

ADAPTIVE RETROFIT GUIDELINE

for TRADITIONAL
LEBANESE
HOUSES



THESIS GUIDELINE
/ 2024-2025

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“ This brochure translate the thesis “Adaptive Retrofitting Guidelines for Traditional Lebanese Houses” into a **PRACTICAL GUIDELINE** intended for owners, architects, policymakers, and anyone involved in the building sector of Lebanon who have a responsibility in safeguarding the country's architectural heritage while advancing sustainable and energy-efficient practices.

THE STEPS

- 1 Identify the House Typology
- 2 Identify Climate Type
- 3 Document Architectural & Climatic Features
- 4 Understand Local Regulations & Policies
- 5 Evaluate Energy Context
- 6 Assess Current Energy & Comfort Conditions
- 7 Plan Retrofit Interventions
- 8 Simulate & Compare
- 9 Develop Tailored Guidelines

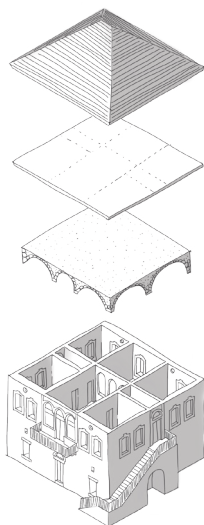
01

T TYPOLOGY

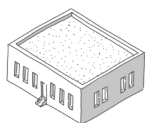
/ IDENTIFICATION

HOW IT WORKS:

Identify your house typology from the one of the five defined traditional forms.



Closed Rectangular House

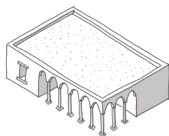


The earliest and most basic type, built as a single rectangular or square space.

All activities (living, working, and storage) took place in one multifunctional room.

Thick stone or mud-brick walls, flat earth roofs, and very small window openings make it instantly recognizable.

Gallery House

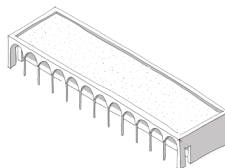


Characterized by an open gallery with arches and columns (Riwaq) facing outward, sometimes wrapping around corners.

It serves as a semi-outdoor reception and circulation space.

The play between the interior rooms and shaded galleries distinguishes this type.

Liwan House

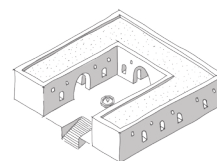


Built around a central "liwan", a covered terrace-like space flanked by side rooms.

It functions as both living area and passage, usually oriented towards the view or slope.

Liwan houses are rare today but recognizable by their deep, vaulted central space and hillside adaptation.

Courtyard House

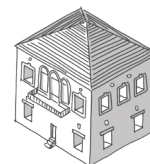


Organized around a central open courtyard, with wings of rooms and sometimes arcaded galleries framing it.

The courtyard serves as the heart of the house, providing light, ventilation, and family gathering space.

It often includes fountains or shaded sitting areas.

Central Hall House



The best-known Lebanese house type, with a large central hall fronted by a triple arch and flanked by rooms on either side.

Mostly two-storey, often with a symmetrical plan and prominent windows overlooking the valley.

This type became the aristocratic villa form in the 19th century.

02

CLIMATE

/ IDENTIFICATION

HOW IT WORKS:

01 Locate your house on the map and obtain its EPW (EnergyPlus Weather) file, or select the closest file within the same climatic zone.

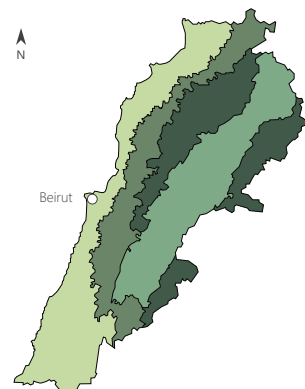
02 Use analysis tools such as Ladybug Grasshopper to get your Heating Degree Days (HDD) and Cooling Degree Days (CDD).

03 Classify your location's climate zone based on these values, following ASHRAE 169 or the Italian Climate Classification.

04 Use this classification to determine whether to prioritize heating, cooling, or both in your refurbishment strategy.

LOCATE YOUR HOUSE

Map of the Different Climatic Zones in Lebanon:



- Cities
- Zone 1: Coastal
- Zone 2: Medium Mountains
- Zone 3: Alpine
- Zone 4: Plateau

USE ANALYSIS TOOLS

--o Browse the EnergyPlus database for EPW files.



--o Select your corresponding EPW file or a similar one to your location.



--o Process the EPW file on an analysis tool such as Ladybug to extract the values.



DETERMINE THE CLIMATE CLASSIFICATION OF YOUR LOCATION

--o *Italian Climate Classification: Defined by D.P.R. 26 Agosto n. 412 Allegato A consolidated in 2018*

ZONE	DESCRIPTION HDD = 20°C (+ 2°C tolerance)	RECOMMENDED HEATING PERIOD
A	HDD < 600	1/12 to 15/03 for 6h/day
B	601 < HDD < 900	1/12 to 31/03 for 8h/day
C	901 < HDD < 1400	15/11 to 31/03 for 10h/day
D	1401 < HDD < 2100	1/11 to 15/04 for 12h/day
E	2101 < HDD < 3000	15/10 to 15/04 for 14h/day
F	HDD > 3001	No restriction

--o *NSI/ASHRAE AddASHRAE Standard 169-2020*

ZONE	ZONE TYPE	DESCRIPTION HDD = 18.3°C CDD = 10°C
1	Very Hot	5000 < CDD ≤ 6000
2	Hot	3500 < CDD ≤ 5000
3	Warm	CDD < 3500 and HDD ≤ 2000
4	Mixed	CDD < 3500 and 2000 < HDD ≤ 3000
5	Cool	CDD ≤ 3500 and 3000 < HDD ≤ 4000
6	Cold	4000 < HDD ≤ 5000

03

ARCHITECTURE

/ DOCUMENTATION

HOW IT WORKS:

Document architectural and climatic passive features of the house and the surroundings.

01 Start by noting the main facade's orientation towards the valley, or along the coast.

02 Note the prevailing breezes, optimal views, and passive solar exposure.

03 Record ventilation elements (high-level openings or "taqat") combined with low windows and high ceilings.

04 Include thermal mass, shutters, shading and greenery, outdoor spaces and elements such as water features, shaded pergolas, or fruit trees that support passive comfort.

05 Describe the roofing type (flat earth or pitched tiled roof) for rain protection and heat storage.

Orientation

Roofing

Shading & Greenery

Openings

Shutters

Ventilation

Thermal Inertia

Outdoor Space



04

REGULATIONS

/ DOCUMENTATION

HOW IT WORKS:

Understand local regulations and policies.

This helps set the first limits to future interventions.

Review the legal frameworks governing heritage conservation.



IDENTIFY APPLICABLE LAWS

→ 1933 Antiquities Law and 1942 Decree

Protection for buildings before 1700.

→ Law No. 35/2008

Reorganizes Ministry, creates heritage fund.

→ Law No. 37/2008

Introduces cultural property status, protection.

→ Heritage Protection Law (2007 and 2017 attempts)

Approved but never implemented effectively.



CHECK THE PROTECTION STATUS

Especially if it was built after 1700, as many traditional buildings are not legally covered.



ASSESS ENFORCEMENT

Note that legal frameworks exist but are weakly implemented, with limited executive decrees, funding, and oversight.



CONSULT LOCAL AUTHORITIES AND MUNICIPALITIES

Their involvement varies depending on priorities.



ENGAGE WITH NGOs OR HERITAGE ORGANIZATIONS

They often lead restoration efforts in the absence of strong governmental action.

Use this understanding to set the first limits of the intervention.

HOW IT WORKS:

Evaluate context.

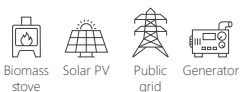
01 Understand the house's source of power and energy mix.

02 Understand the national energy mix and outage patterns.

03 Note grid reliability, cost, and emission factors (Primary Energy Factor).

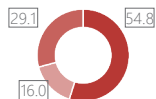
04 Assess potential for renewable integration to improve resilience.

IDENTIFY THE POWER SOURCES OF YOUR HOUSE



UNDERSTAND THE ENERGY MIX

Lebanon's Electricity Mix



■ Oil
■ Hydro
■ Solar PV

Generator's Electricity Mix



■ Diesel

NOTE RELIABILITY, COST & EMISSIONS

Reliability

Record daily power cuts (h/day)



Energy Cost

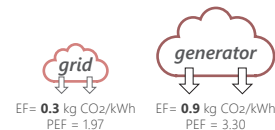
Identify local energy cost /kWh



CO₂ Emissions

Determine the CO₂ emissions

EF = Emission Factor (kg CO₂/kWh)
PEF = Primary Energy Factor



ASSESS RENEWABLE INTEGRATION

Solar Radiation

Analyze annual solar gains on the building's facades and roof



Surface Mounting

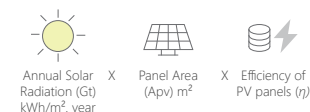
Identify available area for photovoltaic (PV) or solar thermal panels



Energy yield

Estimate the potential energy yield

Total PV Output (kWh/year) = $G_t \times A_{pv} \times \eta \times (1-L)$



And finally adjust for system losses (L).

06

BASELINE

/ ASSESSMENT

HOW IT WORKS:

Assess current energy and comfort conditions.

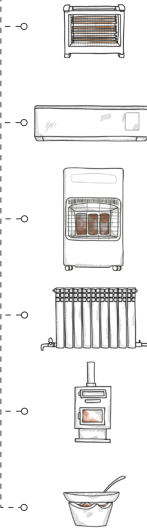
01 Note existing active heating and/or cooling methods.

02 Record comfort issues (overheating, poor insulation, dampness...).

03 Evaluate daylight availability in the rooms and living spaces.

04 Establish a reference case (Case 1) and compare with semi-refurbished (Case 2) and standard (Case 3) scenarios.

NOTE ACTIVE HEATING/COOLING



RECORD COMFORT ISSUES

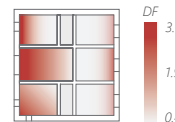
- Overheating in summer
- Underheating in winter
- Glare near windows
- Moisture and condensation
- Limited ventilation
- Air infiltration
- Irregular sun exposure

EVALUATE DAYLIGHT AVAILABILITY

- Calculate your Daylight Factor thresholds (EN 17037 standard)

Define average global horizontal illuminance from EPW file → Define indoor target illuminance → Calculate DF thresholds

- Simulate indoor daylight distribution



- Compare results to target DF thresholds



ESTABLISH REFERENCE CASE AND COMPARE

- CASE 1** Unrefurbished, 100% passive **Testing Baseline:** Assess materials and passive behavior.
- CASE 2** Semi-Refurbished, Heated/Cooled **Realistic Conditions:** Introduce existing heating/cooling.
- CASE 3** Refurbished, Regulated (Standard) **Testing Standard:** Apply regulation values to compare performance.
- CASE 4** Refurbished, Optimized, Integrated **Optimized Retrofit:** Combine passive and efficient strategies with the traditional architecture.

07

STRATEGY

/ ASSESSMENT

HOW IT WORKS:

Plan Retrofit Interventions.

01 Explore retrofitting techniques suitable for your traditional house.

02 Select compatible materials for your traditional house.

03 Test each measure individually using the One-at-a-Time (OAT) sensitivity analysis to understand their performance.

04 Select the most effective strategies based on their performance and compatibility.

05 Group the selected measures into 3 bundles: Low, Moderate and High Impact, balancing comfort, energy savings, and preservation.

EXPLORE RETROFITTING TECHNIQUES

Refer to Table 5.1.1: Retrofitting Strategies Summary

- Insulation
- Finishing
- Secondary glazing
- Shutters
- Air sealing
- PV - Solar Thermal
- LED lights
- Smart control
- MVHR
- Thermal bridging reduction

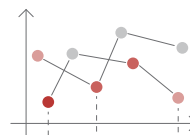
SELECT SUITABLE MATERIALS

Refer to Table 5.1.2: Material Properties and Description

Material	Thermal Conductivity (W/mK)	Density (kg/m³)	Specific Heat Capacity (J/kgK)	Thermal Expansion Coefficient (1/K)
Concrete	1.7	2400	880	10
Brick	0.7	1800	840	10
Insulation	0.03	35	1000	0.01
Glazing	1.0	2500	840	10
Shutters	0.1	1200	1200	10
Air sealing	0.02	1200	1200	10
PV - Solar Thermal	0.04	2300	840	10
LED lights	0.02	2300	840	10
Smart control	0.02	2300	840	10
MVHR	0.02	2300	840	10
Thermal bridging reduction	0.02	2300	840	10

SENSITIVITY ANALYSIS

Test each strategy individually (OAT)



SELECT EFFECTIVE STRATEGIES

Classify them by impact on building

Strategy	Low Impact	Moderate Impact	High Impact
1	✓		
2		✓	
3	✓		
4	✓		
5		✓	

Most performant solution for **Low** Impact

Most performant solution for **Moderate** Impact

Most performant solution for **High** Impact

GROUP THE STRATEGIES INTO BUNDLES

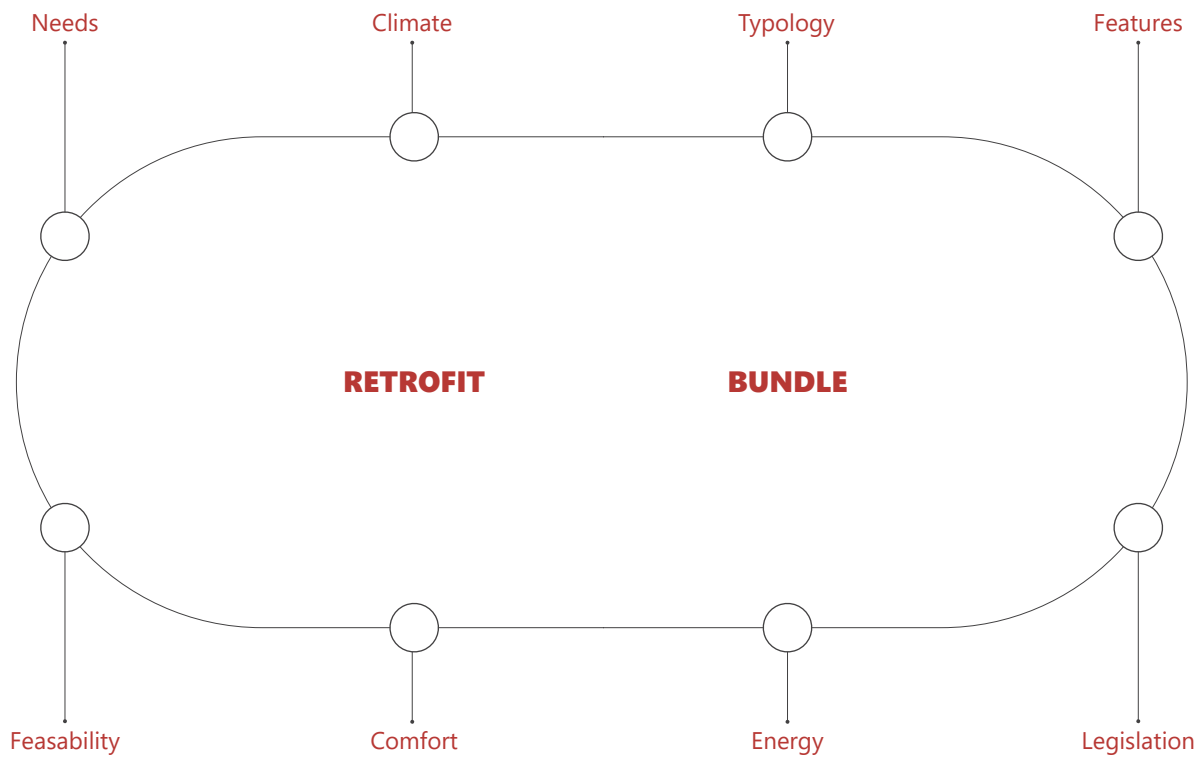
Classify them by impact on building

Low Impact Bundle
Strategy 3
Strategy 4

Moderate Impact Bundle
Strategy 1
Strategy 5

High Impact Bundle
Strategy 2

Each bundle is shaped by the interaction of the following factors:



08

SIMULATION

/ EVALUATION

HOW IT WORKS:

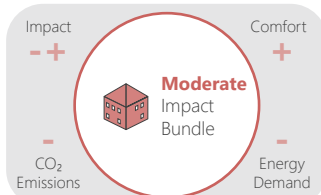
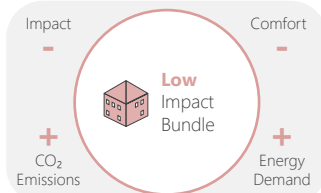
Simulate and Compare.

01 Simulate all retrofit bundles individually (Low, Moderate, High) to quantify thermal and daylight comfort, energy demand (PE and DE), and Carbon Footprint and Renewable contribution.

02 Integrate renewable systems (solar thermal/PV) and determine potential energy and cost savings.

03 Compare all cases to assess overall performance improvements.

SIMULATE THE BUNDLES



INTEGRATE RENEWABLES

Base Case
3% savings

Low Impact
8% savings

Moderate Impact
17% savings

High Impact
25% savings

COMPARE ALL CASES

	Base Case	Low	Mod	High
Impact	-	-	+	+
Comfort	-	-	+-	+
Energy Demand	+	+	+-	-
CO ₂ Emissions	+	+	+-	-
Savings	-	-	+-	+

HOW IT WORKS:

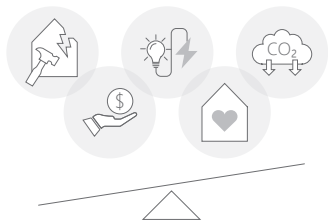
Develop tailored guidelines.

01 Choose the most balanced case: good comfort, good savings, and strong integration and respect for the traditional character of the house.

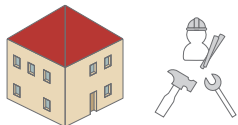
02 Document outcome to inform future refurbishments and support knowledge sharing.

CHOOSE THE MOST SUITABLE CASE

- Consider balancing the main five factors for an optimal choice



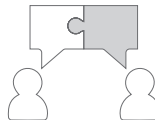
- Implement the changes to your house with professional help

**DOCUMENT OUTCOMES**

- Record and archive results



- Share findings and knowledge



Example of a Central Hall Lebanese house retrofitting plan (Low Impact):

