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HANDBOOK
for Green Housing and Healthy Living

SPONSORED BY THE

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FONA
Research for Sustainability

HANDBOOK
for Green Housing and Healthy Living

PUBLISHED THROUGH THE
Competence Centre for Sustainable Building in Vietnam (CCSB-VN), Hanoi University of Civil Engineering (HUCE)

This handbook was developed under the framework of the project "Climate-adapted Material Research for the Socio-economic Context in Vietnam" (CAMaRSEC), funded by the German Ministry of Education and Research (BMBF) and managed by the CAMaRSEC sub-project 2 team from the Department of Human Geography at the University of Hamburg.

The content is contributed by authors from the Academy for Territorial Development in the Leibniz Association (ARL), Baubildung Sachsen e. V., Fraunhofer Institute of Building Physics, MienTrung University of Civil Engineering, the University of Stuttgart, the University of Hamburg, Hanoi University of Civil Engineering, Keep Vietnam Clean, Ton Duc Thang University, Vietnam Institute of Building Materials and Vietnam Green Building Council.

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HANDBOOK
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Abbreviations

AAC	Autoclaved Aerated Concrete
AC	Air Conditioning
AC	Alternating Current
BMU	Building Maintenance Unit
CFLs	Compact Fluorescent Lights
cm	Centimeter
CUWC	College of Urban Works Construction in Hanoi
CVET	Continuing Vocational Education and Training
DC	Direct Current
EIFS	Exterior Insulation and Finish System
ETICS	External Thermal Insulation Systems
GB	Green Building
HVAC	Heating, Ventilation and Air Conditioning
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
IVET	Initial Vocational Education and Training
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
Low-e	Low-emittance
m	Meter
NBS	Nature-Based Solutions
OTTV	Overall Thermal Transfer Value
PMP	Preventative Maintenance Plan
PV	Photovoltaic
SHGC	Solar Heat Gain Coefficient
USGBC	United States Green Building Council
VGBC	Vietnam Green Building Council
VLT	Visual Light Transmittance
VOC	Volatile Organic Compound
WFR	Window to Floor area Ratio
WHO	World Health Organization
WWR	Window to Wall Ratio

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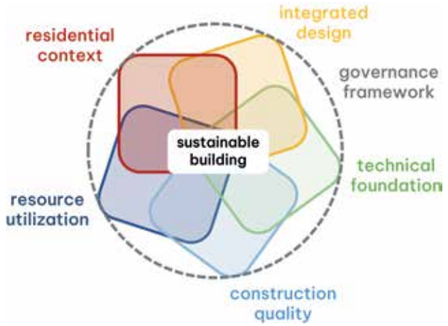
INTRODUCTION

01

ABOUT
CAMaRSEC Project



CAMaRSEC

The collaborative project "Climate-Adapted Material-Research for the Socio-Economic Context of Vietnam" (CAMaRSEC) promotes sustainable construction practice in Vietnam based on interdisciplinary problem analysis and fundamental research and through the strategic development of basic infrastructures for research, characterization, training and education.

CAMaRSEC approaches sustainable building from five aspects of new residential buildings' lifecycle: 1) residential context, 2) integrated design, 3) technical foundation, 4) construction quality and 5) resource utilization. The comprehensive inclusion of all these aspects will ensure an effective governance framework for sustainable building in Vietnam.

CAMaRSEC led by Stuttgart University is funded by the German Federal Ministry of Education and Research (BMBF) in the context of the CLIENT II initiative on "International Partnerships for Sustainable Innovations", implemented in four years from 01.07.2019 to 31.08.2023 with a total funding volume of about 2 million €.

Finally, the CAMaRSEC sub-project of Hamburg University has initiated the foundation of the Competence Centre for Sustainable Building in Vietnam (CCSB-VN) based at Hanoi University of Civil Engineering. CCSB-VN meant as a cross-cutting institution, will bundle trans-disciplinary expertise of sustainable building knowledge in Vietnam and transfer this innovative knowledge to diverse areas of scientific application, as well as to the public. The overall vision is to develop CCSB-VN as Vietnam's leading think- and do tank in terms of sustainable building.

The first major publication of CCSB-VN is the present Handbook for Green Housing and Healthy Living.

CCSB Việt Nam — Đại học Xây dựng

Universität Stuttgart · Universität Hamburg · Fraunhofer · BAU Bildung · VIBM · TDT · CUWC · NETZSCH

ABOUT
Green Housing and Healthy Living

Out of the three sectors mostly contributing to the energy consumption and greenhouse gas emissions in Vietnam (i.e., industry, transport and construction), construction is largely involved in the daily life of the ordinary Vietnamese people. Currently, people, particularly the urban population of Vietnam's metropolis, are experiencing a significant improvement in their living standards. New values are formed, and life concepts with new aspirations and new possibilities are set into place. The danger is that issues of sustainability and long-term benefits crucial for society and mankind have been somehow neglected in this process.

Against this backdrop, the Handbook for Green Housing and Healthy Living has been developed with the support of the German Government-funded CAMaRSEC project. Trying to impart concepts and practices of sustainable housing and health to the public, the Handbook aims to apply a "non-expert" and "easy-to-understand" language, adequate visual effects, and user-friendly design. The Handbook's main target groups are the rapidly developing urban middle classes (the so-called "new consumers") with their sharply rising ecological footprint, agencies of government at all levels, businesses, especially companies in the construction industry, architects, teachers, students, and all others interested in green housing and healthy living. The content follows a multi-disciplinary holistic approach, providing practical guidelines for planning, designing, constructing, operating, and maintaining sustainable housing and behavioral dimensions to improve energy efficiency and healthy living. While the book content might focus on the most rapidly developed housing typology in Vietnam, high-rise residential buildings, the principles and solutions introduced are applicable to all other types of housing in Vietnam.

The chapters of the Handbook for Green Housing and Healthy Living have been mainly written by the CAMaRSEC project partners and other experienced experts in the relevant fields. Its content has been developed by a research team from Hamburg University in collaboration with Hanoi University of Civil Engineering (HUCE). The publisher of the Handbook is the Competence Centre for Sustainable Building in Vietnam (CCSB-VN) based on HUCE campus, a newly founded cross-cutting institution that bundles trans-disciplinary expertise of sustainable building knowledge in Vietnam.

While working on the edition of the Handbook, we received feedback from many specialists in both Vietnam and abroad at the meetings and conferences. Outstanding contributors include Mr. Nguyen Cong Thinh - Deputy General Director of Department of Science, Technology and Environment (Ministry of Construction), Prof. Dr. Sc. Pham Ngoc Dang - Former General Secretary of the State Council for Professorship and Former Rector of Hanoi University of Civil Engineering, Ms. Pham Thu Hang - Chairperson of Vietnam Green Building Council (VGBC) Executive Board, Prof. Dr.-Ing. Sabine Baumgart, and many others.

Despite every effort we have made so far, the Handbook for Green Housing and Healthy Living may still have some shortcomings. We are grateful for your opinions so that this publication can become more valid.

All the feedback should be directed to the Competence Centre for Sustainable Building in Vietnam (CCSB-VN), email: ccsbvn@huce.edu.vn.

The Managing Editors

(Michael Waibel) (Nguyen Thi Thu Thuy) (Nguyen Quang Minh) (Pham Thi Hai Ha)

Source: Michael Waibel

Assoc. Prof. Dr.
Nguyen Hoang Giang
–
Vice Rector
Hanoi University of Civil Engineering

Assoc. Prof. Dr. Nguyen Hoang Giang obtained Bachelor at Hanoi University of Civil Engineering - HUCE (Vietnam) in 2003 and PhD at Saitama University (Japan) in 2007. He has been working at HUCE since 2007 and now he is the Vice Rector of HUCE.

He has also been a Member of The State Council for Professorship (Civil Engineering and Architecture Inter-disciplinary Council) since 2020 and Deputy Editor of Journal of Science and Technology in Civil Engineering (STCE).

He is author and co-author of more than 30 publications of journals and international conferences.

ENDORSEMENT FROM

Hanoi University of Civil Engineering

Dear Readers,

In the era of globalization in economy and internationalization in higher education, cooperation, particularly in research, plays a very important role. Actually, it is a dynamo for the development of any university in Vietnam, when we regard integration into the regional and global university networks as a bold step to take. Over the years, Hanoi University of Civil Engineering has developed a large number of research projects with numerous partner institutions worldwide, of which those from Germany are highly appreciated for the quality and innovation of research.

Starting in July 2019 and funded by the German Federal Ministry of Education and Research (BMBF), CAMaRSEC has been a key research program here at Hanoi University of Civil Engineering, focusing on the use of ecological materials and the efficiency of energy for high-rise apartment buildings in Vietnamese socio-economic context. Our staff who have participated in this joint project from the beginning are all specialists in their own fields. This time we have a very good opportunity to work closely with German partners (University of Hamburg, University of Stuttgart, Fraunhofer Institute, Baubildung Sachsen, Taurus Instruments AG) along with Vietnamese colleagues from Ton Duc Thang University, Vietnam Institute of Building Materials, College of Urban Works Construction and MienTrung University of Civil Engineering.

As a result of such a fruitful collaboration, the "Handbook for Green Housing and Healthy Living" has now been published which aims to provide a basic knowledge of how to make buildings greener and then to suggest simple-but-efficient solutions along with a number of hints and tips for the public in general. The content covers a wide range of green building aspects, from site planning through floor layout and building envelope to dealing with and recycling waste, accordingly presented in 13 chapters intentionally put in order. Each chapter consists of five main sections: rationale, benefits, principles, solutions, and hints and tips. For a better understanding, many well-selected pictures and diagrams have been included, wherever appropriate. We believe that non-expert householders can apply at least some solutions in their daily lives and gain greater benefits from practicing, hereby enhancing the quality of life for themselves and their own families.

Hopefully, with this handbook as a useful guideline, we will change our lifestyles to ensure a much greener and healthier future.

Sincerely,

Mr.
Nguyen Cong Thinh
–
Deputy General Director of Department of Science, Technology and Environment - Ministry of Construction

Nguyen Cong Thinh graduated from the University of Sciences (Hanoi National University) with a BSc and then an MSc in Environmental Studies.

He has been working at the Department of Science, Technology and Environment – Ministry of Construction – for almost 20 years.

Currently, he oversees the following areas: environmental protection, energy saving, development of green buildings and other tasks in science and technology, as well as normalization and standardization in technical infrastructure.

ENDORSEMENT FROM

Department of Science, Technology and Environment Ministry of Construction

Dear Reader,

Housing is an important building type, accounting for a large proportion of the total floor area annually constructed in Vietnam. Statistics show that people spend about 80% of their time living in houses and buildings- including time spent at home, as well as working at schools or offices and relaxing in leisure and entertainment centers.

Historically, people simply needed sturdy, spacious and comfortable houses to live in. In more recent years, we have developed higher standards: we strive for houses that are energy-efficient and achieve green building certifications as seen today. In the future, houses will be required to meet even greater goals, such as sustainability, comfort, safety, well-being for occupants, low emissions, and environment-friendliness.

As of mid-2023, among nearly 300 green-certified buildings in Vietnam- with gross floor area estimated at 7 million m^2- the number of green residential buildings makes up a relatively modest section. With the Government's strong commitment towards the goal of achieving net zero emissions by 2050, we must take specific action towards a green and sustainable future- in the construction industry in general, and particularly in the housing construction sector, thereby making a substantial contribution to the national goal of carbon neutrality. The "Handbook for Green Housing and Healthy Living", written and compiled by experts participating in the German Federal Government-funded CAMaRSEC research project, is a useful, easy-to-read and easy-to-apply document. Geared towards the wider public, the handbook is for state managers, researchers, lecturers, and even for investors, design consultants, constructors, building operation managers, and building occupants across Vietnam. The information, knowledge and experiences shared and presented in its chapters are both truly technical and highly recommended, pertaining to policies, management solutions, technical issues, and changing the behavior of the parties involved.

This handbook will hopefully be useful to all readers- promoting the development of green buildings and green cities, ensuring comfortable and healthy conditions, as well as creating a safe and eco-friendly built environment for us all in our houses and apartments.

Ms.
HANG PHAN (Hana)
–
Chairperson of Board VGBC Vietnam Green Building Council

Ms. Phan Thu Hang has over 20 years' experience in building science, in the field of Acoustics, Fire, Thermal, Environmental and Sustainability solutions in Construction sector.

Her first major is in Architecture at the Hanoi University of Civil Engineering (HUCE) before extending the scope to Building Management and Material, with R&D Project Leader certificate at Ecole University – France, MBA at International University of America.

Besides the current role as APAC Sustainable Market Development Director in Saint-Gobain Group, Hang has been the Chair of Vietnam Green Building Council (VGBC) since 2018, responsible for the VGBC Board of Directors to formulate strategic directions of the Council that drive the green building agenda for Vietnam.

ENDORSEMENT FROM

Vietnam Green Building Council

Dear Readers,

Major changes are coming to Vietnam following the Net-Zero Carbon 2050 Commitment of Vietnam's Prime Minister at COP26. Some of the new policies stemming from COP26, such as the Environmental Protection Law effective from 01/01/2022, regulate the responsibilities of all organizations and individuals in implementing climate change adaptation and reducing greenhouse gas emissions; The National Strategy on Climate Change for the period towards 2050 provides strategic orientations, measures, and an implementation roadmap to bring net emissions to "zero" by 2050.

In 2021, the building and construction sector accounted for around 37% of energy- and process-related CO_2 emissions and over 34% of energy demand globally. The World Green Building Council (WGBC) recently presented three strategic impact areas based on SDGs and climate science recommendations. They are: 1) Climate Action (total decarbonization of the built environment); 2) Health and well-being (delivering healthy, equitable and resilient buildings, communities and cities); 3) Resources and Circularity (supports regeneration of resources and natural systems, and provides socio-economic benefits through a thriving circular economy).

Well-designed buildings, which take into consideration site context, sources of building materials, the construction process and building performance, can have far-reaching impacts. Improving building efficiency represents one of the most affordable and effective ways to cut down on carbon emissions. Green and sustainable buildings have reduced energy costs, water costs, waste and other associated impacts. They improve indoor comfort conditions and therefore productivity. In Decree No.15/2021/ND-CP elaborating on some aspects in building project investment and management, the Vietnamese Government encourages the construction, development, evaluation, and certification of energy-efficient buildings, resource-efficient buildings and green buildings.

The housing sector is in a prime position to mitigate climate change and make environmentally friendly cities. In this context, the Handbook for Green Housing and Healthy Living provides an overview of sustainable housing development practices with a focus on a multi-disciplinary holistic approach, providing practical guidelines for planning, designing, constructing, operating and maintaining sustainable housing and behavioral dimensions to improve energy efficiency as well as healthy living. This is a useful guide full of relevant information for those of us who want to contribute our part to the global effort. Read this book - and learn from the best experts in the field!

Prof. Dr. of Science
People's Lecturer
Pham Ngoc Dang
—
Former General Secretary of the State Council for Professorship
Former Rector of Hanoi University of Civil Engineering

Prof. Dr. Sc. Pham Ngoc Dang was the former Rector of Hanoi University of Civil Engineering (1982 – 1990), the first General Secretary of the State Council for Professorship (1990 -1997), Chairman of the State Interdisciplinary Council for Professorship in Civil Engineering - Architecture (1993 - 2008). He is a Member of the National Council for Sustainable Development and Competitiveness (2008 – 2020).

Prof. Dang recently held the role of Chairman of Vietnam Built Environment Association (1986 - 2015); Vice President of Vietnam Association for the Protection of Nature and Environment (2006 to date). Prof. Dr. Pham Ngoc Dang was awarded numerous prestigious awards such as: the title of Distinguished Lecturer (1986); People's Lecturer (2002); The first Vietnam Environment Award in 2004; Vietnam Talent Award in Environment in 2018. In his career, he has actively participated in the development of legal documents such as Government Decrees, Prime Minister's Decisions, Ministerial Circulars on Environmental Protection, Standards and Regulations. At the age of over 80, he still participates in scientific research and leads research projects related to design standards and assessment of building air quality.

ENDORSEMENT FROM

Prof. Dr. Sc. Pham Ngoc Dang

Dear Readers,

"Green Building" is a sector in construction which, in its whole life cycle including site selection, design, construction , operation, use, renovation and material reuse, meets the following criteria: rational and economical use of natural resources, energy, water, materials, minimizing environmental pollution and adverse effects on human health, facilitating conservation of landscape and natural ecology and creating the best living conditions for people.

In the early 1990s, when the United States increasingly suffered from polluted environment, degraded natural resources, energy crisis and climate change, experts in construction, architecture and environment formed the "American Green Building Council" (US. Green Building Council, USGBC) and initiated the movement to develop green buildings in the United States. USGBC has developed and issued the world's first set of criteria, called "The Leadership in Energy and Environmental Design- Green Building Rating, abbreviated to LEED).

In our country, the green building movement is still in its initial step. In 2005, the Ministry of Construction issued The National Code 09:2005 on energy efficient buildings, setting the first legal foundation for the GB movement in Vietnam. The movement has attracted attention from the government, investors and users, but the number of certified green buildings is still limited.

Aiming to disseminate knowledge on sustainable housing conditions and healthy living styles to the public, with financial and technical support from the CAMaRSEC Sub-Project 2 at the University of Hamburg, the "Handbook for Green Housing and Healthy Living" has been developed and published by the Competence Centre for Sustainable Building in Vietnam (CCSB-VN).

The target groups include all those who are able to invest in new residential buildings or upgrade old houses to green buildings, authorities, enterprises, building consultants, architectural designers, lecturers and students at universities and colleges, and others involved.

The book has been carefully composed and compiled by the authors with updated information and presented in an easy-to-understand manner. The book aims to provide practical guidelines on the processes of building and using a sustainable living environment to achieve a healthier life as an ultimate goal.

We very much welcome and appreciate the sponsorship of the CAMaRSEC Project so that the "Handbook for Green Housing and Healthy Living" can be eventually published and disseminated throughout Vietnam.

Source: Michael Waibel

CONCEPTS OF GREEN HOUSING AND HEALTHY LIVING

02

Towards Healthy Living Conditions

Sabine Baumgart

Source: Michael Waibel

2.1. Housing as crucial factor for health and well-being

People's living situations are shaped by different factors. Crucial to this are their housing conditions. But housing is more than just a roof over one's head because, as a basic need, it protects against external weather conditions and makes an elementary contribution to social well-being. It is a protected and controlled area for the individual.

Health will be defined differently in different contexts. Accordingly, the WHO concretized its definition in 1986 in the Ottawa Charter on Health Promotion: "Health promotion is the process of enabling people to increase control over, and to improve, their health. To reach a state of complete physical, mental and social well-being, an individual or group must be able to identify and realize aspirations, satisfy needs, and change or cope with the environment. Health is, therefore, seen as a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities. Thus, health promotion is not just the responsibility of the health sector but goes beyond healthy lifestyles to wellbeing." (WHO, 1986).

2.2. Determinants of healthy housing

The socio-ecological model by Gunnar Dahlgren and Margret Whitehead ties in with this. Published in 1991, it contributed to the discussion and policy of the WHO. It is based on a holistic approach and includes health determinants as factors influencing human health and well-being in order to explain social inequalities in health. It was further developed by Hugh Barton and Marcus Grant in 2006 using ecosystem theories and the principle of sustainable spatial development. In this model, people are also the focus, but in addition to the focus on health, there is the integration of an anthropogenic definition of sustainable development (Brundtland et al., 1987). Thus, the settlement area is influenced by different spheres and by a multitude of social, economic and ecological variables. While the neighborhood is embedded in and dependent on a bioclimatic situation and the global ecosystem, it is cultural, economic and political forces that determine people's well-being. The design and planning of settlements lie within the realm of the built environment.

Figure 2.1. The health map (Barton and Grant, 2006: 2)

Interventions in the conditions in which people live focus on health promotion and prevention on all framework conditions, i.e. the conditions in people's everyday lives that influence their health. These include the quality of drinking water, food, air, learning, working and living conditions, social situation and integration status and infrastructure, as well as the supply of and access to health care and general political conditions. These are interrelated with people's individual behavior in the sense that people can change their living conditions through their behavior, but on the other hand, their behavior is influenced by their living conditions. Thus, the responsibility for health lies not only with the individual but also with the social framework conditions, including housing.

Source: Michael Waibel

2.3. Healthy and green living environment

The different dimensions of housing, and its importance to the individual, influence his or her behavior towards a health-oriented lifestyle and the possibilities of social participation. This also requires the corresponding spatial living conditions and health-promoting resources. If we look at the environmental resources of a residential location, these are primarily open spaces, such as green forests and recreational areas, but also infrastructural prerequisites, such as cycle paths and footpaths, public spaces, and, in addition, possibilities for shading against heat and ventilation through open-air corridors as well as the guarantee of mobility and disposal of waste and sewage.

Environmental conditions thus play a crucial role. This refers, above all, to the social and spatial distribution of health-relevant environmental burdens and environmental resources ("environmental justice"). In this context, the factors of social location, housing standard and environmental burdens (such as air pollution, noise pollution, waste, shading, heat stress and heavy rain events) are considered both within the neighborhoods of a city and in comparison to each other. On this basis, the spatial distribution of any advantages and disadvantages of environmental use can be assessed from an environmental justice perspective.

Currently, nature-based solutions (NBS) are being tested as strategies in different contexts that are inspired and supported by nature, including health-promoting strategies. Nature-based solutions offer numerous advantages to strengthen the resilience of urban spaces and to promote health-improving conditions. The securing and provision of green and natural areas close to housing for sporting activities and exercise, recreation/leisure, and experiencing nature promote human well-being and the prevention of diseases. Based on the garden city concept, it contributes to health and well-being besides improving air and environmental quality, but it also contributes to healthy eating, e.g. through urban gardening. The implementation of vertical gardens in urban spaces, e.g. at housing façades or public transport stops, supports the microclimate.

Ebenezer Howard's concept of the garden city of 1898 already emphasized the availability of private open space and the pedestrian accessibility of public parks against the background of health-promoting effects. "Howard clearly viewed nature as a source of physical, psychological and mental health. Nature's health benefits, in fact, underpinned much of Howard's argument for the garden city" (Frank et al. 2003).

Source: Michael Waibel

Figure 2.2. Conversion of parking lots into urban green in Amsterdam (2022) (Photo: Rüdiger Bleck)

Figure 2.3. An urban gardening project initiated by the local community in a vacant lot in Bremen, Germany (Photo: Sabine Baumgart)

Thus, NBS are an important component of a sustainable urbanization process. They support the preservation of biodiversity and generate ecological, economic and social benefits as well as health-related effects. For example, the greening of grey infrastructure (roofs, façades, streets) favors evaporative cooling and counteracts the development of heat islands.

Figure 2.4. Popular communication of the Sustainable Development Goals in Bornholm/Denmark (2019) (Photo: Sabine Baumgart)

2.4. Conclusion

Urban and green infrastructure is a basic element for healthy living conditions and housing. This is in line with the 17 Sustainable Development Goals of the 2030 Agenda for Sustainable Development, which was adopted by all member states of the United Nations in 2015. The residential environment, with its infrastructure for local supply, plays an important role. The local living and housing conditions in different neighborhoods according to socio-economic and social status touch on questions of participation in social life and equal opportunities in everyday living. As urban design qualities in the residential environment, a functional and urban design reference to the neighborhood and the taking up of existing urban forms and structures with regard to the creation of green networks are valued, also in order to achieve their own identity through their structural design and their use. Green and water areas, as design and use components, serve as space for physical activity, mobility and fresh air. They can become the starting point of planning for healthy living conditions, particularly in times of climate change and necessary measures to adapt to it. Spatial planning can influence most of these factors with a view to healthy living conditions.

Source: Michael Waibel

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(Photo: ARL)

Prof. Dr.-Ing. Sabine Baumgart (BPW Stadtplanung)

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Sabine Baumgart studied architecture/urban planning, completed her administrative traineeship in Hanover, and worked as a research assistant and as a visiting professor. Since 1989 she has been co-owner of the urban planning office BPW, initially in Hamburg, as BPW Stadtplanung partnership mbB in Bremen since 2004. After the completion of her Ph.D., she held the chair for urban and regional planning at TU Dortmund (2002 to 2018).

She is an associate member of the Institute for Public Health and Nursing Research(IPP), University of Bremen, and was president of the ARL - Academy for Territorial Development in the Leibniz Association, Hanover (2019-2022).

PRACTICAL GUIDELINES TO ACHIEVE GREEN HOUSING AND HEALTHY LIVING

03

Site planning and building orientation

Nguyen Quang Minh

Source: 1+1>2 Architects

3.1.1. Rationale

Site planning is considered the first activity in building design. In principle, selected sites are expected to meet all (or most) of the design requirements to provide an appropriate built environment for people.
Site planning should take into account the following factors: stable geological conditions, easy access to roads and streets, good connection to other parts of the city, well-established technical infrastructure systems, high-quality facilities and convenient social services.

As the next step, optimal building orientation is required to ensure indoor comfort for residents by maximizing advantages (i.e. warm sunlight, cool wind and a nice view) while minimizing disadvantages (i.e. excessive solar radiation, extra heat in the summer and cold wind in the winter). In reality, for whichever reason the site may not be ideal, but a good (even the best) orientation can always be chosen by architects. This principle is taught at schools of architecture but has not always been widely practiced or successfully applied by architects in Vietnam.

3.1.2. Benefits

Site planning and building orientation, together, contribute to:

- ☆ Providing the residents with a convenient living location and accessibility to both technical and social infrastructure systems;
- ☆ Enhancing the quality of living by means of thermal comfort and indoor air quality with sufficient daylight and adequate cross ventilation;
- ☆ Reducing household energy consumption, as a consequence of depending largely on artificial solutions and cutting down on CO_2 emission as a key agent causing global warming and climate change, hereby protecting the environment;
- ☆ Offering residents a nice view of the cityscape.

Figure 1.1a. A site for building houses must be planned to ensure easy access - Times City in Hanoi (Source: Nguyen Quang Minh, 2023)

Figure 1.1b. A site for building houses must be planned to ensure a good connection with social services (schools, hospitals, shopping centers, etc.) - Times City in Hanoi (Source: Nguyen Quang Minh, 2023)

Figure 1.2. A site for building houses must be planned to ensure good thermal comfort and a nice view (e.g. along an artificial lake). Example of: T5, T6, T7, T10 and T11 Buildings at Times City - Hanoi (Source: Nguyen Quang Minh, 2023)

3.1.3. Principles

- ☆ The following factors of a site for high-rise apartment buildings should be considered:
  - Have direct access from at least one secondary street or an indirect access from a main road (through a connecting street) to control the traffic flows;
  - Be located near at least one public transport route (bus, tram, underground or skytrain station);
  - Be situated near as many service buildings (schools, supermarkets, hospitals) as possible;
- ☆ High-rise apartment buildings should overlook large green areas (parks, gardens, grassland) and water surfaces (lakes, rivers);
- ☆ Those sites regarded as inappropriate for housing development should be turned into non-residential areas, such as parks, city gardens, farming areas, etc.;
- ☆ Those sides facing South and Southeast should be prioritized for apartments, because the apartments can take advantage of daylight and cool winds;
- ☆ Those sides facing other directions (particularly West, Southwest, Northwest and Northeast) should be reserved for auxiliary function rooms, for example elevators and staircases, store rooms, mini-farms, corridors, etc.;
- ☆ As an active solution, design should be optimized, not only functionally or structurally, but also bio-climatically considered, even when the chosen building orientation is good;
- ☆ Additional (non-design) solutions can be applied, where and when appropriate, to ensure comfort and convenience, in case of an inappropriate building orientation.

3.1.4. Solutions

In case of an appropriate site

- Make use of all the advantages of the site, as mentioned in the Rationale of this chapter.

In case of an inappropriate site

- Ensure a sufficient set-back (at least 20 m) and plant tall shade trees at the right distance (5 to 10 m), at the right height (at least 10 m), and with a minimum of four rows of trees between the building and the main street. Such a set-back provides a buffer zone. In the case of a highway, this buffer zone should be enlarged to at least 50 m in width;
- Build a high-rise block at the right distance from a site causing pollution (a factory) or bacterial infection (a hospital). The buffer zone could be called a green corridor or green belt, several hundred meters in width;
- Non-residential areas should be planned in the front. Then houses and apartment blocks should be placed in the back, away from the source of pollutants.

In case of an appropriate building orientation
At the building level

- Plan all the apartments towards the appropriate direction(s) and all the other parts of the building (elevators and staircases, store rooms, corridors) towards the opposite side;
- Enlarge the windows and doors in the front, towards the appropriate direction(s);
- Enable cross ventilation by creating gaps on both sides at right positions for air inlets and outlets.

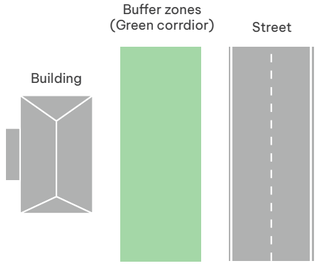


Figure 1.3a. Buffer zone between a high-rise apartment building and a busy street (Source: Nguyen Quang Minh, 2022)

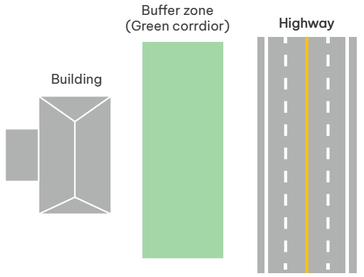


Figure 1.3b. Buffer zone between a high-rise apartment building and a highway (Source: Nguyen Quang Minh, 2022)

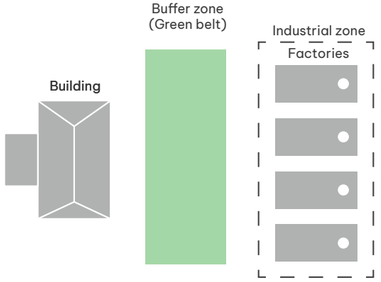


Figure 1.3c. Buffer zone between a high-rise apartment building and an industrial zone (Source: Nguyen Quang Minh, 2022)

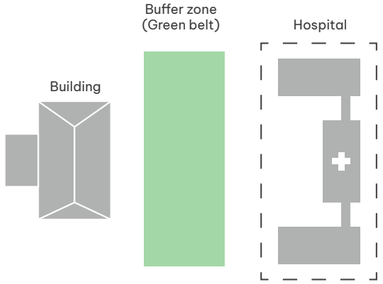


Figure 1.3d. Buffer zone between a high-rise apartment building and a hospital (Source: Nguyen Quang Minh, 2022)

In case of an appropriate building orientation
At the apartment level

- Plan all the main rooms (living room and bedrooms) towards the appropriate direction(s) and all the other parts of the apartment (foyer, bathroom, toilets, kitchen and store room) towards the opposite side;
- Enlarge the windows and doors in the front, towards the appropriate direction(s);
- Enable cross ventilation by creating vents on both sides, right above the windows and right after the doors to enable air flows when closing the doors and windows.

In case of an inappropriate orientation
At the building level

- Rotate the entire building towards the optimal orientation;
- Apply the concepts as proposed for a building with an appropriate orientation;
- If rotating the entire building is not possible; then design buffer zones (usually loggias) and install sun-shading elements (mobile/flexible structures) on the façade.

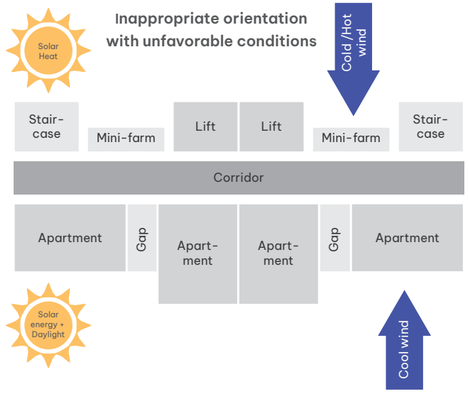


Figure 1.4. Solutions to an apartment building in case of an appropriate orientation (Source: Nguyen Quang Minh, 2022)

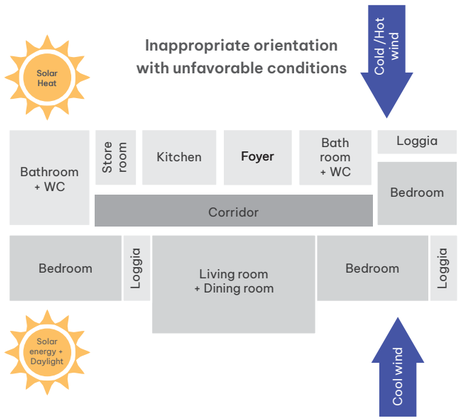


Figure 1.5. Solutions to an apartment in case of an appropriate orientation (Source: Nguyen Quang Minh, 2022)

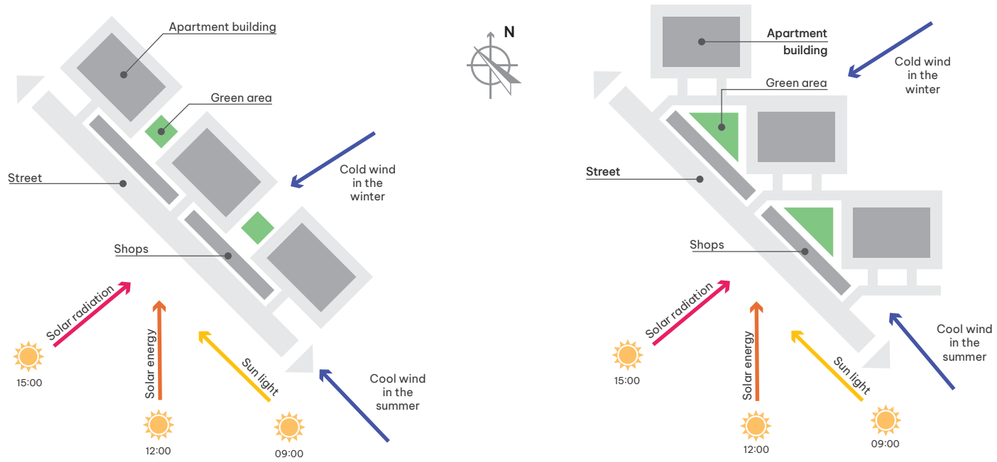


Figure 1.6. Rotating the entire building to fix the problem of having an inappropriate orientation (Source: Nguyen Quang Minh, 2010)

In case of an inappropriate orientation
At the apartment level

- If rotating the entire building is possible, then design the floor layout by applying the concepts as previously proposed for an apartment with an appropriate orientation;
- If rotating the entire building is somehow not possible, then design buffer zones (usually loggias) and install sun-shading elements (mobile/flexible structures) on the façade of the whole apartment.

3.1.5. Hints and tips

- ☆ Appropriate building orientations are suggested in Figure 1.7, with two cases: 1) Optimal orientation from the South to the Southeast (within a 45° angle from the South, counter-clockwise) and 2) Acceptable orientations - within a 15° angle from the South to the Southwest and within a 30° angle from the Southeast to the East;
- ☆ A mobile and flexible sun-shading structure (Venetian blinds, sun louvers, curtains, etc.) should be applied to windows, regardless of building orientation. Venetian blinds and curtains can be installed inside while sun louvers made of aluminum (metal or alloy) may be put outside (Figure 1.8a);
- ☆ Façade greening can also help protect the apartment from negative impacts of climate and environment (Figure 1.8b);
- ☆ Water and vapor are efficient in cooling down the air temperature on hot summer days;
- ☆ A building with an inappropriate direction needs to make full use of surrounding conditions (a hill, a high-rise building, a tall shade tree, a river or a lake, etc.) to reduce the excessive solar heat as recommended and illustrated in Figures 1.9a, 1.9b, 1.9c and 1.9d.

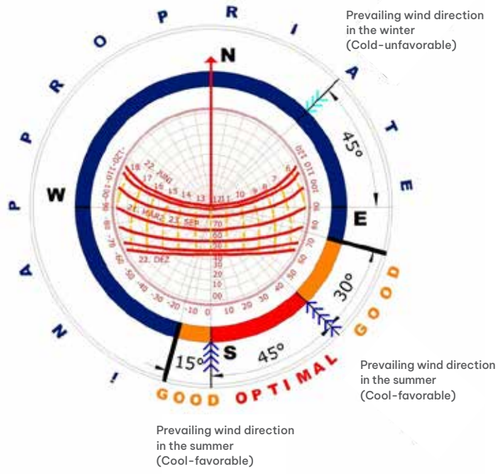


Figure 1.7. Appropriate building orientations for Hanoi (Source: Nguyen Quang Minh, 2010)

Figure 1.8a. Reducing heat by installing a sun-shading structure (Source: Nguyen Quang Minh, 2022)

Figure 1.8b. Reducing heat by greening the façade (Source: Michael Waibel, 2023)

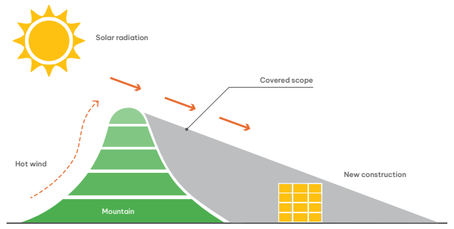


Figure 1.9a. Reducing heat by making full use of shade from a nearby hill (Source: Nguyen Quang Minh, 2014)

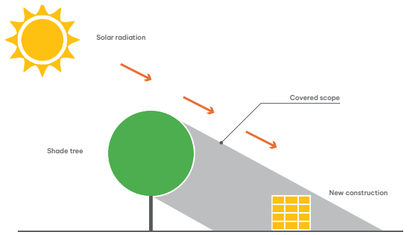


Figure 1.9b. Reducing heat by making full use of shade from a nearby tall leafy tree (Source: Nguyen Quang Minh, 2014)

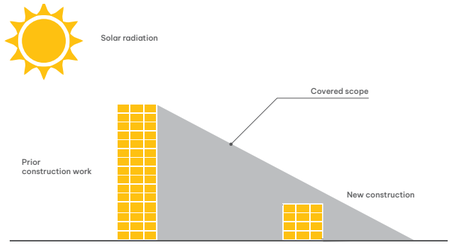


Figure 1.9c. Reducing heat by making full use of shade from a neighboring building (Source: Nguyen Quang Minh, 2014)

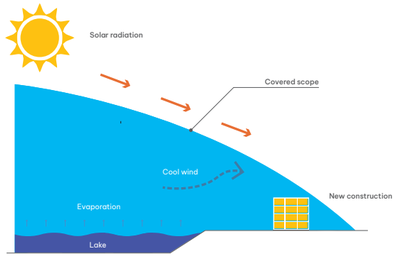
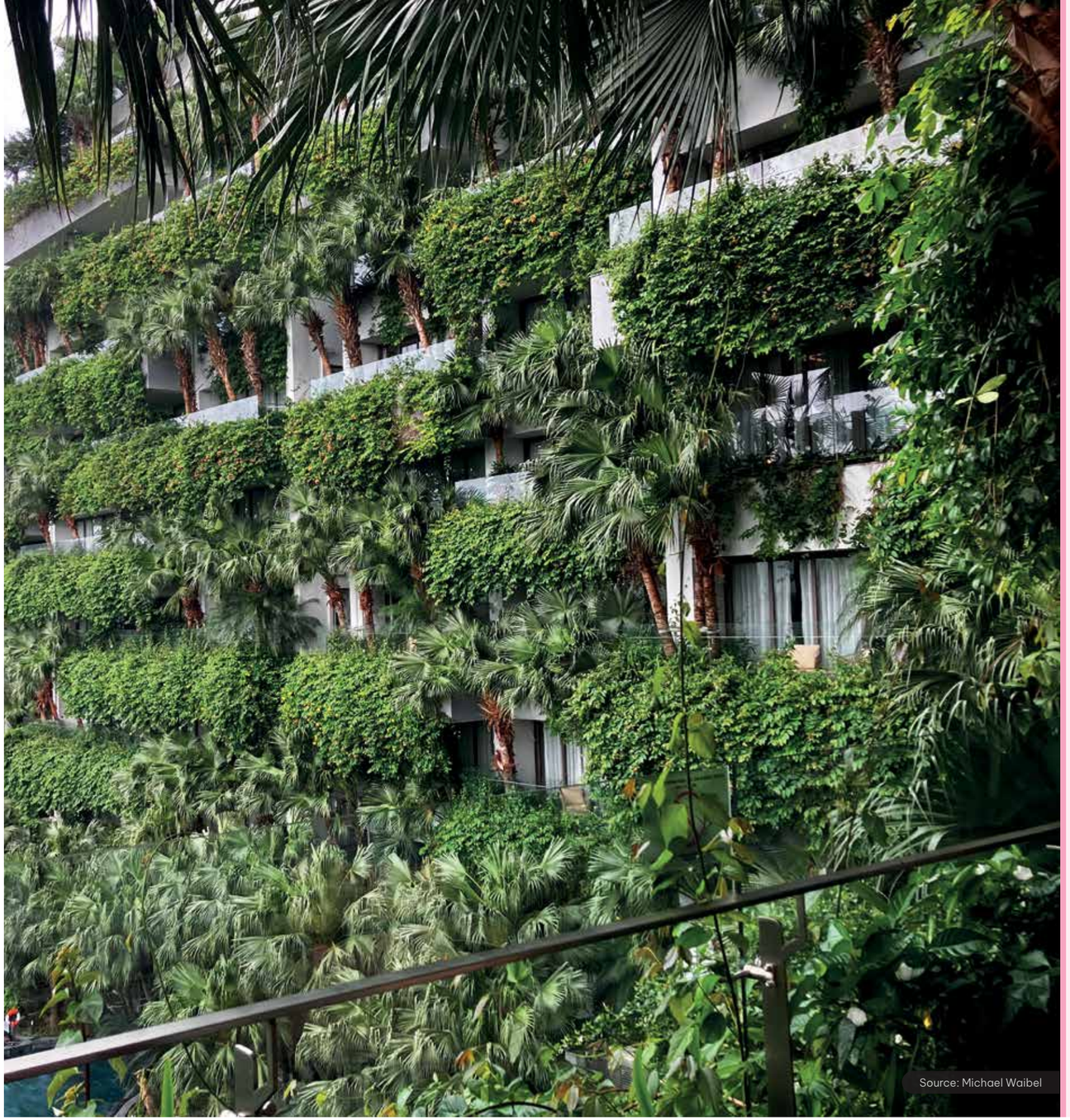


Figure 1.9d. Reducing heat by making full use of evaporation from a nearby lake (Source: Nguyen Quang Minh, 2014)



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Floor plan design

Ngo Le Minh

Source: 1+1>2 Architects

3.2.1. Rationale

In a big and densely populated city like Hanoi and Ho Chi Minh City, it is recommended that a comfortable living environment for people should be created by minimizing adverse impacts on the surrounding environment, consuming less energy, and bringing more trees and plants into buildings.

Floor plan design solutions are supposed to create a favorable and comfortable micro-climate environment, ensuring hygiene, safety and well-being for residents. Solutions to be applied should be as flexible as possible to adapt to the new conditions of climate change.

This concept is particularly meaningful in a tropical country like Vietnam. If the design meets the above requirements, it will create a comfortable living environment that is suitable for the tropical climate of Vietnam.

3.2.2. Benefits

The floor plan layout design of high-rise apartment buildings can:

- ☆ Ensure economic efficiency, technology and convenient use;
- ☆ Make the living space more attractive;
- ☆ Harmonize with the humanistic environment and the historical development of the area, learning from good building experiences of the past and making use of simple but efficient solutions as found in traditional vernacular architecture;
- ☆ Enhance natural ventilation and daylight, as well as microclimatic comfort in the building;
- ☆ Minimize waste, pollution and other causes of environmental degradation;
- ☆ Provide good visual effects, positively affecting occupants' mental and psychological health.

3.2.3. Principles

- ☆ Planning and design of high-rise apartment buildings in cities should be associated with the natural environment and commensurate with local climate conditions. In Vietnam, a climate-adaptive architectural design solution aims to make houses and apartments suitable for tropical climate conditions (with the monsoon, hot sun and high humidity);
- ☆ The master plan should ensure natural ventilation, reduce solar radiation and prevent excessive heat in the summer; avoid the cold wind in the winter, splashing rain and drought;
- ☆ The building should be environment and user-friendly, close to nature, bringing more trees into the courtyard(s) and rooms; preventing dust and noise from the streets;
- ☆ Residential area planning, location, orientation, size of the building and distance to neighboring buildings are crucial factors affecting ventilation efficiency (see Fig. 2.4). Buildings should not affect each other in terms of gaining sunlight and cool wind (see Fig. 2.1);
- ☆ The architecture in the master plan should minimize the impacts of moisture and moss, as well as negative influences on the surrounding environment by using clean and renewable energy sources, saving land, water and other resources (see Fig. 2.2); Design solutions need to apply new energy-saving technologies;
- ☆ A passive design strategy should be adopted to regulate the temperature and reduce resource consumption;
- ☆ In principle, if the deviation angle is small, natural ventilation will be preferred. The main façade of a high-rise building should not be perpendicular to the prevailing wind direction but deviated within an angle of 15-30° compared to the prevailing wind direction, in order to make the most of the wind (see Fig. 2.3).

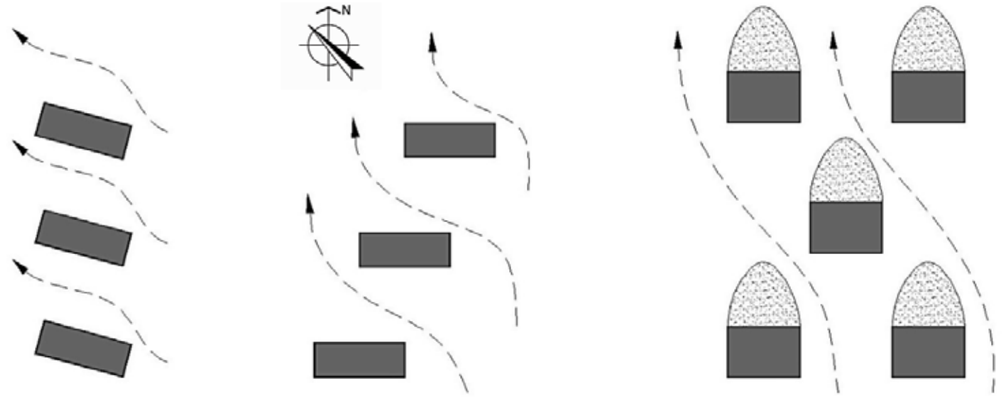

Figure 2.1. Solution for master planning of the housing area, enabling natural ventilation (Source: Ngo Le Minh, 2013)

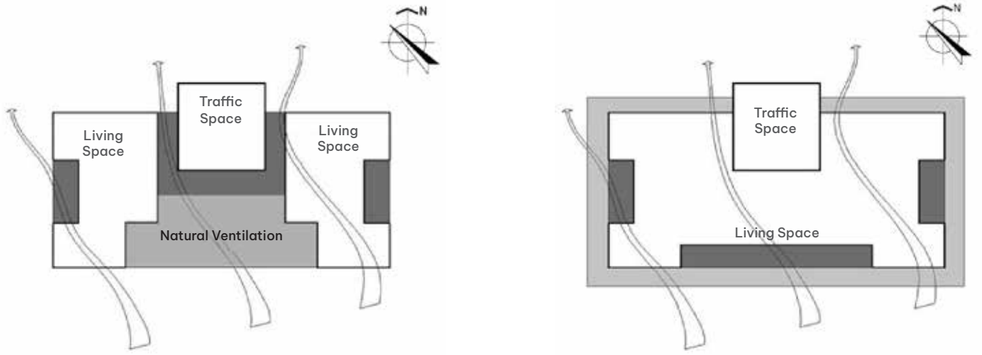

Figure 2.2. Residential floor plan solution, with voids ensuring natural ventilation (Source: Ngo Le Minh, 2013)

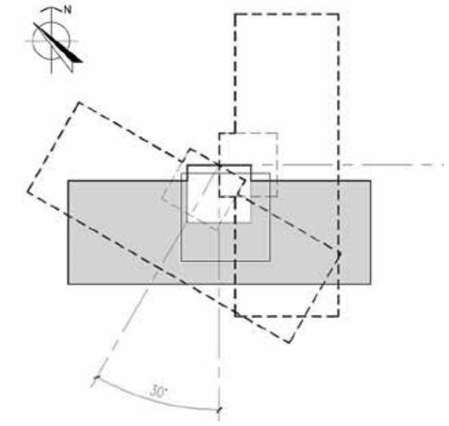

Figure 2.3. Buildings are allowed to turn to the East and tilt to the West at an angle not exceeding 30° compared to the South direction
(Source: Ngo Le Minh, 2013)

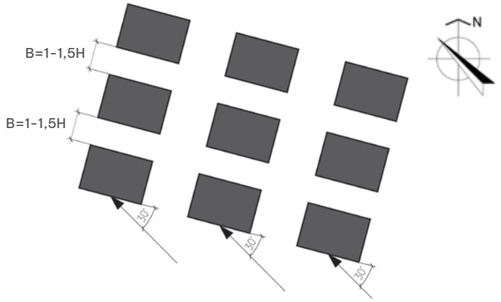

Figure 2.4. Main wind direction (Source: Ngo Le Minh, 2013)

3.2.4. Solutions

- Preferred design strategies: Improve natural ventilation, reduce solar radiation on the outer surface of the wall, reduce direct solar radiation into the room, use proper mechanical ventilation, etc;
- The overarching design principle is to reduce solar radiation and heat gain on the outer wall surface, minimize temperature fluctuation inside the building, mitigate direct sunlight into the room, enable natural ventilation and control the operation of mechanical ventilation;
- Natural ventilation is considered a suitable solution for Vietnam's hot and humid tropical climate. The prerequisite for cross ventilation is to have air inlets (positive pressure) and air outlets (negative pressure) on the opposite side, the pressure difference on both sides is determinant in the efficiency of ventilation (see Fig 2.4);
- The Overall Thermal Transfer Value includes:
  - → Heat conduction through solid walls: < 5%
  - → Heat conduction through the glass door: 10-20%
  - → Heat through glass: 70-85%
- For outer walls, it is essential to have a heat-proof material (such as organic fiber or mineral) between the two wall layers;
- Reduce direct sunlight into the room, applicable to countries with hot and humid climate like Vietnam. It is necessary to design shading elements for the windows (see Fig 2.5);
- Use new technology for window glass, which is called low-emittance glass (or in short low-e). On the surface of this window glass there is a thin metal layer with low- radiation coefficient, which helps reduce the radiant heat flow through the window;
- Apply ventilation with electric fans as a familiar solution in hot and humid climate conditions, and an indispensable device in Vietnamese households, no matter high-income or low-income they are;
- Electric fans contribute to creating a favorable microclimate, saving electrical energy for air conditioners, contributing to environmental protection of the urban and global climate.

Figure 2.5. The shading structures for glass windows on the surface of the building wall (Source: unsplash.com)

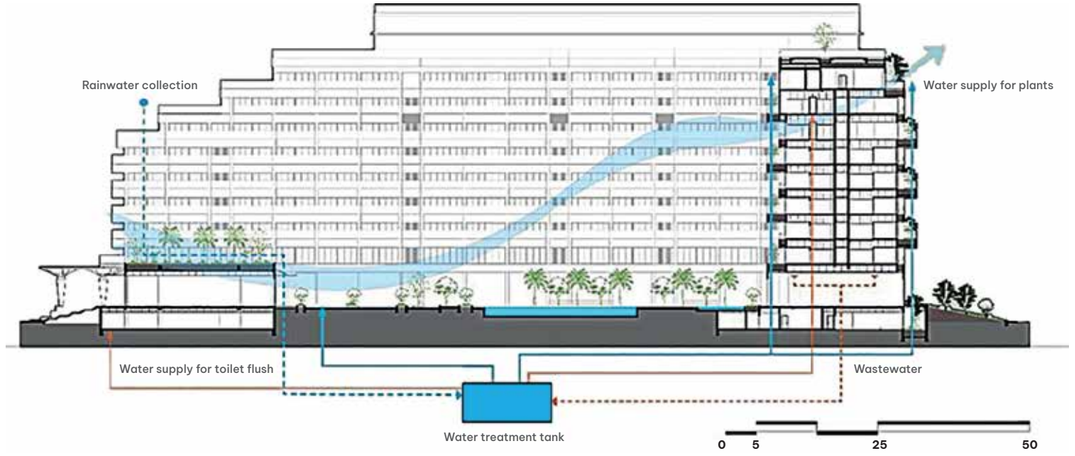

Figure 2.6. Cooling solution and effects in Flamingo Dai Lai Resort in Vinh Phuc (Source: ArchDaily, 2018)

3.2.5. Hints and tips

- ☆ The orientation of a building is significant in term of choosing the right time of sunlight exposure, optimizing daylight and natural ventilation for the building;
- ☆ It is conventional that the orientation of an apartment is seen as the orientation of the main rooms in that apartment, not related to the entrance;
- ☆ The orientation of an apartment building does not only directly affect the floor layout but will also be decisive for the solution of the floor plan and the shape of the building;
- ☆ When choosing an appropriate orientation of an apartment building, it is essential to study both the compass and wind rose chart of the area to come up with rational architectural design solutions for building blocks, in order to make full use of the prevailing wind directions to cool off the outer surface of the building, as well as bring fresh cool air from outside into the rooms inside the building;
- ☆ The bedrooms, living room and main balcony or loggia in one apartment should face South, if possible, or can just slightly be deviated from the right orientation as prescribed to gain the cool breeze in the summer and avoid the cold wind in the winter;
- ☆ In the Northern region of Vietnam, where the weather can be very cold in the winter, an important requirement for housing design is to avoid or minimize cold wind and gain sunlight. The North-facing floor plan is usually designed with auxiliary rooms and corridors as well as staircases, so the traffic is often planned in the North direction. This architectural feature is evident on the North façade of the building;
- ☆ Various floor plan patterns of a high-rise building: corridor, tower, multi-block, and mixed form (see Figs. 2.7, 2.8 and 2.9) can be applied to building design;

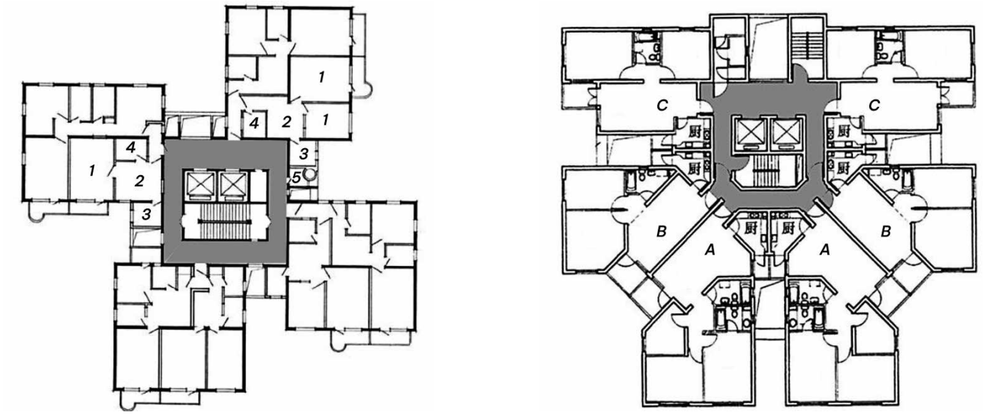

Figure 2.7. Floor plan of a 22-story building (1990) (picture left) and a 24-story building (1995) for reference (Source: Li Zhenyu, 2009)

- ☆ Factors affecting the shape of high-rise buildings in Vietnam include economic efficiency, technology, convenient use and tropical climate factors;
- ☆ Solution in terms of cubic forms: Using beveled surfaces slanting from top to bottom, or leveling floors that gradually shrink downwards in the shape of an upside-down pyramid, or create a convex space (an extruding block next to a set-back block) to cast shadows on the façade, having the same effect as sun-shading structures, minimizing heat absorption effects;
- ☆ Plant trees on roofs and floors, interior trees are highly efficient solutions, both helping enhance insulation and resist the solar heat and radiation on the building. Additionally, this helps create more green space and surface area (see Fig 2.10);
- ☆ The floor plan of a tower building with long and short sides is almost the same, thus it is difficult to guarantee that each apartment has a South-facing room. A solution is to open windows in the East and West with a properly designed sun-shading element;

- ☆ Green and energy-saving architecture can help improve the living environment in apartment buildings significantly, such as solar water heating systems; water collection and filtration systems in buildings.

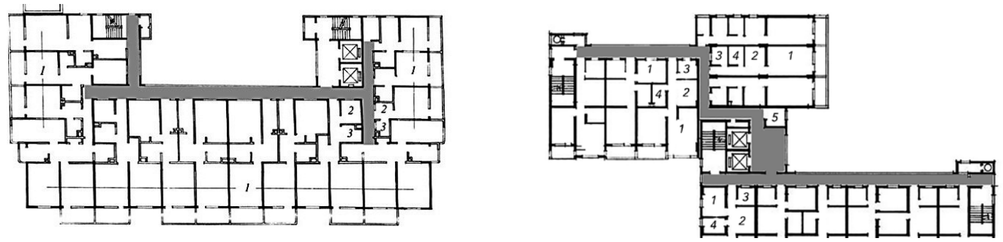

Figure 2.8. Floor plan of a 15-story building (1985) (picture left) and a 20-story building (1987) for reference (Source: Li Zhenyu, 2009)

Figure 2.9. Floor plan of a 16-story building (2008) (picture left) and a 24-story building (2012) for reference (Source: Li Zhenyu, 2009)

Figure 2.10. Dream Residences in Hanoi (Source: Nguyen Thuong Quang, 2018)

Firgue 2.11a. Diamond Lotus Riverside building in Ho Chi Minh City - Apartment building with trees on floors and balconies
(Source: Phuc Khang Corporation, 2022)

Figure 2.11.b. Him Lam Riverside Residential Area, Ho Chi Minh City
(Source: Ngo Le Minh, 2022)

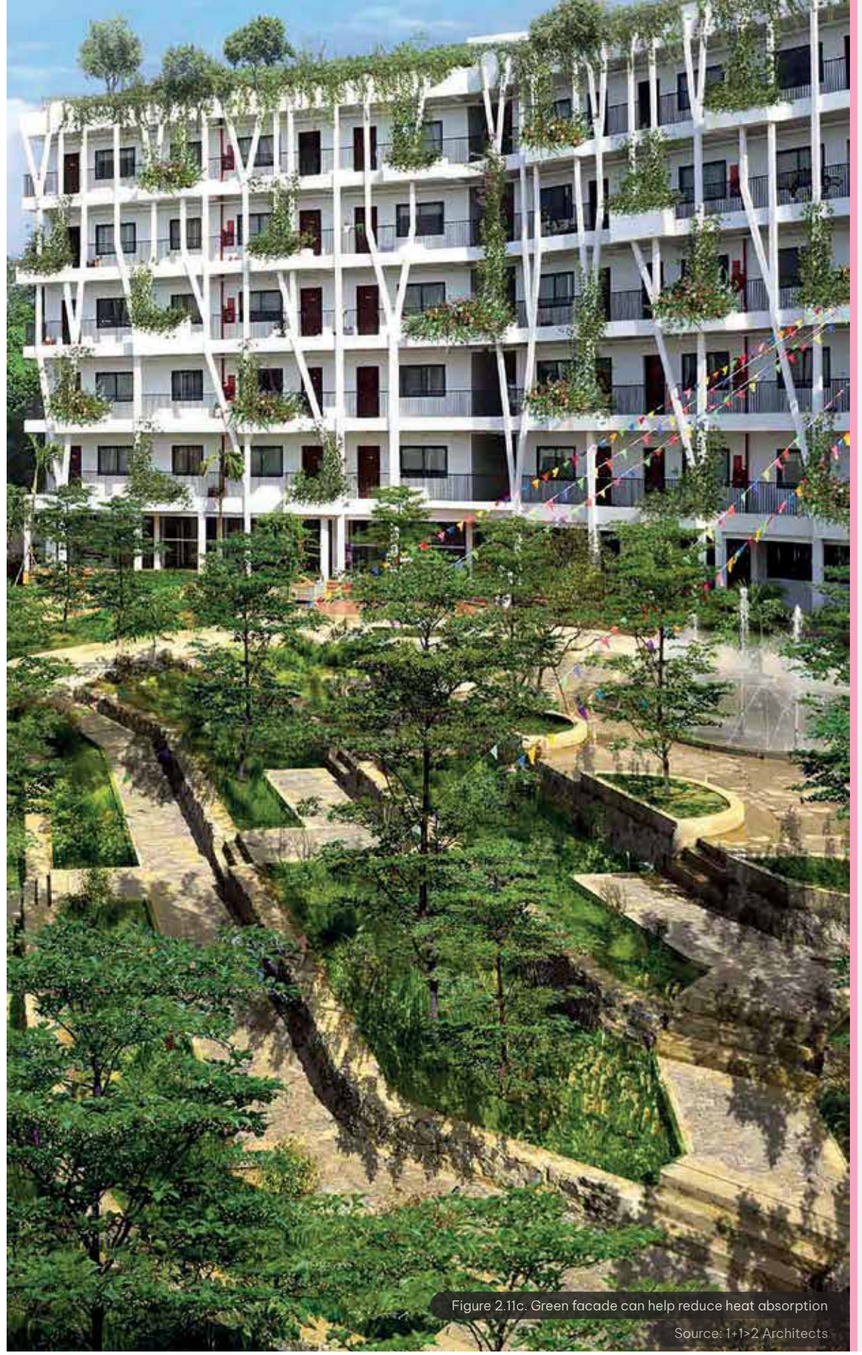

Figure 2.11c. Green facade can help reduce heat absorption
Source: 1+1>2 Architects

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Building envelope design

Pham Thi Hai Ha & Nguyen Van Tuan

3.3.1. Rationale

The building envelope is the entire structure that covers the building. It includes the outer walls, roof(s), floors, windows, doors, glass walls, sun-shading devices, rain-splash protecting structures, etc.; it is the physical separation between the interior and exterior of a building.

The building envelope affects the building's energy efficiency due to its cooling and heating effects on the indoor air, and the building envelope's inner surface temperatures.

The envelope's design also affects the building's ability to take advantage of daylight. In addition, the building envelope can significantly impact the building's durability, as well as its occupants' health and psycho-physiology.

The green building's rating and certification systems require that the building, on the whole, should be more energy-efficient than existing ones.

A key strategy to achieve this is to design high-performance building envelopes that ensure a comfortable indoor environment, durability, economic efficiency and architectural aesthetics.

3.3.2. Benefits

A well-designed building envelope can significantly reduce the negative impacts of the climate, and so improve the indoor thermal comfort and the living environment as a whole. Some of the benefits include:

- ☆ Lower level of energy consumption, by reducing the dependence on artificial lighting and lowering the cooling/heating requirements of the building. This is especially true during the hours of peak heat gain.
- ☆ Reduced energy consumption leads to lower household bills and a smaller environmental footprint;
- ☆ A more comfortable indoor environment through the utilization of natural light, water vapor control, airflow control and sound control;
- ☆ Improved vision through glass doors, windows and other openings in the building envelope;
- ☆ Improved psychological well-being through more direct contact with the outside environment; This enhances natural bio-rhythms during daily activities which facilitate better physical health;
- ☆ Reduction of households' expenses and environmental footprints by paying lower monthly energy bills.

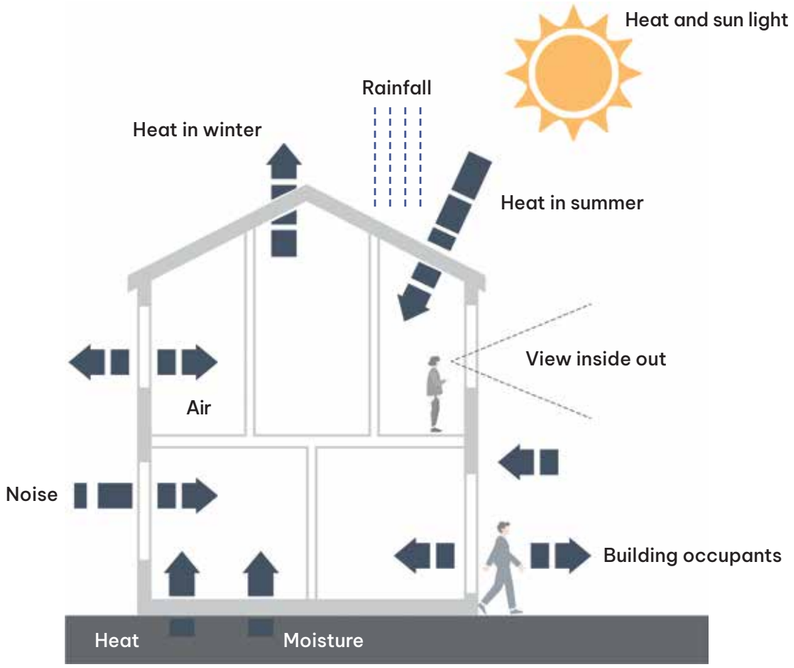

Figure 3.1. Building envelope and the roles it plays in reality (Source: Pham Thi Hai Ha, 2020)

3.3.3. Principles

Building envelopes are usually divided into two key components: transparent structures, such as doors and glass walls; and opaque (non-transparent) structures, such as walls and roofs.

Vietnam is a tropical country with strong solar radiation and long hot seasons where the sun goes through the zenith twice a year. Daylight is also abundant due to a large amount of radiation diffused through the cloudy skies. Because of this, most of the energy in a typical building in Vietnam is used for cooling; with air conditioning accounting for 29–47% of the total energy consumption of the building (IFC and MOC, 2014).

Building designers should therefore pay special attention to minimizing heat transfer into the building, while still making the best use of the daylight available. This design requires the consideration of several inter-related principles as follows:

- ☆ Heating, Ventilation and Air Conditioning (HVAC) devices control the indoor microclimate on the basis of thermal comfort parameters;
- ☆ The efficiency of heat resistance in a building is directly related to the insulation of the building envelope. It is measured as the Overall Thermal Transfer Value (OTTV). The cooling load of the HVAC system in an air-conditioned building can be lowered by reducing the OTTV value of the building envelope;
- ☆ The building envelope should be properly designed to meet the recommended values in the QCVN 09:2017/ BXD (MOC, 2017);
- ☆ For a non-air-conditioned building, the microclimate depends largely on natural ventilation through openings. Inside and outside temperatures are similar, so the heat gain through the envelope itself does not affect the room temperature so much. Only the building envelope's inner surface is slightly influenced;
- ☆ Living rooms, bedrooms and study rooms must be well-lit with daylight which benefits the physical and mental health of the occupants. Because of this, building envelopes should be designed while considering the daily changes of the sun's position to optimize energy efficiency while still reaching a balance between lighting and cooling;

☆ Windows are the most significant components of the building envelope in terms of comfort and energy use per surface area unit (T. Carmody et al., 2004);

- In Vietnam, the window to floor area ratio (WFR) should be between 13.5% and 16.3% at 300 lux illuminance (T. K. P. Nguyen et al., 2021);
- The higher the Window to Wall Ratio (WWR) is, the better lit the rooms can be. However, it may increase the cooling load for the HVAC systems and cause discomfort from glare. Additional measures can be taken to reduce these impacts (i.e., the optimization of sun-shading devices for windows in the building façade design);
- Other factors that affect daylight gain through building envelope include neighboring buildings, trees, vision requirements, glazing types, etc.;

☆ Factors affecting the durability of building envelopes also need to be taken into account (i.e., the expansion and contraction of building materials, deterioration of organic materials, vibration, destruction of microorganisms, chemical erosion and extreme weather conditions).

Figure 3.2. Building envelope of the College of Urban Construction Works (CUCW), Hanoi (Source: Department of Environmental Architecture, 2023)

3.3.4. Solutions

Design energy-efficient building envelopes

- Install sun-shading devices onto the exterior of the building to block solar radiation before it passes through the window glass;
- Design and install windows to ensure heat efficiency, lighting efficiency, and to optimize the view from inside, while considering WWR (%), properties and specifications of glass, and the type of a sun-shading system;

Figure 3.3a. Horizontal and mixed sun-shading structure
(Source: Pham Thi Hai Ha, 2018)

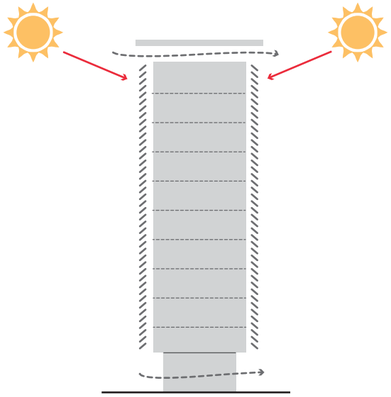

Figure 3.3b. Double layer façade
(Source: Pham Thi Hai Ha, 2018)

- Select an appropriate glazing type based on: low SHGC value (Solar Heat Gain Coefficient), low U value (W/m²K), and high VLT value (Visual Light Transmittance). In tropical countries, the SHGC value is the more important parameter when considering the amount of solar heat absorption versus the visual light transmittance of the glass type selected;

- Choose the right colors, insulation materials and structures to improve the heat resistance as well as heat reflection coefficients of walls and roofs;
  - → Insulation materials can be a soft sheet, rigid sheet, hollow granules, pour-in-place foam, or spray. Soft sheet insulation can be fabricated from fiberglass, mineral wool or cotton. Rigid sheet insulation, such as the use of polyfoam; hollow material cellulose, vermiculite, or perlite or spray foam can be used;
  - → Each type of insulation material has a different conductivity value, of which air is the best option for thermal resistance with λ = 0.025 W/m.K, other common thermal proof materials have a value between 0.03 and 0.2 W/m.K;

- Apply a multi-layer structure to walls in the West, Northwest and Southwest directions to reduce solar absorption intensity in the afternoon and allow quick cooling down at night. The multi-layer structure involves a thinner outer wall isolated from the inner wall with an insulation layer or air layer between them. For example, a 0.11 m thick fired clay brick for the outer wall and 0.15 m thick AAC (Autoclaved Aerated Concrete) brick for the inner wall;

- Install roofs with two layers of insulation:
  - → The circulating air layer (the main insulation layer with a minimum thickness of 0.35 ÷ 0.40 m) has low heat retention and good insulation during the day, cooling quickly at night, reducing room heating after sunset;
  - → The second layer of insulation has its optimum effect when air conditioning systems are switched on inside the building;

- Maximize natural ventilation by placing high-rise apartment buildings to face the direction of the prevailing cool summer wind, locating windows and doors to maximize the cool winds and facilitate cross ventilation. This enables sunlight to enter the rooms while minimizing unwanted solar heat transfer;

- Choose durable, non-toxic (no VOC, no radio-active rays and other toxins) materials for building envelopes that are reusable at the end of the building life cycle;
- Protect the building envelope, especially those that are made of metal, or light-weight materials like aerated concrete, with protective coatings (i.e., paints, mortars) to minimize climatic impacts and damage over time (i.e. corrosion and water absorption into the structure).

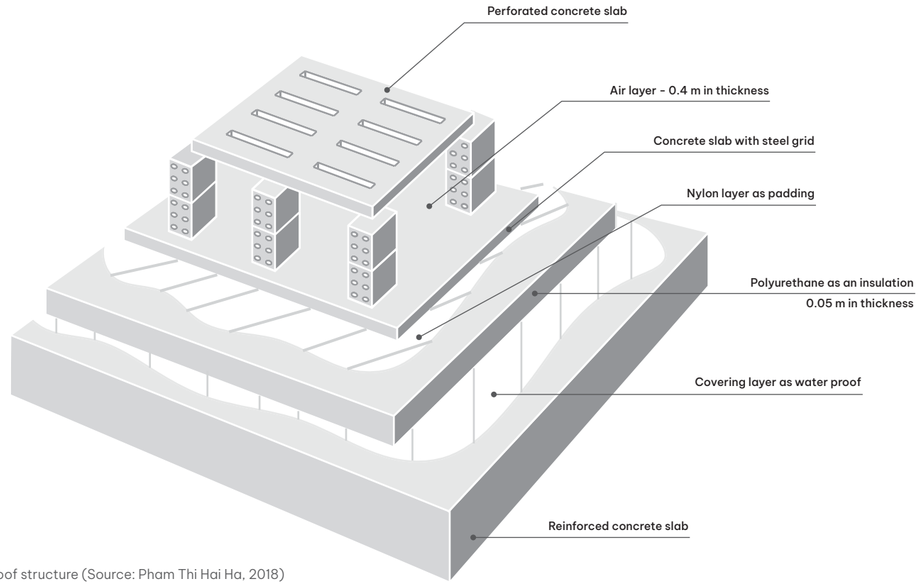

Figure 3.3c. Roof structure (Source: Pham Thi Hai Ha, 2018)

3.3.5. Hints and tips

Enhancing the efficiency of external sun-shading systems

- ☆ Install the external shading devices first and then choose glass that has suitable thermal and optical properties. These two are the most efficient solutions in passive cooling that prevent excessive solar heat from entering the building. They also optimize daylight penetration while minimizing the heat absorption. High-performance glass should not be a stand-alone solution;
- ☆ To reduce the energy consumed by cooling and air conditioning; design 'egg-crate' devices for loggias, glazed façade doors and windows. These can be façade gridding; or walls made of blocks or bricks with various patterns;
- ☆ Continuous horizontal sun-shading devices are also recommended for all glazed openings;
- ☆ Sun-shading and rain protection devices can work in harmony with roof structures, balconies, loggias, etc. to protect the facade and other outdoor spaces from sun and rain.

Minimizing solar heat absorption on the roof and outer walls of a building

- ☆ Roof solar reflectivity should be higher than 0.7;
- ☆ Wall solar reflectivity should be higher than 0.4;
- ☆ A fixed shading structure can be installed and the building can still be ventilated, by designing a structure to be at least 0.35 ÷ 0.40 m off the wall;
- ☆ Install green walls and green roofs to reduce the impact of excessive solar radiation; increase thermal insulation, through air layers and voids; and retain rainwater, thereby improving the buildings' microclimate, eco-features, and esthetic values;
- ☆ Install PV panels and solar collectors on the roof and wall surfaces to convert solar radiation into useful energy and reduce unwanted solar heat from being absorbed into the building envelope.

For West-facing façades

- ☆ Optimize the building by orientating the building to minimize the west-facing façade and design auxiliary spaces and rooms adjacent to the West-facing façade;
- ☆ Window to Wall Ratio: Reduce the area of glazing on the West-facing façades.

In case of glare

- ☆ Consider using curtains and blinds to help reduce glare and discomfort that may arise;
- ☆ Curtains and blinds need to be light in color to ensure an appropriate amount of useful diffused sunlight into the space, and at the same time reduce heat absorption through the windows.

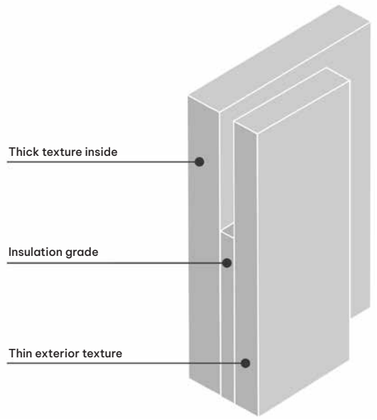

Figure 3.4a. Wall structure (Source: Pham Thi Hai Ha, 2018)

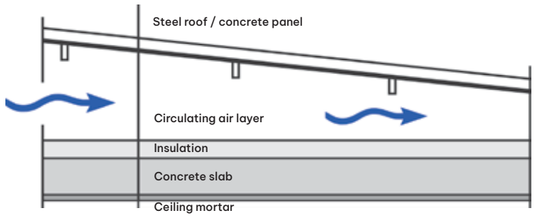

Figure 3.4b. Sloped roof structure (Source: Pham Thi Hai Ha, 2018)

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Source: 1+1>2 Architects

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Chapter 04

Green building materials

Le Thi Song, Luu Thi Hong & Nguyen Thi Tam

Source: Michael Waibel

3.4.1. Rationale

In Vietnam, the construction industry is responsible for using over 30% of the extracted natural resources, consuming nearly 40% of its electricity, 12% of drinking water, and generating about 45-65% of waste in landfills (Saigon Businessmen, 2023)

On global scale, CO_2 emissions from building operations have reached an all-time high in 2021 (UNEP, 2022). When including estimated CO_2 emissions from producing building materials, buildings represented around 37% of global CO_2 emissions (UNEP, 2022) and about 33% of total final energy consumption (REN21, 2023).

To minimize the negative impacts of construction on nature and on people's health, the use of materials derived from natural resources must be limited. However, construction in Vietnam is increasing. According to the Ministry of Construction of Vietnam, the growth rate of the construction industry in the first six months of 2022 increased by about 4% compared with the same period in 2021. The national urbanization rate is estimated at about 41%, and the average floor area per capita reached approximately 25 m². Against this backdrop, it has become necessary to find solutions: To apply new materials as well as recycle materials, and to utilize sustainable and eco-friendly building materials in order to minimize the negative impacts of the construction industry on the natural environment and on people's lives.

In response to this need, the Strategy for the Development of Building Materials in Vietnam for the 2021 - 2030 period, which extends towards 2050, has put an emphasis on the importance of the efficient use of natural resources; radically saving energy and raw materials; and minimizing the environmental impact in the mining process as well as in regard of the production of building materials and products. This is in line with a global response to climate change that is targeting at building materials to reduce greenhouse gas emissions and conserve natural resources. Achieving sustainable development is the ultimate goal. Most tools developed for the evaluation of green buildings clearly indicate the need to use green materials in construction. Some examples are shown in Table 4.1.

Table 4.1. Criteria of some material standards for green buildings

Certification system	Requirement
EDGE Green building certification (International Finance Corporation)	Energy stored in the material must be decreased by at least 20% compared with a baseline of the local zone
LOTUS Certification (Vietnam Green Building Council)	Using non-fired materials, recyclable materials, eco-friendly materials
Green Mark certification (Singapore)	Using local materials, non-fired materials, recyclable materials, eco-friendly materials
LEED Certification (USA)	Using non-fired materials, recyclable materials, eco-friendly materials

3.4.2. Benefits

The use of green building materials brings many benefits compared to using traditional building materials as follows:

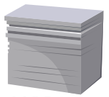
- ☆ Applying environment-friendly strategies: The production process of non-fired materials and green materials creates fewer harmful gases and releases fewer toxic substances into the environment;
- ☆ Developing advanced technologies: The use of green building materials contributes to the development of new technologies that are more effective than traditional ones;
- ☆ Saving natural resources: The development of green building materials helps save natural resources for the country, because the amount of raw materials used is reduced. This further protects the environment;
- ☆ Ensuring a better quality of life: Green building materials do not pollute the environment, resulting in cleaner air and so less respiratory illness;
- ☆ Achieving sustainable development: Green building materials create many benefits for today, and they also increase the sustainability of future construction works.

3.4.3. Principles

Green building materials are also called eco-friendly materials. They are construction materials that have a low environmental impact. They are composed of renewable resources rather than non-renewable resources. They must be natural and not be spoilt by heat, humidity or cold weather. Eco-friendly materials must have at least one of the following criteria:

- ☆ Contain low or non-toxic materials;
- ☆ Be made from recycled materials and must be recyclable;
- ☆ Be a resource-saving material, using energy and water efficiently;
- ☆ Be a material with a long service life;
- ☆ Be a material that considers environmental issues during production, use and recovery after use.

Table 4.2. List of building materials for green construction

Group of Materials	Illustration
Non-fired materials: Foam concrete, autoclaved aerated concrete (AAC), autoclaved aerated concrete panel, extruded hollow concrete panel, non-fired tiles, recycled aggregate, low-e glass and solar control glass, zero VOC paints, reflective tiles and roofs with high solar reflective index (SRI).	 AAC Bricks
Recycled materials: This group of materials commonly contains recycled ingredients during the production process, such as cement made from industrial waste, concrete pavement bricks, fired clay bricks, ready-mixed concrete, wood, plastic, bricks from construction and demolition waste.	 Insulation concrete made from recycled foam
Bio-based materials: Straw bale, natural fibers (coconut, cotton, yarn, etc.), sandbags, materials derived from soil (mixed clay, corncob, lime, rammed earth, bamboo, etc.).	 Material made from bamboo
Insulation and sound-proof materials: Ecological roofing, synthetic roofing, insulation panel, PU foam, XPS foam, etc.	 PE insulation sheet

Chapter 04

3.4.4. Solutions

- Worldwide, labeling programs for green building materials aim to increase the sustainable use of natural resources and protect the environment throughout the product's life cycle, from raw material extraction, production, packaging and with transport, consumption and finally to product disposal.

- Most green building standards and certification systems, such as LEED or LOTUS, require an integrated design and material selection process to reduce negative environmental impacts, improve the indoor environment and use resources efficiently.

- In Vietnam, labeling and certification programs for selecting materials with regard to energy saving, natural resource saving and environmental protection have not yet been developed. Decree No. 08/2022/NDCP stipulating eco-labels criteria, and certification of Vietnamese eco-labels, has been issued; however the sets of criteria for ecological products are yet to be issued by the Ministry of Natural Resources and Environment.

- At the institute level, the Vietnam Institute for Building Materials (VIBM) has developed a set of criteria for evaluating and labeling green and energy-saving building materials to help customers choose the suitable products for their responsibility to the environment and society. Green cement label and energy label for construction materials have been announced and managed by Vietnam Institute for Building Materials (VIBM) – Ministry of Construction - under Decision No. 201/VLXD dated 29 September 2022 with code NXVLXD 01:2022 – Green Cement Label and code NNVLXD 01:2022 – Energy Label for Construction Materials. The criteria for evaluation of green cement are specifically shown in Table 4.4.

- Energy labels for construction materials are applied for external covering and roof structures, such as wall panels, wall structures, glazing, window, door, etc. These labeling iniatives are implemented to provide information for investors, designers, consultants, construction contractors and consumers, etc. to enable them to select the most suitable materials for energy efficiency purposes (according to QCVN 09:2017/BXD – known as the National Technical Regulation on Energy-efficient Buildings).

Table 4.3. Green Cement Label and Energy Label for Construction Materials from VIBM

Green Cement Label	Energy Label for Construction Materials		
XI MĂNG XANH - GREEN CEMENT VIBM ECOLABEL	AAAA-BBBB λ – YYYY (W/m.K) ISO 8301:1991	AAAA-BBBB SRI – YYYY ASTM E 1980:2011	AAAA-BBBB SHGC– YYYY TCVN 11857:2017
	For the material of the outer covering structure and the roof of the building	*For finishing material of external covering structure and building roof*	*For transparent materials, such as glass doors and glass walls*

Table 4.4. Criteria for evaluation of green cement products from VIBM label

Criteria	Value
1. Requirements for the use of alternative raw materials and fuels	
Use of alternative fuels	Up to 15%
Use of industrial waste as an alternative material	Minimum 39%
2. Energy consumption and emissions	
a) For the clinker production stage	
Heat consumption	≤ 800 kcal/kg of clinker
Electricity consumption	≤ 65 kWh/ton of clinker
The emission level of fuel gas	+ SO_2 ≤ 200 mg/Nm³; + NO_2 ≤ 800 mg/Nm³; + dust ≤ 30 mg/Nm³.
b) For the cement grinding stage	
Electricity consumption	≤ 40 kWh/ton of cement
CO_2 emissions from the cement production process	≤ 650 kg/ton of cement

- Following the current trend and assisted by many State policies and regulations, green building materials and products have a great potential for further development and nationwide uptake. The Government's support includes tax exemptions, reductions for listed eco-friendly products, green credit policy, preferential loans from international organizations, etc. This development is also driven by the increasing general public awareness that tends to select energy-saving and eco-friendly building products, and the recycling of building materials saves natural resources and supports the development of sustainable construction.

- The trend of using these kinds of materials is not only increasing among architects, contractors and investors; but is also promoted by the State and the Ministry of Construction, so it has a growing interest among consumers. However, there are some difficulties as follows:

  → Manufacturers are not really interested in the development of green building materials and green building products;

  → Consumers have not yet been fully aware as they need to be;

  → There is a lack of suitable policies and regulations to promote the marketing of green materials;

  → The criteria, regulations and policies for determining green building materials/ecological building materials have not been completed;

  → Lack of appropriate standards, testing methods, testing facilities for new and specific products.

3.4.5. Hints and tips

☆ Green materials in buildings bring significant benefits to the society and enhance long-term sustainable development due to their ability to reduce environmental pollution and other negative environmental impacts;

☆ At the same time, the use of green materials also offers "holistic solutions" to construction projects. Apart from the technical requirements that must be achieved to ensure the quality of products, the selection of green building materials and green building products must also be made based on relevant environmental criteria. Some notes when selecting green materials are taken as follows:

- For indoor products, such as flooring materials (chipboard, fiberboard, plywood and timber), gypsum boards, wall panels, adhesives and coating materials: Consider the controling indicators of VOC emission and formaldehyde emission. These are toxic compounds that may cause cancer, mutagenicity, teratogenicity, etc.;

- Prioritize the selection of materials that can be reused in construction as their original purpose or used for new purposes; some materials can be reused either on-site or on other sites, such as tiles, doors, sliding doors, windows, floor materials, ceiling panels, etc;

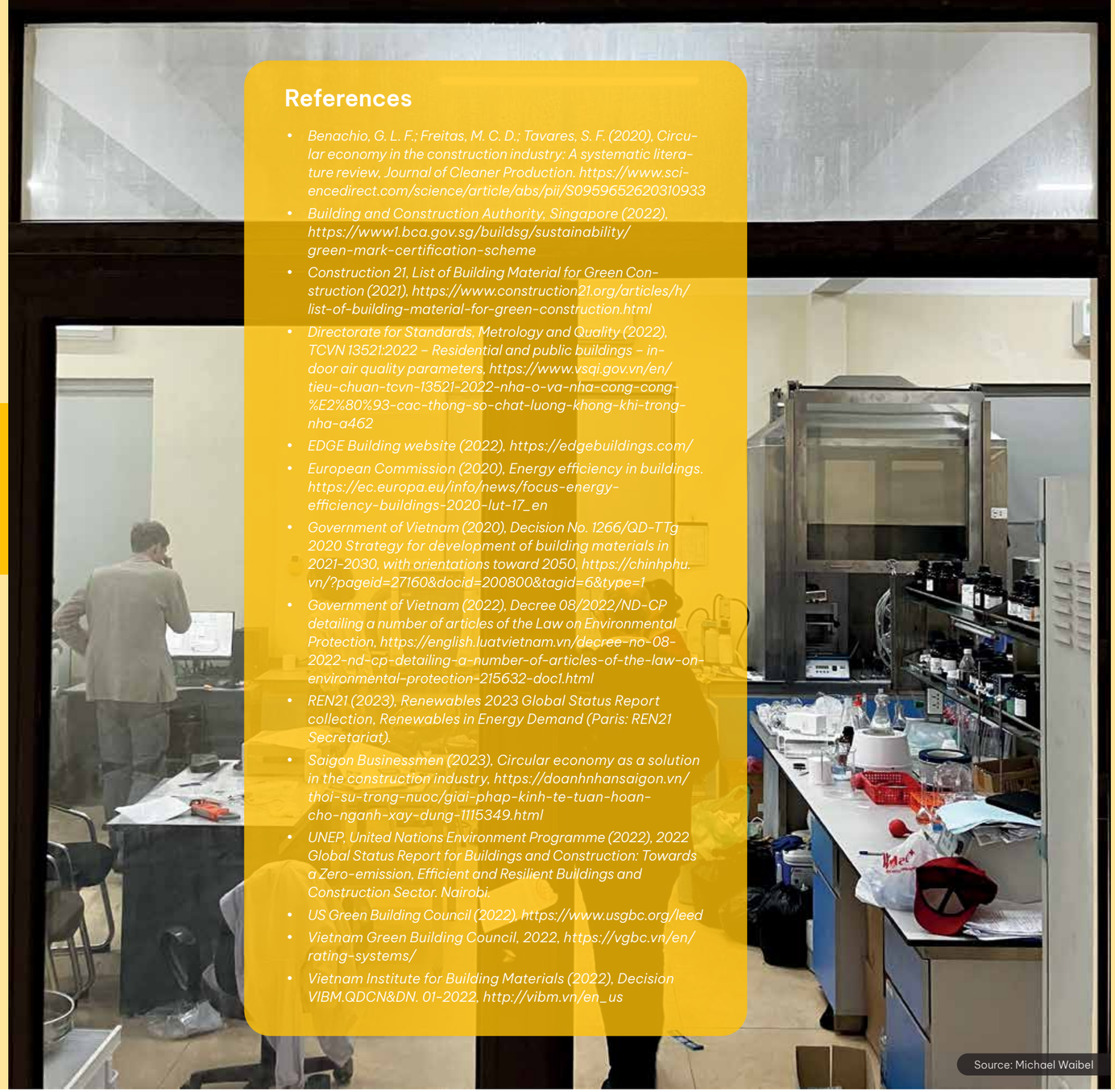
- All building materials or products can be considered to be recyclable materials;

- Prioritize using non-fired materials (concrete bricks, gypsum boards, precast concrete, etc.) and quickly renewable materials (bamboo, coconut, reeds, straw, etc.) and especially products that have been certified and labeled as eco-friendly materials, energy-saving materials or green materials.

Figure 4.2. Example of bio-based building material: Coconut fiber (Source: Michael Waibel)

Figure 4.1. Impressions for VIBM outdoor building material teststand in Ha Long City and from VIBM laboratory in Hanoi.

Source: Michael Waibel



Source: Michael Waibel

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Selection of building and finishing materials

Hartwig M. Künzel & Andreas Zegowitz

Source: Andreas Zegowitz

3.5.1. Rationale

The building sector is responsible for a major part of global carbon emissions. Despite the continuous development and installation of energy-efficient building envelopes as well as HVAC systems, the global energy consumption for building operations is still rising.

Urbanization and global warming in regions with fast population growth rates are responsible for climbing consumption as well as growing floor area per capita and occupant comfort demand. Today, it is possible to design buildings that are labeled as carbon neutral, which means they can generate more energy than they actually use. However, building operation energy savings and onsite energy generation do not represent the whole picture. The embodied energy, i.e. the energy required to produce and install building components, is the other side of the coin. Some building materials such as steel, concrete and fired clay brick have a very large carbon footprint, while recycled and renewable materials have a low or sometimes even negative carbon balance.

3.5.2. Benefits

Selecting appropriate building and finishing materials provide the following benefits:

- ☆ Limitation of embodied energy;
- ☆ Conservation of natural resources;
- ☆ Mitigation of the urban heat island effect;
- ☆ Reduction in demand for cooling energy;
- ☆ Durable façade systems;
- ☆ Hygienic indoor environment.

Figure 5.1. Example of insulating panels (Source: Andreas Zegowitz)

3.5.3. Principles

For choice of building materials:

- ☆ Limiting the embodied energy of building materials and conserving natural resources imply a careful selection of construction and finishing materials and systems. The manufacturing and transport of these materials should be as energy-efficient as possible. At the same time, mining necessary raw materials must not deplete natural resources. Therefore, renewable (bio-based) or recycled materials should be preferred;
- ☆ Reusing building materials is also a favorable option that has been practiced widely in pre-industrial times. Building with lightweight materials has less mass per cubic meter than massive concrete or masonry structures, and they generally contain less embodied energy;
- ☆ Timber and other bio-based materials sequester CO_2 during their growth, which is subsequently stored over the lifetime of the building. Figure 5.2 below shows the differences in global warming potential for various kinds of constructions. Three of them are considered to be massive, and two of them are considered to be light-weight building types;
- ☆ While the choice of structure and the material selection are key factors for limiting the global warming potential in new buildings, rehabilitating, or even better, retrofitting of existing buildings, has far less impact on the environment and should be preferred where feasible.

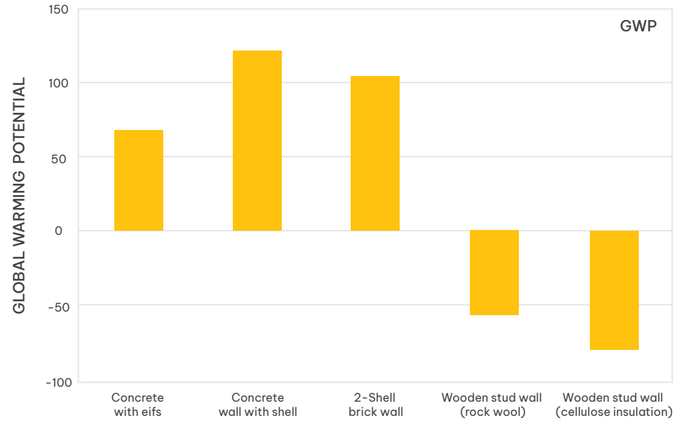

Figure 5.2. Global warming potential for multi-family buildings have different structures and building envelopes determined based on established German calculation methods (Source: Schwede & Störl, 2018)

Figure 5.3. Development of Expanded Polystyrene (EPS)-based light-weight concrete sandwich wall panels "NUCEWALL" at Hanoi University of Civil Engineering (HUCE) (Source: Andreas Zegowitz)

Figure 5.4. Air chambers in the building blocks increase the thermal insulation effect (Source: Andreas Zegowitz)

Figure 5.5. Example of two kinds of plaster walls (Source: Andreas Zegowitz)

For finishing materials:

- ☆ Finishing materials cover the exterior and interior surfaces of the building structure. While their purpose has often been mistaken as being only decorative, they have very relevant and specific functions in high-performance buildings;
- ☆ Both exterior and interior finishing systems should be airtight to prevent air in, or exfiltration through or into the structure. At least one side must include an insulation layer to ensure thermal comfort and energy efficiency, unless the building structure has enough thermal resistance itself (e.g., Autoclaved aerated concrete [AAC] masonry);
- ☆ A high moisture buffering capacity of the interior finishing system helps reduce indoor humidity fluctuations caused by the occupants' activities or intermittent air-conditioning operations;
- ☆ The most relevant functions, such as long-term weathering protection and radiation control, must be assumed by the exterior finishing system. Figure 5.6 demonstrates the climatic impacts on external wall construction. In the hot and humid regions of Vietnam, the most relevant impact parameters are solar radiation and wind-driven rain;
- ☆ Solar radiation heats up the façade surface and the absorbed heat is propagated through the wall towards the interior spaces. Adding an insulation layer helps mitigate this problem;
- ☆ However, the hot external surface is also affecting the ambient air temperature, which contributes to the urban heat island effect and will also increase the temperature of the air supply if windows are opened, or if decentralized ventilation systems are employed. Thus, the whole building envelope should be designed to reflect solar radiation in order to keep the exterior surface temperature as low as possible;
- ☆ In addition to radiation control, evaporative cooling, e.g. provided by the garden roof, can further reduce the exterior surface temperature;
- ☆ The influence of wind-driven rain on an external wall can be seen in Figure 5.6. During rainy spells, water is absorbed through the exterior finishing system (mostly a lime-cement render), and afterwards, the water will partially evaporate again. Depending on the material of the load-bearing structure and the hygrothermal properties (characteristics of a material in relation to moisture) of the render, as well as on the annual amount of wind-driven rain, there will always be some residual water in the construction;
- ☆ Practical experience proves that the bulk of this residual water is concentrated in a layer, some centimeters beneath the exterior surface. Since the long-term presence of water in building materials is often accelerating damage or degradation, it should be controled to ensure a durable building envelope that is free of mold and other micro-organisms.

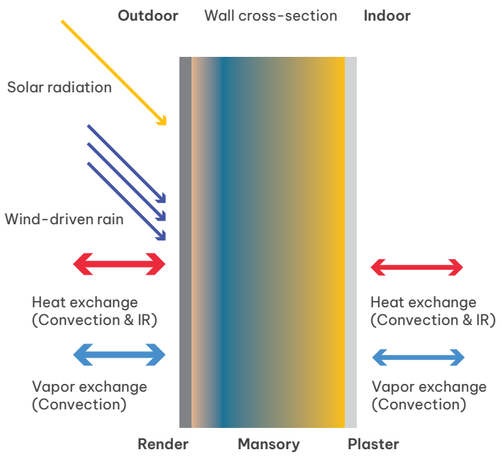

Figure 5.6. Heat and moisture loads acting on masonry walls. Rainwater absorption through a traditional render raises the water content of the masonry blocks. Alternating rainy and dry spells lead to long-term moisture peaks somewhere below the exterior surface, which may diminish the thermal resistance and stability of the wall (Source: Hartwig Künzel)

3.5.4. Solutions

For building materials:

- Assuming that the standard construction type consists of a load-bearing frame structure made of either concrete, steel or timber, the materials recommended in this chapter only need to be self-supporting and possibly shear-stress resisting. In the case of timber structures, masonry infill or wooden sheathings can perform both functions, while curtain walls are only self-supporting;

- All wall types must fulfill the requirements in building physics, such as weathering resistance, fire resistance, airtightness as well as heat and sound insulation;
- The importance of air-tight building envelopes is often ignored in warm climates, because good natural ventilation helped improve thermal comfort in the past;

- However, if the building is air-conditioned, leaky envelope components waste energy, and even worse, they may raise the indoor humidity and cause hygienic problems in very humid climate zones;

- Most AC systems are designed to handle sensible heat loads, but their capacity to remove moisture (latent heat load) is limited, since AC systems remove heat and moisture simultaneously at a certain rate. This problem becomes more severe in green buildings because the heat load is smaller, but the moisture load remains almost unchanged.

For finishing materials:

- The option of finishing materials depends on the building materials selected. Masonry infill, consisting of light-weight blocks with low thermal conductivity and very thin mortar joints (masonry adhesives), such as Autoclaved Aerated Concrete (AAC) blocks, light-weight concrete blocks with pumice, expanded clay or foam glass aggregates, are often covered at the outside by a mortar rendering system applied at the construction site;

- Since masonry blocks absorb liquid water readily, adequate moisture protection is essential to prevent performance failure or damage. Effective driving rain protection can provide water-repellant rendering systems for walls exposed to considerable wind-driven rain loads (Künzel, 2015);

- Traditional lime-cement mortars mixed at the building site are insufficient. Mortars for external renders must be made from pre-mixed compounds by adding water and respecting the manufacturer's application guidelines to obtain the specified properties;

- In colder regions, e.g. at higher altitudes, insulating rendering systems covering the whole exterior surface help prevent problems caused by the thermal bridge effect of the load-bearing structure;

- In hot and very humid climate zones, the vapor permeability of the external render should not be too high, because the vapor flux from outside may also lead to an increase in the water content of the masonry, especially when the interior surface is rather impermeable, e.g. covered with tiles or vinyl wallpaper;
- Timber frames and opaque parts of curtain walls can usually accommodate enough insulation to comply with the requirements of warm and moderate climate zones. Owing to multiple joints and connections, the long-term air tightness of the envelope may be a challenge;

- While the application of render and interior plaster ensures adequate airtightness of masonry structures (unrendered and unplastered masonry walls are rather air-permeable), timber frame and curtain walls should include a continuous air barrier design. This may be realized by membranes or rigid elements taped at the edges and connections;

- Envelope systems with proper vapor permeable insulation materials, such as mineral wool, may need so-called vapor control layers to prevent interstitial condensation at the colder side of the wall component. Therefore, a climate-adapted moisture control analysis should confirm the design specifications;
- Independent of the type of construction, the façade should have a high short-wave reflectivity (bright color or cool color cladding, respectively, a green plant cover) to avoid hot exterior surfaces;

- A small window-to-wall ratio is also beneficial. On the interior side, moisture buffering finish materials help control humidity peaks in living rooms. They are able to dampen the indoor humidity fluctuations by absorbing vapor at high humidity levels and releasing it again when the indoor humidity drops, e.g., when the AC is running (Künzel et al., 2005). This leads to healthier and more comfortable indoor environments.

3.5.5. Hints and tips

☆ Replacing fired clay bricks with light-weight concrete or other material blocks may cause moisture-related damage, because clay bricks show a very benign moisture behavior. Solutions to this problem are at hand, but practitioners must be informed about them;

☆ Wind-driven rain protection is essential and may require special water-repellant rendering systems or additional coatings;

☆ Bright façades or roof colors reduce the absorption of solar radiation and keep surfaces cooler;

☆ Green roofs protect the roof from overheating and improve the urban environment;

☆ Moisture buffering interior lining materials help keep a comfortable and hygienic climate in air-conditioned interior spaces;

☆ Building envelope design should focus on adequate and continuous thermal, air-flow and moisture control layers to ensure energy efficiency, comfort and durability.

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In many projects on the national and international levels for the industry and for the ministries, his working group has performed tests and climate simulations on thermal insulations, windows, façades and all kinds of building envelope components. Current projects deal with the development and research concerning building materials to replace fired-bricks for wall structures in Vietnam.

Building execution quality

Michael Wieczorek

Source: www.istock.com

3.6.1. Rationale

Developers of new residential buildings often focus on high-level planning, good-looking simulations and beautiful green façades. There is, however, an increasing awareness of the products that are used to make the building greener and more energy efficient, such as Autoclave Aerated Concrete (AAC) bricks, optimized external thermal insulation systems (ETICS) and windows with a low U-value or low solar heat gain coefficient (SHGC).

However, there needs to take more focus on the qualifications and competence of the workers on the construction site that use these innovative products, and who make the building green and healthy in reality.

Source: Michael Waibel

Green buildings are only one hundred percent sustainable and energy efficient if they are both sustainably planned and professionally constructed to the highest standard possible. Therefore, experts like professional masons and a qualified building quality control are very much necessary during the whole construction process to ensure the 'Building Execution Quality'. It is also essential to ensure that sustainable and energy-efficient planning follows through to become 'best-practice' on the construction site.

'Building Execution Quality' in Vietnam should be implemented based on both national and international construction management standards and regulations. This requires a well-structured project management system and a comprehensive practitioner-certification program. This implementation needs to be included in all aspects of construction, from below and above ground to installing technical systems.

3.6.2. Benefits

- ☆ Full implementation of green products which leads to enhanced material efficiency;
- ☆ Reduced waste on-site which leads to reduced environmental impact;
- ☆ A consistently healthy living environment;
- ☆ Minimal risk of structural damage;
- ☆ Minimal operating and maintenance costs;
- ☆ Building value retention - It is important that a high-quality building that is worth paying for can keep its value.

3.6.3. Principles

☆ **100% sustainably planned and 100% sustainably constructed**

The idea sounds easy, but it is actually rather difficult to achieve this goal. First of all, all people related to a construction project should be aware of that idea and consider it in every step during the planning and construction phase, from the first line drawn on paper to the final stone on the roof.

☆ **Qualified workers construct green buildings**

The high qualification level of workers and supervisors on-site is a key to realizing a healthy living in green buildings. Products for a green construction are directly linked to the qualification of workers that use them on a construction site. Only if workers and supervisors understand which effect every single product may have on the final quality of the green building, they will take care of and use or apply it in an appropriate way.

☆ **Working hand in hand**

An increased qualification level will be further achieved when construction workers do not only focus on the high-quality execution of their trade-related tasks but will also know what other construction workers have to take care of. The key point is the management of interfaces between the different trades. An electrician who installs a power cable line between an outer wall and the rooms inside a building should know where he can drill a hole and how he has to do it. He has to know that he must avoid destroying (even by mistake) the thermal insulation system that the mason has professionally constructed earlier.

Figure 6.1. Construction of a laboratory building at Vietnam Institute for Building Materials (VIBM) in Hanoi (Source: Andreas Zegowitz)

3.6.4. Solutions

Enhancing the basic qualification level of construction workers

- Increasing the quality level of the initial vocational education and training (IVET) of young people at professional skill training schools and vocational colleges;
- Enhancing the quality level of continuing vocational education and training (CVET) of construction experts, who have already had an existing basic qualification;

- Changing the view of teachers and trainers, in vocational education, to a more practical understanding of which qualification is actually needed on-site;
- Teachers and trainers need to focus on real-world tasks and procedures and then follow them up with the information required to make the training more relevant to the work on-site;

- Expecting qualified tradesmen to stay up-to-date with the difference between existing and new products, understand their characteristics and specifications, and know how to use them;

- Qualifying workers ought to select a suitable plan of action for the task-at-hand and to develop an appropriate plan of action to solve problems.

Source: www.istock.com

With knowledge comes awareness

- With a higher standard of qualification, construction workers become more aware that their work is important to practicing sustainable construction and more efficient in environmental protection. They know the difference between common and high-quality construction products, and they are qualified to use and install the products in a right way to achieve the maximum effect, e.g. to avoid or control thermal bridges through the outer walls of a building.

Quality control

- Construction projects always deal with complex undertakings, whether constructing a bridge, or a single or multi-story building. Many trades are involved in building a new house, from its grey basement to its green top. For a construction project to have a green and healthy living outcome, it is a “must” to have professional site management;

- The site management team does not only coordinate the different trades and logistics but is also responsible for the general supervision of the construction processes on-site and the detailed quality control plan for every step. Therefore, professional and successful site managers also need to be professional communicators. They give important hints of construction details to the workers at the right time and organize the timed interaction of trades with the general teamwork on-site.

3.6.5. Hints and tips

☆ Ask for qualified workers and professional site management;

☆ Look out for experts trained in special qualification programs like the ones coming from the College of Urban Works Construction (CUWC) in Hanoi;

☆ The common understanding should be that construction workers like masons, carpenters, etc. significantly increase the energy efficiency of buildings by means of:

- Precise and high-quality construction work;
- Appropriate use of modern materials;
- Knowledge and consideration of interfaces between the different trades in the construction process;
- Consistent quality control.

☆ The one who builds cheap is the one who builds the same thing twice.

In short-term thinking, green products and qualified construction experts are often more expensive than others, because the price that has to be paid when buying or hiring them is higher. But in the long run, it will be cheaper.

Lower-level products used by less-qualified workers make a construction project become much more expensive, energy will not be saved, a healthy living is not considered, maintenance of the building costs much more, and unskilled workmanship leads to unexpected repair costs and an earlier need for maintenance.

Be more clever!

The picture in the background shows the Center for research, training, application and transfer of green building technology in Vietnam. It is a five-story building on the campus of the College of Urban Works Construction (CUWC). The building is designed according to international standards and local regulations to create a model for green building with the application of modern international technology in Vietnam, a place for teaching, studying and transferring of new technology. The building was opened in the fall of 2022 and obtained a LOTUS-Gold certification.

Source: Nguyen Trung Kien

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Since 2007 he has been responsible for international projects related to energy efficiency in the construction sector of European and Asian countries (e.g. Vietnam, India and China). Focal point of his work is capacity building for construction workers and the middle management on a construction site including trainings of trainers in theory and practice.

Building operation and maintenance

Christina Karagianni, Le Dam Ngoc Tu & Pham Thi Hai Ha

Source: Department of Environmental Architecture, 2023

3.7.1. Rationale

Building operations and maintenance include all the activities people need to perform so that a building can work effectively. Another title commonly given to this work is facility operations and maintenance, a phrase that better encompasses all the activities, processes and workflows that keep the operations running properly. This includes management of building service systems, such as electrical, HVAC, mechanical, plumbing, security and telecommunication (voice/data/signal); maintenance of building structures; ground keeping, landscaping, site improvements; maintenance of interiors, furniture and equipment.

In this chapter, we divide these into two groups: maintenance and management of building services, and we pay attention to some of the more important issues involved. Occupants want the building to be pleasant, safe and healthy. However, because they are paying rent, they also want their space to be not too costly. Building owners and managers generally work towards a reputation of providing a high-quality property at a reasonable cost, but they also need to make a profit. Facility staff are often caught in the middle, trying to control operating and maintenance costs while still keeping occupants satisfied.

Regardless of the points on which they may disagree, building occupants, managers and staff do agree on the goal of providing a healthy indoor environment and reducing energy consumption. Sustainable building strategies can do both; while also increasing property values, attracting conscientious occupants and saving money on utility bills.

Building maintenance is a collection of tasks performed to ensure the normal and safe functionality of the building in accordance with the design regulations during operation and use.

Maintenance is important to ensure quality, increase the durability of the building, avoid building defects and control costs. This includes evaluating "green" alternatives where appropriate. A growing trend is that the regulations associated with building maintenance are increasingly being incorporated into Vietnamese construction law and other legal documents relevant to the building. They require that the owners or the occupants be responsible for the building maintenance in compliance with its associated legal and technical regulations on maintenance.

3.7.2. Benefits

☆ Building management is responsible for ensuring the functionality, comfort and safety of the building environment. Its goals should be to implement operational efficiency strategies and to identify the ways to improve the efficiency of energy consumption, water use and environmental quality (including indoor air quality) across the facilities. They should be adopting maintenance practices that help ensure a safe and comfortable environment for tenants while also making the building operate more efficiently;

☆ By adopting greener building strategies it is possible to:

- Maximize the return on investment, because it is reducing the operating expense of energy usage (lighting, cooling and heating);
- Achieve a higher green assessment value, making resale easier;
- Reduce waste and emissions by reducing the amount of energy consumed;
- Reduce allergies, asthma and other respiratory problems by using more natural products that contain fewer dangerous chemicals;
- Establish the impression that the building is maintainable by design, by doing so this will facilitate ongoing maintenance and minimize the impact of the building on the surrounding environment, thus reducing labor and the life cycle costs of the building, as well as energy.

3.7.3. Principles

Managing a building for good indoor air quality (IAQ), and sensible energy and water use involves reviewing current practices and establishing new procedures, if necessary, to:

☆ Operate and maintain HVAC equipment:

- Keep all equipment and controls in proper working order;
- Keep the interior of equipment and ductwork clean and dry.

☆ Oversee activities of staff, tenants, contractors and other building occupants that may have an impact on IAQ such as:

- Smoking;
- Cleaning and housekeeping;
- Apartment and building maintenance;
- Pest control;
- Food preparation and other special uses.

☆ Maintain communication with occupants, so they are informed of any complaints in time:

- Identify specific building management and staff members to be responsible for IAQ and energy use;
- Contact health and safety committees of the building.

☆ Educate staff, occupants and contractors about their responsibilities in relation to IAQ and energy use: identify aspects of planned projects that could affect IAQ and manage them, so that good air quality is maintained. Such activities include:

- Redecorating, renovation or remodeling;
- Building cleaning;
- New construction.

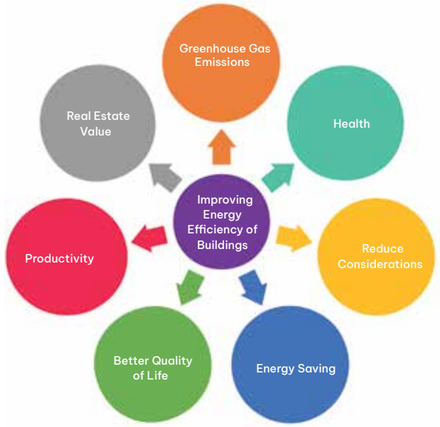

Figure 7.1. Multiple benefits as a driver of energy-efficient building renovation (Source: Humboldt – Viadrina Governance Platform)

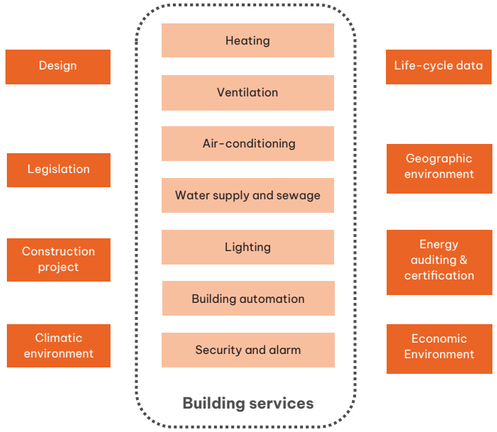

Figure 7.2. Framework of building service engineering (Source: Alanne, 2015)

Building maintenance needs to adhere to the following specific principles:

- ☆ The maintenance must be carried out while any of the building's construction work is in progress;
- ☆ The maintenance process must be established and approved by the investor before beginning any building or construction projects;
- ☆ The maintenance must ensure safety for people, property and buildings;
- ☆ The owner, user or manager of the building is responsible for maintaining the construction work, construction machinery and equipment;
- ☆ The maintenance of construction works and construction equipment must be carried out according to the approved maintenance plan and maintenance process;
- ☆ Large-scale buildings, complicated techniques and buildings that greatly affect the safety and interests of the community must be periodically assessed during operation and use.

Figure 7.3. Building Technical Room at College of Urban Works Construction, Hanoi (Source: Department of Environmental Architecture, 2023)

3.7.4. Solutions

To improve the efficiency of green buildings, solutions to maintenance must be considered from the outset of design to the operation phase for all the systems.

- Produce a Building Operation & Maintenance Manual including necessary information: a description of the main design principles or a description of the operation principles of the main systems (for buildings in operation):
  - → As-built drawings and specifications;
  - → Instructions for building operation and maintenance;
  - → Schedule of all equipment;
  - → Commissioning and testing results (if any);

- Guarantees, warranties and certificates (if any):
  - → Produce a Preventative Maintenance Plan (PMP) for the main services and equipment of a building, including energy-intensive and water systems, such as heating, ventilating, air conditioning and refrigeration, artificial lighting, metering and monitoring, control systems, hydraulic and renewable energy systems;
  - → Carry out planned and preventative maintenance on a regular basis, including systematic inspection, periodic partial or complete overhauls, oil changes, lubrication, cleaning and recording equipment deterioration to repair or replace;
  - → Ensure safe and efficient access for maintenance of façade, sky bridges, roof and all protruding parts by choosing the most efficient types of façade access system, such as Building Maintenance Unit (BMU), monorail system, temporary suspended working platform, rope access, ground-based access equipment or ladders and gantries.

Figure 7.4. A building maintenance unit (BMU) with trolley on rail track on top of LOTTE Tower, Hanoi (Source: Michael Waibel, 2014)

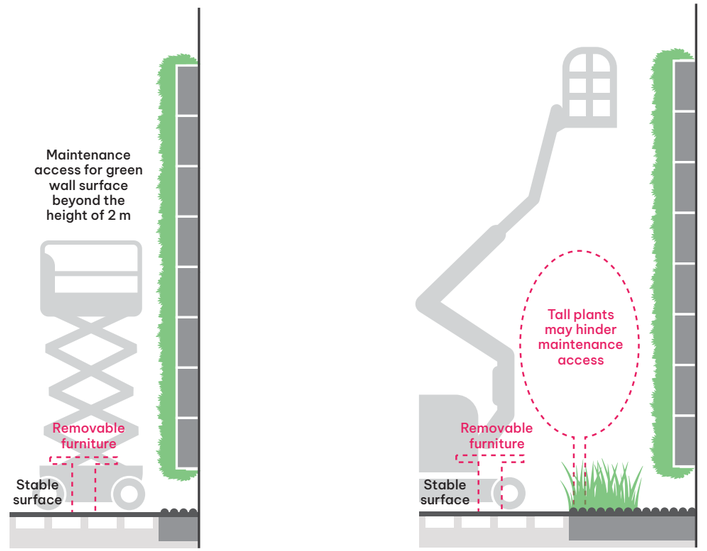

Figure 7.5. Examples of scissor lift and boom lift to maintain vertical greenery
(Source: Façade Access Design Guide, Building and Construction Authority of Singapore, 2017)

Chapter 07

Some actions to be taken to improve building operation:

- Upgrade systems and equipment: Starting with HVAC systems. Old HVAC systems are not only energy-inefficient, but they may also do a poor job of managing air quality. Upgrading old equipment could, on its own, save money every month;

- Install LEDs in all common spaces: LED bulbs are longer-lasting and consume only a quarter of the energy that conventional bulbs do. In addition, LED lights radiate less heat, which can further reduce the cost of air conditioning;
- Use time scheduling, in combination with simple occupancy sensors, to match lighting to usage time: Sensors located throughout a building can help maximize the energy-saving potential of infrequently used areas;

- Consider energy saving for both interior and exterior lighting;
- Occupancy sensors: It is possible to install occupancy sensors and software to manage lights and HVAC systems. When unoccupied, the system automatically turns off the heat or dims the lights;
- Energy audits: Knowing the baseline energy-use can help design strategies on how people can reduce electricity consumption;

- Water consumption: The first step to take in mitigating overuse of water is to detect any leaks and have them repaired;

- Encourage occupants to go green: Highlight green behavior by running an extensive awareness-raising campaign, including periodic energy-awareness days combined with energy-efficiency tips on posters and via email;

- Maintain good IAQ and thermal comfort by ventilating all common spaces: During pleasant and comfortable periods (whenever possible), keep windows and doors open to enable any pollutants to be removed and room temperature to be more agreeable;

- During cold periods, work out appropriate time intervals for ventilation (5 - 10 minutes) so that good IAQ is maintained but thermal comfort is not compromised;

- Trash disposal: Follow proper trash disposal procedures. If there is a restaurant in the building, require daily collection of trash. Ensure that the containers are covered, pest control is applied, and that the trash collection area is cleaned at least once a day.

3.7.5. Hints and tips

- ☆ The maintenance should be performed by qualified in-house staff and/or outsourced contractors who should be contacted in advance to participate in the installation and the commissioning of all equipment;
- ☆ Integrating maintainability into the building design will make the maintenance efficient, labor-saving and cost-effective;
- ☆ Façade access needs to be considered early in the design of a building to integrate the most suitable access systems into the building design;
- ☆ At the management level, set specific energy targets for a building and its facilities to achieve these targets can be built into the manager's personal performance appraisal;
- ☆ Understand the fundamentals that affect indoor air quality in the building (see Chapter 10 for more information). Periodically inspect the building to discover and remedy IAQ problems;
- ☆ Know the difference between predictive, preventative and reactive maintenance, and when to apply which concept. There are generally three approach methods to building maintenance used by facility managers:
  - *Reactive* - This is the "fix it when it breaks" approach;
  - *Preventative* - This is the "check it and make repairs before it breaks" approach;
  - *Predictive* - This is the "use technology to forecast when a problem will occur and provide maintenance accordingly" approach;
- ☆ Initiate and maintain a good communication with the building occupants, because they are the ones that will most probably notice a problem first and can help address it as soon as possible.

Source: Michael Waibel

Figure 7.6. Building maintenance as periodical activity (Source: Michael Waibel)

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Household energy saving

Nguyen Thi Thu Thuy

Source: Michael Waibel

3.8.1. Rationale

Household energy is the energy used by households to serve their daily needs. Depending on local climate, economic and housing conditions, household energy can be electricity, fuels, natural gas, oil, wood, etc., and is mainly used for space and water heating, cooling, cooking, lighting, and electrical appliances as well as other end-uses outside the dwellings (i.e., daily commuting).

There are two key sources of household energy consumption: fossil fuels (i.e., natural gas, oil, and coal) and renewable energy (i.e., conventional biomass, solar, wind and geothermal energies).

Saving energy is the practice of using less energy to reduce costs and carbon emissions into the atmosphere. This chapter discusses relevant opportunities for households in Vietnam to save energy.

SAVE ENERGY
SAVE MONEY!

3.8.2. Benefits

Saving household energy is beneficial for each individual household and also for the national economy. Saving energy can be supported by:

- ☆ Reducing energy bills;
- ☆ Minimizing operation, maintenance and replacement costs of household appliances and devices;
- ☆ Improving human health (e.g., through reducing dependence on AC usage and retaining thermal comfort in the case of unexpected energy shortages and blackouts);
- ☆ Reducing householders' environmental footprint and so protects the environment;
- ☆ Reducing the burdens on the local energy system by reducing the demand;
- ☆ Increasing the value of the properties by embedding energy saving solutions;
- ☆ Inspiring and disseminating an environmentally friendly lifestyle.

3.8.3. Principles

- ☆ Implementing energy saving is more about changing individuals' attitudes and daily life habits than just about using energy-efficient appliances;
- ☆ Even the adoption of minor energy saving habits may lead to significant monetary saving and does not mean "being mean" or "not being able to afford";
- ☆ Lifestyles that save energy also tend to improve personal health and happiness, and show the individual's awareness of, as well as responsibility for the environment;
- ☆ Environmentally friendly lifestyles are becoming more popular in developed societies and practiced by all social groups (i.e., choosing to use a bike and public transport instead of driving a car, etc.).

3.8.4. Solutions

Solutions to save household energy range from small changes in daily habits to more costly investments in energy-efficient technology. The following solutions cover aspects of efficiency, feasibility and affordability.

Individual habit adjustments

Adjusting individuals' day-to-day behavior and habits is cost-free and applicable in any household. Actions can be taken in the following areas:

Lighting and devices

- Make use of daylight because it is healthier and cost-free;
- Turn off lights when leaving the room or your desk;
- Replace traditional halogen light bulbs with energy-efficient alternatives, such as compact fluorescent lights (CFLs), and light-emitting diode bulbs (LEDs) which consume up to 80% less electricity and last up to 25 times longer than traditional bulbs. Energy-efficient light models may also look more stylish and modern;
- Unplug devices or appliances when they are not used, because devices in standing-by modes still consume a considerable amount of energy.

Cooking and eating

- Always cook with the lid on. This preserves the food's nutrition value and saves cooking time as well as energy;
- Try to cook an appropriate amount of food according to the meal plan to avoid the unnecessary waste of energy for a bigger portion, fridge storage and reheating. Note that reheated food may lose its nutritional value and good taste as well;
- Steamed food and plant-based food take less cooking time which results in less energy consumption; Steamed food is also generally healthier than fried food while plant-based food is generally healthier than animal-based food;
- Try to include more fresh fruits and salads in your daily diet, because they do not need any energy for cooking. They also make for a healthy diet.

Figure 8.1a. Lighting and device unplugging (Source: Nguyen Thi Thu Thuy)

Figure 8.1b. Turning off light when going out of the room (Source: Nguyen Thi Thu Thuy)

Figure 8.3. Faster cooking with lids on (Source: Nguyen Thi Thu Thuy)

Figure 8.4. Plant-based healthy and energy-saving diet (Source: Nguyen Thi Thu Thuy)

Figure. 8.5 Cold washing setting (Source: Dien May Xanh, www.dienmayxanh.com)

Figure 8.6: Energy saving by using both the ceiling fan and the air-conditioner (Source: Nguyen Huong Lan)

Washing

- Try to limit unnecessary changes of clothes during the day. This reduces the need for unnecessary washing and also saves time;
- Only turn on the washing machine when it has a full load of clothes;
- Wash clothes at a cooler temperature than recommended. This saves the energy that is used to warm the water and further prolongs the lifespan of your clothes;
- Do household tasks manually where possible, such as hang-drying washed clothes instead of using a drying machine;
- A fully packed dishwasher might be more energy-efficient than washing the dishes manually, but this does depend on the dishwashing habits. In many households, manual dishwashing does not require running a tap which then allows for the reuse of dish-rinsing water.

Thermal comfort and the indoor environment

- Using the human body's natural adaptation towards thermal comfort is usually better than using artificial means. This can be achieved by body hydration (drinking enough water, eating more fruits, vegetables, etc.); wearing warm clothes in the winter and breathable materials in the summer; and also by using natural bedding materials like linen, bamboo, cotton (Jerden, 2022);
- Natural ventilation can improve the local indoor environment remarkably through design solutions, the complete opening of windows several times a day and the use of fans which minimizes the need for using air-conditioning;
- If the AC has to be used, set the thermostat at 21-26°C to achieve comfort and also save energy;
- Ceiling fans should be used in addition to the AC machine to circulate cool air into the room. This is because ceiling fans use less electricity but further increase the AC's efficiency by allowing the thermostat to be set at 4°C higher. For example, at 26-28°C instead of at 22-24°C.

Figure 8.7. Curtain to adjust the sunlight through glass window/balcony door (Source: Nguyen Thi Thu Thuy)

Daily commuting

- Make a smarter choice to commute, especially in big cities with a higher vehicle density;
- Walking or biking is healthier, cheaper and also faster in case of traffic jams;
- Pay regard to the rising opportunities of public transportation which is getting continuously better as network connections improve;
- In modern societies, individual car possession and expensive fancy cars are no longer perceived as a sign of success and status.

"A developed country is not a place where the poor have cars. It is where the rich use public transportation."
Gustavo Petro, former Mayor of Bogotá, now President of Colombia

Chapter 08

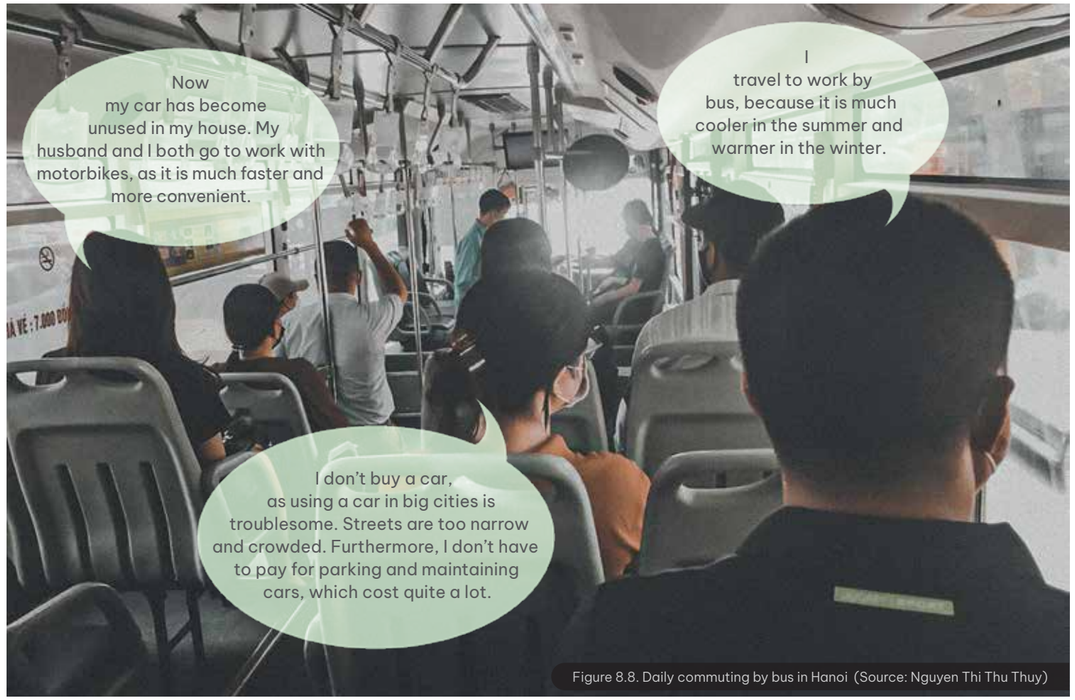

Figure 8.8. Daily commuting by bus in Hanoi (Source: Nguyen Thi Thu Thuy)

Appliance usage and maintenance

Energy-efficient appliances can cut electricity bills by half!

- Consider installing a programmable smart thermostat to control heating or cooling temperature. A programmable thermostat can be set to automatically turn off or reduce heating and cooling whenever necessary;
- Replace home appliances (such as ACs, refrigerators, water heaters and dryers) with those with energy star certifications and smart automated devices which automatically turn off the electricity supply when they are not in use;
- Use smart power strips, also called advanced power strips, which turn off the power when electronic devices are not in use or when a "turning-off" time is set;
- Consider installing smart meters inside your home to monitor the power consumption of each appliance or activity.

Appliance maintenance

- Maintain electrical appliances regularly to sustain their energy efficiency;
- Replace air-conditioner filters regularly. This sustains efficiency and reduces repair costs;
- If possible replace appliances that are not energy-efficient;
- Keep a maintenance diary to effectively monitor the maintenance of household devices and appliances.

Figure 8.9. Energy efficiency labels in Vietnam (Source: moit.gov.vn)

Improving the physical aspect of houses

The physical aspect of the house influences the need for cooling, heating and lighting significantly. This has a flow-on effect on the occupants' health.

Households can save energy through the passive design of new constructions and also through retrofitting measures:

- If possible, pay attention to the location of the house or building and also the location and sizes of the doors and windows to take advantage of natural sunlight and ventilation;
- Utilize horizontal airflow channels (depending on local wind conditions): e.g. set windows on the South façade to allow the South wind to blow through to the North side of the apartment; The same principle applies to the East façade;
- For apartments on the leeward side, make use of cross-ventilation through low wind pressure ventilation (Zhiyi et al., 2021; see Handbook chapter 10 for more details);
- Benefit from insulated walls, double-glazed windows, and insulated doors:
  - → Apply low-emissivity coatings on windows to reduce heat gain by reflecting more light and so lower the heat absorbed into the room (i.e., glass window with a thin coating applied to one side of the glass will reduce the transport of heat or cold through the glass);
  - → Decorate windows with shades, shutters, sunscreens and awnings to provide an extra layer of insulation between the room and outside;
  - → Inefficient windows or doors (with air leaks) can add up to 10-25% to the total cooling or heating bill (Ohio State University, 2022).

- Develop energy-smart landscaping which supports home comfort that can also save energy expenses. Examples can be:
  - → Wind-breaking vegetation, green façades, indoor living walls or other greening solutions to make the living space cooler in the summer and warmer in the winter (Nguyen & Waibel, 2022);
  - → Planting shrubs, vines and bushes near the home's walls which creates a layer of air insulation and helps regulate temperatures throughout the different seasons;
  - → There should be spaces between the house and the full-grown vegetation to protect the house foundation and to prevent pests from flying into the building;
  - → Evergreen plants can protect homes in both winter and summer months.

- Apply smart floor layout and design. Multi-purpose spaces (for example connecting the kitchen and living room) can help enhance natural lighting, ventilation and efficient use of fans or ACs.

Figure 8.10. Curtain to adjust the sunlight through glass window/balcony door (Source: Nguyen Thi Thu Thuy)

Saving water

- Although water is not energy, it needs energy for it to be treated, pumped or heated for use in the household. Hot water for showers, baths and other washing purposes is a major driver of energy consumption. Other household water uses, such as irrigation and landscaping features, also require additional energy.
- Practical tips for saving water in the household include:
  - → Small actions can save a lot of water (i.e., turning off running taps when unused even for seconds, taking a shorter shower, tapping cold water for quick hand rinse even in the cold season, because rinsing hands usually finishes before the hot water comes from the tap);
  - → Hold and reuse water (for example, water to wash vegetables or fruits can be used for watering plants or even flushing purposes, etc.);
  - → Try to regularly monitor water consumption with a smart meter to adjust the usage accordingly.

Figure 8.11. Quick rinsing with cold water (Source: Nguyen Thi Thu Thuy)

Figure 8.12. Water use measure (Source: Nguyen Thi Thu Thuy)

See Chapter 11 for more details on saving water.

3.8.5. Hints and tips

Figure 8.13. (Source: ICCDI AFRICA, @ClimateWed)

- ☆ Saving energy should become a basic daily habit of each householder. A visible reminder such as a note on the kitchen wall helps make everyone do this subconsciously;
- ☆ Cooling expenses generally make up for the majority of an average home's power bills in Vietnam. Therefore, reducing the intensity and frequency of cooling can save household energy significantly;
- ☆ Shading the West and East sides of the house could save energy for cooling, because the heat from the sun penetrates primarily through the West and East sides of a house. The West side should be a priority as the sunshine is much stronger in the afternoon hours;
- ☆ Building renovations and retrofits, if executed health-consciously, can significantly improve the building's energy efficiency. The professional consultancy will help set up an effective plan;
- ☆ Windbreak vegetation could decrease wind to around a distance of 10 times its height and decrease wind speed by as much as 70% to 80% (Tatarko, 2022). This reduces the impacts of monsoons and energy consumption for cooling and heating; Strategically planting trees and shrubs on the site can save up to 25% in energy bills by reducing air-conditioning and fuel costs year-round (US Department of Energy, 2022);
- ☆ Green walls and green roofs enhance building envelopes' thermal insulation through intercepting solar radiation, screening wind and plants' evapotranspiration (Wong & Baldwin 2016). Green walls have better environmental performance than shading systems in aluminum or PVC (Blanco et al., 2021). Green walls can absorb solar radiation up to three times higher than conventional walls (Zhang et al., 2019). Thus, green roofs reduce up to 80% of heat flow and roughly reduce between 2 and 17% of energy consumption in the summertime depending on the green roof type and cover rate (Besir & Cuce, 2018) (for further information, see the GIZ Implementation Guideline: Green walls, green roofs: Nature-based solutions to Urban Adaptation in Vietnam);
- ☆ Changing behavior patterns in using ACs has been found to have the highest potential for saving households' energy consumption as a result of a recent empirical large-scale household survey in urban Vietnam (Nguyen, Waibel & Andersen, 2021);
- ☆ Turn down the thermostat of your water heater. Tankless water heaters require power for instant heating, but they save energy, because they do not maintain hot water temperature in the tank. Tankless water heaters might not be suitable for families of more than four members.

Figure 8.14. Putting plants on your balcony to beautify and cool down your apartment (Source: Michael Waibel, 2023)

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Source:1+1>2 Architects

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Information on her professional affiliation can be found at the end of Chapter 13.

Greening your home

Nguyen Quang Minh

Source: Michael Waibel, 2023

3.9.1. Rationale

Home greening is a key solution to creating a better living environment. In a densely populated and constructed city, home greening brings nature closer to people. It can contribute substantially to reducing the urban heat island effect which is one of the biggest problems in urban development today.

This is particularly relevant in a tropical country like Vietnam. Home greening, on a small scale, can fill a gap that city greening (which is usually on a large scale) does not reach. This is especially true in the case of apartments and shop-houses. Home greening is surprisingly easy to apply and can work well with the trends of city gardening. In addition, city gardening as a social trend can be combined so well with home gardening.

Home greening has recently begun in Hanoi, Ho Chi Minh City as well as other cities and towns across Vietnam. However, this trend has been somewhat spontaneous. People need to be more aware of its benefits and know how to use their home environment best in order to realize the value of their home green space.

3.9.2. Benefits

Home greening can:

- ☆ Make the living space more beautiful and attractive;
- ☆ Provide a good visual effect, adding positive influence to the occupants' mental health and psychology;
- ☆ Reduce the solar heat intake of roofs and external wall surfaces;
- ☆ Minimize noise from the street;
- ☆ Filter dust and other pollutants in the atmosphere;
- ☆ Improve indoor air quality by providing additional vapor in the dry season;
- ☆ Mitigate stress caused by the pressure of hard work and intensive study;
- ☆ Provide fresh and safe vegetables for daily meals.

Figure 9.1a. An eco-hub in the living room brings a good visual effect to occupants (Source: Ngo Le Minh, 2023)

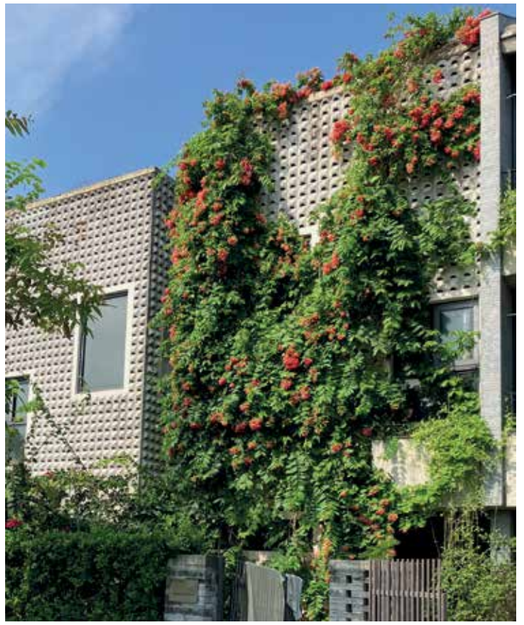


Figure 9.1b. Roof and façade greening is chosen because of low heat absorption compared to other materials like concrete or galvanized steel (Source: Picture left: Michael Waibel, 2023; picture right: © GIZ/Luong Thanh Trung, 2023)

Figure 9.1c. Greening the façade helps filter dust and reduce noise as well as pollutants (Source: Picture left: Michael Waibel, 2023; picture right: Nguyen Quang Minh, 2022)

Figure 9.1d. Growing vegetables as part of city gardening and greening (Source: An Viet Dung, 2022)

3.9.3. Principles

- ☆ Vernacular plants should be prioritized in home greening;
- ☆ If possible, a variety of species should be chosen to ensure bio-diversity in the city;
- ☆ Growing vegetables is strongly recommended to assist with on-the-spot supply of food;
- ☆ Plants should be grown in pots and also in trays for horizontal greening;
- ☆ A frame should be fixed to the walls for vertical greening of creeping plants;
- ☆ Make use of all the surface areas that are available for greening purposes (floor, walls and roofs);
- ☆ The available areas should be utilized according to their exposure to sunlight: external walls, roofs, loggias and balconies for heliophytes; and indoor areas for sciophytes;
- ☆ Both hydrophytes and drought-tolerant plants can be chosen;
- ☆ Plants that do not contain poisons or attract pests or insects should be selected;
- ☆ Landscape design concepts should be applied based on advice given by landscape architects, if possible and wherever appropriate;
- ☆ Appropriate watering and drainage systems should be designed and installed to maintain large planting areas;
- ☆ The amount of water daily needed should be calculated and water saving is required. Use rainwater or used water from the kitchen instead of tap water.

3.9.4. Solutions

Indoor and outdoor landscaping

Indoor landscape

Solution 1: For large rooms (living room, dining room and master bedroom)

- Ornamental plants (sciophytes) can be grown in multiple pots and place them on metal wall holders;
- The corner of the room is a good place. To develop bio-diversity, at least three species should be selected per room.

Solution 2: For small rooms (kitchen, bedroom and bathroom)

- Ornamental plants (sciophytes) can be grown in single pots and placed on terra cotta seats;
- The corner of the room is a good place. To develop bio-diversity, at least two species should be selected per room.

Solution 3: For the space under the stairs

- Grow ornamental plants, such as Japanese Phyllostachys (sciophytes);
- It is helpful to apply a 'dry landscape' concept here;
- At least three species should be selected per location to develop bio-diversity.

Figure 9.2a. Indoor greening for a living room
(Source: ABlueBird House Design Office, 2023)

Figure 9.2b. Indoor greening for a bedroom
(Source: ABlueBird House Design Office, 2023)

Outdoor landscape

Solution 1: For courtyards

- Both wet landscape and dry landscape concepts can be applied here;
- Different plants can be mixed, such as flowers, vegetables, medicinal and herbs;
- Priority is given to evergreen plants;
- At least five species should be selected and mixed in various patterns to enhance bio-diversity;
- Plants can be grown in pots or in beds;
- Multiple stacks can be applied to vertical greening.

Solution 2: For balconies

- Similar to recommendations for courtyards.

Solution 3: For loggias

- Similar to recommendations for courtyards.

Solution 4: For front gardens or back gardens

- Similar to recommendations for courtyards;
- At least ten species should be selected and mixed in various patterns in view of bio-diversity;
- Shade fruit trees can be grown, if the garden area is large enough (at least 20 m²).

Solution 5: For fences and gates

- Thornless ornamental trees with beautiful flowers can be chosen.

Figure 9.3a. Example of outdoor greening (terrace)
(Source: Nguyen Quang Minh, 2022)

Figure 9.3b. Example of outdoor greening (loggia)
(Source: Nguyen Quang Minh, 2023)

Roof and façade greening

Roof landscape

Solution 1: With flower and plant beds

- Flower and plant beds are constructed for either flat roofs or gently sloped roofs;
- Waterproofing layers must be added to the roof construction;
- A layer that protects the roof structure from root development also needs to be installed.

Solution 2: Without flower and plant beds

- Normally, only flower pots are acceptable on a flat roof where plant beds are not appropriate;
- Waterproofing options should be added, if necessary.

Façade landscape

Solution 1: Bottom-up planting

- A flower bed should be constructed, or a row of flower pots could be put under a frame that is firmly fixed to the wall;
- Evergreen plants are prioritized.

Solution 2: Top-down planting

- Similar to bottom-up planting, but a flower bed or a row of flower pots could be constructed or put along the roof edge;

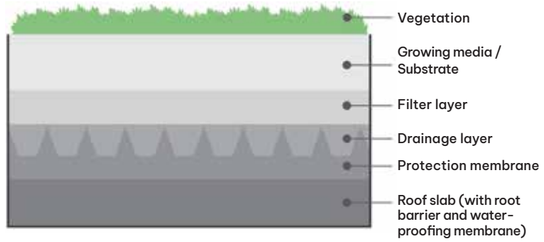


Figure 9.4a. Roof greening diagram (Source: Nguyen Quang Minh, 2022)

Figure 9.4b. Façade greening diagram (Source: Nguyen Quang Minh, 2022)

Urban gardening in low-rise housing

Urban gardening in low-rise housing

- Fruit trees and vegetables can be selected, including herbal plants that are used daily as spices or medicines, such as ginger, paprika, basil, coriander, cinnamon, peppermint, etc.;
- Fruit trees are grown furthermost from the external wall of the building;
- Other plants are grown next to one another in various patterns, depending on the area or surface available;
- It is advised to grow as many species of plants as possible to enhance bio-diversity.

Urban gardening in high-rise housing

- Only vegetables and flowers can be grown;
- Certain vegetables are commonly grown, depending on the household's demand;
- Due to the limited area of balconies and/or loggias, stacking is the right option.

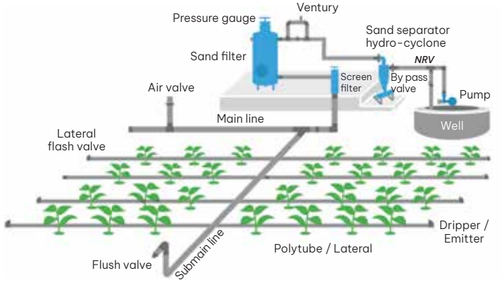


Figure 9.5a. Drip irrigation diagram (Source: www.gardeningsite.com)

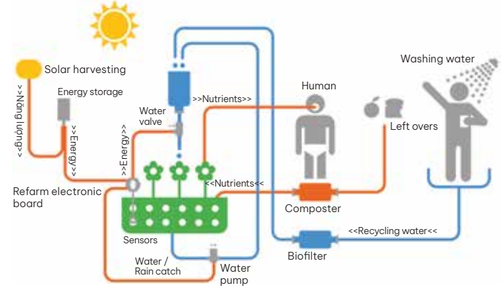


Figure 9.5b. Aquaponic gardening diagram (Source: www.gardeningsite.com)

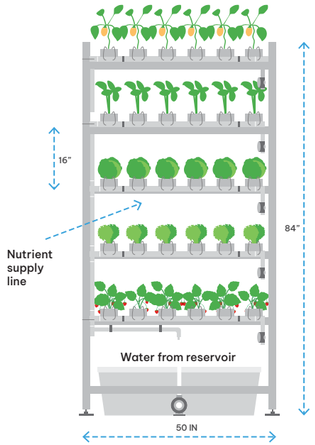


Figure 9.5c. Stacking gardening concept (Source: www.gardeners.com)

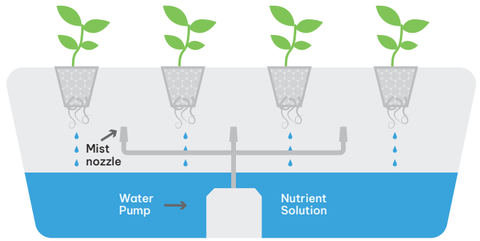


Figure 9.5d. Aeroponic gardening diagram (Source: www.aquaponichowto.com)

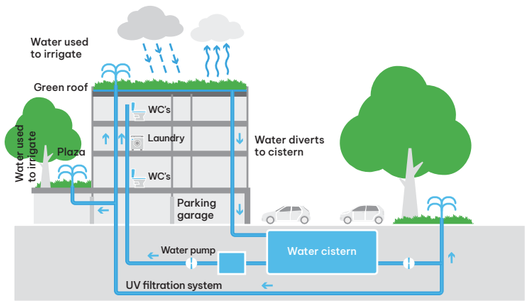


Figure 9.5e. Rainwater harvesting diagram (Source: www.studiohilier.com)

3.9.5. Hints and tips

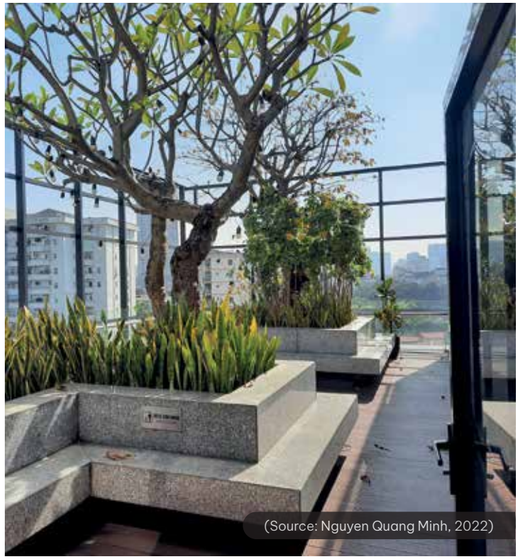
☆ For stack greening:
- The upper stacks are reserved for heliophytes;
- The lower stacks are suitable for sciophytes;
- The distance between two stacks should be 40 cm for small plants;
- The distance between two stacks should be 60 cm for medium-sized plants.

☆ For vertical greening:
- A frame - 15 cm off the outer wall surface - should be put up for creeping plants;
- Densely leafy plants are not appropriate;
- Plants that may be home to venomous snakes, particularly vipers, are to be avoided.

☆ Water supply for watering plants:
- Rainwater from the roof should be collected and stored for this purpose;
- Water from washing vegetables or cleaning rice in the kitchen can also be used.

☆ For water-saving purposes, drip irrigation systems are recommended;
- Two sub-systems need to be installed - one for hydrophytes and one for non-hydrophytes;
- Two modes need to be programmed - one for the summer months and one for the winter months.

☆ For urban gardening:
- Hydroponic and aeroponic cultivation can be applied.



(Source: Nguyen Quang Minh, 2022)

Source: Michael Waibel, 2022

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- *Tips for the Gardener, https://www.gardeningsite.com/.*

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Nguyen Quang Minh holds a PhD degree awarded by Bauhaus University Weimar (Germany) in 2010 with an intensive study on ecological neighborhood development for Hanoi and the surrounding area. Since 2010 he has pursued two main research directions, namely green buildings (particularly focusing on energy efficiency and water saving) and urban ecology as a mixed/integrated system at the neighborhood level, and has several academic papers as well as book chapters internationally published in these domains. He has also been an active team member of CAMaRSEC project sponsored and administered by BMBF. Thanks to this research project, he has an opportunity to undertake a two-year intensive study starting in October 2023 at the University of Stuttgart and Fraunhofer Institute for Building Physics with a research fellowship awarded by the Alexander von Humboldt Foundation for an experienced international scientist.

Chapter 09

Ensuring indoor air quality and thermal comfort

Christina Karagianni, Dirk Schwede & Yuanchen Wang

Source: Yuanchen Wang, 2023

3.10.1. Rationale

Health, thermal comfort and indoor air quality are topics of great concern for improved indoor living, especially under extreme weather conditions, pandemics or other situations that require spending a lot of time inside apartments. Indoor air pollution and extreme temperatures, as well as humidity, can affect the quality of staying indoors and even be harmful to our health.

The purpose of this chapter is to provide simple solutions for building owners, occupants and tenants so that they learn how to address such issues and what to do to improve the overall indoor environmental quality. It will help them understand the connections between housing, climate and comfort in relation to Vietnam's variable exterior climate and how all these topics are related to household energy consumption.

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and can be assessed by means of subjective evaluation. The term is used to help us express how comfortable we feel in a space, depending on the temperature of its structural elements and the surrounding air. By using the term Indoor Air Quality (IAQ), we refer to the air quality within and around buildings, with regard to the health and comfort of building occupants.

3.10.2. Benefits

☆ In Hanoi, Da Nang and Ho Chi Minh City buildings are usually dependent on the ventilation and air conditioning systems to control the indoor air quality and comfort;

☆ With increasing extreme weather events, these systems are used more frequently, affecting the building's energy use and the occupants' health. By incorporating various concepts related to thermal comfort and IAQ, like ventilation systems and effective temperature control, into the building design and use, it is possible to:

- have more eco-friendly and energy-efficient buildings, known as green buildings;
- help the global environment;
- benefit our health and overall well-being;
- lower our energy use and electricity bills.

Figure 10.1. User-AC-Climate interaction
(Source: Design by Karagianni based on Karagianni, C. et al., 2022).

3.10.3. Principles

Maintaining good indoor air quality and thermal comfort requires attention to:

- the ventilation and air-conditioning system of a building;
- the building envelope;
- the design and layout of the space;
- pollutant source management.

Thermal comfort

The environmental conditions required for comfort are not the same for everyone. Overall, the parameters that determine the feeling of thermal comfort can be divided into three categories:

☆ Physical parameters (air temperature, relative humidity, air speed, radiant temperature);

☆ Biological parameters (sex, age and habits of people);

☆ Exogenous factors (type of activity and type of clothing).

AC and ventilation system operation

For mechanically ventilated buildings, good operation requires attention to:

☆ Ventilation system design: The air delivery capacity of an AC system is partially based on the number of people and amount of equipment in a building. For example, if a storage area is converted into space occupied by people, an HVAC system installed there may require alteration to deliver enough conditioned air to the space;

☆ Outside air supply: Adequate supply of outside air is necessary for any indoor environment to dilute pollutants that are released by equipment, furnishings, products and people. Distribution of ventilation air to occupied spaces is also essential for comfort. The minimum outdoor airflow required for any space in the building is calculated according to TCVN 5687:2010;

☆ Space planning: The use and placement of furniture and equipment may affect the delivery of air to an occupied space. For instance, the placement of heat-generating equipment, like a computer, directly under an AC may cause the system to deliver too much cool air, because the thermostat senses that the area is too warm. Furniture or partitions that block supply or return air can affect the function as well and need to be positioned with attention to airflow.

Figure 10.2. Parameters that determine the feeling of thermal comfort
(Source: Design by Christina Karagianni, 2022)

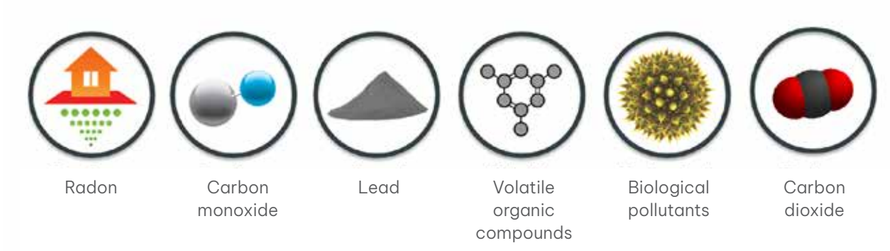

Figure 10.3. Hazardous substances to eliminate in buildings (Source: Design by Christina Karagianni, 2022)

Building envelope

Heat transfers through the building via opaque areas, walls and roof, along with transparent areas, windows and doors. It may vary depending on the orientation. Using low thermal conductivity wall materials, window shading and natural ventilation can further reduce building energy demand. To learn more about this topic, please refer to Chapter Three.

3.9.4. Solutions

Building envelope

For a thermally comfortable room, people can either choose their options of control or make some personal changes as follows:

Control the environment

- For warm periods: Use natural ventilation first when applicable;
- Increase air movement during warm days by means of ventilation or air conditioning;
- Use of indoor and outdoor sun-shading structures, depending on warm and sunny periods;
- Use a dehumidifier to control the air humidity during the rainy season.

Personal adaptations

- Adapt clothing where possible;
- When feeling warm
  → First open the window or use a personal fan;
  → Drink water or other cool drinks;
  → Take a shower.

Indoor Environmental Quality (IAQ)

The best way to control exposure to pollutants is to perform source control (i.e. minimize the emission of either primary or secondary pollutants to the air that we are exposed to). Besides source control, there are three other ways to control exposure – by means of ventilation, air cleaning and activity control.

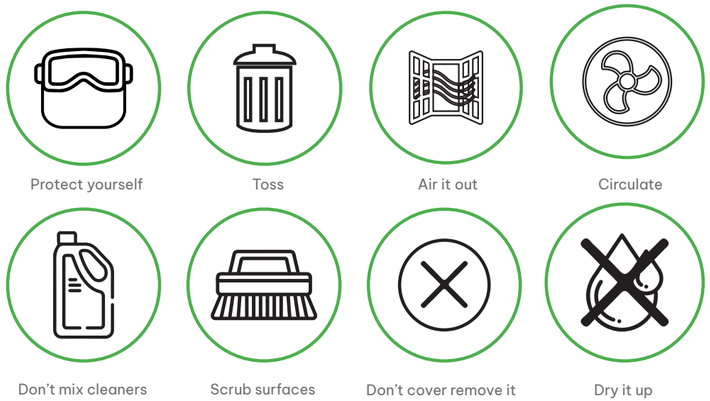

Figure 10.4. General tips to protect family members from potential dangers (Source: University of Nebraska Medical Center, 2020)

AC Operation

After systems have been installed, proper maintenance is key (check Table 10.1 for frequency of each system):

☆ Minimize leakage: If there is leakage in the building envelope and the air is transferring in, and out of the building, then IAQ, thermal comfort and efficiency of the AC system will be lowered;

☆ Proper maintenance: An air filter that is overloaded with particulates increases resistance and reduces airflow.

Table 10.1. Recommended interval for checking the cleanliness of ventilation and air-conditioning systems according to TCVN 13521:2022

Components of the ventilation - AC system	Test frequency
Heat exchanger	06 months
Air supply pipe	12 months
Return air duct	12 months

Figure 10.5. AC outdoor unit maintenance (Source: Creative Commons)

Visually inspect the AC or ventilation system frequently for any leakages, dirt and/or dust either on your system or released during its operation

Maintenance depends on several other factors like the age, condition, size and particular brand of each HVAC system.

A good indicator of possible problems is the presence of unusual smells or vapors when an AC or another system is switched on

Maintain the thermal environment and make changes as necessary. Seasonally adjusting the temperature control of the AC is vital to maintaining thermal comfort. The draft of Vietnamese Standard TCVN 306: 202x suggests slightly different indoor air temperatures between summer and winter operation, but also for naturally and mechanically ventilated buildings (Table 10.2). This change does not only help maintain thermal comfort, but will also result in significant energy savings.

Table 10.2. Suggested indoor air temperatures for the cold and warm seasons depending on the type of ventilation (Source: Adapted from the draft of Vietnamese Standard TCVN 306:202x)

Suggested indoor air temperatures for thermal comfort (°C)

Type of room	With mechanical ventilation	With natural ventilation	With mechanical ventilation	With natural ventilation
	Cold season: Heated room		Warm season: Cooled room	
Room in the house	22 - 24.5	≥ 21.5	26 - 28	≤ 30
Living room and study room in the house	22 - 24.5	≥ 21.5	26 - 28	≤ 30
Living room with guests/visitors	22 - 24.5	> 21.5	26 - 28	≤ 31
Dining room	21 - 23.5	≥ 20	27 - 29	≤ 31
Kitchen	21 - 23.5	≥ 20	27 - 29	≤ 31

Run fans and ACs at the same time. The two can supportively work to cool down homes. Position fans so that they are near AC vents helping distribute cool air faster and more efficiently than the AC alone could. Use a stationary tower fan or a pedestal fan underneath or beside the vents.

Figure 10.6. Building designed with natural ventilation (Source: 1+1>2 Architects)

3.10.5. Hints and tips

Here are some things people can do right away to improve the air quality at home and to help keep energy bills down:

- ☆ Do not put pieces of furniture or objects on top of or near vents;
- ☆ If using ceiling fans, rotate them counter-clockwise when it is cooler, as it will help push the warm air back into the room;
- ☆ When hosting a large group of people during the cold season, turn the thermostat down a couple of degrees. People's body heat will make up the difference;
- ☆ Be mindful that excessive ventilation can cause loss of comfort and increase energy consumption;
- ☆ Do not forget about other air filters. Be sure to check the filters in other household appliances. A vacuum cleaner and kitchen vents should all be inspected and maintained periodically;
- ☆ Use cooking vents. Many indoor air pollutants come from the kitchen. So, when cooking, be sure to turn on kitchen vents, or open a window to help filter out the air even more efficiently;
- ☆ Avoid the use of carpets if possible, Otherwise, make sure to keep them clean. Rugs and carpets act as their own air filters, trapping humidity, dust and other particles in their many fibers. For high-humidity climates, they are not recommended, but if one still chooses to use them, vacuum them weekly;
- ☆ For new or renovated buildings, check the presence of pollutants before moving in. Measure and check whether the concentration of VOC and formaldehyde meets the requirements as specified in the Vietnamese Standard TCVN 13521:2022;
- ☆ During the first few months of use, regularly open windows for natural ventilation or use mechanical ventilation systems in the room and ventilate to minimize harmful pollutants generated in the home;
- ☆ Have some plants to freshen the air. Indoor plants function as natural air filters;
- ☆ Let fresh air in! Cross-ventilation is always the fastest way to cool and renew the air in a room. Even in the cold months, open windows from time to time to allow fresh air to move into the house;
- ☆ For better air quality, keep windows slightly open even during AC use. This will result in energy loss, but will improve air quality inside. Optimally use a controled ventilation unit for demand-controled ventilation so that only little air is exchanged and a minimum of energy is lost.

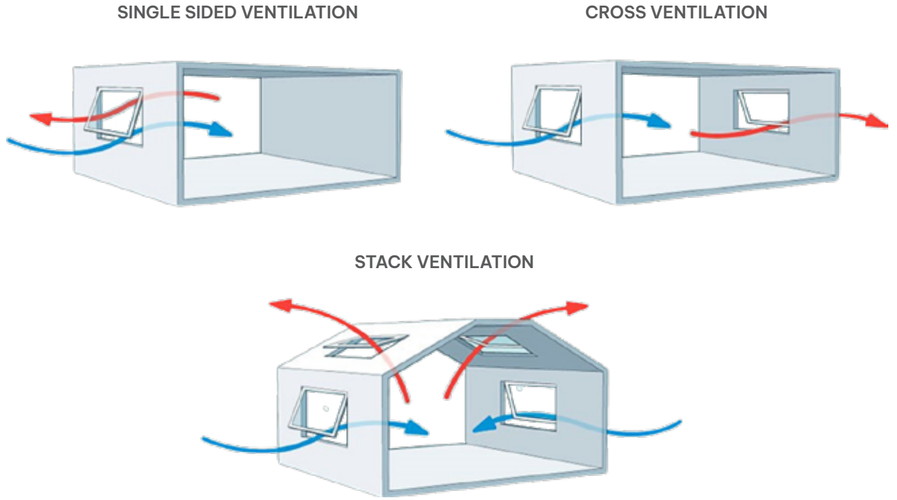

Figure 10.7. Different types of ventilation controls (Source: www.tealproducts.com)

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Source: 1+1>2 Architects

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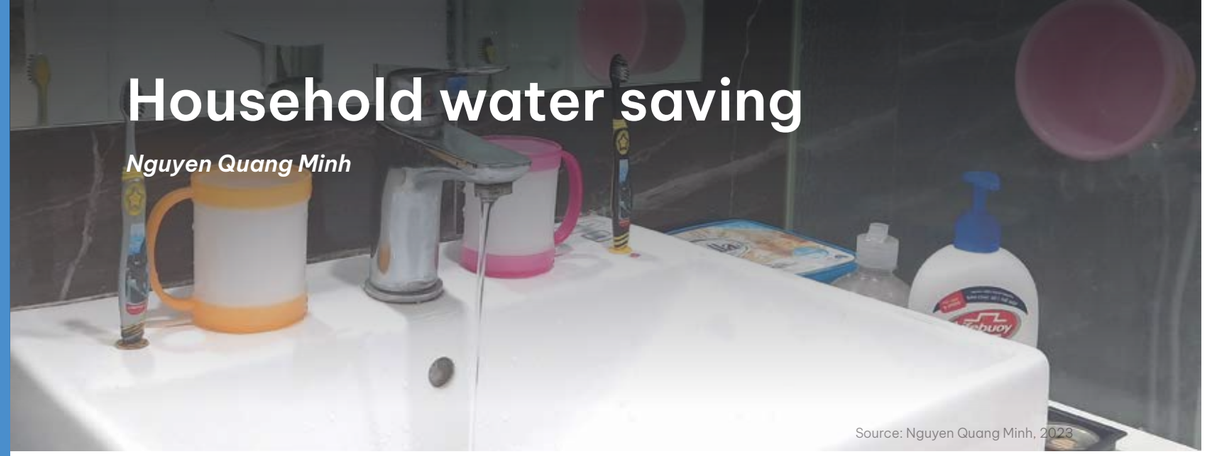
He is working on several large research projects on sustainable and energy efficient building in Vietnam (CAMaRSEC, REBUMAT) and Cambodia (Build4People).

Household water saving

Nguyen Quang Minh



Source: Nguyen Quang Minh, 2023

3.11.1. Rationale

Fresh water accounts for just 3% of all the water on Earth and is not distributed evenly (US Geological Survey, 2018). As the world population grows, the demand for fresh water increases quickly and already exceeds the supply capacity. Global climate change has led to droughts and water shortage in many countries and communities. Today, water security has been as important a topic as energy or food security.

In Vietnam, pipeline water loss is high, contributing to its water supply challenge. Because water is a limited resource, its conservation forms an integral part of the worldwide criteria for 'green building'.

In the world's most popular building certification tool, the LEED-system, for example, water efficiency in residential buildings is given 12 points out of 110 points in total, as the fourth most important indicator of how green a house could be (USGBC, 2018).
Vietnam has developed its own LOTUS rating system which ranks water efficiency as third in priority because of Vietnam's water shortage challenge, equally to material efficiency, with 13 points out of the total 108-point scorecard in the Home Category, only behind energy efficiency (32 points) as well as site and environment combined impact (20 points) (VGBC, 2016).

Because water is vital to life, water saving is a must and should be daily practiced.

3.11.2. Benefits

Water saving can:

- ☆ Ensure that people have enough water to use every day in case water may become scarce for some reasons, such as due to drought caused by climate change, water supply cut because of water source contamination, water pipeline repair/upgrading or suddenly high demand that goes beyond the supply capacity;
- ☆ Regulate water supply among living quarters within a city in case of water shortage (from communities with surplus water saving to those in need without having to increase daily water supply amount);
- ☆ Enhance the public awareness of the significance of fresh water as a valuable (but not inexhaustible) gift from nature;
- ☆ Help buildings meet the green building requirements and enable them to be awarded certificates;
- ☆ Protect the environment, because of a fewer amount of wastewater discharge as a result of a lower volume of clean water consumed.

3.11.3. Principles

- ☆ The amount of water needed for a specific purpose based on experience or advice. For example, washing mustard greens clean bought from a supermarket three times, for four people, needs about 24 liters of tap water. Two thirds of a 12-liter wash basin could be enough, three quarters may be unnecessary;
- ☆ A water-saving button or mode on a machine, or a system, should always be chosen, if there are two or more options;
- ☆ Alternative water sources should be used, instead of tap water, for certain purposes where clean water is not necessary;
- ☆ Home education programs that raise public awareness should be promoted and targeted at children, even before they go to school;
- ☆ Several solutions should be applied at the same time, case by case, to enhance the level of water saving as advised by experts.

3.11.4. Solutions

Technology and technique-based solutions

- Install water-saving devices and apparatuses, such as washing machine, dishwasher and shower head;
- Install a drip or jet watering system for plants and vegetables, instead of using a common watering system (similar to fire-fighting hose reel);
- Program watering time for an automatic watering system subject to season of the year (in the winter plants need less water than in the summer, so with the same flow of water the watering time in the winter is shorter) and dependent on the species of plant (hydrophilic plants need watering every day while non-hydrophilic plants can be watered once every two or three days, or even just once a week).

Figure 11.1a. Clean water is used in households for watering plants and vegetables (Source: Nguyen Quang Minh, 2023)

Figure 11.1b. Clean water is used in households for flushing the toilet (Source: Nguyen Quang Minh, 2023)

Figure 11.2a. Water-saving washing machine at home (Source: Waibel, 2023)

Figure 11.2b. Water-saving dishwasher at home (Source: Waibel, 2023)

Figure 11.2c. Water-saving shower (Source: Pham Thi Hai Ha, 2022)

Figure 11.2d. Watering hose with a water-saving head (small jets) (Source: Nguyen Thi Khanh Phuong, 2023)

Design-based solutions

Harvesting rainwater

- Rainwater can be collected from the roof or from the ground and then led to a container or tank for specific purposes;
- Rainwater can be used instead of tap water for watering plants, cooling the atmosphere in form of evaporation, flushing toilets and cleaning objects as well as some household wares.

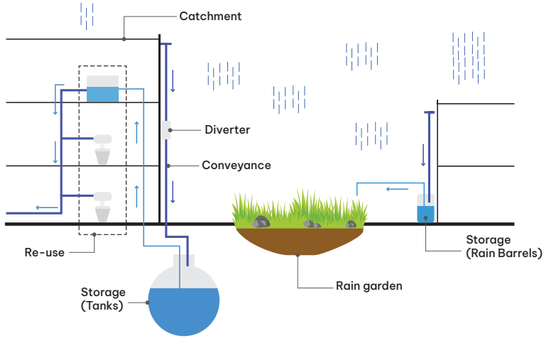


Figure 11.3a. Rainwater collecting system (Source: www.next.cc)

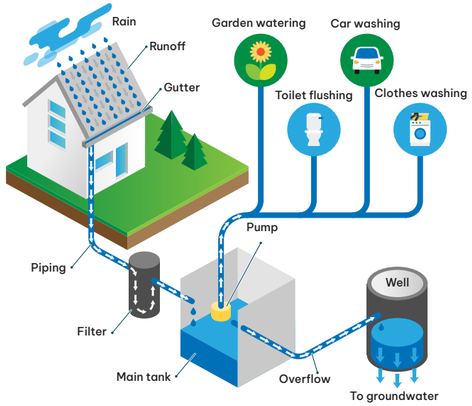


Figure 11.3b. Rainwater is collected for various purposes in place of tap water (Source: www.gutterhelmet.com)

Figure 11.3c. Rainwater container as a decorative object (Source: Nguyen Quang Minh, 2023)

Chapter 11

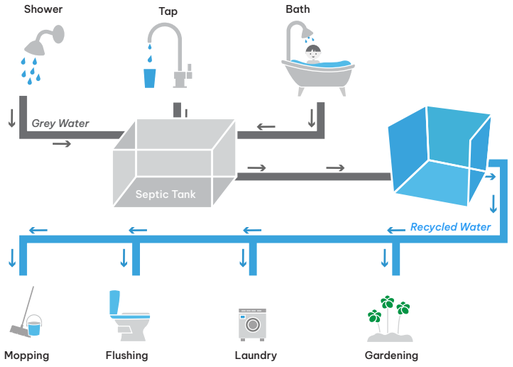


Figure 11.4a. Grey water treatment system diagram (Source: www.zandxmechanicalinstallations.com)

Figure 11.4b. Grey water can be used for cleaning balconies or loggias in apartments (Source: Nguyen Quang Minh, 2023)

3.11.5. Hints and tips

To save water more efficiently, it is required to regularly check the whole water pipe network within the house or apartment for leakage, preferably once a month. In case of leakage, either in the pipes, in the joints, in the taps, in the heads or in the valves, it must be fixed or the part needs to be installed as new, because water loss is a big problem in many cities in Vietnam, at a rate of 16-17% of the total supply (MoC, 2021).

☆ A leaky loo can waste an average of around 400 liters of water a day (Thames Water, 2022). That is equal to four full bathtubs. It is easy to check whether one may have a leaky loo by just:
- waiting for 30 minutes after flushing and then wipe the back of the pan dry with toilet paper;
- placing a new and dry sheet of toilet paper on the back of the pan, leaving it there for up to three hours without using the toilet (it might be best to do this overnight);
- looking if the paper is wet or torn, a leaky loo is likely happening;
- checking if a flush valve is faulty or filling the valve inside the tank;
- marking the water level inside the tank and popping back 10 minutes later. If the water level has dropped, the flush valve is the problem;
- seeing if any water is still running into the overflow tube inside the toilet tank. If the tank takes a long time to refill or the flush is not as powerful as usual, that could also be a sign that the fill valve is not working properly.

☆ Start a dishwasher once it has fully loaded. Similarly applied to a washing machine, at least 80% of the designed wash weight. A fully loading washing machine every time can save up to 4,000 liters a year (Thames Water, 2022);

☆ A running tap can use six liters of water per minute (Thames Water, 2022). Turning off taps when not in use is a really simple way to save water at home. By turning off the tap just five seconds earlier, one can save half a liter. Try not to keep tap water flowing while doing the washing up or brushing teeth;

☆ In high-rise residential buildings, where the amount of collected rainwater may not be sufficient to meet the real demand of all the residents, wastewater after treatment should be used as an abundant source in place of rainwater in certain households;

☆ Water, after washing rice and/or vegetables clean in the kitchen, can also be collected and used for watering plants and flushing toilets, especially in apartment buildings where rainwater may not be easy to gain as in low-rise housing blocks;

☆ A drip watering system - as illustrated with Figure 9.5a (Chapter 9, page 93) - can save up 40% of the amount of water needed for watering purpose (according to Khang Thinh Irrigation Technology Joint Stock Company, 2021);

☆ In terms of water efficiency and economic pricing, choosing four-star labeled washing machines and/or dishwashers is the best option for the majority of households in big cities.

Source: Michael Waibel

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Dealing with household waste

Douglas Snyder

3.12.1. Rationale

The incredible convenience and comfort of our modern lives has also brought other less desirable consequences. Some may have noticed the pile of trash at the end of the day or week in our homes growing much larger than remembered from our childhoods. It is true – a booming economy has led to us consuming more products than ever before and a flood of trash flowing from our homes and businesses. From 2010 to 2019 alone, domestic solid waste in Vietnam increased by 46%, from 44,000 tons/day to 64,458 tons/day (VnExpress, 2020). Besides the quantity, the quality of our waste has also changed, with much more of it being man-made materials, such as plastics. Dealing with waste means treating it efficiently (in terms of cost and processing time) and safely in view of environmental protection and human health. As far as waste treatment is concerned, most of our waste is buried (71%), and the rest is either composted (16%) or burned (13%) (Ministry of Natural Resources and Environment, 2019). Recently, more and more of Vietnam's garbage landfills have become full, leaving government officials and nearby towns struggling to find more space to dump the stream of this never-ending waste. While the garbage challenge can seem overwhelming, it is still a problem we created, so it is a problem we can solve. There are some basic steps which homeowners can take to better deal with our waste stream, such as segregating waste, learning to compost and becoming a smart shopper. We will explore these in the remainder of this chapter so that you are better prepared to take action in your own home.

Figure 12.1. Dealing with daily household waste in Hanoi by means of landfill (Source: VnExpress, 2020)

3.12.2. Benefits

The following benefits can be secured if we improve our waste habits by:

- ☆ Ensuring better health by using durable and reusable non-plastic food containers, such as glass or stainless steel. Plastic containers used in food delivery and sold in stores contain harmful chemical "plasticizers" that also end up in our food.
- ☆ Saving more and avoiding paying extra for plastic bags in supermarkets;
- ☆ Gaining personal fulfilment and exercising your environmental consciousness and values;
- ☆ Managing more easily household waste with 50 - 80% less waste;
- ☆ Making air in neighborhoods cleaner from less open burning of excessive waste;
- ☆ Eliminating bad smells from garbage in our homes, on city streets and in towns near landfills;
- ☆ Protecting farmland, because none would be needed to be converted to landfills;
- ☆ Reducing greenhouse gas emissions (methane) arising from rotting food in landfills;
- ☆ Ensuring a return of farm nutrients to our soils, instead of sending them to landfill;
- ☆ Securing a much better conservation of our natural resources, with less trees cut for paper and oil drilled for plastics;
- ☆ Providing a happier, healthier and safer working environment for waste workers;
- ☆ Promoting a new circular efficient economy full of innovation.

Figure 12.2. Overflowing waste carts (Source: Douglas Lee Snyder)

3.12.3. Principles

- ☆ Every material has its value, even waste. Nature teaches us this with its system of infinite recycling. Everything is used again and again, perfectly;
- ☆ Waste does not magically disappear when we throw it away. Every day, we can find waste in garbage piles in and around cities, along hiking trails, and on once pristine beaches. Vietnam's landfills are also rapidly reaching and exceeding their capacity;
- ☆ The longer we wait, the more difficult it will be for us to stop the spread of waste and control its negative impacts. Today, we can find plastic particles in the rain, in the air we breathe, in the food we eat, and even in our blood;
- ☆ The materials we use every day need to be designed for circularity. We can mimic nature by considering the full lifecycle of materials. A whole economy based on this is called a circular economy;
- ☆ A circular economy needs active participation of all people – our government, businesses, scientists, every household and citizen;
- ☆ As consumers, we can vote with our purchases. We can create demand for better and less wasteful products and packaging;
- ☆ A "zero-waste" lifestyle is one that aims to reduce daily waste to as small an amount as possible and even to zero;
- ☆ Hundreds of cities globally are "zero-waste cities" where public decision makers, business leaders and urban citizens work together to reduce pollution and waste.

3.12.4.Solutions

STEP ONE

Understand what kind of waste we have. Once we know our waste profile, then we can create a plan. The waste breakout from Hanoi below is similar for many cities in Vietnam. From the pie chart below, we can see that organic waste (kitchen and garden scraps) is the largest component of waste (52%), second is "other" (38%), and recyclables rank third (7%). These are all areas where we can take action.

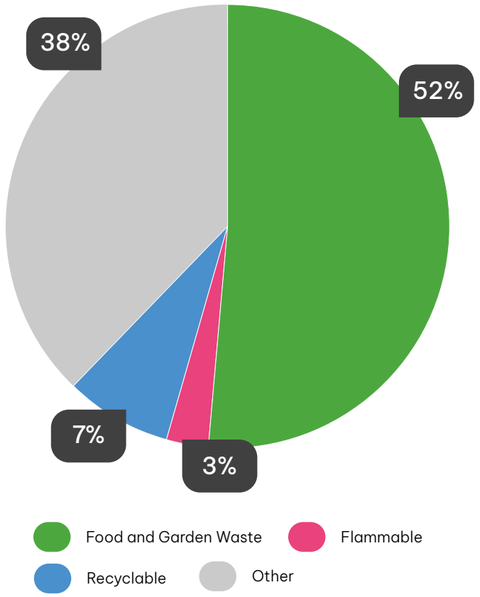

Figure 12.3. Waste profile of Hanoi in 2019
(Source: Ministry of Natural Resources and Environment [2019] "National Environmental Status Report in 2019: Management of Daily Solid Waste")

Figure 12.4a. Reusable daily item
(Source: Green Gem Shop, a project of Keep Vietnam Clean)

STEP TWO

Get familiar with the strategies and tools to tackle our waste. Often we simply need to ask the question, is there a better alternative? The following list of 4 R's gives us several tools to choose from and try with different kinds of waste:

- **Reduce** – the best way to eliminate waste is to not create it in the first place. By making smart consumer choices, we can choose natural materials and avoid plastics, have little or no packaging, or simply avoid buying things we do not need;
- **Reuse** – here we can repurpose things, like glass jars or plastic jugs for continued use. We should also repair things so that we can keep using them indefinitely. Buying quality items is a smart choice, since they last longer;
- **Recycle** – this process usually involves breaking a product material down into smaller parts, so that it can be reformed into something new. We simply need to know which items can be recycled and then make sure they are collected properly for recycling;
- **Rot (Compost)** – with organic matter accounting for 52% of waste, this should probably be the first choice. Composting can be done at home, on farms or in large town facilities. For the home, even a balcony space can be big enough to compost.

STEP THREE

Start to segregate your waste to make it easier to use the tools above. This usually means creating separate piles for paper, cardboard, glass, plastic, metal and organics (food and garden waste).

STEP FOUR

Compost your organic waste and let your recyclables be picked up by a waste collector. Vietnam's informal waste collectors are very efficient, and by putting cleaned recyclables in separate bags, you can help make their work even easier.

Figure 12.4b. Compost (Source: Douglas Lee Snyder)

Figure 12.4c. Sorting waste at home (Source: Improving the Environment and Public Space in Bo Vo Area, a project of Keep Vietnam Clean)

3.12.5. Hints and tips

- ☆ Use simply wrapped bar hand soap (handcrafted gourmet soap is a nice treat) instead of liquid soaps that come in plastic dispensers;
- ☆ For snacks at work or school, eat fruits like bananas and oranges that come already wrapped by nature;
- ☆ Shopping for sustainable products can be a fun and rewarding challenge! Just ask yourself, is there a better alternative? Usually there is;
- ☆ Try reusable daily items like cloth shopping bags, metal or bamboo drinking straws, and stainless-steel water bottles;
- ☆ Apply reuse: Some containers, such as glass or plastic jars, can be reused when buying food and house products in bulk;
- ☆ If you order food to be delivered to the home, ask if they have non-plastic packaging;
- ☆ Shopping at second-hand clothing stores is a great way to find a bargain and prevent good quality clothing from heading to the landfill;
- ☆ Consider exchange: Some online groups offer "free-cycle" exchanges of still useful products;
- ☆ Make sure to clean your recyclable containers that had food and put them in separate bags for waste pickers to easily take. You could even label them;
- ☆ For home composting, use inexpensive 18-liter construction buckets and even stack them to save space;
- ☆ Remember: Compost just needs 1) brown materials (cardboard, plain paper, dead plants, etc.) and 2) green materials (fruit, vegetable and grain food scraps);
- ☆ Remember: Never put meat, dairy or oil into your compost bin;
- ☆ Remember: Finished compost will look dark brown and smell rich and earthy. It can be used on top of the soil around your house plants as a soil amendment;
- ☆ Go back to using natural materials (i.e., banana leaf wrappings for food and hemp, silk or cotton clothing) and away from man-made materials (i.e., plastics, nylon, polyester fabric).

Chapter 12

Figure 12.5. A variety of reusable daily items
(Source: Green Gem Shop, a project of Keep Vietnam Clean)

Figure 12.6. Plastic bottles collecting
(Source: Keep Vietnam Clean)

Source: Keep Vietnam Clean

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Household renewable energy

Nguyen Thi Thu Thuy & Michael Waibel

Source: Ton Duc Thang University

3.13.1. Rationale

Renewable energy can be generated from the sun, wind, flowing water, biomass, hydrogen gas and geothermal heat, among other things. In the past few years, renewable energy has become by far the cheapest source of electricity compared to conventional energy (IRENA, 2022). In particular, the use of rooftop solar PV in buildings is growing on a global scale (REN21, 2023).

At the household scale, the most popular renewable energy technologies currently used are solar water heaters- converting the sun's radiation, in the form of heat, into hot water- and solar power systems / photovoltaic systems (PV)- converting the sun's radiation, in the form of light, into usable electricity.

In the case of Vietnam, the heavy dependence on the import of non-renewable fuels, the prevalent danger of energy shortages, and the decreasing costs of solar power systems make the use of renewable energies increasingly attractive.

3.13.2. Benefits

By using renewable energy, households can:

- ☆ Reduce monthly electricity costs and minimize pressures in case of electricity price increases;
- ☆ Generate income by selling the surplus electricity to the local grid (the electricity provider);
- ☆ Contribute to the general electricity supply, in case of generation of surplus renewable energy;
- ☆ Overcome power failure, if using excess electricity storage systems, e.g. batteries;
- ☆ Use clean energy and contribute to environmental protection by reducing the use of fossil fuels;
- ☆ Receive additional benefits from solar panels serving as sun protection, reducing heat intake into the building;
- ☆ Become active part of the energy transition.

3.13.3. Principles

- ☆ The production, transportation, and installation of renewable energy equipment might be costly and have environmental impacts, but renewable power generation itself is clean and carbon neutral;
- ☆ Renewable energy production depends on the weather conditions. A battery storage system may support the use of renewables if the weather is not favorable;
- ☆ Renewable energy technologies for households are growing in popularity. Even if installation costs are still comparatively high, they will be paid off in the long run. The related costs continue to fall due to technology improvements and (hopefully) increasing governmental incentives, among other reasons;

3.13.4. Solutions

Solar-powered electricity

Background

Solar power is generated through photovoltaic panels (PV), which capture and convert the sun's energy into electricity. These panels consist of cells made from layers of semiconducting material (most commonly silicon). A flow of electricity is created when sunlight shines on this material. Electricity can be generated even on cloudy days, with no direct sunlight. However, more electricity is generated if the sunshine is strong. Power is generated for use in homes or for selling back to the grid (if the local electricity provider allows for this). Solar energy is a suitable choice for Vietnam as the country enjoys abundant amounts of sunshine with more than 2,000 sunshine hours per year, and relatively high solar radiation, averaging 3.7 kWh/m²/day in the North and 5.9 kWh/m²/day in the South of the country (VnExpress, 2021).

System components

- A solar module, which typically generates around 355 W of direct current (DC) electricity (in case of excellent sunlight conditions), and accounts for most of the overall expense;
- Inverter to convert DC to alternating current (AC) to be used by home appliances;
- Metering equipment (if it is necessary to see how much power is produced);
- Other various housing components along with cables and wiring gears;
- Battery storage system (optional).

Household solar power systems can be installed with the capacity of 1 kWp, 3 kWp, 5 kWp and 10 kWp. Higher capacity is more applicable in the Northwestern, South Central and Southern regions, due to higher radiation intensity. In the Northeastern and North Central regions, the capacity is lower (about 2.10 kWh/m²/day, on average);

- A capacity of 1-3 kWp is good for lighting and for some occasional devices, such as air conditioners, TVs or in combination with the grid in some specific situations;
- A capacity of 5-10 kWp serves higher electricity demand, suitable for families with electricity bills over 2 million VND per month;
- For high daily electricity needs, the grid-connected solar power (without batteries) model is often recommended. This model requires a low maintenance cost as there is no need to change the battery. However, no solar power is generated at night and there is no electricity in case of grid failure.

Costs

- Costs for a solar power system vary depending on the power generation capacity;
- Costs include: the upfront payment of installation costs (accounting for most of the total cost), installation labor, operation and maintenance (regular cleaning of the panels), and replacement of inverters and batteries (if installed) after several years of use;
- Solar power is more applicable for households living in low-rise housing with separated roof systems. About 25 m² roof area is needed for a system with an average capacity of 4.2 kWp;
- South-facing roofs can generate the most electricity. East or West-facing roofs generate about 15-20% less energy than ones facing South;
- Shade from neighboring buildings, trees or chimneys can negatively impact the system performance.

Examples of costs (according to VnExpress, 2021)

- One 1-3 kWp system: 20-30 million VND- including panels, inverters, charge controller. and storage batteries- equal to about 800-1,200 USD;
- One 5-10 kWp system: 50-150 million VND- equal to about 2,000-6,000 USD.
- Systems without batteries are significantly cheaper.

Source: Ton Duc Thang University

Solar water heating

- Hot water is used in each home for bathing, laundry, dishwashing, etc. The electric water heater is normally on to keep hot water constantly available for these purposes, therefore consuming significant power. Solar water heating technology reduces this cost, especially the “standby heat loss”;
- Solar water heating is based on the principle of transforming solar radiation into thermal energy. Tank capacities of 100 liters, 120 liters, 160 liters, and 200 liters are suitable for household use.

There are two types of solar heating water options:

- Direct heating system: cold water is directly heated by the solar collector and rises to the storage tank through the thermo-siphon principle;
- Indirect heating system: cold water is stored in an internal tank, and indirectly heated by fluid that is contained in the external tank and directly heated up by the solar collector.

Main components of solar water heater system are:

- **Solar collector** to collect solar energy;
- **Insulated tank**, made with high-tech insulation and durable heat-absorbing materials, to store hot water and maintain water temperature;
- **Supporting stand** with different options: free-standing, wall-mounted;
- **Connecting pipes and instrumentation** (solar water heater controller, AC DC hybrid solar charge controller, spare part pressure relief valve, etc).

There are three types of solar collectors in Vietnamese market:

- **Vacuum tube solar collector**
  - → Affordable price, easy installation, popular and longest history in the Vietnamese market;
  - → The heat-transferring vacuum tubes are connected to the water tank and set at a 45-degree angle in order to absorb the most heat from the sun;
  - → Cold water flows from the tank to the tubes, is heated and then flows back to the tank.
- **Oil tube solar collector**
  - → The structure and functions are similar to vacuum tube solar collector;
  - → The tubes contain oil layers, instead of glass, which better transfer heat and keep water warm;
  - → Longer lifespan and lower cost for maintenance.
- **Flat solar water collector**
  - → Most advanced technology with bending-design extrusion aluminum frame, package laser welding absorber for 360° heat transfer, embossed aluminum and zinc, full aluminum foil-packed high-density fiberglass insulation layer, and 3.2 mm thickness low iron tempered textured glass cover;
  - → Water is pumped through pipes located below the glass panels;
  - → Electricity is required to pump water through pipes.

Chapter 13

Balcony power plant

- **Background**

So-called balcony power plants have recently gained tremendous popularity in Germany. These are small photovoltaic plug-in systems usually consisting of one or two solar panels connected to an inverter. This converts the direct current of the modules into normal household alternating current. The electricity produced is fed into a socket via a power cable. In this way, household appliances automatically use solar power, instead of drawing power from the public grid.

Such small solar systems can be attached to the balcony railing, a flat roof or the terrace.

In Germany, the maximum output of a solar system for the socket is currently limited to 600 Watts of nominal current.

- **Characteristics**

→ Compact system;

→ Plug & Play installation doesn't require an electrician;

→ Recommended for households with annual power consumption from 1,500 KWh;

→ Each panel produces up to 400 kWh of environmentally friendly electricity per year;

→ Anyone who does not have their own roof may have a suitable balcony and thus can also benefit from the energy transition.

Figure 13.1. A balcony power plant - example from Germany (Source: Michael Waibel, 2023)

3.13.5. Hints and tips

☆ Try to develop electricity-saving habits to reduce your dependency on energy, and to lower your bills and carbon footprint;

☆ Use the washing machines and dishwasher- or set the operation time- for during the day to make the best use of solar power;

☆ Combine photovoltaic panels with solar water heaters to benefit from the full potential of renewable energy;

☆ Apart from the technology, a reputable and experienced contractor is essential for the project quality;

☆ Regular maintenance is needed to optimize the solar power functions:

→ Comprehensive check-up of the whole system at least four times a year;

→ Monthly cleaning of solar panels which might be affected by outdoor dust and dry leaves;

→ Replacement of batteries and inverters every few years;

→ Inox metal supporting system to protect the system from typhoons, strong winds, etc.

Figure 13.2. Examples of solar power usage on house roofs from Germany (Source: Michael Waibel, 2023)

Source: Hoang Nguyen, 2020 (VIETSE, Vietnam Initiative for Energy Transition).

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