Green Energy and Technology

Stefano Piraccini
Kristian Fabbri

Building a Passive House

The Architect's Logbook

Springer

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Awards and Recognitions
The *Fiorita Passive House* project has obtained the following recognitions: Pilot building for the European Projects: Passreg (*Intelligent Energy Europe Programme of the European Union*) and SEEDpass (*South East Europe strategic partnership vocational education and training in Passive House Design for nearly zero energy buildings development*); Sustainability special award, XI edition of the prize *IQU-Innovazione* e *Qualità Urbana* (2016).

Contributing to the Realisation of this Book were
Centro InfissiDue srl, CNA Forlì-Cesena, Mitsubishi Electric Europe B.V, Studio Piraccini/Architettura sostenibile a consumo zero, Zero Energy srl.

To Margherita,
without whom this would have been much
more difficult (or even impossible),
and to my daughter who she is carrying.

Stefano Piraccini

Citation

It is possible this Book may fall into the Hands of some Masters of Ships, and honest Mariners, who frequently, by contrary Winds or Tempest, or other Accidents incident to long Voyages, find themselves reduced to great Dissestress, either thro' Scarcity of Provision, or Want of Stores. I say, it may be a Direction to such as those, what Lengths they may venture to go, without violating the Law of Nations, in Case they should meet other Ships at Sea, or be cast on some inhospitable Shore, which should refuse to trade with them for such Things as are absolutely necessary for the Preservation of their Lives, or the Safety of the Ship and Cargo.

Daniel Defoe (1972) A general story of Pyrates, J.M. Dent & Sons, London, UK

Premise

This book is the first person account of the vicissitudes, as well as the design and technical solutions, involved in the construction of the *Fiorita Passive House*: the first Passive House certified multi-residence in wood in the Mediterranean area.

The style, simple and intuitive, describes the problems—*and the solutions*—which may be encountered in various moments of the construction process of Nearly Zero Energy Buildings (NZEB).

In the literature consulted during the planning stage, we found books that give step-by-step explanations of what architectural details to include and how to design them, what problems may arise in the construction site and how to resolve them, which products are more suitable or more economical, which expedients to adopt during construction to ensure the quality of laying, etc. The problems one could encounter are many and varied, but during the process, the authors of this book came to realise that what is lacking is a book that explains what the actual process is comprised of, … what actually can happen, …. in other words, to make a nautical analogy—which is present throughout the book—while you can find books that explain how to navigate, the characteristics that a boat must have or the characteristics of the various ports of call, it is more difficult to find books that explain how to tackle the journey, and so, this book is the tale of a journey, the journey that has led to the construction of a Passive House, and to the discovery—for all the actors involved, designers, construction company, tradesmen—of new territories, of a new way of dealing with the *architectural project*.

The objective is to reveal to the reader just how exciting this voyage is, and just how marvellous the new territories to explore can be.

In a more prosaic way, the project of the *Fiorita Passive House* has undergone a building process that is different from ordinary buildings: in the final construction design, in the role of the designers and collaborators, and other experts in the field, in the training of the tradesmen, in the organisation of the phases of the construction site and in the construction costs.

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Designing a Passive House means establishing a new dialogue—*together with travel, "dialogue" is the other key word of the book*—between composition, technology of the architecture and building physics, different from traditional architecture: dialogue is necessary, putting yourself in a position of reciprocal listening in order to adopt the best solutions, even in the smallest construction detail, combining form and energy efficiency. We have gone from the "bioclimatic" approach—where the physical phenomena are represented with "*little arrows*", the sun that is sad or smiling or other schemes—to modelling with a calculation algorithm able to furnish us with the actual energy performance.

For this reason, this book is the work of two authors—the previously mentioned *dialogue*—from one side, the story of the project coordinator, which constitutes the narrative corpus of the book, the voyage from the inside, and on the other side, *or, more aptly, from alongside*, the support, the clarification of the "*instrumentation*", the thermophysical magnitudes and energy aspects that come into play in the design of a Passive House, as well as the monitoring—*as built*—of the comfort and of the actual thermophysical performance.

Stefano Piraccini and Kristian Fabbri, June 2017.

***

We would like to make some clarifications:

- The Passive House standard relates exclusively to energy efficiency and comfort. The Fiorita Passive House project introduces, with respect to the standard, further verifications that concern the summer season such as the shading and the calculation of the thermal lag. In addition, to aim for sustainability understood in the broadest sense, we have used dry technology, a wooden structure, insulation with mineral or biological origin, recovery of the rainwater and condensation.
- the *Fiorita Passive House* was designed and built using the PHPP Software, version 7 of 2014 (date in which the design began), which indicated a heating load equal to 7 W/m^2 and a cooling load equal to 6 W/m^2. Given this kind of performance, within the building we used for heating and air-conditioning system exclusively a controlled mechanical ventilation system with heat exchanger and post-treatment battery. For the *Passive House Certification*, which took place on 13 January 2017, the PHPP Software, version 9.6A of 2016, was used, which updates the calculation method, especially in the summer season, and indicates a heating load equal to 8 W/m^2 and a cooling load equal to 10 W/m^2.
- once the construction was completed, during the 8 months that passed between the end of the construction and the arrival of the occupants, the monitoring in the site (described in Chap. 10) shows that the building is able to guarantee a temperature of 25°C in the summer and 21°C in the winter, with minimum consumption, and relative humidity around 50%, with absence of the "dry air" phenomenon.

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For academic purposes, Stefano Piraccini is the sole author of Chaps. 1, 2, 3, 4, 5, 7, 8, 9 and 11; Kristian Fabbri is the author of Chaps. 6 and 10.

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Stefano Piraccini and Kristian Fabbri, June 2017.

Personally, I would like to thank Kristian Fabbri for having convinced me to write this book, the tradesmen for their preparation, availability and assiduous collaboration: it is not a common thing to enter into a construction site and perceive the enthusiasm of the many who work there, aware of being an integral part in the realisation of a truly innovative project. To tell the truth, the highest levels of enthusiasm were clocked at 3 in the afternoon, when, from the building opposite the construction site, the owner's live-in nurse, an attractive Moldovan, just over thirty years old, started watering the rose garden. For 20 minutes, the noise of the construction site abated and all the workers, with a forearm resting on the parapet of the scaffolding, enjoyed the spectacle, smoking a cigarette. The ritual was repeated, like

clockwork, every day, with even greater peaks of enthusiasm during the summer season: when the comely young woman adapted to the climatic context, with clothes that were rather skimpy.

Stefano Piraccini

Personally, … hey, why didn't you warn me? I would like to thank those who collaborated in the realisation of the monitoring system, Antea Franceschin and Christian Iasio, and I would like to thank Margherita and Stefano for letting me climb aboard.

Kristian Fabbri

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- *CNA (Confederazione Nazionale dell'Artigianato e della Piccola e Media impresa) Forlì-Cesena*, Via Pelacano no. 29, 47122 Forlì (FC), Italy;
- *Mitsubishi Electric Europe B.V*, Centro Dir. Colleoni, Palazzo Sirio, Ingresso 1 —Viale Colleoni no. 7, 20864 Agrate Brianza (MB), Italy;
- *Studio Piraccini/Architettura a consumo zero,* Via Luigi Carlo Farini no. 90, 47522 Cesena (FC), Italy;
- *Zero Energy srl*, Via Raffaele Cadorna no. 25, 47522 Cesena (FC), Italy.

Contents

Nomenclature

ACPH	Certified Passive House Tradesperson
BEP	Building Energy Performance
BEPS	Building Energy Performance Simulations
BP	Building Physics
CLT	Cross-Laminated Timber
CMV	Controlled Mechanical Ventilation
CO_2	Carbon Dioxide (ppm)
DHW	Domestic Hot Water
EIFS	Exterior Insulation and Finishing System
EPDM	Ethylene-Propylene Diene Monomer
EPS	Expanded PolyStyrene
FSC	Forest Stewardship Council
HVAC	Heating Ventilation and Air-Conditioning
IAQ	Indoor Air Quality
IPHA	International Passive House Association
MVHR	Mechanical Ventilation Heat Recovery
PD	Percent Dissatisfied (%)
PHPP	Passive House Planning Package
ppm	Parts per Million
RH	Relative Humidity
U	Thermal Transmittance (W/m^2K)
VOC	Volatile Organic Compounds (ppm)
WHO	World Health Organization
XPS	Extruded PolyStyrene
YIE	Periodic Thermal Transmittance (W/m^2K)

Chapter 1
An Uphill Trek

In June, every evening after 7:30 when it is cooler, I leave work, put on some comfortable clothes and take a walk. My favourite destination is the hillside that surrounds Cesena, the city in which I live, situated in north-central Italy. In that season, just before twilight: the sun's low rays, the scent of the countryside, the pleasant temperature, all combine to create a relaxing atmosphere, perfect for restoring myself after a day's work. Everything began on one of those evenings in June 2014: I'm walking along Via Garampa, a road that starts from the centre of the city and makes its way through the nearby hills, when I receive a call from Davide, an old friend of mine.

Davide told me about a property belonging to his family, built by his grandfather in the mid-1950s, composed of two shops and two large apartments, which has been on the rental market for several years. My friend was complaining about the low earnings through rent, barely enough to cover the maintenance costs of the entire building:

> I spend too much money in repairs, energy expenses have become unsustainable … the tenants complain because despite having the radiators running at maximum capacity they feel cold in some rooms and too hot in others, … and it's the same in the summer, despite having installed split system air conditioners,

and then he asked me:

> you're an architect, what type of intervention would you suggest?.

In the meantime, having finished the uphill climb of Via Garampa, my voice broken and rather breathless from that effort, I answer:

> "Davide," (deep breath) "you've got to make a Passive House! There's no other solution!".

S. Piraccini and K. Fabbri, *Building a Passive House*, Green Energy and Technology,
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1.1 The House of the Twentieth Century (1950s)

Let's take a step back.

The building that Davide is describing to me is located in a residential district of the city of Cesena, in an urbanised area dating from the years 1950–1970. It is a multi-storey brick building. The building has been subject to constant upkeep throughout the years with many small, specific interventions: a new coat of plaster here, a door frame replaced there, a gutter repaired above, an infiltration fixed below, wall painting to cover blackish stains that appeared on the inner side of the perimeter walls, the installation of air conditioners for cooling during the summer, the installation of a few frames with double glazing and a new boiler in the desperate attempt to reduce fuel consumption.

Despite these minor interventions, problems have continued to crop up in the building, such as the formation of moulds, water infiltration and, above all, astronomical bills for climate control.

However, Davide's building is neither better nor worse than other buildings built in those same years.

The 1950s and 1960s are characterised by a period of vigorous economic recovery and technological development. The boom would primarily involve the countries that participated in the conflict, such as the USA, Europe and Japan. The 1950s and 1960s are, for Italy, the period of the economic boom. It is in this decade that Italy makes the move from being a predominantly agricultural country to becoming an industrialised nation. They are years characterised by robust renewal followed by the increase of international trade, by the exchange of technology and the need to rebuild a modern country from the ashes of the war. The favourable moment carries with it an exponential growth in the construction industry, increasing the demand for accommodation in the city by the new masses of workers, merchants, labourers, new entrepreneurs, etc., accompanied by the progressive abandonment of the countryside, where farming represents a legacy of the past, far from the new lifestyle which demands a prevailing modernity.

Armando, Davide's grandfather, together with his family, had abandoned agricultural activity and the rural house in which he lived since his childhood for a move to the city in the search for better living conditions. Here, he used his savings in the construction of a new building for his family to settle in (the building that is the subject of this book), composed of two large apartments on the first and second floors and two shops on the ground floor. Armando and his wife sought to build a modern and functional building equipped with the best technologies of the era, such as heating, hot sanitary water and the bathroom in the house: a new frontier of progress now within the reach of many pockets.

Armando (finally) could forget about worrying himself with the supply of wood, and in spite of it, still waking up to the cold. He could now take as many hot baths as he wanted to, at long last getting rid, once and for all, of that annoying smell of soot that impregnates the clothes of the country dweller, differentiating him from the pleasant scent of the man of the city.

The building constructed in Via Ariosto 250 in Cesena has a structure in load-bearing masonry, a building envelope in brick, completely devoid of thermal insulation, wooden window frames with single glass panes, cornices and some terraces in reinforced concrete and, above all, a brand new boiler that pumps hot water in the showers and within the radiators. This is a building similar to many buildings built in that period throughout Italy, and it is not even very different from those built in other contexts. The economic boom, due also to the financing of the Marshall Plan and the policies for achieving, in a short time, a home for everyone, led to the diffusion of large residential districts composed of buildings made with standardised construction techniques that employed the materials of industrial production: these "new" buildings rely on the heating system for the fulfilment of any requirements related to comfort.

Before this new age, most rural dwellings were heated with wood-burning fireplaces, in other words, they guaranteed levels of comfort limited only to the hearth, through a progressive functional optimisation of their form and the use of local materials. Therefore, they had adapted to the climatic context by means of expedients for containing the heat internally and exploiting the heat produced by solar radiation and by the body heat of the persons and animals living within the walls. From the moment in which it became possible to install a heating system in each new home, relationships between construction and the climatic context were considered as nothing more than a tribal legacy.

In this regard Victor Olgyay, the father of bioclimatic design, has said (Fig. 1.1):

Fig. 1.1 Building owned by the Zoffoli family, subject of the intervention

> Despite the diversity of these contrasting community layouts, they have something in common: all of them have marked regional characteristics, strong statements that are a clear answer to their respective climatic demands. (Olgyay 1963, p. 9)

1.2 The House of the Nineteenth Century

Like many "modern" buildings built in the same period, the house in Via Ariosto has no relation to the climatic context in which it is located: its morphology is not a function of a correct orientation, it does not have systems to favour natural ventilation, the thin walls dissipate heat during the winter months and do not help to counteract overheating in the summer, there is no shielding for protection from the direct solar rays during the summer, nor to take advantage of their heat during the winter.

The lack of a relationship between the building and the climatic context has been replaced by the presence of a gas-fired boiler for heating and hot sanitary water. In this way, comfort levels were satisfied that for the time appeared to be high.

In some respects, the house that Armando built in Via Ariosto is the opposite of the rural house where he grew up, which he had abandoned in the move to the city. We are considering the rural house as a traditional typology developed through a slow, but progressive, adaptation to the climatic context. It was built by optimising the utilisation of the heat produced by the available energy resources (sun, people, animals, firewood) and keeping as much heat as possible within the walls. According to Jean Dollfus, author who has catalogued traditional houses in every corner of the world, the shapes of the dwellings are mainly defined by the environmental context in which they are located, and by elements which relate to taste and culture. Dollfus in this regard writes:

> the proportion of solid surfaces to openings in the exterior façades depends as much on popular psychology as on the climate and the material used. In the zones of extreme temperature, for inverse reasons to safeguard against the sun or the cold, the walls are pierced only in a small proportion of their surface. And in general, rural interiors are much more stingy of air and light than those of the towns. … In northwest Europe the shade of urban streets sets the demand for more illumination, and it is in those gabled houses that windows attain their greatest development. (Dollfus 1954, cited in Olgyay 1963, p. 7)

The rural house where Armando grew up is classified (since it still exists) as a "*Cesena-Rimini*" vernacular house, inhabited by an extended family of three generations, typical of the agricultural settlements of the plains and hills of the geographical region of Romagna, in north-central Italy, with the Adriatic Sea to the east and the Apennine mountains to the south-west. Armando's rural house is a masonry building, distributed on two floors, with a pitched roof and a large portico.

Luigi Gambi, in *La casa rurale in Romagna* (Gambi 1950), introduces the classification of the traditional types of this region and describes their development in the scattered settlements, starting from the isolated houses in the rural plain

following the Roman centuriations (185–180 B.C.). The information, described by Gambi, is the result of extensive documentation obtained thanks to archaeological excavations. The centuriation is still visible today, since a large part of the territory is defined by a network of traces and orthogonal roads that comprise squares measuring 715 m per side. In the sources cited by Gambi, significant data emerges: the census of Anglic of 1371 testifies the presence in the plains of isolated houses built in masonry, while the characteristic of the portico has been documented since 1481, in a notarial deed of the nearby city of Rimini. To have some documentation of layouts or elevations, we must wait until the middle of the eighth century, where more precise evidence can be found in the land registers of the period of the Enlightenment. Lastly, to have an in-depth understanding of how the rural house has evolved; it is possible to study some ecclesiastical or nobiliary inventories of the second half of the fourth century, where there are perspective drawings and watercolours that give an accurate description of the construction materials.

The "*Cesena-Rimini*" vernacular house appears to be the result of a very lengthy process of technical and formal refining, with the purpose of optimising:

1. the use of local materials for its construction, for example, clay, lime, sand and wood;
2. the distribution of the spaces in relation to the agricultural culture and lifestyle of the time;
3. the adaptation to the regional climatic context in order to generate the best comfort level possible in all seasons.

The "*Cesena-Rimini*" vernacular house is oriented with the main elevation to the south to better take advantage of the sun as a source of heat. The walls, with a thickness greater than 50 cm, allow the staggering of the heat from solar radiation over time, so as to "release it" during the night hours. In the same way, the heat generated during the day, thanks to the fireplace or the hearth, is maintained within the building for the entire day. On the north face, which always remains cold because it is not heated by the sun, there are small openings (windows) that are rarely opened, so as to limit the dispersion of heat.

The ground floor is intended for housing animals: in this way, the heat produced by their bodies rises upwards, contributing to greater comfort in the rooms on the first floor that are used as living space. The large portico has the function of regulating solar radiation by creating a cool and shady place to work and restore one's strength.

The "*Cesena-Rimini*" vernacular house, in the same way as many examples of vernacular architecture, such as the *trulli* in Puglia, the *masi* of the Alps or the *Baraccas* of western Sardinia, are an intelligent example of bioclimatic architecture that combines compatibility with the environment, low management costs, comfort (in relation to the cultural context of the time) and sustainable use of energy and environmental resources (Fig. 1.2).

Fig. 1.2 *Cesena-Rimini* vernacular house

1.3 The Chickens Come Home to Roost

Victor Olgyay, in 1963, warned us with these words:

> The spread of populations and modern communications have accelerated the age-old interchange of ideas and technological effects. We must realize, however, that the wide dissemination of Western forms should proceed with caution. These forms evolved from the challenge of cool climates, and can pose grave problems when adopted as undigested and inappropriate symbols of cultural progress. (Olgyay 1963, p. 21)

So, was Davide's grandfather Armando wrong in abandoning his rural house: a building so skilfully built?

Absolutely not! Who would prefer living in a building where it is necessary to heat pots of water on the hearth every time one takes a bath, or waking up one morning in winter with the contents of the chamber pot literally frozen, if on the other hand, we have heating and water and showers that are always hot?

In fact, come to think of it, given that the mid-1950s was an historic moment where technology was able to provide most of the houses with a system for heating and the production of sanitary hot water, it would have seemed useless to worry about issues relating to energy savings, environmental impact or the search for even greater comfort.

For starters, it took another war, more precisely the Arab-Israeli war during Yom Kippur that led to the oil crisis of 1973 and the decision of the Arab members of OPEC (Organization of the Petroleum Exporting Countries), to interrupt the supply of oil to countries that supported Israel, such as the USA and all of its allies. The effects of the embargo had a devastating impact in all countries that were dependent on oil, primarily Europe and Japan, where emergency measures were launched that had strong repercussions on the economic and cultural levels. In Italy, for example, with the increase in the prices of oil products, the government introduced substantial austerity policies that brought about restrictions on the use of heating and electricity. Public lighting was halved, including Christmas decorations, while the shops had to shorten their opening hours. There was to be an early closing of cinemas, bars and nightclubs, and even the national television network was forced to end its programming schedule before the usual time.

Starting on 2 December 1973, a total blockade of private traffic during Sundays and holidays was imposed throughout Italy. It had been estimated, in fact, that only one day of suspension of the use of private cars entails a saving of 50 million litres of petrol.

Today we know that we have to pollute less, we know that we need to reduce the consumption of non-renewable energy sources, we also know that we must review our development model so as to preserve the environmental resources for future generations.

The energy requirements of our buildings, whether residential or commercial, for air conditioning in the summer and heating in the winter as well as for the production of sanitary hot water, account for approximately 40% of the energy produced in the entire European Union (Directive 2002/91/EC and Directive 2010/31/EU). The same is true for the building of Via Ariosto that today appears to us as energy intensive and obsolete.

Moreover, in 2016, alongside the problem of fuel consumption in Italy for heating is the progressive request for summer cooling in buildings, so as to obtain greater comfort. Following the summer of 2003, when high temperatures and excessive humidity caused numerous deaths, especially among older people, there has been an upsurge in the sales of split-systems for cooling.

Furthermore, the majority of buildings use non-renewable energy sources whose emissions increase the emission of greenhouse gases, carbon dioxide and particulate matter.

Apparently, a change of course is necessary, and this is what Directive 2010/31/EU calls for, wherein an ambitious objective is set: from 2020 new buildings should be Nearly Zero Energy Buildings (NZEB). What Europe asks of us (and, to some extent, of our conscience) must happen "tomorrow"; the year 2020 is upon us, but then: *from where we can begin to build a near zero energy consumption building?*

1.4 The House of the Nineteenth Century

In order to answer the question of the previous paragraph, in this chapter, we provide a brief overview of the buildings of the last century. We have seen how the "*Cesena-Rimini*" vernacular rural house of Davide's grandfather Armando has been refined over time by adapting its shape and use to the best local materials in relation to the climatic context, so as to obtain the maximum level of comfort possible at the time, a level which has progressively increased, making the dwelling obsolete.

We have seen how Armando, in the post-war period, in a particularly favourable moment of economic and technological growth, chose a house with a new heating system, which would have resolved any problem related to comfort. His new house in the city, built in Via Ariosto, equipped with a heating system, turns the factors of orientation, solar radiation, the characteristics of walls and windows into irrelevant ones.

The house in Via Ariosto, today owned by Davide and his brothers, despite being well-equipped with the systems of the time, is a perfect example of a building with low energy efficiency: it has relatively thin walls, there is no thermal insulation, its cornices, terraces and niches create thermal bridges, there are draughts everywhere, the heat of the sun is not taken advantage of in the winter and neither is the shade in the summer and so forth. In addition, the windows are placed on the faces of the building without taking into consideration exposition to solar radiation. Moreover, in 1989 a loggia placed on the south side of the building was closed with the intention of turning the space into a new bedroom. The closure was carried out using a system of sliding doors where the absence of an effective obscuration system caused serious problems of overheating in the summer. Added to this is the fact that the window frames, substituted in the last decade, with poor energy performance, have increased the dispersions of the building envelope and consequently the energetic costs for air conditioning.

In summary: the heat produced by the heating system escapes from the building as if the building were a sieve, the same is true for the cooling system. Unlike the buildings constructed in the post-war period, the normative evolution that began in the 1970s, continuing in the twenty-first century, has introduced on the market buildings with a greater attention to energy consumption.

So the building of Via Ariosto became obsolete even compared to buildings built at the end of the twentieth century that at least have a layer of thermal insulation and more efficient heating systems. Attention to energy efficiency demonstrates a clear change of tendency in the construction market.

Directive 2002/91/EC, transposed in Italy in 2005, introduced a requirement in the event of new construction, sale or rental of buildings: the drawing up of the Energy Performance Certificate (EPC). In this way, the real estate sector has a tool for evaluating the energy costs of a building.

Davide's tenants have often complained, saying:

It's not worth paying low rent for an old building, because then I am going to have to pay high bills for heating and air conditioning: I'd be paying higher rent in a new building, but the energy costs would be lower and my comfort would be much greater.

And that is why I told Davide that:

there is only one solution: you have to intervene on the property to make it more energy efficient and improve the comfort level, so as to obtain a greater appeal on the market.

At this point, given the only direction possible: "*Why not reach the maximum possible objective: a building with near zero energy consumption*?"

In order to obtain the objective, it is necessary to focus on six elements:

1. relying on a serious and sufficiently tested design protocol, capable of guaranteeing the result in energetic terms and able to meet the needs of the project owner;
2. recovery of the bioclimatic attention of the "*Cesena-Rimini*" vernacular house with its exploitation of passive energy resources (remember how it made use of the heat of the animals and the sun?);
3. using everything that technological innovation has produced in terms of building materials to produce an efficient building envelope;
4. relying on technical physics during the design phase to obtain control of the actual energetic behaviour of the building;
5. protecting the thermal bridges and reducing draughts to avoid energy losses;
6. using as few systems as possible and among them, only the most efficient ones.

This is what (**That's all folks!**), more or less, went through my head in that uphill trek along Via Garampa when, with a broken and breathless voice I said (Fig. 1.3):

Dear David, you've got to make a Passive House! There's no other solution!.

Fig. 1.3 Old and new building in comparison

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Chapter 2
Is the Passive House Right for Us? (Follow the Money)

Davide seemed excited by my proposal, so we agreed to meet the following week to discuss it. Once back at the desk in my studio, I organised my thoughts about my skills:

- I have already constructed buildings with good energy efficiency;
- I have adopted construction solutions for protecting the thermal bridges;
- I have used the design solutions of bioclimatic architecture;
- I have studied the general criteria of passive buildings in the preparation of my lessons at the University (where I teach Architectural Final Construction Design for energy efficiency);
- I have read quite a few books on the topic, finding mostly theoretical concepts and practical applications that are partial and not all-encompassing.

Even if I did not feel as if the task was totally beyond my capacity, I've never actually built a Passive House, though it's always been my wish to do so. An excellent opportunity fell into my lap, but I was lacking what anthropologists call "*field experience*".

The anthropologist Bronislaw Malinowski writes about field experience:

> It would be easy to quote works of high repute, and with a scientific hall-mark on them, in which wholesale generalisations are laid down before us, and we are not informed at all by what actual experiences the writers have reached their conclusion. No special chapter or paragraph is devoted to describing to us the conditions under which observations were made and information collected. I consider that only such ethnographic sources are of unquestionable scientific value, in which we can clearly draw the line between, on the one hand, the results of direct observation and of native statements and interpretations, and on the other, the inferences of the author, based on his common sense and psychological insight. (Malinowski 1922, p. 11)

There were many things that I still did not know and many questions still ran through my mind without finding an answer. I took a deep breath and thought "this will be my field experience". I know I can do it: all I need to do is avoid the traps hidden in the thick of the jungle and dodge any poisoned arrows.

I stopped daydreaming and began to concentrate on the main objective of every architect: satisfying the client.

S. Piraccini and K. Fabbri, *Building a Passive House*, Green Energy and Technology,
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How much time is saved and therefore how much money, if a building is built in brick? *Is there any way of knowing*? One can only make rough estimates. Should the work be done with a truck-mounted crane or with a tower crane? Should all the curing times be calculated? How long does it take for the client to make his or her choices, because the mason has to fit the wiring and tubes in the wall while that isn't necessary with wood? And if it rains? And even more difficult: how much have you saved in terms of bank interest through reducing the time by one month and how much more have you spent building a wooden slab rather than a concrete and masonry flooring system? How much more is spent building a Passive House compared to a building with energy performance standards regulated by law? One would have to make an economic analysis of the specifications, minus all the costs of the extra thickness of insulating, obtain estimates from several companies in order to arrive at the correct price, divide some all-encompassing items to subtract the elements relevant to the protection of the thermal bridges, etc.

Transforming the specifications in a detailed economic analysis of the intervention is equivalent to writing an encyclopedia: the focus of this book is the Passive House, the technology, the construction site and so forth.

This is a "logbook" of the professional activity, the approach is operational and aimed at optimising the times and choices for the construction of a Passive House. In regards to the economic aspects, I reasoned that the construction times of technologies in wood are usually lower than those in concrete and masonry, so I enquired with the undertakings which gave me estimates and construction schedules, confirming my hypothesis.

In this chapter, I discuss all the preliminary evaluations that I have made before beginning the planning for the construction of a Passive House capable of achieving Davide's objective: increasing the number of real estate units, framing the building intervention in renovation in order to obtain tax incentives, finding the right technology to build a passive building that would keep the thickness of the walls to a minimum in order to gain useable and commercial surface area.

Davide's objective was primarily increasing the income received from the old building in Via Ariosto. In the current state, the building is composed of two apartments and two shops, all of them on the rental market.

The new project must therefore meet such a requirement by creating apartments with nearly zero energy consumption and high standards in terms of comfort, all of it ensuring the economic sustainability of intervention so that, figures in hand, would make it worth the effort. *But what is the relationship between zero energy consumption and the increase in income from rent?* The tenants of the old building in Via Ariosto complained about energy costs that were simply too high. Davide was forced to reduce the rent to avoid a mass migration of his tenants towards newer and more energy-efficient apartments. Apartments with near zero energy consumption and high comfort levels would have justified higher rents for Davide and meant high appeal on the market, given that, at least as far as Italy is concerned, it would be the first building of its kind.

To increase the income, the new project must be based on the following strategies:

1. increasing the number of real estate units compared to the existing property: with more apartments, there is an increase in the income from rents;
2. obtaining the tax incentive provided by Italian law for the interventions of building renovation and retrofitting;
3. individuating a construction technology capable of reducing the thickness of the external walls, so as to increase the usable area;
4. reducing construction time, thus limiting the interest on loans requested from banks and accelerating the generation of income from the property;
5. building a Passive House standard building so as to place on the market buildings with near zero energy costs and high levels of indoor comfort;
6. seeking to combine sustainable economics and environmental sustainability.

2.1 Increasing the Number of Real Estate Units

The building in Via Ariosto has to be demolished to allow for the reconstruction of a new building composed of 8 apartments, the maximum permitted by the regulations of the Municipality of Cesena (FC—Italy).

The new building should produce greater income, and the increase of the real estate units plays in our favour: at the same location and with the same construction quality, the sum of the rents of two small apartments measuring 50 m^2 is greater than the rent of one apartment with an area of 100 m^2. To determine the most convenient size for new apartments and to make an estimate of adequate rents, we have availed of consultants in the real estate market, data banks made available by the Revenue Agency and real estate agents located in the territory. This method allowed us to verify the rental cost of newly built apartments of the same type that are located in the vicinity.

The rental market was showing a robust demand for real estate of small/medium dimensions (studio apartments, two-room and three-room apartments) compatible with the maximum number of eight apartments that local laws allowed us to build.

The preliminary project thus provides apartments that are different from one other, with medium/small dimensions that respond to market demands. The types, studio apartments and two-room and three-room apartments, on the one hand, guarantee diversification of the commercial offer, and on the other hand, they aim at social sustainability by ensuring access to many categories: singles, students, couples without children, families with children and so forth.

In order to evaluate whether this would be the right strategy, we need to make a rough economic evaluation, comparing the assumed rents of the new project with those received from the old building.

The overall income received by the monthly rents of the old building amounted to € 2560, divided as shown in Table 2.1.

The rents were rather low, the reason being that the property had not aged well and, especially, it was due to the high energy costs that on many occasions the tenants were deprived of the money needed to pay the rent.