

Developing and embedding eco-sustainable solutions: the evolution of the Leaf House network

COMPETITIVE PAPER

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Keywords: eco-sustainability, technical development, embedding, resources, network evolution

Abstract

This paper analyses the evolution of a network that emerged around the “Leaf House” project, initiated by the Italian firm Loccioni Group in 2007. The idea proposed by Loccioni Group was to create the first ecologically sustainable integrated community in Italy in collaboration with ENEL (the Italian former electricity monopolist) and home appliance producer Whirlpool. In this so called “Leaf Community” it is already now possible to live in a zero carbon emission house, the “Leaf House”. Previous research of ours applied a “resource interaction” perspective (Håkansson & Waluszewski, 2002; Wedin, 2001; Baraldi, 2003) to examine the structure, the key resources and the social-technical interdependencies in the industrial network that emerged around the Leaf House. While searching for conflicts among the intervening actors, we analyzed their motivations to take part into the project and found that there were very few conflicts during the period leading to successfully completing the building because all intervening actors had something to gain and more or less nothing to lose in participating in this project. Using the “4-Resources” model (Ibid) we discussed how eco-sustainable the Leaf House is if we first view it as a facility and then as a product. We concluded that the Leaf House played and plays an important role as a *testing facility*, proving that it is possible to build a zero carbon emission house and allowing to test and experiment at a pilot scale various individual components (generators, solar panels, control systems, home appliances etc.). However, viewed as a *product*, it seems much more difficult to reproduce the Leaf House and to embed it in a large-scale production and using setting.

In the light of these early findings, the purpose of this paper is twofold. Firstly, we aim to relate the difficulty in large-scale embedding of successful pilot solutions with the *most recent events and changes* in this network in constant evolution. For instance new actors have become involved that can facilitate the commercialization not of the Leaf House as a whole, but of certain selected components (e.g., solar panels, radiant floor and automation devices). Involving these new actors also encouraged changes in the role and strategy of Loccioni Group, who started viewing itself as a certifier in the field of zero CO2 emissions at European level and began new business activities aiming to commercialize selected solutions taken from the Leaf House “laboratory”. Secondly, we aim to provide a more detailed *description of the evolution of this network*, starting from its original conditions and goals and showing how various events set into motion further changes in this network that led to an unexpected impact on Loccioni’s network position and strategies in the area of environmental solutions. In addressing these two purposes, this paper focuses on the resource layer of the investigated network and applies the 4-Resources model (Håkansson & Waluszewski, 2002). Moreover, we relate the evolution of this network with the three settings of “development”, “production” and “use” (Håkansson et al., 2009; Håkansson & Waluszewski, 2007): these are the three possibly overlapping but also partly conflicting contexts wherein a new solution needs to fit in and be embedded in order to become a commercially viable product.

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INTRODUCTION

The theme of environmental sustainability, which falls within the broader framework of sustainable development, in recent years has assumed particular importance mainly regarding two aspects:

- a) the deterioration of the natural environment as a consequence of human activities has become more evident;
- b) emerging economies such as China, India and Brazil greatly increased their natural resource consumption and pollutants emissions as a result of their sustained economic and industrial development.

As eco-sustainability and the environment have become key political, economic and social issues, authors such as Hart and Milstein (2003) suggest that firms need to prepare for the future by moving toward a sustainability-oriented strategy and “clean technology” competences. In fact; firms are increasingly investing in technical innovations which allow matching *simultaneously* cost and “green” targets (Stone & Wakefield, 2000; Porter & van der Linde, 1995). Achieving these two originally conflicting goals requires starting from the very *development* of eco-sustainable solutions, which entails devising and designing specific solutions by taking into account both cost and green targets (Maxwell & van der Vorst, 2002). But developing green products is complex and often requires combining technologies from several actors (see Håkansson & Waluszewski, 2002a, 2002b). Considering these two points, it is relevant to view the creation of eco-sustainable solutions from an industrial network, interactive perspective (see Håkansson & Snehota, 1995; Ford et al., 2003).

The “Leaf House” is one of such eco-sustainable solutions: it is a technologically innovative building that relies on environment-friendly solutions for an efficient production and use of light and energy. Loccioni Group, an Italian medium size firm, is the promoter of the “Leaf House”, which is part of a bigger project called “Leaf Community”, aiming to create the first ecologically sustainable integrated community in Italy, allowing living in a zero carbon emission house, moving with electrical or hydrogen cars and working in eco-compatible buildings. This case is particularly interesting from the viewpoint of eco-sustainable technologies because of several reasons: the project embraces not a single product or technology, but several technologies that needed to be integrated into a complex building (and even a whole extended community). Moreover, these technologies were all more or less already available on the market and simply needed to be tied together into a functioning whole. However, this was not a technically trivial task because obtaining a truly zero-CO₂-emission house required advanced solutions for producing, monitoring and controlling energy and for optimizing the management of energy sources so to match the energy and comfort needs of individual users. For instance, all single hardware pieces needed to be connected with sensors capable to interface with ICT solutions handling several software languages.

Loccioni proposed the idea of the Leaf House to a set of partners who accepted to bring together their specific technical and commercial competences to solve the various technical problems. Thus, during the project a network was formed that promoted cooperation among several suppliers in order to improve existing solutions and occasionally develop new ones that were both technically and economically more viable. An important motivator was using the building and infrastructure of the Leaf house as a location to conduct tests for new energy saving solutions open to all partners.

During the first part of our research on the Leaf House project (January-March 2009), we observed the development, the structure and the key resources in the industrial network that emerged around the Leaf House. We could clearly see how Loccioni Group engaged and mobilized a network of other actors in order to carry out the project so to involve and combine several technical and organizational resources (Håkansson & Waluszewski, 2002b). We also highlighted that there were very few conflicts among the actors during the period leading to successfully completing the building. Devising and implementing this prototype house was facilitated by minimal conflicts because all intervening actors had *something to gain and more or less nothing to lose* in participating in this project, which is an important condition for sustaining the development of technologies in a business network setting (Ibid; Håkansson, 1987). In particular, the Leaf House turned out to be either a source of revenues for contracted suppliers or a real-life testing facility offering experimental data to energy producing and using partners (ENEL and Whirlpool respectively). Our preliminary analysis suggested that it would be instead more challenging to achieve a large-scale embedding in a broader producing and using setting of this successful pilot

solution. In other words, it would be more difficult to transform this first installation into a *commercially viable product* to be produced and purchased in large volumes.

Against this background, the aim of this paper is twofold. Firstly, we aim to investigate the recent events and changes occurred in the network around the Leaf House in order to stress the difficulty of moving from pilot scale to large-scale embedding. This difficulty derives from the fact that in order to become a commercially viable product a new solution needs to fit in and be embedded progressively in three partly overlapping, but also conflicting contexts, namely a “development”, a “production” and a “use” setting (Håkansson et al., 2009; Håkansson & Waluszewski, 2007). Secondly, we aim to analyze the constant evolution of this network, starting from its original conditions and goals and then identifying key events and periods, in order to connect the changes occurred in this network with changes in the organization and strategy of the initiating actor, Loccioni Group.

A key question that we address in relation to both purposes is whether a *marketable eco-sustainable solution* is emerging and which features it is assuming as a result of the evolution of the Leaf network. In addressing this question and the purposes of this paper we focus on the resource layer of the investigated network and apply the 4-Resources model (Håkansson & Waluszewski, 2002a, 2002b). Moreover, we relate the evolution of this network with the three settings of “development”, “production” and “use” (Håkansson & Waluszewski, 2007, 2009).

THEORETICAL FRAME: RESOURCE INTERACTION AND NETWORK EVOLUTION

Relying on Penrose’s work (1959), we argue that the specific way in which resources get combined with each other generates different types of value of the extant combinations such as new products: this relativistic view is particularly important at the network level, where it is both new combinations of resources and specific inter-firm interactions that contribute to the development of particular new products. Therefore, we choose to analyze the emergence of technical solutions during the evolution of the Leaf House network by focusing on the resource layer of this business network. More precisely, we apply a “resource interaction” perspective (Håkansson & Waluszewski, 2002a; Baraldi, 2003) in order to analyze how different resources have been combined and activated within this network in order to create environmentally friendly solutions.

The framework that oriented our data collection and analysis is known as 4Rs model as it distinguishes between four types of resources: *products* and *facilities*, which are physical/technical resources, and *organizational units* and *business relationships*, which are social/organizational resources (Wedin, 2001; Baraldi & Bocconcelli, 2001; Håkansson & Waluszewski, 2002a, 2002b; Baraldi, 2003). The 4Rs model is useful in our study as it allows penetration into the interactions between single-resource items or groups of them. In fact, the focus should not be on the single-resource items, but on the interplay between items (see e.g., Baraldi, 2003). By interacting, resources affect each other’s features and usage. Within the frame of this model, eco-sustainability can be viewed as an important *feature* of the physical resources *facilities* and *products*, namely as the degree to which they save or allow conservation and renewal of key natural resources such as water, air, woods/forests. In other words, eco-sustainability is a value that is created when specific products and facilities cause as little as possible negative impact on natural resources. However, embedding such a positive value in a specific resource (e.g., a car, or a piece of furniture) requires that several resources get combined (Baraldi & Strömsten, 2006) in ways that are not only technically functional but that have minimal environmental impact. For instance, IKEA’s table Lack present positive ecological features because it saves natural wood, as it is mostly empty inside, and

because its lightness and flat packages reduce the pollution in its transportation (Ibid; Baraldi, 2006).

Achieving ecologically sustainable solutions often requires creating closer connections between previously separated networks, as shown by Andersson & Sweet (2002) in the case of retailing and recycling networks as food retailers in Sweden were seeking to reduce the environmental impact of their waste. The roles of the actors involved in the new “environmentally sustainable recycling of waste” network needed to change to accommodate the new way of performing activities and a higher degree of technical interdependencies (Ibid: 474). The need to bring together previously separated actors and resources in new network configurations holds even more if we are dealing with innovative buildings, like the Leaf House.

Thus, it seems that the initiative of some key actor, be it a construction company or a main contractor, is important to induce other actors to combine their resources to devise project-specific solutions, as well as to identify replicable and economically feasible ones. It is therefore important that this actor is aware of the structure of the network that is being formed, of the content of the various network relationships, and of the match or mismatch between the goals of the other actors involved (Baraldi, 2008: 103-4). In the Leaf House case it is interesting to analyze the above issues, including how the main contractor Loccioni viewed and interacted with the network involved in this project.

Bringing together previously separated actors and unconnected resources is a key type of change that needs to be achieved within a network that focuses on the creation of an innovative eco-sustainable solution: this suggests that such a network undergoes a constant evolution in terms of actor composition, that is, the number and types of actors, and of resource configuration, namely how the involved resources are connected and interfaced (Baraldi & Strömsten, 2006). Network evolution can be manifested in new actors entering the network, in actors initiating changes in some relationships, in resources getting recombined and in activities being performed in new ways, which reflects the three dimensions of actors, resources and activities of the ARA model presented in Håkansson and Snehota (1995). Those authors also suggest that developments and the evolution of any business network can be influenced by exogenous factors (i.e. new technical solutions developed somewhere else) or by endogenous factors (e.g., changes in how actors are organized internally or in their inter-organizational relationships).

The changes and the evolution of a network centred around a focal technology, such as an eco-sustainable building, can be related to different moments and contexts that need to be brought together if this technology is ever to be turned into a commercially viable product. Håkansson and Waluszewski (2007) and Ingemansson and Waluszewski (2009) identify three separate contexts that together impact the fate of a new technology: a “developing” setting, a “producing” setting and a “using” setting. Each of these three settings is governed by its own logic, particular actors or specific goals, which can be very different from a setting to another.

- The *developing* setting of a focal technology includes actors performing R&D activities such as academic institutions, research centers, product development teams and units: the goals of these actors tend to coalesce around the creation of new solutions whereby unique, cutting-edge and often untried knowledge and resource combinations are viewed as very valuable (Håkansson & Waluszewski, 2007; Ingemansson & Waluszewski, 2009: 23).
- On the other hand, the *producing* setting of a technology includes actors dealing with routine-like activity stretching from raw material provision to production, manufacturing and transportation. Most of these actors are companies who have made considerable

physical investments in order to achieve efficiency in the daily production of both the focal technology and other products. Therefore, one of the main goals of the actors in the producing setting is trying to avoid changes in the key features of the technology, which would jeopardize the value of their investments, and to refuse untried solutions still open for discussion in the developing setting, which are too uncertain to justify large investments. Consequently in order to guarantee the embedding of the new technology it is very important that this technology does not require too big adaptations and changes in the established solutions and if it fits the other interfaces in the production structures a higher efficiency will be reached (Ingemansson & Waluszewski, 2009: 24).

- Finally, the *using* setting includes the direct and indirect users of a technology ranging from firms to public organizations and individual consumers. The using setting is particularly important for a new technology because it is the users who determine whether an “invention” will ever become an “innovation”, that is, reach widespread use and eventually become a commercial product with actual customers paying for it (cf. Tidd, Pavitt & Bessant, 2005). Using is however more than a simple purchase and superficial adoption of a new product, but typically it entails changes and even costly adaptations that users have to make in their own technologies and behaviours in order to be really able to utilize the innovation (van de Ven et al., 1999). Even if a new technology can easily engage a few “lead users” because they are highly skilled and motivated in using it (von Hippel, 1986), users as a whole present different profiles in terms of interest, motivation and barriers concerning new technologies. Moreover, the new solution will need to fit into a complex system of other technologies and investments spread across all users, both direct and indirect ones (Ingemansson & Waluszewski, 2009: 24). Therefore, becoming eventually embedded in the using setting is never a “natural” process: to achieve user embedding the new technology needs to overcome several barriers and adaptations will be needed from the side of users as well as of other third parties related to users (for instance the users’ own customers and other suppliers).

From our review of the three settings of developing, producing and using it appears clear that their logic are diverging, or even conflicting. However, a new technology needs to move across all three settings in order to become a viable commercial product. Put differently, the three contexts need to get connected for a technology to become embedded. Despite the conflicts among the three settings, there is however also some overlap due to the fact that some actors and resources are found in more than one context or that their interfaces (Baraldi, 2003; Baraldi & Strömsten, 2006) span the boundaries of one setting. Moreover, the network associated with a new technology can evolve in terms of boundaries and composition, so that the aforementioned connections between the developing, producing and using settings become possible in different moments of its evolution.

METHODOLOGY

Our research design is based on a single longitudinal case study conducted according to an abductive logic (Dubois & Gadde, 2002): this means that we combined theory and data collection continuously during our research process, moving between theoretical models and empirical data several times as a result of conducting a continuous analysis of the material that re-directed both our data collection and theoretical focus. More precisely, we started out with collecting data about the Leaf House network in January 2009 guided by general industrial network models such as ARA (Håkansson and Snehota, 1995). As soon as early data was gathered we viewed it as an interesting case of developing a new complex technological solution. Therefore we decided to focus on the resource layer of this network and we accordingly chose to penetrate the case deeper with the help

of the 4Rs model (Håkansson and Waluszewski, 2002a; Wedin, 2001; Baraldi, 2003). This specific theoretical and analytical focus led us to collect further material that we then analyzed it in search of preliminary findings in March-April 2009.

The analysis that we conducted at this stage of our research process was mainly concerned with structural aspects of the investigated network, stressing the actor composition of the network and the type of “interfaces” (Baraldi, 2003) connecting the various resources involved. Our preliminary findings in relation to actor composition was that Loccioni had been able to bring together highly complementary actors and that the level of conflicts had been kept to a minimum because actors were not only complementary but all of them could also gain advantages from partaking in the Leaf House project. Another important finding of this preliminary analysis was that conflicts could be minimized also because the resource interfaces around the Leaf House were configured as if this were a one-of-a-kind artifact, acting as a testing facility which contributed positive values to many other surrounding resources and actors. In fact, the Leaf House appeared as a working prototype that could offer useful experimental data to established actors in their efforts to develop new eco-sustainable technologies.

At this point, these findings triggered a new key research question: how would the Leaf House network change, in terms of actor composition and resource interfaces, if those unique technical solutions had to be transformed into commercial products, produced and sold in a large scale. Inspired by network inspired innovation literature (e.g., Håkansson et al. 2009), we expected that, compared with creating a prototype and a testing facility, embedding the Leaf House on a large scale would be more challenging and create more tensions and conflicts with established structures and investments in the production and using system within the building industry. Therefore, we included in our theoretical frame models about user-embedding of technologies and about the three settings of developing, producing and using (Håkansson & Waluszewski, 2007; Ingemansson & Waluszewski, 2009). At the same time we conducted further data collection that, as we shall see in the case section of this paper, actually showed how the network started to evolve while Loccioni undertook an effort to commercialize the solutions developed for the Leaf House. All of our data was analysed in this paper by making use of both the 4-Resource model, as a way to map the Leaf House network and its resources at specific moments in time, and of the three different embedding settings, as a way to connect the evolution of the network with the diverging pressures deriving from the different contexts that an innovation needs to be exposed to before becoming a commercial success.

We explicitly collected data for this case between January 2009 and March 2010. Moreover, one of the paper’s authors was personally involved in the Leaf House project between February and September 2008 and could therefore perform a great deal of direct observations. Our complete data set is presented in the Appendix of this paper. We made a total of 19 interviews spanning from one to several hours in length, including interviews at Loccioni’s three main partners in the Leaf House project – ENEL, Whirlpool and Beckhoff. The respondents inside Loccioni Group were the owner, R&D, sales and marketing managers, next to the team of engineers who participated in the Leaf House project development. All of the interviewees were informed of the purpose and scope of the research prior to the interview. An interview guide was prepared before each interview and adjusted based on the outcomes of the previous ones. Several interviews were tape-recorded. Moreover, we have been engaged in informal conversation, e-mail and phone calls to follow up on interviews. When we oriented our research question to following the evolution of the Leaf network we made interviews also with one of the main scientific consultant of the project and to the “new” actors who were involved after the completion of the Leaf House. In this way we collected information from “old” and “new” actors belonging to the network.

Next to these direct oral sources and observations, data was collected in the form of numerous internal reports, brochures and specialized publications such as Home Energy Magazine featuring the Leaf House (e.g., Ceppa, 2009). We collected data with the explicit task to identify not only key resources involved in the network that emerged around the Leaf House, but also to provide a more detailed description of the original conditions and goals. In this way we collected information about early events that set into motion further changes in this network in order to better understand the important although largely unexpected impact that the evolution of this project-related network has had on Loccioni's position and strategies in the area of environmental solutions. Moreover, our interviews dealt with such issues as the goals that induced the various actors to participate in the Leaf House project and potential conflicts among them.

CASE STUDY: THE LEAF HOUSE PROJECT AND NETWORK

The Loccioni Group and the background of the Leaf House

Loccioni Group (Loccioni) was founded by Enrico Loccioni in 1968 nearby Ancona, Italy. The firm operates within the high-tech industry and its turnover was around 50 million Euro in 2009 and its employees were about 300. Loccioni is a system integrator mainly of *measurement and testing machines* for automotive and home appliance components. During the last 20 years Loccioni has increased its level of investments in R&D activities reaching last year 5% of its total turnover. As a consequence, Loccioni expanded its focus from automotive and home appliances industrial sectors to ICT, health, and environment applications.

In particular, in the beginning of the 1990s Loccioni started producing tailor-made solutions to face environmental issues: for example, emissions analysis systems for incineration plants, or control, traceability and process integrated systems for the petrochemical industry. The aim of these activities was to support customers with new technologies to face their own environmental efforts. Afterwards, Loccioni started to invest in R&D in order to investigate the connection between technology and environment: the main goal was to find solutions satisfying the growing needs of comfort, offered by modern technology, but also respecting the environment. Since 2007 Loccioni focussed even stronger on eco-sustainability issues starting a research project called "Leaf Community". The main idea behind the project was to create, in the area surrounding Loccioni's headquarter, an eco-sustainable community allowing people to live in perfect balance with nature.

The main features of the "Leaf House" and its origins within the Leaf Community project

Loccioni assumed that existing technologies as well as research and development would enable to create an area where the impact of man on nature would be minimal. The original idea was to create a community where it would be possible to live in a zero-carbon-emission house, to move with electrical or hydrogen cars and to work in eco-compatible buildings (see figure 1).

INSERT FIGURE 1 HERE

The project was born when Loccioni Group was planning a residential building to be used for staff and visitors. In the beginning of 2007 the decision was made to construct a "classe A" building¹. During 2007, Enrico Loccioni took part in a conference on zero-emissions buildings and was particularly interested in the speech of Mario Butera, a well known Italian professor in Environmental Engineering at "Politecnico di Milano" and an expert in ecologically sustainable

¹ The "classe A" label refers to the energy certification of a building and is a classification promoted by "Casa Clima", an Italian energy certifier. "Classe A" indicates energy consumption levels of a building less than 30 kWhm² per year.

buildings. Loccioni had a first meeting right after the conference with prof. Butera and explained his project to create a “classe A” building. Butera was fascinated by the idea and suggested Loccioni to make a real qualitative leap: turning it into a building with *zero emission*, since the energy needs may be low depending on how they can be designed. It meant to create a building where energy is produced entirely by renewable sources without CO2 emissions. In that moment the “Leaf House” project was concretely launched.

The interaction between Enrico Loccioni and Federico Butera went on and included discussions beyond the issue of the building design: Butera stressed that the building was not made only of walls or heating systems but also appliances that require and utilize energy (TV, radio, etc.). For this reason, interactions started also with actors who were producers of other technologies involved in creating the built environment and producing or using energy. Loccioni soon succeeded in involving key actors such as Whirlpool, one of the most important home appliance makers, the Swedish furniture retailer IKEA, the major Italian electricity provider ENEL, and Beckhoff a German maker of automation technologies solutions. According to Butera “this type of approach, in fact, can only be systemic” and rely on “the logic of an eco-sustainable network”.

Let us now turn to the key technical features of the Leaf House. One of its most important characteristics is that it would become the very first house in Italy boasting to produce zero CO2 emissions. The Leaf House, with its six flats, was designed and constructed so that it would require a very limited amount of energy to ensure thermal comfort, both in the winter and the summer. Integrated geothermal heat pumps and photovoltaic and solar panel system provided to the Leaf House more energy than it needs (see figures 2 and 3).

INSERT FIGURE 2 and 3 HERE

100-meter deep vertical pipes extract energy from the earth, but can be used in the summer also for cooling the house as the soil underneath is very wet. According to Clara Ceppa, of the Department of Architectural and Industrial Design of Turin Polytechnic University, the Leaf House’s solar-thermal system will provide 26,500 kWh per year of electricity, eliminating about 18 metric tons per year of CO2 emissions, and 10,200 kWh per year of heat energy, eliminating about 2.5 metric tons per year of CO2. Moreover, important energy savings are obtained because the house is thermally insulated and very efficient in keeping the requested temperature. For instance, walls are built with several layers of insulating materials such as expanded polystyrene. Moreover radiant floors constantly distribute heat, air is mechanically shifted between rooms where warmer/colder conditions are needed, and lighting systems and all home appliances are energy-efficient (see figure 4 and 5).

INSERT FIGURE 4 and 5 HERE

In order to monitor and control all the aforementioned equipment the Leaf House is provided with over 1,000 sensors. Based on sophisticated IT solutions, these sensors and meters are integrated and allow remote assistance and maintenance of the installed equipment. The information and measurements delivered by these IT systems allow the people leaving in the Leaf House to learn more about their own consumption habits in order to improve their energy efficiency. The same information is useful also for the Loccioni Group and the other suppliers of technical solutions in their quest for improving these solutions: the Leaf House works thus as a *clean energy laboratory*, a place to be analyzed but also visited by those who are interested in solutions for energy problems. Besides containing integrated technologies to improve energy efficiency the building houses several employees of Loccioni; they accepted to live in the house while testing all its parts and structures. According to these people the house is very comfortable, but sometimes there were technical

problems such as in the air flow from the ventilation system. Loccioni continuously analyzes the behaviour of the people who live inside the building in order to understand for instance the patterns of energy consumption associated with different lifestyles at different hours of the day or days or the week.

As one of the purposes of this paper is to follow the evolution of the network that accompanied the development of the Leaf House, figure 6 below presents the time line of this project highlighting the key events. These are namely the meeting Loccioni-Butera in January 2007, the construction start in November 2007, the inauguration of the Leaf House in June 2008 and the first job order of Leaf House-related solutions obtained from meat producer Fileni in November 2009. The remaining parts of this section describe first the set up of the supplier network around the Leaf House (in the period 2007-8), then the main changes in the composition of this network and in its types of relationships occurred right after the Leaf House inauguration (in the period mid 2008-mid 2009), and finally the most recent developments related to the appearance of actual customers for the eco-sustainable solutions emerged from the Leaf House (in the period 2009-2010).

INSERT FIGURE 6 HERE

Setting up the Leaf House supplier network and the three main business relationships

Loccioni managed to involve behind the Leaf House project a large network of suppliers and partners, including about 80 actors in all. Among these 80 partners about 45 had only a minor contribution, both in economic and technical terms, as they provided for instance wholly standard solutions with limited financial impact. Instead 35 suppliers can be considered as more active and important. Loccioni made a classification of the most important suppliers based on their technical and economical role and contribution to the project. ENEL and Whirlpool were considered as “lead partners” in the project and represented moreover the two ends of the energy equation following the reasoning of prof. Butera: ENEL is an energy producer, while Whirlpool ideally represents energy users because it is a home appliances maker.

The network set up to create the Leaf House also included “technological partners” such as Beckhoff, National Instruments, Schueco, and Viessmann, who supplied backbone solutions. Another important category of suppliers were “energy saving partners”, including companies like Rehau and Roccheggiani that provided solutions enabling to save energy. There were also so called “energy production partners” like Grundfos and Solar Spot, who delivered energy solutions. Finally, the project network included “technology integration partners” such as Bticino, Wimax and CISCO, all producers of special components and subsystems mainly in the ICT sector. Figure 7 below shows the supplier network of the Leaf House and the key resources involved as it appeared at the end of 2008.

INSERT FIGUER 7 HERE

The Ancona store of IKEA also played a role as it provided furniture for free to the house, as a way to increase its visibility as an actor promoting eco-sustainability. In the choice of the suppliers to involve in the project between February and September 2007, Loccioni started to present and promote the Leaf House project among its *existing* suppliers and customers, that is, the actors invited were first of all taken from Loccioni’s established industrial network. From a strategic point of view Loccioni meant to prioritize its existing partners by giving them the opportunity to participate in a high-profile eco-sustainability project. For example ENEL and Whirlpool were two historical customers of Loccioni; Grundfos and National Instruments had for several years supplied many of Loccioni’s product areas. However, not all the necessary competences were available at

existing partners so Loccioni explicitly asked the existing partners for help in finding other competent ones among their own networks. Thus, several new partners with the right technical and commercial skills were found thanks to the indications of existing ones.

The Leaf House network presented in figure 7 was formed for developing a unique product. The building was created by integrating and simply adapting existing components. The network was centralized around Loccioni who acted as general contractor and system integrator. As a general contractor Loccioni was in charge of guaranteeing that the “zero emission” target was reached in the Leaf House, both in terms of single components and the whole building. Loccioni was responsible for the means and methods used in the construction and execution of the project. Moreover Loccioni conceived and developed one of the critical technological components of the Leaf House, namely the building automation system. This is a new solution which enables the measurement of several parameters inside the Leaf House: the integration of this system with the other technological components in the Leaf House was a key endeavour. Next to this role as technical system integrator, Loccioni also had the task of managing directly and closely those business relationships where the need of technical adaptations of components was high, like in the case of Beckhoff², while trying to reduce the need of complex supplier-supplier interactions.

Beckhoff developed key hardware solutions for the core “framework” for building automation, one of the most complex systems for the Leaf House, developed together with Loccioni’s IT manager, Mr. Olivi. Managing information was essential for this building automation system because the ambition was that the many sensors placed in the Leaf House could constantly deliver a wealth of data. It was also very important for Loccioni to exchange with Beckhoff software prototypes before finalizing the building automation infrastructure: this implied a lot of interactions between the two companies and, even if both actors view the relationship very positively, there were occasionally divergent opinions on software applications and a short delay of one month in putting the “framework” into operations.

Another important business relationship in the Leaf House network was engaged with Whirlpool³, one of Loccioni’s historical customers in the business of testing and measurement machines for home appliances. The relationship with Loccioni dates back to 1987, when Loccioni designed an automatic test system for washing machines, installed in their German plant in Schondorf. The relationship developed constantly, with Loccioni delivering several testing systems for other Whirlpool products such as dish washers and refrigerators. The collaboration with Loccioni in the Leaf House project was considered by Whirlpool as an excellent opportunity to connect with the company’s overall sustainability goals, in terms of development of more energy-efficient products. Whirlpool supplied the Leaf House with a green set of electrical appliances and also created a special loft called ZEOS (zero-emission open space) which represented a special laboratory where Whirlpool expected to install and test soon its futuristic concept of “Green Kitchen”. Whirlpool viewed very positively its participation in the project: it did not entail any particular conflicts, but it was instead a forum that provided several contacts with other actors engaged in the area of eco-sustainability, with the possibility of entering into other active collaborations for the future.

² Beckhoff Automation participated in the Leaf House project via its Italian subsidiary, manned with 17 employees and selling in 2007 for Euro 7 million; this subsidiary belongs to a larger group with about 1,000 employees and Euro 232 million in turnover. Beckhoff develops and markets automation technology solutions including industrial PCs, fieldbus components, automation software and drive technology

³ Whirlpool is a major producer of home appliances; Whirlpool sells for about \$19 billion and employs more than 70,000 employees in over 70 plants and R&D centers around the world. Whirlpool’s main products are laundry appliances, refrigerators, cooking appliances, dishwashers and mixers. Whirlpool Europe has 13 plants, of which 6 in Italy, where its headquarters are located, in Comerio.

The relationship with the third key actor in the Leaf House network, ENEL⁴, started in the beginning of the 1980s. Loccioni supplied then ENEL with components such as wirings and during the 1990s Loccioni started to provide solutions about gas and emissions analysis in ENEL's coal power plants. ENEL became recently very focussed on environmental and eco-sustainability issues. In the last few years the company got increasingly interested not only in renewable energy sources, but also in how the energy it produces/distributes is actually utilized depending for instance on consumers' lifestyles and installed equipment. Considering the above technology-specific goals, ENEL's "Innovation & Environment" office considered as highly relevant to get directly involved in the Leaf project, due to its focus on energy utilization efficiency at the level of final users, namely private homes and local community. The Leaf House project allowed ENEL to test in a real using context one of its new technical devices, the "electronic meter" aimed to monitor in real time the energy consumption patterns of private homes. Moreover, the Leaf House includes a system for producing, storing and re-using hydrogen generated out of the energy produced in the house's photovoltaic panels: having this type of system installed in the house enabled ENEL to analyse, verify and test in a real life situation one of the key problems related to renewable energy sources, namely the storing and utilization of energy in those hours of the day when solar power is not available.

The Loccioni Group invested in this project between 2007 and 2008 around €1.7 million for R&D, purchased materials/equipment and own salaries, and €600.000 for marketing and communication related to the Leaf House initiative. Whirlpool, ENEL and IKEA were the only other actors that made direct investments, firstly as a contribution to Loccioni's marketing and communications costs and secondly "in kind". The network picture of figure 7 also shows the resources involved in this project. The most important *technical* resources were the following components/subsystems: ENEL's hydrogen plant, the ICT solution by Cisco, Solar Trading's solar collectors, Whirlpool's home appliances and, finally, the building automation system jointly developed by Loccioni and Beckhoff.

Network evolution around the Leaf House: new actors and changed relationships

Figure 7 shows the network composition and structure at the end of 2008 (based on our analysis made in February-March 2009). Since then several changes occurred in this network. In particular new actors entered the network around the Leaf House and the relationships between Loccioni and some key actors also evolved. Figure 8 below illustrates the status of the Leaf House network about one year after the snapshot provided in figure 7 above, that is, in early 2010. The evolution of the supplier network is crucial because it provides new opportunities to Loccioni and the other actors involved. The majority of business relationships between Loccioni and several actors have continued to be very fruitful in terms of intensity and the exchange of resources. In other situations however there have been some problems that have led to a decrease in the frequency of contacts between Loccioni and the actors. In some cases, business relationships have grown very much while at the beginning they were not relevant as partnerships. Let us now review these changes referring to figure 8

INSERT FIGURE 8 HERE

Starting from 2009, ENEL tried to achieve in concrete terms a complete overview of energy utilization in a real-life situation, with the help of its intelligent electronic metering installed inside

⁴ ENEL is Italy's main energy producing and distributing company. This former national monopolist was privatized in 1999 along with a process of liberalization of the Italian energy market, even though ENEL still controls 80% of energy distribution in Italy. The 2008 turnover of Enel was around 62 billions of Euro with 82.000 employees all over the world.

the Leaf House. In this way, ENEL has a real opportunity to check the validity of its future development ideas. For them the Leaf House became a useful observatory to understand how a concrete community can run tomorrow's efficient energy. In addition ENEL is using the Leaf House as a PR and communication tool, which can be viewed in relation with ENEL's plans to invest in nuclear power plants and the potential problems this move can create among the Italian public opinion. When it comes to the concrete collaborative tests performed inside the Leaf House, ENEL has been somewhat absent and did not perform any actual test on the premises of the Leaf House. According to prof. Butera ENEL is probably not willing to share information about such tests and will perform them somewhere else.

The collaboration in the relationship between Loccioni and Whirlpool expanded and intensified from a technical point of view. Whirlpool was involved in the project supplying its home appliances in the apartments of the Leaf House, and since June 2008 they began the monitoring of energy consumption. Moreover, at the same time Whirlpool asked Loccioni to develop special software for monitoring according to their specifications the power consumptions of washing machines. This has to do with the fact that the washing machine is the most value added home appliance in Whirlpool's range. From a technical point of view, individual users select a particular washing program and when the cycle begins, the water and electricity consumption is monitored in real-time. Whirlpool analyses then these data in order to make product improvements. But according to Loccioni, Whirlpool could better exploit the opportunities given by the Leaf House project by following the measurement activities with own technicians in place.

There have been improvements in several business relationships within the Leaf House network since the project has been inaugurated: for instance, the relationship of Loccioni with I Guzzini, IKEA, Roccheggiani and Solar Trading are more intensive compared with before. During 2010, I Guzzini is expected to supply Loccioni with lighting equipment of last generation, such as new LED technologies that are not yet on the market but that I Guzzini offered as a preview. After testing them, Loccioni was completely satisfied and plans to use this LED equipment for its new headquarters. The relationship with IKEA also promises to become more fruitful in the near future for Loccioni. The two companies are trying to develop common projects and in particular they are working together in order to build "the house of the future". The relationship with IKEA at the beginning of the Leaf project was a mere supply of furniture, with IKEA probably seeking also a way to gain a stronger hold on this territory as an IKEA store is located near the Leaf House, in the city of Ancona. However, after one year IKEA has become one of Loccioni's key technology partners related to the Leaf House. There are close contacts with IKEA's research and development managers, and marketing and sales people of Loccioni visited IKEA's headquarters in Sweden. Another important relationship has been created with IKEA's distribution center located in Piacenza. Now Loccioni also established a direct contact with Roberto Monti, the managing director of IKEA Italy. Quite interestingly, IKEA may now become a customer of Loccioni. In fact, Loccioni made a bid for the replacement of lighting fixtures in their Ancona store, and has also been proposed for the realization of the photovoltaic system at IKEA's distribution center in Piacenza. Loccioni's relationship with Roccheggiani has also been developed in order to find sales and commercial opportunities. Roccheggiani was involved in the Leaf House project as they provided the air handling unit (UTA). Now this company is a stable partner of Loccioni and collaborates with Loccioni from a technical point of view thus enabling to match specific customer needs. Similarly Loccioni now works with Solar Trading, a company that joined Leaf network and now supports Loccioni when there are initiatives for the supply of solar tubes to customers.

A couple of other relationships depicted in figure 8 have instead lost momentum and intensity: Firstly, Schueco is no longer considered by Loccioni as a partner to be involved directly in projects with other customers because Loccioni realized that the solar panels developed by Schueco do not

match well Loccioni's cost/quality requirements. When fulfilling customer orders of solar energy systems, Loccioni chose instead solar panels delivered by other vendors which better match such technical variables as roof size, orientation and weight. In particular, a new company called Solindra (introduced to Loccioni by Gianni Silvestrini of the Kyoto Club) is now the preferred supplier of solar panels, because their latest product generation is very well suited to buildings that have special needs in terms of load and weight of the roof, and these are customers to whom Loccioni is addressing its offerings. Secondly, National Instruments is trying to get more involved in the future developments of the Leaf House project, suggesting for instance Loccioni to replace some sensors inside the house with their last generation wireless sensors or to place in the house other products for free. But Loccioni is not currently interesting in these suggestions.

Next to Solindra there are a few other new actors that entered the Leaf House network during 2009. One of these is UBI Bank, a financial institution who previously provided funds to Loccioni. This relationship was grounded on a personal contact between Enrico Loccioni and one of the owners of UBI Marche. Since mid 2009 UBI has become Loccioni's financial partner in setting up industrial projects in the energy field. In particular, UBI provides "complete funding packages" to Loccioni's customers who want for example to install photovoltaic systems. The bank is ready to finance up to 100% of a project's cost if the customer, who is bound to purchase after-sales services from Loccioni, has solid financial standing and can present a strong business plan. Therefore, through this relationship with UBI, Loccioni can stimulate potential customers to start projects in the eco-sustainability field.

Loccioni's R&D manager stresses how the Leaf House network will expand with the inclusion of *other home appliance makers* next to Whirlpool, and probably of Ariston Thermo Group. The Leaf House assumed in fact after 2009 clearly the primary function of an open laboratory for Loccioni's customers, suppliers and potential partners in eco-sustainability activities. Other home appliance makers seemed to be interested in the opportunity Loccioni can offer them to conduct testing on their products inside the Leaf House. The potential entrance of the Ariston Group in the Leaf House network is instead related to a technical problem that occurred in 2009 with the heat pump supplied by the German firm Viessman. The heat pump provided by Viessman does not fulfil the technical expectations established at the beginning of the relationship with Loccioni. There is actually a dispute between Loccioni and Viessman concerning who is to blame because of the unsatisfactory performance of this pump. On the other hand, the relationship Loccioni-Viessman never really took off because of diverging cultures and ways of working. When Loccioni selected Viessmann as the partner in charge of the heat pump, they did so because the technical specifications of their pump seemed to match better to the needs of the project than Ariston's pumps. But after installing the pump and keeping it in real-life operations the expectation was not matched. Therefore Loccioni is considering replacing Viessman's pump with one by Ariston. Involving Ariston in the Leaf House network could lead to broader effects for Loccioni, including the possibility of delivering energy efficiency solutions to Ariston's production facilities, in a similar way to the development within the relationship with IKEA.

Marketing the Leaf House solutions and the future outlook for this network

The evolution of the Leaf House network has had effects at several levels for Loccioni, firstly on its internal organization and secondly on the discovery of important business opportunities. In September 2009 a new business unit called Loccioni Energy was formed. This unit includes 5 employees: a manager who also performs sales activities, two other sales people, a marketing staff and an engineer who studies solutions and applications in the eco-sustainable context. The inspiration to create this business unit came from external consultants such as prof. Butera and an

architect who was engaged since the beginning in the Leaf project. Many of the competencies and resources that have joined Loccioni Energy were previously involved in related pilot projects such as construction and integration of various types of machinery. The activities in which these employees are particularly skilled include replacement of engines, discovery of new suppliers, and testing of components. From a marketing perspective, this business unit targets big industrial groups with solutions for energy efficiency, which they propose on three levels, namely the level of single products/components manufactured by customers, that of their production processes and finally whole buildings.

- **Products:** this is the case for instance of customers within the automotive industry, where Loccioni operates since the 1980s. For instance, Loccioni Energy now helps their customers to make fuel injectors more efficient.
- **Production processes:** one of Loccioni's customers in the home appliance sector is Elica Group. This company has a very energy-consuming production process to make the exhaust fan. Therefore Elica invited Loccioni to make an audit and propose solutions that will make the production process less energy-consuming, which includes interventions directly on Elica's manufacturing plant.
- **Buildings:** in this area Loccioni starts off projects with monitoring the energy consumption of a building and then suggests improvements to customers. The applications that Loccioni will then contribute to install can be building automation, replacement of the inverter, cooling by energy from renewable sources, etc.

Another important commercial effect of the Leaf House project appeared between June and December 2009 when the Fileni⁵ group became the first customer of Loccioni's to purchase technologies developed within the Leaf House. In a first phase it was crucial the role of the marketing area of Loccioni for creating the contact with Fileni's technical people who visited the Leaf House. In this way meetings and technical discussions were encouraged. Fileni's need was to save energy during the manufacturing process of chicken meat. Loccioni's solution focussed on improving the natural habitat of chickens, such as ventilation and maintaining constant the floor temperature with a radiant floor like the one installed in the Leaf House to prevent chickens mortality. Moreover in spring 2010 the installation will start of a photovoltaic system at Fileni's factory. The objective of the Fileni's project is to integrate the technologies from the Leaf House into Fileni's production plant.

Another key subsystem of the Leaf House which promises to become a marketable product is the core "framework" for building automation developed in collaboration with Beckhoff. In this case however Loccioni's strategy will be to address large industrial customers that can in turn provide the framework to construction companies. Thus Loccioni does not aim to offer the framework directly to final customers but prefers to establish relationships with intermediaries that have themselves established relationships with this type of users.

In a broader perspective, the main purpose of the Leaf House project is to help develop and test several new lines of products and components, according to Loccioni's R&D manager Gino Romiti. Moreover, building on the Leaf House experience, another key step in the eco-sustainability research field for Loccioni will be to devise and build another carbon neutral building with its partners, right after 2011. The aim of this new project being discussed with many of the key partners in the Leaf House network will be to develop a self-sufficient building with no need to be connected with the electric grid and made completely of wood. Another key aspect of Loccioni's

⁵ Fileni represents an important firm operating in the food farming sector. It has a manufacturing plant very close to the Loccioni's Headquarter in Castelpiano (AN) and basically Fileni is a food (chicken) processing firm. Fileni was established in 1978 and the turnover of 2008 was around 200 millions of euro.

eco-sustainability research and development is grounded in a strong collaboration with prof. Butera: the goal of this cooperation is to develop an artificial intelligence product that can be applied in the area of plant management, but could be used in any other building, in order to reduce energy consumption and at the same time ensure high levels of comfort. This will essentially be a form of software which simulates the behaviour of a building from an energy consumption viewpoint during the whole day.

All in all, Loccioni considers as one of the most important outputs of the Leaf project the knowledge acquired on the energy market and its related technologies. Moreover the Leaf House project helped Loccioni identifying and approaching business opportunities in the market for eco-sustainable solutions. However, according to prof. Butera and to Gino Romiti it appears as more challenging to embed the Leaf solutions outside the Leaf House context. The transition from a prototype product to a full blown market for these solutions is very long and complex. At a broader level many changes are necessary in the eco-sustainability culture and awareness of final users and other stakeholders, next to policy support for eco-friendly solutions. At a more concrete level, according to Butera and Romiti, reaching a broad market also requires a concrete evaluation process based on an *official system of certification* showing clearly how eco-sustainable a product is. Confirming the importance of environmental certification, Loccioni entered in discussions with NGOs and other bodies dealing with this issue such as the Kyoto Group and IEA (International Energy Agency), who were made aware of the Leaf House project. Even if the Leaf House has not been officially certified, we can provide some key indicators shown in table 1 below.

INSERT TABLE 1 HERE

ANALYSIS AND DISCUSSION OF THE LEAF HOUSE CASE

Our analysis of the case revolves around two major themes: first, the evolution of the Leaf House network in terms of changes in its structure, actor composition and goals, and, second, the exposure of the Leaf House technologies to the three contexts of developing, producing and using (Håkansson & Waluszewski, 2007). These two themes are related but we choose to discuss them separately

The evolution of the Leaf House network

The Leaf House started as a project with a dual goal for its promoter, Loccioni: to *enable a general learning* about the new technical and commercial area of environmental solutions, and to *communicate* to various stakeholders Loccioni's engagement in this new area. As for the other about 80 actors that participated from the beginning the goals included: *direct economic returns* in terms of sales to the project (this holds especially for smaller subcontractors); *specific technical learning* on how to devise and develop their own components and subsystems (this holds for partners who delivered complex and adapted solutions); obtaining *a real-life testing* of own products (this holds for Whirlpool and ENEL); and *public relations* effects (this holds for IKEA and partly ENEL).

During the first period of the Leaf House project (2007-8), leading to the inauguration of the building, the network revolved around three key relationships of Loccioni's, namely those with ENEL, Whirlpool and Beckhoff (see figure 7). Through these relationships each actor assumed a clearly defined role characterised by clear complementarities in relation to the technical interfaces in the project: ENEL was the supplier of *energy producing* equipment, Whirlpool was the supplier of *energy using* machines, Beckhoff was the supplier of a key *subsystem for building automation*,

and Loccioni had the role of *supervising* the whole project and acted as *system integrator* for the efforts of all other actors. During this first period, the level of conflicts between the participating actors was kept to a minimum thanks to several reasons: the roles and the resources of these actors were complementary, their goals were compatible (see above) and everyone had to gain something from participating in this project, at least at this stage.

In the second period (2008-9) leading to obtaining a first order of a Leaf House-related technology from Fileni, a few changes occurred in the composition and types of relationships in the network that had led to the Leaf House inauguration (see figure 8). A first change concerns Loccioni's goal shifting towards *finding customers* for the technical solutions included in the Leaf House. While this specific goal of selling Leaf House solutions was not reached during this second period, still the Leaf House network worked as a conduit to actual customers buying other solutions of Loccioni's: an important customer was found immediately within the very Leaf House network, when IKEA accepted to deepen its relationship with Loccioni. But a more explicit commercial orientation by Loccioni also led to substituting some relationships with wholly new ones: for instance, due to problems in fitting downstream customer needs the solar panel supplier Schueco was replaced by Solindra. The same commercial drive is also behind the entrance in the network of a very new type of actor with limited connections with environmental issues, namely UNI Bank, with the purpose of financing potential customers of Loccioni. While conflicts were kept to a minimum during the first period, now they tend to surface: the unsatisfactory performance of Viessman's pump leads to opening to a new supplier and the interest of other home appliance makers can create a potential conflict with the key partner Whirlpool.

In the last period we analyzed (2009-10) the most important change in the network is the inclusion of at least one actual customer for the eco-sustainable solutions emerged from the Leaf House, with the Fileni installation of the radiant floor. This evolution parallels the slight shift of Loccioni's goal from commercializing the whole integrated Leaf House solution to *marketing specific components and subsystems*, such as the building automation framework developed with Beckhoff. This reviewed goal is clearly manifest in an important organizational change within Loccioni, namely the creation of a new business unit, Loccioni Energy, dedicated to developing and marketing eco-sustainable solutions. However, the mission of this BU goes somehow beyond the Leaf House project and involves any type of integrated or stand-alone solution to environmental issues, including consulting and solutions not developed within the Leaf House project. In this sense, the network becomes potentially open to the influence and entrance of any new customer depending on their special needs, as in the case of Elica's production process reengineering. A last important change that further opens up the initial Leaf House network is related to Loccioni's newer goal of obtaining *environmental certifications*: as common standard and objective evaluations are an additional barrier to marketing environmental solutions, Loccioni took the initiative of initiating a dialogue with organizations involved in this field, such as IEA or the Kyoto Group.

Is the Leaf House becoming embedded in the developing, producing and using settings?

The boundary expansion and the reconfiguration of the Leaf House network, especially when moving across the second and third period reviewed above, witness the important changes that a technology and its context need to undergo when moving from pilot scale to large-scale embedding. Some of these changes also point at the difficulty and the challenges in trying to achieve this embedding. In particular, technical problems in matching actual customer needs on large scale applications led to the substitution of partners who developed the original solutions with new ones who actually supply to real customers, as in the case of Solindra taking over Suheco's supplier role for solar panels. Other partners are instead being replaced because an unsatisfactory technical

performance and relationships can be tolerated during the restricted time frame of an R&D project, but cannot be kept for the long run, as in the plan to substitute Viessman with Ariston.

More precisely in the imminent substitution of Ariston for Viessman one can see a broader conflict between an R&D logic and a commercial logic, because closely involving Ariston in the Leaf House network offers the possibility to turn it into a customer of Loccioni's energy saving solutions. The trend that emerges from the case material is that when moving closer to the production and using setting more conflicts as the ones above appear. For instance, one might expect a negative reaction from Whirlpool if other home appliance makers will be involved in the Leaf House with the possibility of using it for testing their products. Whirlpool informal exclusivity would disappear with the further risk of having to share confidential R&D data with competitors.

The Leaf House assumes different and multiple functions in relation to the three settings of developing, producing and using. These various "shapes" depend on the fact that a complex artefact can be viewed as both a developed and sold *product* and as a usable tool/functioning *facility* within the 4R model (Baraldi, 2003; Håkansson, & Waluszewski, 2002a, 2002b). Let us now review six of these specific shapes of the Leaf House and how each one of them relates to the developing, producing and using settings.

1- First of all the Leaf House is a *product being developed*. Between 2007 and 2008 about 80 actors combined their resources in order to conceive, devise and concretely develop both a set of components and subsystems and a whole, integrated solution. The efforts of these actors during this period were mostly concerned with solving new technical problems, sometimes for the very first time (e.g., the automation framework) and sometimes by simply recycling or recombining already existing technical solutions into new configurations (e.g., solar panels). Therefore, the activities involving the Leaf House in this first shape (a product being developed) belong mostly to the "developing" setting, especially if we take the perspective of Loccioni and a few other central actors such as Loccioni, ENEL, Beckhoff, Cisco and Viessman. However, for some of the actors, especially smaller subcontractors, the Leaf House as a product being developed is simply an opportunity to provide their offerings on a routine basis, entailing the delivery of standardized large scale solutions. Therefore, this first shape of the Leaf House also involves routine activities taken from the "producing" setting.

2- But once completed, the Leaf House becomes a *production facility* that processes energy inputs into living conditions outputs for its individual users and other waste products. This facet of the Leaf House is relevant for the people living inside this building and using it on a daily basis. But even if the activities embracing this second shape of the Leaf House definitely belong to the "using" setting, this does not mean that the Leaf House has become embedded in such a setting. The reason is one of extension in numbers and space of these using activities: after June 2008 it is only a dozen of people living in 6 apartments that are routinely using this production facility. An important technical feature of the Leaf House as a production facility is that its CO₂ emissions are almost zero. The zero-emission feature of this facility makes it a reference object and a proof that it is possible to create such a building, thereby creating a connection with other developers who may gain inspiration from it or even stimulating attempts for the large scale production of similar buildings (even if we could not find explicitly such traces at the moment of our investigation).

3- The functioning Leaf House also became very soon a *testing facility*. Several actors such ENEL and Whirlpool used it starting from mid 2008 in order to test their own individual technology to be then refined, produced and sold separately. These are activities of utilization that bring the Leaf House closer to a special type of "using" setting, namely industrial use by product developers, which is clearly bridging towards the "developing" setting of specific solutions complementary to

the Leaf House, such as home appliances or electricity generators. As the home appliances tested were both standard large volume products and products in development, we can also trace a connection between this third facet of the Leaf House and the “producing” setting: the Leaf House as a testing facility can help compare the performance of existing and upcoming products by putting them into a real-life using situation.

4- One of the original functions of the Leaf House was to act as a *PR tool*, as witnessed by the important involvement of the marketing department of Loccioni in the project. But Loccioni is not the only actor that could use this PR tool, as also IKEA and ENEL did clearly so. A PR tool like this was certainly part of the “developing” setting as it helped to draw attention on the actual technical project and to attract key partners for the various R&D activities. This fourth facet of the Leaf House also opened for a connection with the “producing” setting: the finished building with its zero-emission performance acted as a reference object to stimulate other producers to move along a similar path. However, the lack of a formal and official certification on the environmental features of the technical object hindered the full promotional effect of the Leaf House towards industrial producers of environmental solutions. The connections between the Leaf House as a PR tool and the “using” setting are somehow difficult to trace: identifying the influence on home builders or the mass market is beyond the purpose of this paper, but one can identify indirect effects on a restricted set of actual customers who did purchase Loccioni’s environmental solutions because they heard about them in relation to the Leaf House project and its communicative campaign (e.g., Fileni).

5- The Leaf House is also possibly as a *complex product to be produced on the large scale*. But the key question is: what type of product is actually being produced in large volumes? At the end of the period we analyzed, it certainly does not seem to be a whole integrated solution, that is, a complete zero-emission building. What appears to be produced on large volumes is instead a set of *single components and subsystems* taken from the Leaf House. This facet of the Leaf House is clearly part of the “producing” setting even if the concrete connections do not stretch so far away from Loccioni, the company in charge of providing the packaged solutions, and the actual manufacturers, such as Rehau for under floor heating or Solindra for solar cells. Within the “producing” setting, *efficiency and costs* of manufacturing and supply activities are pivotal and can be achieved only if specific investments can be motivated by large volume of standard products or if the new solutions to be produced fit with the existing manufacturing systems (Håkansson & Waluszewski, 2007). However, in the Leaf House case the issues of production efficiency and costs are not handled by means of large standard volumes or reliance on existing investments. In fact, the single components or subsystems of the Leaf House are not really produced and sold on a pure standard basis, but require being adapted from time to time to the specific needs of each customer in a project-like fashion. Therefore, the Leaf House-based products produced on a large scale are always open to slight changes, negotiations and hence marginal developments, making them close to a “developing” setting. In this way, the problem of containing production costs can be solved only with individual large customers ready to pay for customized solutions.

6- Finally, the Leaf House aspires to become a *product used on the large scale*. Building on the previous point, what appears to be used in large volumes is not the whole integrated building, but some of its single components and subsystems, as witnessed by actual customers already placing orders of these particular solutions. Thus, the Leaf House-based components and subsystems are becoming embedded in a “using” setting, even if this embedding is not happening on a very large scale, but only on a restricted one. A possible reason for this restricted use may be that this embedding is dependent on the single products being partly redeveloped in the sense that they need to be adapted to specific customer projects or repackaged together with other non-Leaf House originating solutions. There are very little standard interfaces among these solutions and the other resources in the “using” and “producing” settings: standard interfaces have not been developed also

because the volumes exchanged are not large enough to justify the investments in building such standards. Moreover, the technical, economic and social barriers to user embedding of an innovation (Håkansson, 1987) are overcome in this case by adapting each time the product to every single user's context. Therefore a constant dialogue with the "developing" setting is necessary to permit an embedding on the using side. But the other side of the coin is that this type of embedding remains restricted in terms of numbers and places because costs are still high inside the "producing setting" and the current cost structure is not attracting large number of users.

CONCLUSIONS

The Leaf House case shows in practice both how the three settings of "developing", "producing" and "using" (Håkansson & Waluszewski, 2007; Ingemansson & Waluszewski, 2009) are *overlapping*, and thereby may help an innovation through its journey from idea to commercial product, and how they are *conflicting*, and thereby create barriers for the same journey. The overlap between the three settings derives at a superficial level from the fact that there are actors who intervene simultaneously in more than one setting: for instance Loccioni intervenes both in the developing and in the producing setting of the Leaf House; while IKEA intervenes in the developing setting and in the using setting, being an early partner of the Leaf House project and a current buyer of Loccioni's ecological solutions for its own buildings. It is not easy to find actors playing a central role in all three settings, but two candidates may be ENEL and Whirlpool, who intervene in the developing and producing settings and also partly in the using setting, even if only as industrial users of the Leaf House as a testing facility.

At a deeper level of the Loccioni network, the overlap between the three settings also depends on the interfaces that connect the resources (Wedin, 2001; Håkansson & Waluszewski, 2002b, Baraldi, 2003) found in each of the settings. Even if this paper did not conduct a detailed analysis of these resource interfaces, the six variable and multiple facets of the key resource in this network, namely the Leaf House building, which we reviewed in the analytical section can let emerge some of these interfaces spanning across the three settings. For instance, the fact that the Leaf House is both a *product to be developed*, a *PR tool* and a *testing facility* may help connect the three settings by forming interfaces that span the boundaries of two or three settings but are centred on the same key resource.

But despite these potentials for bringing together the three settings, the case also points that there still are many challenges and conflicts between the three settings due to their different logics. For instance, the developing logic promotes a close and exclusive relationship between Loccioni and Whirlpool, whereas a large scale production and the creation of broader and standard user connections would require involving more home appliance producers via open and non-exclusive collaborations around the Leaf House. But this opening would create conflicts between Loccioni and Whirlpool. Moreover, some relationships work well in a developing context, such as the one between Loccioni and Schueco, but need to be changed or even replaced when moving to the producing context. Finally, we have the classical conflicts in terms of acceptable costs and levels of standardization within the three settings. At present, resources have been combined and the three settings have become connected in such a way that allows for high costs in production as a consequence of high adaptation of the solutions produced for individual industrial users who still act as project customers rather than as a mass market for standard products.

A key question that we raised in the introduction of this paper was whether a *marketable eco-sustainable solution* is emerging in relation to the Leaf House project and which features it is assuming as a result of the evolution of the Leaf network. We can now conclude that there are eco-

sustainable solutions deriving from this project which can be currently produced, sold and utilized. These solutions are not however the whole, integrated Leaf House building, but some of its specific components and subsystems (the radiant floor, solar cells, the automation framework etc.). Another feature of these solutions is that, at least in the near future, it is hard to expect a very large scale production and user embedding of these components and subsystems: the path seems to be towards a restricted number of installations of adapted solutions bundled together with other offerings by Loccioni or other vendors and addressed to medium-to-large industrial customers.

Limitations and further research

A first limitation of this study is that we have followed the evolution of the Leaf network only during its first three years (2007-10). Therefore, it is certainly quite soon to draw conclusions on the embedding of a technology which have been created only two years ago, while the innovation journey can easily take one or two decades (van de Ven et al., 1999). A second limitation is that our data is currently centred on one actor in this network, namely Loccioni, the promoter of this project. This focus could entail a bias in our understanding of the structure and dynamics of this network.

In order to overcome both limitations above, we suggest as further research firstly expanding the time span of this study by continuing the investigation of the evolution of this network in the near future. If an embedding in the using setting is happening, it will be easier to analyze it in retrospect in the coming years. Secondly, we suggest taking explicitly the perspective of several actors in this network in order to better capture their goals and hear their views on the innovation process and the network around the Leaf House. This second research avenue would enable to identify both more conflicts and possibilities of connecting the three settings of developing, producing and using.

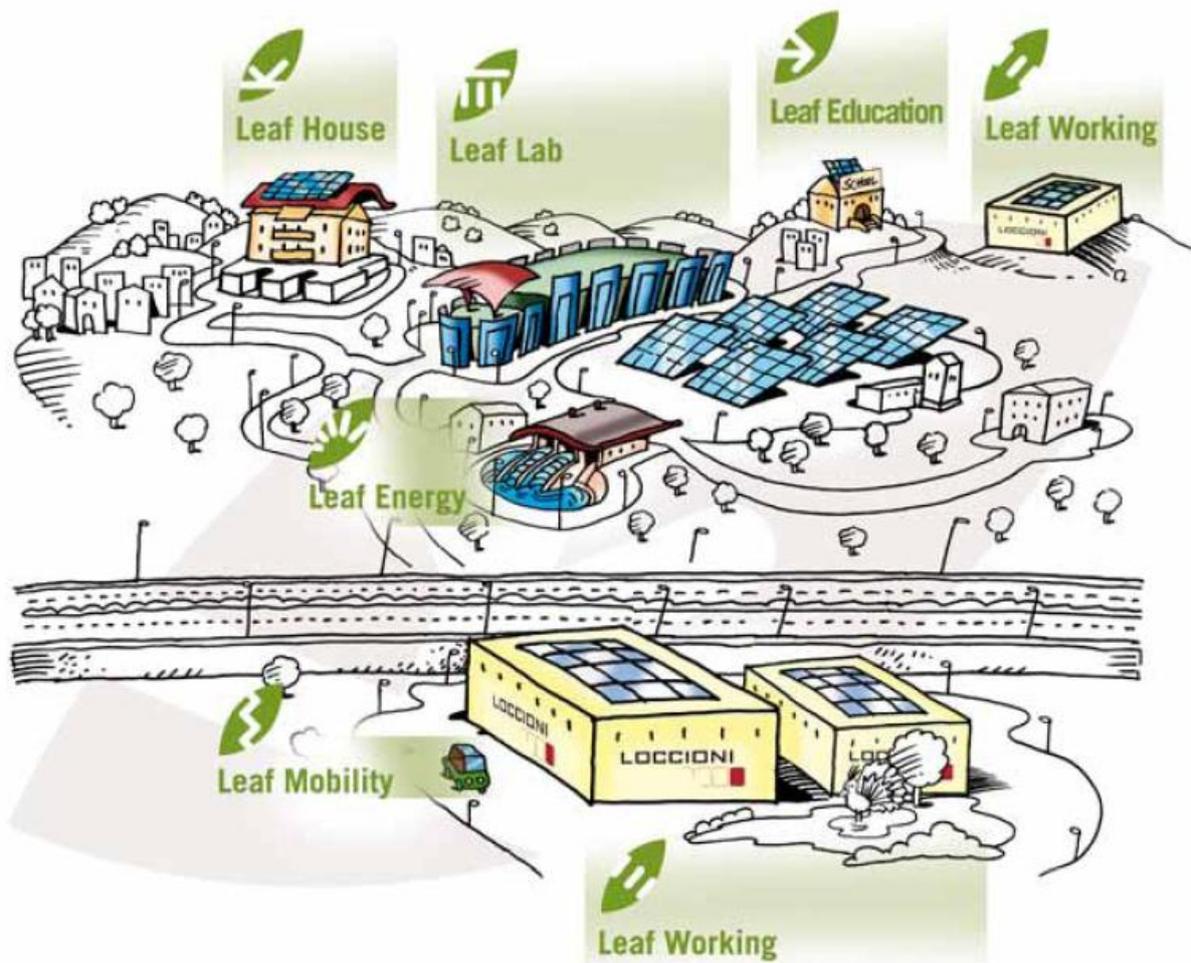
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FIGURES and TABLES

Figure 1: A stylized image over the LEAF Community, with the LEAF House (upper left corner)



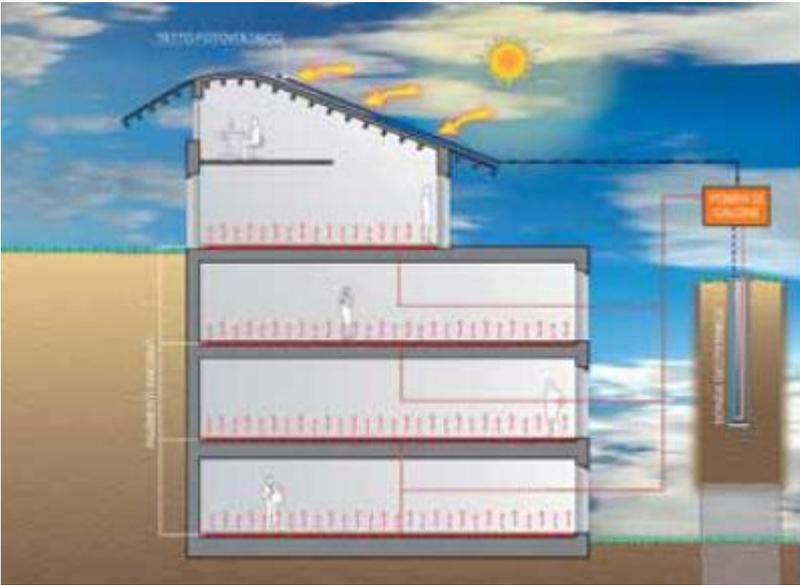
Source: Loccioni's LEAF Community brochure

Figure 2 & 3: A couple of images of the exteriors of the Leaf House



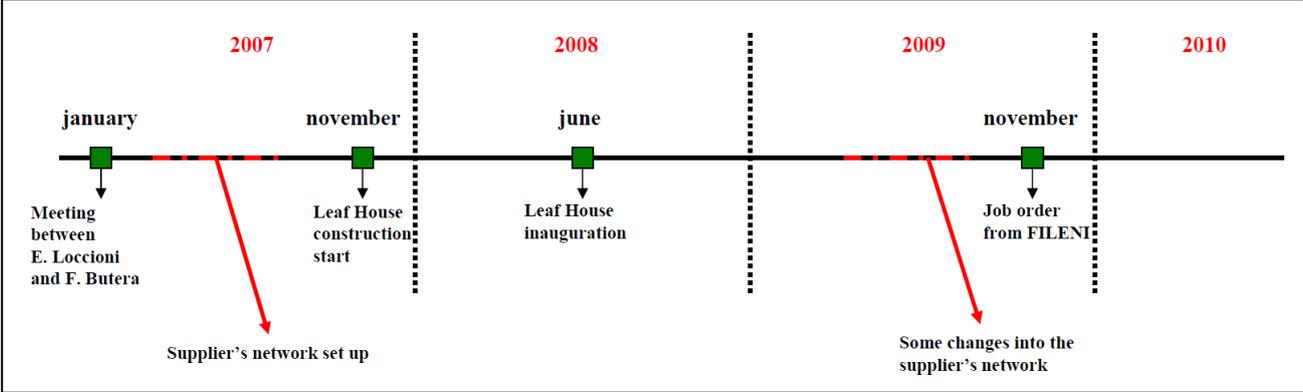
Source: Loccioni's brochure

Figure 4 & 5: The thermal distribution system based on the heating/cooling floor



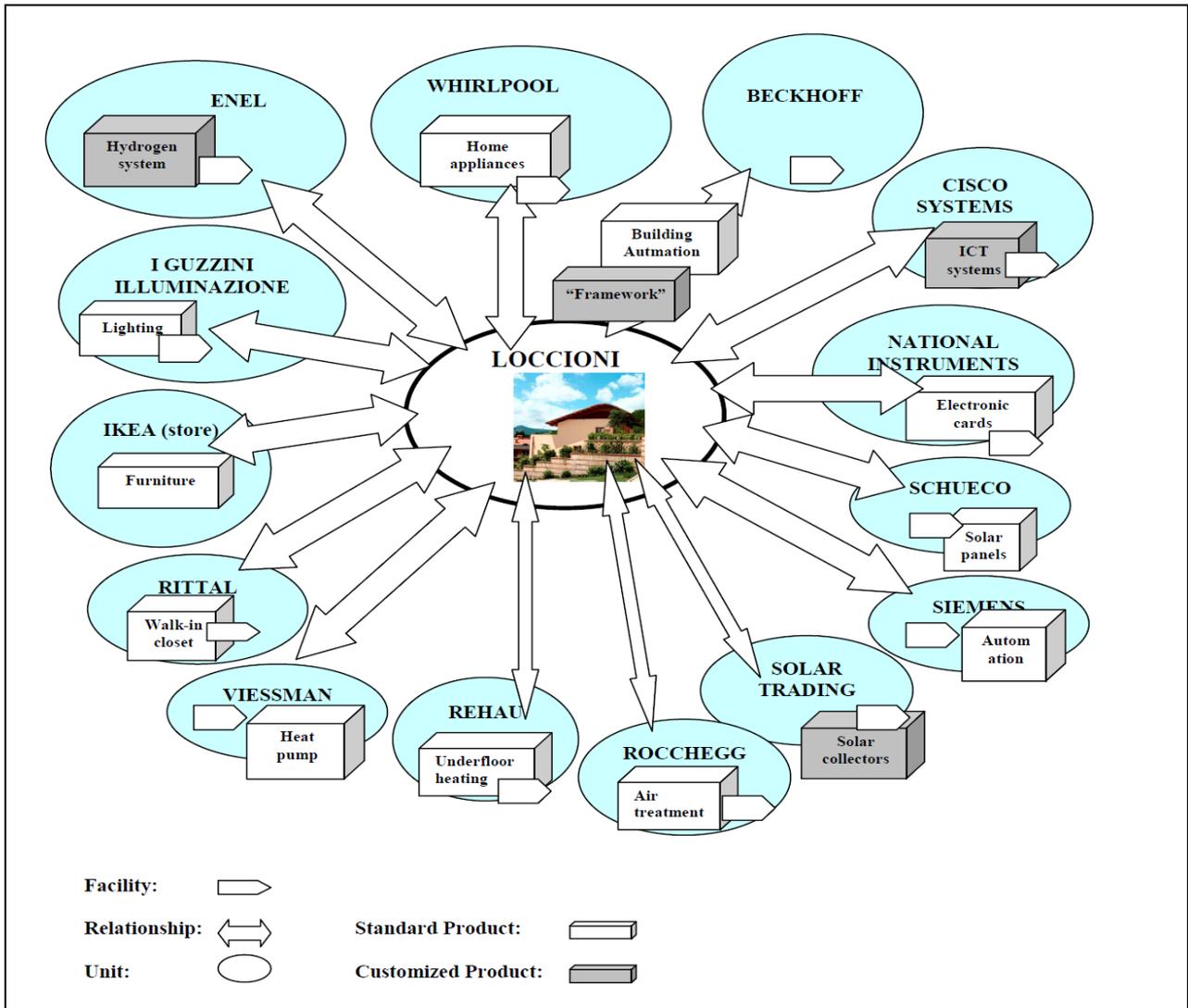
Source: Loccioni's brochure

Figure 6: the Leaf House time line



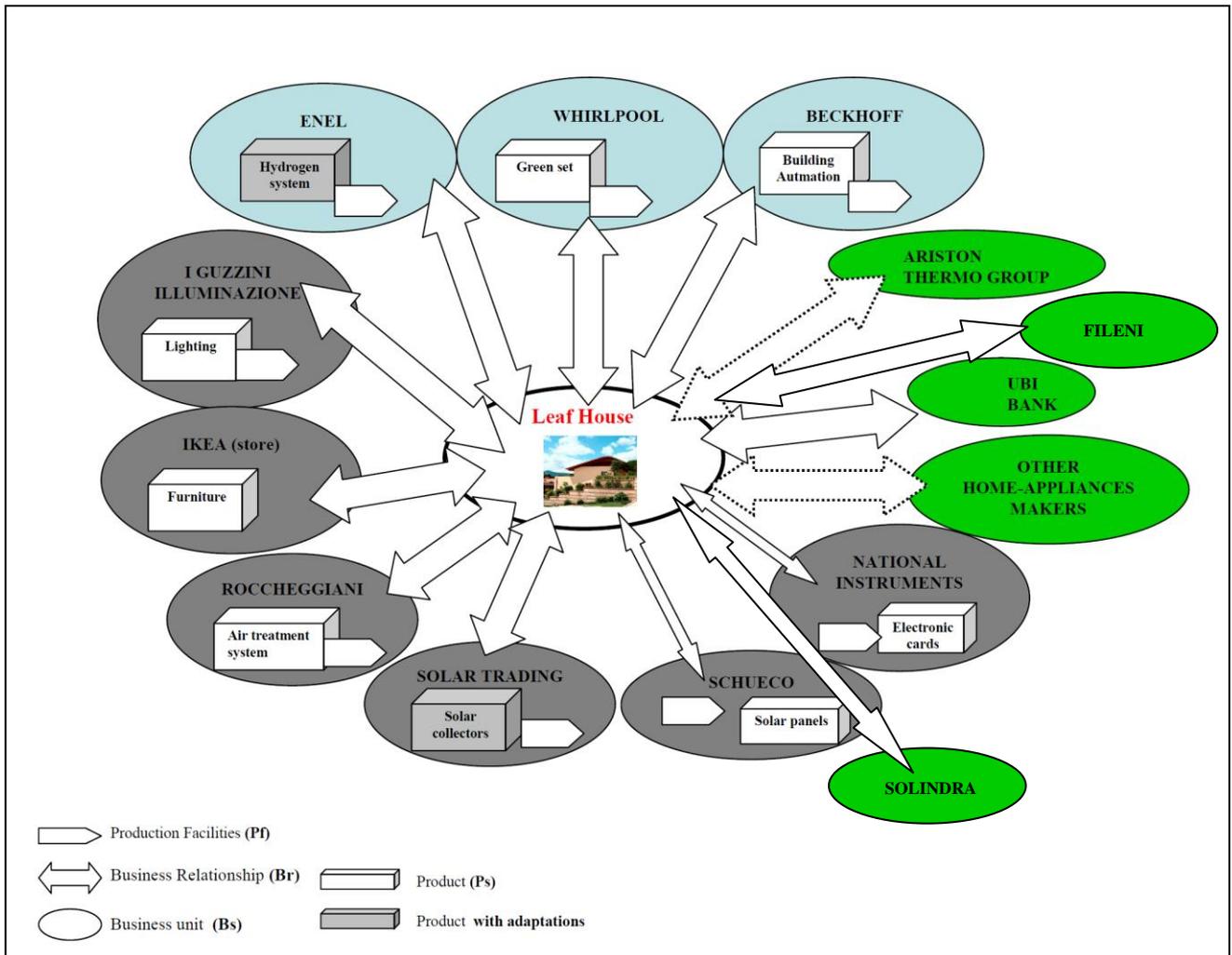
Source: our elaboration on empirical data

Figure 7: the Leaf House suppliers network in the end of 2008



Source: our elaboration on empirical data

Figure 8: the Leaf House network in early 2010



Source: our elaboration on empirical data

Table 1: Selected indicators on the Leaf House

More than 2.000 people visited Leaf House

	Normal/traditional House	Leaf House	NOTE
HEATING DEMAND	100 kwh/m ²	27 kwh/m ²	
COOLING	30 kwh/m ²	20 kwh/m ²	
WATER CONSUMPTION			- 69%
CO2 emissions SKIP OUT			34.080 Kg (would be necessary 3408 trees)
Total costs (per year) of equipment (electricity, water, heating, cooling)	12.254 €	4.563 €	Leaf House makes money (14.967 €)
Money saved			22.658 €

Source: Loccioni's internal documents

Appendix: Data sources

	Role of the interviewees	Company	Interview date	Type	Lenght
1	Marketing office	Loccioni group	05.02.09	DIRECT	About 1 hour
2	Public relation manager	Loccioni group	05.02.09	DIRECT	1 hour
3	Innovation & Environment manager	Enel	20.02.09	Questionnaire/by e-mail	
4	Innovation & Communication manager	Whirlpool	25.02.09	Questionnaire/by e-mail	
5	R&D manager	Loccioni	11.03.2009	DIRECT	1 hour, 15 minutes
6	Marketing office	Loccioni group	11.03.2009	DIRECT	About 1 hour
7	Energy department	Loccioni group	11.03.2009	DIRECT	45 minutes
8	Sales and Communication	Beckhoff	17.03.2009	Questionnaire/by e-mail	
9	Marketing office	Loccioni group	17.03.2009	DIRECT	1 hour
10	IT manager	Loccioni group	17.03.2009	DIRECT	1 hour
11	Marketing office	Loccioni group	12.01.2010	PHONE	30 minutes
12	Public relation manager	Loccioni group	12.01.2010	PHONE	30 minutes
13	Prof. in Environmental Engineering	Politecnico di Milano	21.01.2010	DIRECT	50 minutes
14	Marketing office (energy division)	Loccioni group	17.02.2010	DIRECT	1 hour
15	Marketing office	Loccioni group	17.02.2010	DIRECT	30 minutes
16	Marketing office (energy division)	Loccioni group	17.03.2010	DIRECT	1 hour
17	Marketing office	Loccioni group	17.03.2010	DIRECT	1 hour
18	R&D manager	Loccioni group	17.03.2010	DIRECT	1 hour
19	Marketing office	Loccioni group	18.03.2010	PHONE	30 minutes

Company visits:

- Visit at Loccioni premises, 5-2-2009
- Visit at Loccioni premises, 11-3-2009
- Visit at Loccioni premises, 17-3-2009
- Visit at Loccioni premises, 21-1-2010
- Visit at Loccioni premises, 17-2-2010
- Visit at Loccioni premises, 17-3-2010

Participant observation:

-February-September 2008

Direct participation to the Leaf House project by one of the paper's authors within Loccioni Group and with the functions of communication and marketing manager, as well as development of key contacts with partners.