

# ***Design, incubation and realization of the Roundel egg production system in the Netherlands as an example of sustainable development of complex agricultural systems***

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## **Abstract**

This paper tells the story of the design 2004 of two innovative design concepts in 2004 for the production of table eggs, the initiatives and activities in the subsequent period of incubation, and the final realization in practice of three Roundel houses in the Netherlands. The case shows how an interactive redesign process facilitated the successful realization of a radically new housing system for laying hens, in which fulfilment of the needs of the laying hen, the farmer and citizen/consumer was realized in an integrated way.

*Additional keywords:*

laying hens, sustainable development, new husbandry concepts, reflexive interactive design (RIO), societal concern, structured design method

## **Introduction**

The story told in this paper started in 2003 and tells in a chronologic order the process from design to realisation in practice in 2010. Table egg production in the European Union (EU-15) totalled 93 billion in 2002, which exceeded consumption by 3% (Anon., 2004). Table egg production in the Netherlands in that year was 9.5 billion, of which 32% was sold domestically. The Dutch table eggs were produced in four production systems: conventional cages (66%), barn systems, either multi-tiered aviary (7%) or single tiered floor systems (27%), free range systems which combine a barn system with an outdoor run, and organic production systems (2%) (Tacken *et al.*, 2003). The dynamics in the distribution of hens over the various systems since 1950 are shown in Figure 1. The EU market distinguishes four categories of table eggs: category 0 (organic – with outdoor access), category 1 (free range –with outdoor access), category 2 (multi-tiered and single floor systems - indoor), and category 3 (cages, conventional or furnished cages) (EEC regulation 1907/90).

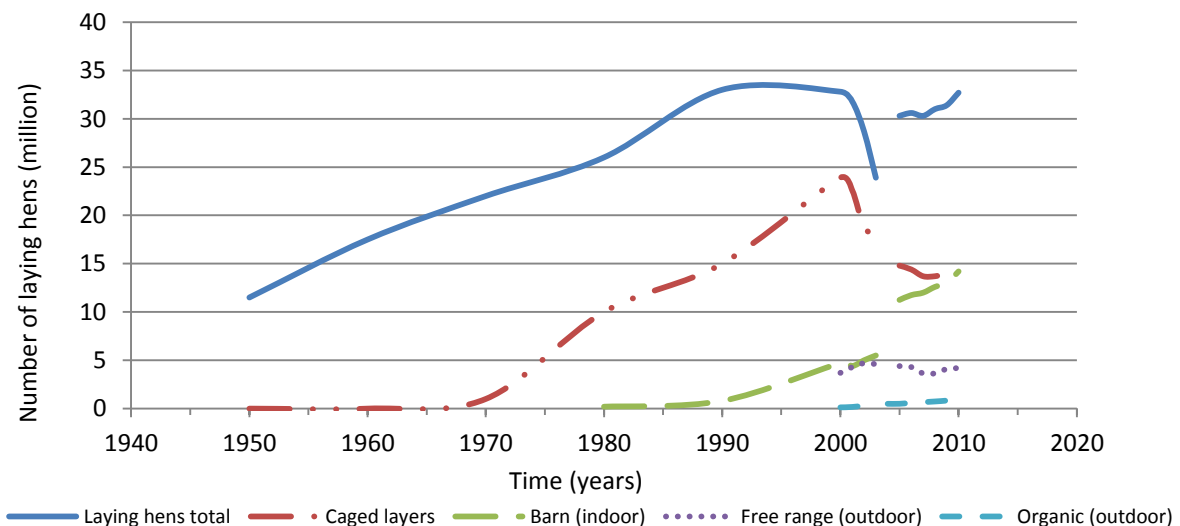


Figure 1. Number of hens per type of husbandry system in the Netherlands since 2000. In the year 2003 an outbreak of Avian Influenza occurred leading to a fall in number of hens. Free range and organic systems have an outdoor run for the hens (PVE, 2007; Loefs & Methorst, 2006).

The production of table eggs in the Netherlands as well as in the EU-15 as a whole was confronted with pressure (tension) from outside which forced the sector to changes: (1) an intense public and political debate about the poor welfare of caged hens, that resulted in an EU ban on conventional cages to become effective from 2012 (EU Directive 1999/74), (2) the lack of public and political acceptance of furnished cages (e.g. Windhorst, 2006), and (3) an outbreak of Avian Influenza, its effects on human health and the subsequent culling of millions of birds (Koch & Elbers, 2006).

These and other societal points of criticism directed to a change of the egg production sector towards more sustainable production systems, viz. systems that are environmentally friendly, economically feasible and socially acceptable (Mollenhorst, 2005; Binnekamp & Ingenbleek, 2006; Balkenende *et al.*, 2007).

In the period 2003–2005, the distribution of hens in various production systems in the Netherlands changed in the wake of the Avian Influenza outbreak and the shortage of eggs from barn and free range systems on the German market (Figure 1). Nevertheless it was expected that the non-cage systems in use were not viable alternatives for the battery cages on the larger farms that still housed some 40% of the Dutch laying hens. The single- and multi-tiered production systems, with or without an outdoor run, had and still have their own specific problems and negative side-effects for laying hens as well as for farmers, consumers and society related to free ranging, including (1) parasites (e.g. worms), (2) risk on Avian Influenza (Meuwissen *et al.*, 2006), (3) higher production costs (labour, housing, feed; Vermeij & Horne, 2006; Vermeij, 2007), (4) food safety risks (*Salmonella*, *Campylobacter* and dioxins; Vries *et al.*, 2006) and (5) environmental issues (higher emissions of ammonia, odour nuisance, nitrate leaching to the groundwater, fine dust; Aarnink *et al.*, 2006). However, good use of an outdoor run by hens reduces the risks of feather

pecking and cannibalism, thus improving animal welfare (Knierim, 2006; Hegelund *et al.*, 2006; Mol *et al.*, 2006). The foreseen legislation in the Netherlands to ban beak trimming (Anon., 1996) would increase the risks of feather pecking and cannibalism in none-cage systems, with a major impact on animal welfare and possibly increased public concern. Furthermore, the discussion on the desirability of furnished cages hampered the introduction of these systems.

As a partial response to the tension between sector and society a research project named *keeping and loving hens (Houden van Hennen in Dutch)* was commissioned by the government in 2003 aiming to initiate and stimulate a sustainable development of the laying hen industry, especially the production of table eggs. Three elements were considered crucial. First of all, the approach of the project had to express the new role of the Dutch government in the development of a sustainable agriculture. Sustainability was to be achieved not by means of new national legislation (retreat of government), but through agreements and support of self-responsible actors that take initiative and responsibility themselves to regain their licence-to-produce, in co-operation with other non-governmental organizations (in line with governance literature, e.g. Rhodes, 1997). Secondly, the project had to take benefit from progress made in innovation studies on the interactive formulation of long term sustainability goals (formulated in shared visions; including Sustainable Technology Development - STD, Weaver *et al.*, 2000) and short term actions by farmers and other actors striving for realisation. Theories and approaches included back casting (Quist and Vergragt, 2006) Interactive Technology Assessment (ITA; Grin *et al.*, 1997) and Strategic Niche Management (SNM; Hoogma *et al.*, 2002). Thirdly, the meaning of the terms *robustness* and *naturalness* used in the political and public debate about livestock farming had to be interpreted.

An integrated design approach was developed to design new husbandry systems for laying hens, and at the same time could help to assess two basic questions: (1) how could sustainable development of a complex food production system, like the table egg production industry, be concretised and (2) How can such a development be successfully initiated during the project and be stimulated afterwards. The synthesized approach was worked out in greater detail as 'Reflexive Interactive Design' (RIO; Bos *et al.*, 2009; Bos *et al.*, 2011).

This paper tells the story of the integrated design approach that came up with two innovative design concepts for the production of table eggs in 2004, the initiatives and activities in the subsequent period of incubation, and the final realization in practice of three Roundel houses in the Netherlands.

## **The design phase**

### *The integrated design approach*

The integrated design approach consisted of five elements. Firstly, an approach was chosen for analysis of the problem which focused on the husbandry system in

interaction with its entrepreneurial and societal surroundings. In this approach the ethological needs of the laying hen were explicated as well as other needs of hens and other actors in relation to egg production. These included needs related to behavioural and physiological responses to maintain a preferred emotional state of living entities. Needs have to be fulfilled to prevent deprivation and negative effects on welfare and health. Besides requirements (precise and quantifiable conditions) were formulated that have to be met in the ideal situation where needs are fulfilled, and wishes (a condition preferably to be met). Perceptions, opinions and beliefs of the actors in the production system (e.g. farmers and workers) and food chain (e.g. processing and retail companies and consumers) and the relevant actors related to this food chain (citizens and consumers concerned about laying hens in husbandry systems; Verhoog, 1997) were analysed deeper and translated into needs and requirements. Secondly, a systematic and structured design process was used for finding solutions. Essentially, solutions and their related normative choices were deferred to later stages of the project. Thirdly, the project was interdisciplinary, encompassing and combining different disciplines such as animal welfare, farm management, philosophy, architecture and communication. Fourthly, both scientific and experiential (tacit) knowledge from these disciplines was used in the project. The fifth element was the close interaction with the egg production sector and related societal groups. Details of the methods used can be found in Groot Koerkamp & Bos (2008) and are part of the scheme of the RIO approach (Bos et al., 2009). The project team interacted during most phases of the project with various relevant stakeholders, such as poultry farmers, supply industry, feed companies, housing equipment, veterinarians, advisors, and NGO's like animal protection organizations, and tried to address strategic long-term goals as much as possible.

The Brief of Requirements (BoR; list of all requirements specified in quantitative terms with traceable sources, either numerically fixed or a variable range) was based on the needs (instead of interests) of the four addressed stakeholders: citizens (three consumer groups from the Mentality model; Lampert *et al.*, 2002; Anon., 2007: Cosmopolitans, Traditional Bourgeois and Post-materialists), consumers, farmers and the laying hen. The needs and requirements of laying hens were based on an extensive body of ethological literature (over 1000 scientific statements) as well as practical knowledge from farmers and other specialists. In this brief the desired level of welfare of the laying hen was defined according the fulfilment of the 'ethological needs', i.e., the needs that have to be fulfilled in order to prevent unwanted, abnormal behaviour (e.g. feather pecking & stereotypical behaviour), chronic stress and laying floor eggs (Duncan, 1998; Jensen & Toates, 1993). Analysis of the space requirements of laying hens per type of behaviour and activity was based on the model of Mol *et al.* (2006).

The structured design process (Kroonenberg & Siers, 1999; Siers, 2004) originates from engineering design and architecture, and emphasises a thorough investigation and analysis of the problem in relation to the needs and requirements of

the prospected actors in the system. Key functions (trivial and new) were identified that could link the broad range of requirements with system functions for egg production, and establish synergy and compatibility at the same time. Functions describe in an abstract way the things that have to be done (the so-called 'what') to make the system run, but do not describe the way how the task is carried out. In various workshops with stakeholders solutions for these functions were listed in morphologic charts, combined to structures of draft and final designs and evaluated against the BoR and in more detail on economic and welfare aspects.

During the design phase special attention was given to the aim of the project to articulate – in verifiable and concrete terms – meaning for the concept of *robustness* (e.g. Napel *et al.*, 2006) and *naturalness* (e.g. Verhoog *et al.*, 2003), as they played a central role in societal debates on the future of animal husbandry. Both concepts were operationalized in the BoR.

### *Results*

The main results of the design phase (see Groot Koerkamp & Bos, 2008) were (1) the strategic problem definition, (2) the fundamental needs of the laying hen, farmer and citizen/consumer and the resulting Brief of Requirements (BoR) as a basis for a new husbandry concept, (3) the key functions that have to be fulfilled, (4) a description of two design concepts, and (5) some results of the evaluation.

The Strategic problem definition formulated, among others, that hens should be allowed to have a productive and happy life, and that the new husbandry concept should have an outdoor access that meets the various concerns of stakeholders in the egg-production sector.

The final brief of requirements of citizens/consumers, the farmer and the laying hen consisted of approximately 250 entries, categorized according to the needs of the different actors involved. The complete BoR (Anon., 2005) can be obtained from the authors and at <http://www.houdenvanhennen.nl>. The BoR for the citizens shows that a plurality of values and visions existed between the three groups involved (Goenee & Le Goff, 2003). So, animal welfare as a general concept means different things to different groups of citizens. The *Traditional Bourgeois* in the Mentality-model expressed their wish for a caring and respectful treatment with a dominant reference towards traditional farming, which is perceived by them as paradigmatic for a respectful relation between men and animal. On the other hand, for *Cosmopolites*, animal welfare means a dynamic life combined with a sufficient amount of privacy. In this group a very close relation with the ideals for their own life could be identified, witnessing for instance their strong emphasis on wellness and health, which also is a strong trend in current consumer behaviour (Figure 2).

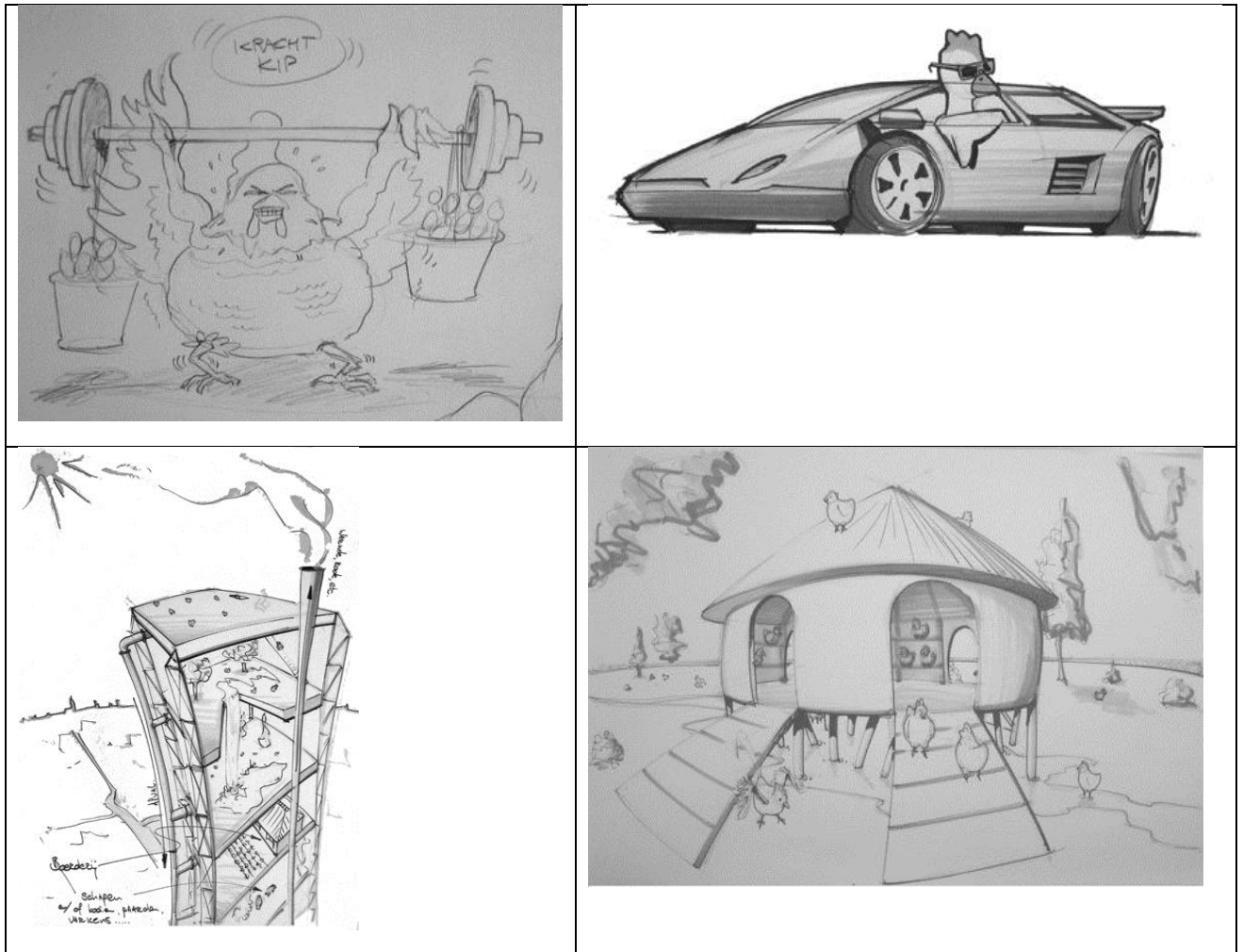


Figure 2. Four visual expressions of demands of Cosmopolites: the fitness layer, the fast Ferrari chicken, high-tech housing system, and round indo-like hen house above a river.

The requirements for the poultry farmer were based on the needs of the three different roles he has: as an animal keeper, as an entrepreneur, and a labourer. By differentiating and abstracting these needs we were able to overcome the contradictions in certain respects. Based on the ethological needs of the hens, and their variation in time (e.g., daily rhythm) and place (and interactions and synchronization), total space requirement for all functional areas (related to key functions) of a group of hens was assessed to amount 2214 cm<sup>2</sup> per animal. This is considerably more than space allowance in current systems (e.g., 1111 cm<sup>2</sup> in single and multi-tiered aviary systems, 750 cm<sup>2</sup> in furnished cages and 500 cm<sup>2</sup> in current cage systems). Essential to this was the spatial split between functional areas (no overlap) and direct accessibility of all facilities.

Key functions within the husbandry system were systemically linked with requirements of the stakeholders and this showed us that compatibility in the design process can be arranged at the level of requirements, at the level of existing functions or by defining new functions, such as 'provide visiting facilities' and 'provide information' to fulfil the need of citizens to understand husbandry systems.

Two significantly different design concepts were elaborated into designs for husbandry systems, one with (*The Plantation*) and the other without (*The Roundel*) an outdoor run. Both concepts synthesized the ethological needs of laying hens and the needs and requirements of farmers, and appeal in form and function to specific classes of citizens/consumers.

### *The Roundel*

The Roundel (Figure 3 and 4) resembles a large round cake from which one piece is missing. A large two-stories-high loft consisting of 12 segments covered by a roof but open to all sides surrounds a central management area. This area provides space for the egg-collecting system, as well as storage space for the eggs, feed and other items. Ten of the 12 segments consist of a pen area and a foraging area and are used for the housing of 3000 hens each. Each segment is used by one group of hens.

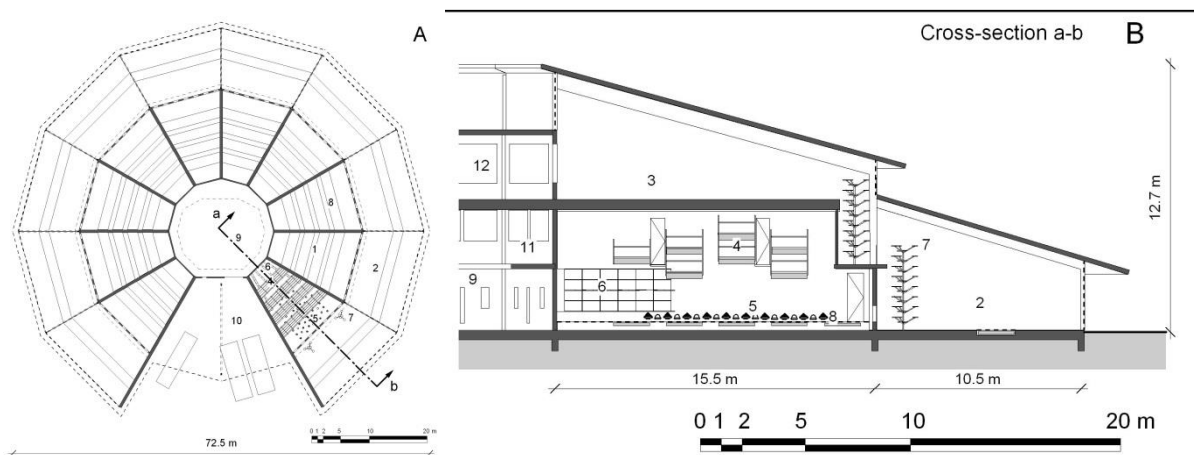


Figure 3. Top view (A) and cross-section (a-b) of one segment (B) of the Roundel husbandry concept. 1: unit for 3000 hens; 2 & 3: foraging areas; 4: perches (for resting) over manure belts; 5: water and feed supply; 6: laying nests; 7: artificial trees; 8: manure belts at floor level; 9: room for collection eggs; 10: expedition; 11: visitors and control gallery; 12: technical installations (drawn by JvR architectuur).

Its name, Roundel, conveys values like robustness and security. The space is used in a compact way, but functional areas are separated for easy access by the hens. At the same time, its radial form improves accessibility and overview by the poultry farmer, while the round yet robust shape is chosen to appeal to the class of citizens who stress the importance of safety and care (the *Traditional Bourgeois*). At the same time, the diversity of the inner open and private space, which includes a diversity of materials for exploration, scraping and dust bathing, appeals to another class of citizens, the *Cosmopolites*, and allows for individual variation of needs within the flock.

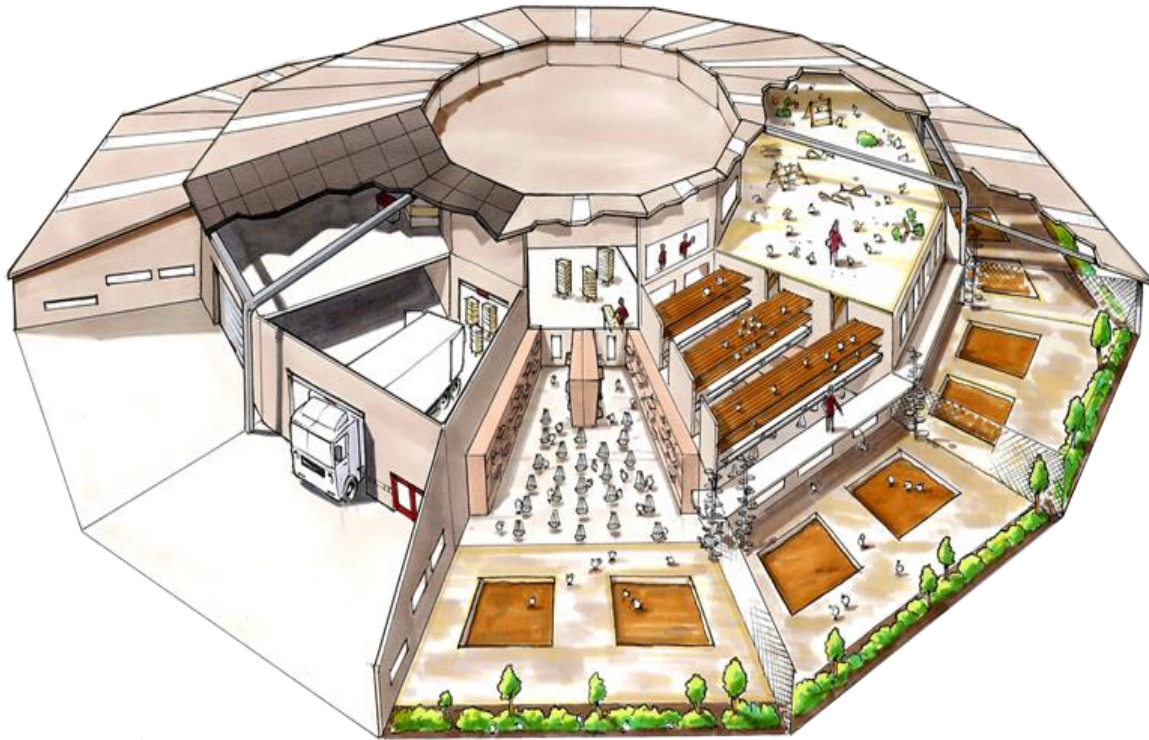


Figure 4. Artist impression of the Roundel husbandry concept.

There are two foraging areas, one in the outer ring at ground level and separated from the neighbouring segments, and one above the central ring that can also be utilized for dust bathing, foraging and exploration. Both areas are enriched with a thick layer of dry litter material and with all sorts of plants, and grain seeds are scattered for a few minutes a number of times during day time, using an automated rotator. Daylight reaches the loft area and the ground segment through large windows in the ceiling, and through the sidewalls made of netting, which also allow for ventilation. There are two climatic zones. The climate in the pen area is relatively stable at 20°C, whereas the climate in the foraging areas on the ground and in the loft varies under the influence of sunlight, outdoor temperatures and wind. However, extreme temperatures do not occur.

The Roundel is designed to provide much protection for the hen, but also for the poultry farmer. The hens have no contact with birds from outside the system and foxes and vermin can easily be kept outside. So the hens are not exposed to extreme conditions. A type of laying hen that has a slightly lower requirement for foraging and exploring, but that prefers resting, continuity and the expression of behaviour like preening or dust bathing is best suited to this system.

### *The Plantation*

The Plantation (Figure 5 and 6) is spatially characterized by two lightly curved lines of buildings cut into the landscape and enclosing a large inner yard area. This ensemble is positioned amid several hectares of land with fruit trees, willows and



maize fields, which are part of the system. Its name, Plantation, refers to the former large colonial estates where living, working and recreation were combined. Characteristic for its design is the combination of natural and technical elements, and the emphasis on exploration and self-sufficiency. It is meant to appeal to a class of citizens, the *Post-materialists*, who value the potential of nature, while being open and interested in creative linkages between sophisticated technology and organic and ecological processes. Another group of citizens, the *Cosmopolitans*, may be pleased by the choice-freedom for the hen, the range of possible activities and the availability of privacy.

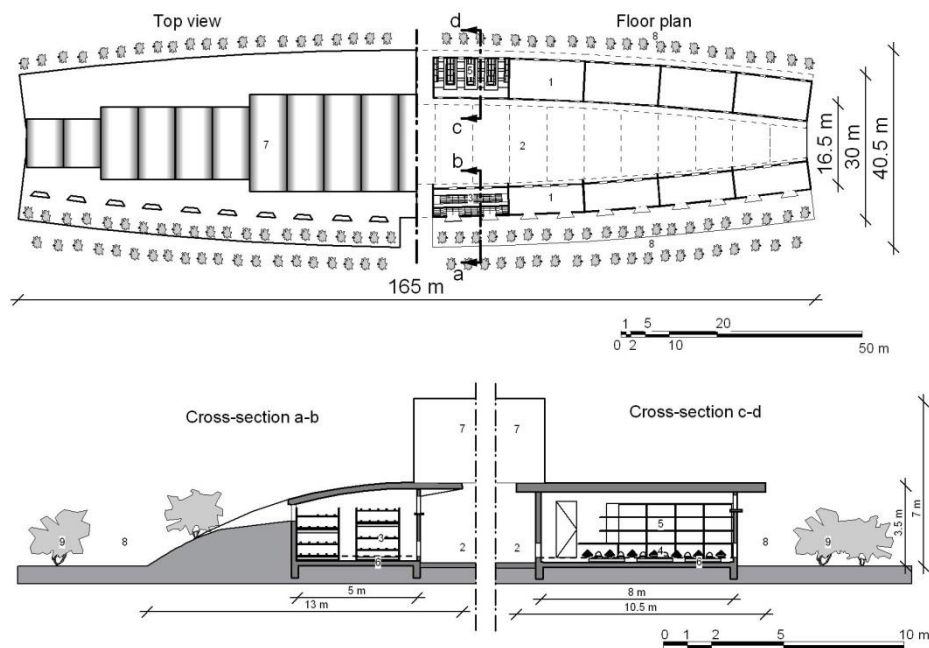


Figure 5. Top view (top left), floor plan (top right) and cross-sections (bottom) of the two houses of one unit of the Plantation husbandry concept. 1: unit for 3000 hens; 2: inner foraging area; 3: perches (for resting) over manure belts; 4: water and feed supply; 5: laying nests; 6: manure belts at floor level; 7: roof of semicircles covered with plastic foil that can be opened and closed; 8: shrubs & trees (drawn by JvR architectuur).

The inner yard of the Plantation forms the central area of the system. With rain a sliding roof covers the central area within minutes, maintaining it as a suitable foraging and exploration place for layers. The inner yard contains a lot of greenery and distraction for the hens, such as grains, green waste and cut wood from the outer area. The inner yard plus the buildings already satisfy all ethological needs of the hens.

The large outer areas on both sides of the buildings have a dual function. Tree crops and maize can be grown there, providing the hens with ample opportunity for exploration. Under the safe cover of this vegetation the hens can move far away from the inner yard and buildings. The hens in turn may be useful by eating weeds and hunting insects.

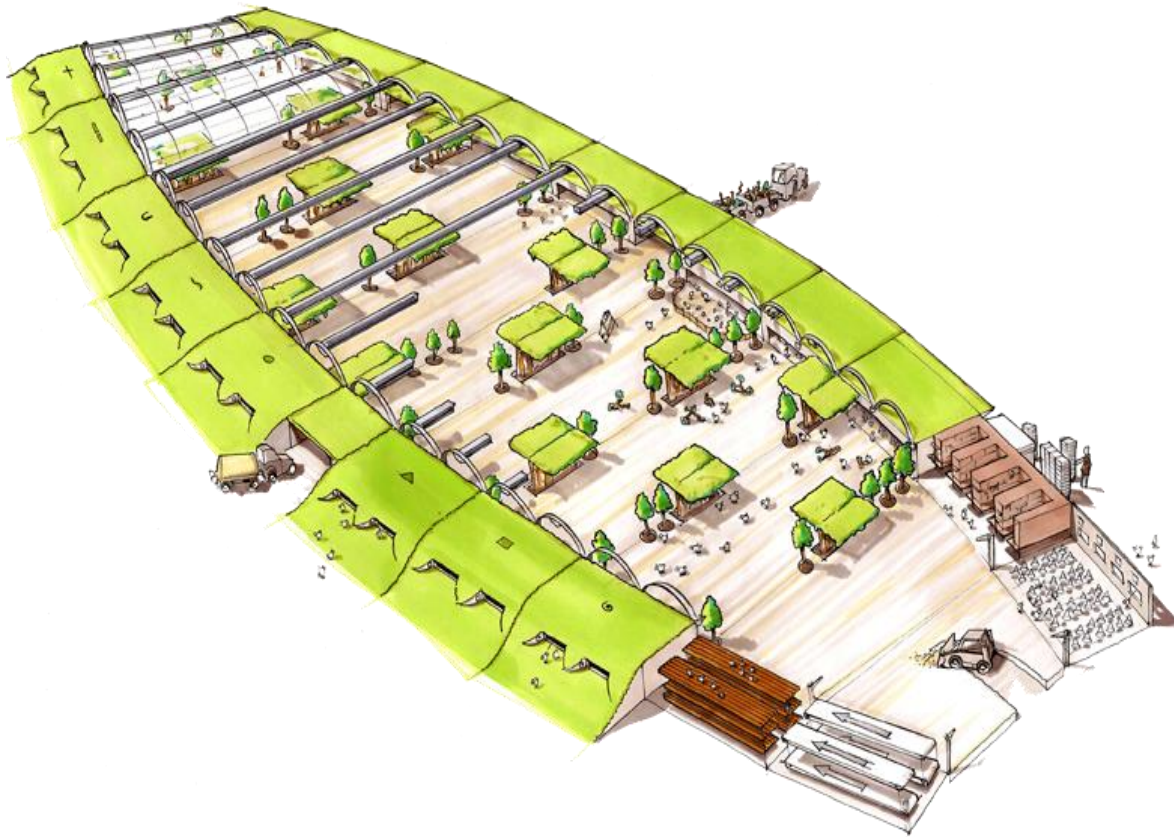


Figure 6. Artist impression of the Plantation husbandry concept.

The two lines of buildings consist of units of 3000 hens that are not separated at the inner yard. Both lines have their own function. On one side there is a covered resting space, on the other side the hens have access to facilities to eat, drink and lay eggs. Activities such as resting, eating, egg laying, foraging and exploring are functionally separated, but are interconnected by logical routes. The two pieces of land of at least 3 ha on both sides of the buildings have a dual function: crop production and exploration. The hens can look for their own food, but there is no protection against foxes or birds of prey. These areas can be used alternately, in order to let the soil recover and grass and weeds re-grow.

The Plantation very well suits a type of hen that is more inquisitive, less easily frightened and that remains alert. The hens may be a little heavier and will have a greater feed intake to compensate for the climatic variation in their environment. The raising of hens for future laying hens also takes place on the farm. The young animals will be separated from the adults and get gradually more space in the yard. This has several advantages: the hens experience no stress from transport or the change in living environment. By teaching them at an early stage how to use the yard, they will concentrate their pecking behaviour on the ground rather than on other hens. As the hens are gradually exposed to farm-bound diseases, they will be able to adapt to local circumstances by building up a strong immunity at an early age (Savelkoul & Tijhaar, 2007).

### *Welfare and economic evaluation of the Roundel and Plantation*

The welfare evaluation of the Roundel and Plantation, performed with the FOWEL model (Mol *et al.*, 2006), produced a score of 210 and 204 points out of 246, respectively, compared with 181, 163 and 93 points for an organic, a multi-tiered aviary system and furnished cages, respectively. In 2004, the costs of table egg production in the Roundel and Plantation were estimated to be 20 and 34% higher than for furnished cages. Compared to a multi-tier aviary or free free-range system the increase of costs amounted on average 5 and 17%, for the Roundel and Plantation respectively. However, production costs would still be 40 to 50% lower than for organic table egg production. Investment costs of buildings and machinery were higher for both designs, but accounted only for some 10% of the total costs. Especially the expected increase of feedings costs (higher feed intake) and lower numbers of produced eggs were responsible for the higher costs.

### **Incubation: entrepreneurial initiatives elicited by *Keeping and loving hens*.**

Interactivity during design workshops and communication resulted in 2004 in 4 poultry farmers expressing their interest in a follow up by either investing in new laying hen facilities based on the principles of *Keeping and loving hens* or by participation in developments of concepts for marketing (Wisselink, 2005; Bijleveld, 2006). The four entrepreneurs (June 2005) formed a network within a governmental extension program offering support from a knowledge worker to explore and develop their innovation system (Wielinga and Vrolijk, 2009). The learning history of this network (Bos, 2007) revealed that individual plans to build new facilities and the time-consuming procedures to obtain municipal building permits and subsidies to mitigate excessive entrepreneurial risks hampered collective planning and learning leading to a dissolving of the network activities in 2006. One of the farmers involved proceeded with his own plans, and built the Lankerenhof ([www.lankerenhof.nl](http://www.lankerenhof.nl)), based on the ideas in the Plantation design concept, and supported by the people from the *Keeping and loving hens* project.

In Summer 2006, an egg packing station showed interest in further development, building and exploiting a Roundel-like housing and started building its own innovation network. Notably the possibility of a new marketing concept based on sustainability and the round form of the housing appealed to the firm. They acquired the trade mark of the Roundel in 2005 and started cooperation with a company specialised in housing equipment, Vencomatic. The consortium achieved co-financing from Transforum, an organisation aiming to match governmental and private resources in co-innovation projects (Veldkamp *et al.*, 2008). In 2007 the egg packing station withdrew from the consortium. A separate firm, 'Rondeel Ltd', ([www.rondeel.org](http://www.rondeel.org)) was established within the equipment firm and a number of poultry farmers as main participants. It successfully developed building plans, acquired municipal building permission, and acquired the highest label with regard to animal welfare from the Dutch Society for Protection of Animals based on a comparison of expected performance with published animal welfare criteria (Mol *et al.*, 2006). A contract was

obtained with a major Dutch retailer, Albert Heijn, to market the eggs within their newly introduced range of premium sustainability food products. However, the farmers, Rondeel Ltd, retail and bank considered the entrepreneurial risks too high for sufficiently long-term contracts, so realisation did not occur before a security bond had been obtained from the national government for a bank guarantee to compensate excess entrepreneurial risks taken by the consortium and farmers (compare Meijer *et al.*, 2007).

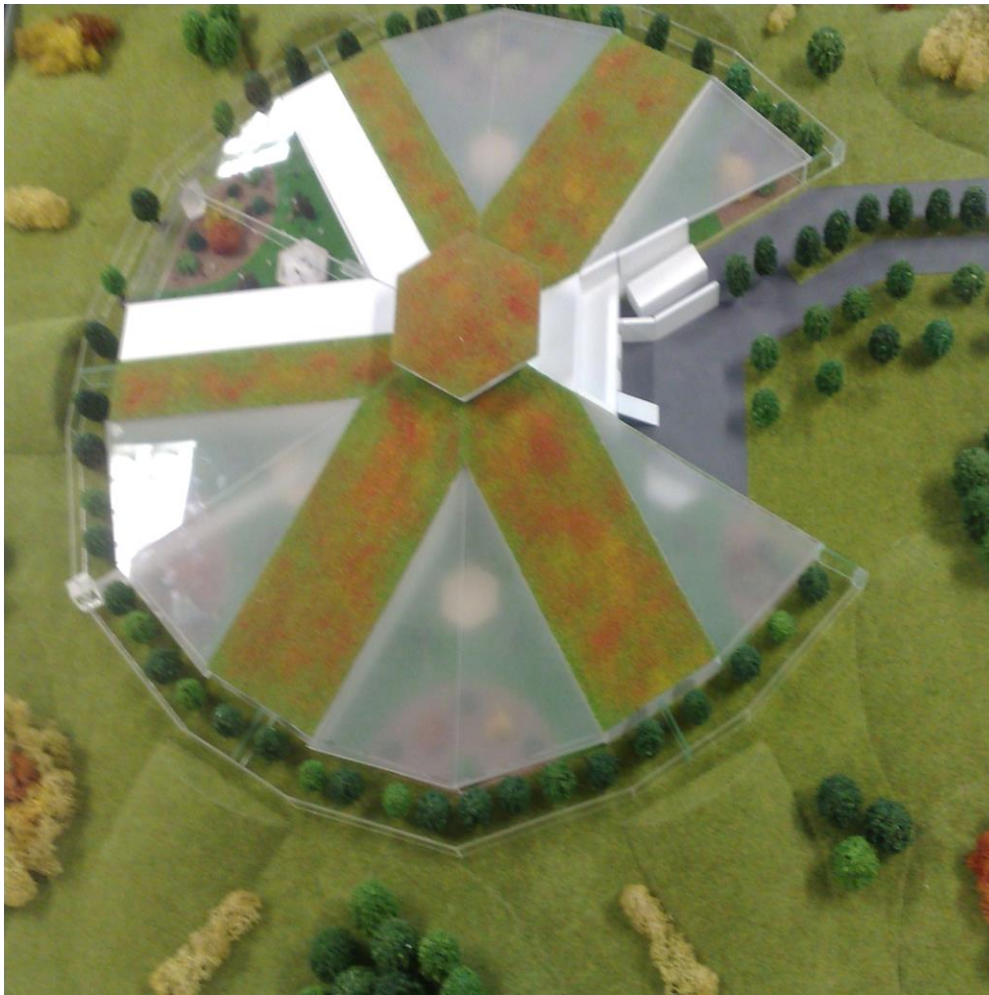


Figure 7. Scale model of the Roundel house made to open up discussion with societal groups, legislative bodies, farmers and neighbours of locations to build a real Roundel house.

The process is chronologically described and reviewed in detail by Klerkx *et al.* (2010) based on the Agricultural Innovation Systems (AIS) framework, more and more used to analyse technological, economical and institutional change in agriculture. In the AIS approach, innovation is considered to be the result of a process of networking and interactive learning among a heterogeneous set of actors, such as farmers, input industries, processors, traders, researchers, extensionists, government officials, and civil society organizations. The AIS approach emphasizes that agricultural innovation is not just about new technologies but also about institutional change; it requires alternative ways of organizing, for example, markets,

labour, land tenure and distribution of benefits. Among others, the *laying hen husbandry* case showed that “interaction between innovation networks and their environment is only steerable to a limited extent. Because innovation networks can only partially influence their institutional environment, and because unintended consequences of actions and random events influence the course of the innovation process, innovation network actors need to continuously re-interpret the contexts in which they move. This constant reflection by the innovating actors on their position vis-à-vis their environment needs to be supported by dedicated facilitators and monitoring and evaluation methods aimed at system learning. This implies that agricultural innovation policies should, instead of aiming to fully plan and control innovation, foster the emergence of such flexible support instruments that enable adaptive innovation management.” (Klerkx *et al.*, 2010 ).



Figure 8 and 9. Top view made on April 8<sup>th</sup> 2010 during the opening festivities of the first Roundel house in Barneveld, and view from outside-in: hens dust bathing in the outer fringe .

Spoelstra *et al.* (2012) elaborated on the innovation process of the Roundel. The artist impressions of the designs served as future attractors for improved sustainability, though based on solid science and knowledge (e.g. the Brief of Requirements) and participation of stakeholders in the design process. This shaped space for entrepreneurs to adopt the design concepts, synthesize them with other ideas and developed them into the designs that were realised in real life. This points to a possibly perceived duality in the design concepts of on the one hand being visual attractive representations of an ideal shared by participants in the design process (see Figures. 4 and 6), on the other hand being detailed blue prints based on exact calculations and laid down in exact drawings (see Figures 3 and 5). This duality results from the analytical phase and contributed to convince stakeholders that the artist impression actually where based on realistic assumptions, feasible solutions, and sound economical estimations.

### **Realisation of the Roundel laying hen house in practice**

On 8th April 2010 the first Roundel was opened in Barneveld, The Netherlands. It contains 5 units for 6000 laying hens each, 4 units with hens that were beak trimmed (nowadays softly touched) and one unit with birds with intact beaks. After the opening

of the first Roundel (Figures 8 and 9) several evaluations were made. An overall sustainability comparison of the Roundel was made with standard free range and aviary systems in the Netherlands by Scholten and Van der Vlier (2010). The Roundel compared favorably on indicators on animal welfare (Mol et al., 2006), notably by offering variation in environment to the hens and no beak trimming, community involvement by its high transparency and accessibility by public watching areas and meeting rooms, and financial balance for the farmer including a contract from farmer to retail with a compensation for fluctuations in feed costs to the farmer. The main weaknesses of the Roundel were the double investment costs as compared to a standard multitier system and the uncertainty on the robustness of the market to pay the premium for the eggs in the long run, which is needed to compensate these higher investments (Vermeij, 2009). Animal welfare assessment was performed in the first round of laying hens and included behavioural studies and comparisons between compartments with hens with treated and intact beaks on pecking and feather cover. The results showed a reasonable well feather plumage and limited feather pecking behaviour (Van Niekerk and Reuvekamp, 2011).



The second Roundel house is situated in Wintelre, The Netherlands, and was opened on February 11<sup>th</sup>, 2011. The third Roundel house is located in Ewijk, The Netherlands, and opened March 10<sup>th</sup>, 2012. All Roundel houses can be visited by the public, and all hens are now non-beak trimmed. Eggs are being sold by the supermarket chain AH (Albert Heijn) in special boxes with seven (instead of the regular six or ten) eggs (see Figure 10).

Figure 10. The box made of coconut fibre with 7 Roundel eggs as being sold in the supermarket AH.

### **Concluding remarks**

The integrated design approach worked out well for the identification of a meaningful interpretation of sustainability of a complex heterogeneous production system in a food chain, resulting in an overall Brief of Requirements and two innovative design concepts. Application of the design method learned that participation of various stakeholders in design activities can play an important role in catalysing discussion between society and agriculture, and by this in the incubation and realisation phase of innovations. This was exactly the aim of the project. Not only to influence and increase the knowledge of the poultry sector and the various interest groups, but also to have an impact on their attitude towards animal production and other parties and their willingness to take action towards the development of sustainable egg production in Europe. For further reading on this case and innovation of sustainable husbandry systems we advise the papers of (Bos *et al.*, 2011) Spoelstra *et al.* (2012) and Klerkx *et al.* (2010), and the website [www.duurzameveehouderij.nl](http://www.duurzameveehouderij.nl).

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