the production system, could make farmers satisfy important sustainability conditions posed by the market and public society. With this (relatively easy) modification they might realize more sustainable production circumstances, but at the same time they would restrain from a more radical shift towards sustainable pig production, as is realized in Vair Varkenshuis. This is different for the pig toilet that can be considered an integrally sustainable partial innovation, by offering advantages for animal welfare, reducing emissions of ammonia and odour, and improving manure quality.

5. Conclusion

In this paper we used the three forms of anchoring distinguished by Elzen et al. (2012a), i.e. technological anchoring, network anchoring and institutional anchoring. Our main interest is to shed more light on the dynamic of these anchoring processes as a stepping stone towards understanding the linking between niches and regimes (Smith 2007) or, in terms of the theme for this workshop, the upscaling of the application of novelties.

It appears that the various forms of anchoring do not neatly follow one another in a specific order but show a process of continuous leapfrogging. Moreover, two or three or these may be occurring at the same time and become visible depending on the perspective taken. For technological anchoring, the reasoning starts from the perspective of an actor or a network. Technological anchoring takes place when a radical concept (which can either be a rather abstract technological concept or a concrete material manifestation of a concept) takes on meaning as something they support (as user, maker, or outsider). When we reason from the perspective of the technology, however, network anchoring takes place, i.e. the network of actors for whom the technology becomes meaningful grows.

Does this mean, then, that all forms of anchoring are really describing the same process? This is certainly not the case if we acknowledge that technological anchoring is not just a quantitative phenomenon (i.e. more or less, or weaker or stronger technological anchoring) but also has qualitative characteristics. In both cases, technological anchoring started on the basis of a rather abstract concept of a novelty. Gradually, the concept became more specific without changes in the network (e.g. in a design meeting). We see this as an important characteristic of technological anchoring which we call the *specification of the technology*. It describes a process in which anchoring progresses by way of certain technological characteristics becoming seen as an essential aspect of the novelty while this specification is shared among the actors in the network.

Our cases suggest that this process of specification has the effect that anchoring becomes more robust. In our cases, both of which started as a design process, initial anchoring took place on the basis of rather abstract concepts. In this phase, the networks related to it frequently changed composition, showing that anchoring was not very robust. With the further specification of the technology, however, for the actors that remained part of the network their links with the more specific technology appeared to be stronger than with the initial more abstract concept. This process is clearly recognizable in connection with the “brooding hood” but also with the “pig toilet”.

Concerning institutional anchoring, the cases show two opposing processes. One is that the technology was modified to fit existing institutions. When the ‘mini barn’ appeared not to fit national and EU regulations, this concept was modified to eventually become the “brooding hood” that allowed to ‘bypass’ these regulations. The alternative process was that existing institutions are modified or ‘bent’ to fit the new technology. An example is the bypass of local building aesthetics regulations to allow the construction of the curved shape of the Windstreek. Other examples can be found in the cases for each of these two processes.

From the very beginning, the RIO projects had the ambition to radically change the current animal husbandry system in the Netherlands, i.e. to contribute to a system innovation or a sustainability transition. In both cases, this was quite successful at the local scale, i.e. the development of a first production farm with far better sustainability performance on a range of issues. Whether this marks the beginning of a wider change of the sector, however, remains to be seen.

One striking phenomenon in both cases is that there were repetitive attempts to downgrade the ambition to better fit the existing system, i.e. to realise institutional anchoring by adapting the technology to existing institutions. Even if these were not successful eventually for the pilot barns, they may well be successful in the terms of the uptake of various ‘partial innovations’ in conventional husbandry systems. The interest in doing so is already emerging in connection with the “brooding hood” and the “pig toilet”. This would increase the sustainability performance of such conventional systems somewhat but the ‘integrally sustainable’ ambition from the initial RIO project would be lost.

This raises the question of how such a high ambition can be upheld against the forces to downgrade the ambition. Key to this is to understand in further detail the issue raised before, i.e. how institutional anchoring is shaped: by adapting technology to the existing institutions or by adapting the existing institutions to the emerging technology. To answer that question is beyond the scope of the present paper and will have to be the topic of further research.

References

Bos, A. P. & Groot Koerkamp, P. W. G., 2009. Synthesizing needs in system innovation through methodical design. A methodical outline on the role of needs in Reflexive Interactive Design (RIO). In: Poppe, K. J., Termeer, C. & Slingerland, M. (eds.) Transitions towards sustainable agriculture, food chains and peri-urban areas.Wageningen: Wageningen Academic Publishers.

Bos, A. P., Groot Koerkamp, P. W. G., Gosselink, J. M. J. & Bokma, S. J., 2009. Reflexive Interactive Design and its application in a project on sustainable dairy husbandry systems. Outlook on Agriculture, 38, 137-145.

Bos, A. P., Spoelstra, S. F., Groot Koerkamp, P. W. G., De Greef, K. H. & Van Eijk, O. N. M., 2011. Reflexive design for sustainable animal husbandry: mediating between niche and regime. In: Spaargaren, G., Loeber, A. & Oosterveer, P. (eds.) A transition perspective on sustainable food and agriculture. London: Routledge.

Cross, N. 2008. Engineering Design Methods - Strategies for Product Design. Fourth Edition, Hoboken, NJ, Wiley.

Elzen, B., Leeuwis, C. and Van Mierlo, B. C., 2012a. Anchoring of innovations: Assessing Dutch efforts to harvest energy from glasshouses. *Environmental Innovation and Societal Transitions*, 5, 1-18.

Elzen, Boelie, Barbier, Marc, Cerf, Marianne and Grin, John, 2012b. Stimulating transitions towards sustainable farming systems. In Darnhofer, Ika, Gibbon, David and Dedieu, Benoit (eds.). *Farming Systems Research into the 21st century: The new dynamic.* Dordrecht: Springer.

Elzen, Boelie and Wieczorek, Anna, 2005. Transitions towards sustainability through system innovation. *Technological Forecasting and Social Change*, 72, 651-661.

Geels, F. W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31, 1257-1274.

Geels, F. W. 2004. From sectoral systems of innovation to socio-technical systems; Insight about dynamics and change form sociology and institutional theory. *Research Policy*, 33, 897-920.

Grin, J., van Staveren, A., 2007. Werken aan Systeeminnovaties (Working on System Innovations). Van Gorcum, Assen.

Janssen, A. P. H. M., Nijkamp, R., Van Geloof, E., Van Ruth, J., Kemp, H. & Bos, A. P. 2011. Broilers with Taste - Sustainable chicken takes flight, Wageningen and Lelystad, Wageningen UR.

Loeber, A., 2003. Inbreken in het gangbare: Transitiemanagement in de praktijk – De NIDO benadering (Breaking in into the Usual: Transition Management in Practice – The NIDO Approach). NIDO, Leeuwarden.

Rogers, Everett M. (1962) Diffusion of Innovations, Glencoe: Free Press.

Siers, F. J., 2004. *Methodisch ontwerpen volgens H.H. van den Kroonenberg* (*Structured Design according H.H. van den Kroonenberg*). Amsterdam: Wolters-Noordhoff.

Smith, A., 2007. Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis and Strategic Management*, 19, 427-450.

Van den Kroonenberg, H. H. & Siers, F. J. 1998. *Methodisch Ontwerpen (Structured Design).* Groningen: Noordhoff Uitgevers B.V.