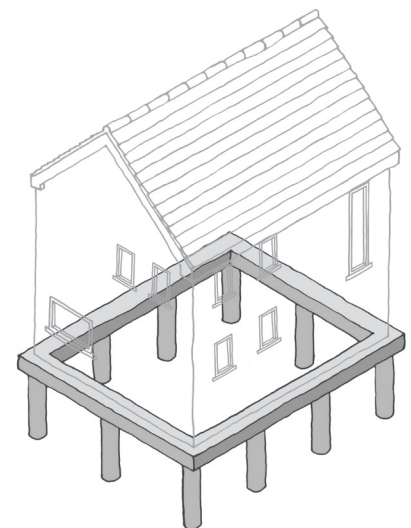
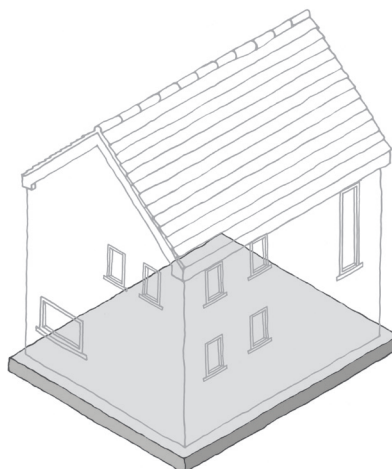
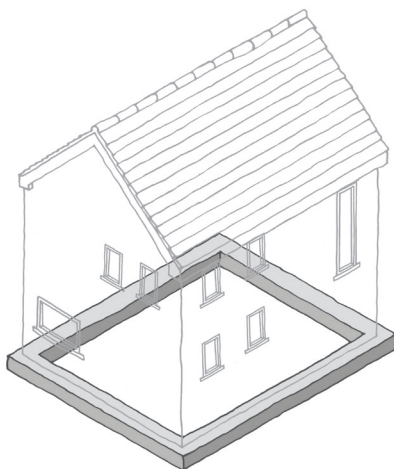


Contents

Acknowledgements	v	Working at height	93
Foreword	viii	Excavation	98
Introduction	ix	Electricity and hand-held power tools	99
Section 1 Design: Context	1	Manual handling	100
Chapter 1 Sustainability	3	Site vehicles	101
Sustainability	4	Revision exercises	101
Sustainable design of buildings	5	Chapter 10 Construction Materials	102
Revision exercises	7	Identifying sustainable materials	103
Chapter 2 Energy Resources and Carbon Dioxide Emissions	8	Managing waste	107
Our impact on the planet	9	Physical properties	108
Energy	11	Aesthetic properties	109
Revision exercises	16	Revision exercises	109
Chapter 3 Water Resources	17	Chapter 11 Envelope Design Concepts	110
Global water scarcity	18	Sustainability	111
Water scarcity in Ireland	18	Structural stability	112
Water consumption in the home	20	Durability	114
Revision exercises	23	Thermal resistance	114
Chapter 4 Urban Design	24	Thermal bridging	115
Neighbourhood	25	Wind resistance	118
Site	28	Moisture resistance	120
Home	31	Airtightness	125
Revision exercises	32	Fire resistance	128
Chapter 5 Rural Design	33	Sound resistance	130
Site selection	34	Aesthetics	130
Site layout	35	Revision exercises	132
House design	37	Chapter 12 Site Assessment	133
Landscape design	38	Site selection	134
Revision exercises	42	Soil investigation	134
Chapter 6 Universal Design	43	Revision exercises	137
Principles	44	Chapter 13 Foundations	138
Design brief	45	Functions	139
Layout	46	Performance criteria	139
Key areas of the home	47	Factors influencing design	139
Revision exercises	55	Foundation types	141
Chapter 7 Building Control System	56	Revision exercises	152
Technical Guidance Documents A–M	57	Chapter 14 Floors	153
Certification of building products	58	Functions	154
Planning	59	Performance criteria	154
Revision exercises	71	Factors influencing floor design	154
Chapter 8 Heritage	72	Floor types	154
World heritage	73	Radon	158
National and local heritage	78	Revision exercises	160
Vernacular architecture	79	Chapter 15 Walls	161
Georgian architecture	80	Functions	162
Recognising a heritage building	82	Performance criteria	162
Conservation	83	Factors influencing external wall design	162
Revision exercises	86	External walls designed to building regulations standard	163
Section 2 Design: Structure	87	External walls designed to Passivhaus standard	164
Chapter 9 Health and Safety in Construction	88	Wall finishes	169
Safety management principles	89	Revision exercises	172
		Chapter 16 Roofs	173
		Functions	175
		Factors influencing roof design	175

Performance criteria for roofs	175	Chapter 24 Energy Standards	313
High-slope roof structures	177	Design and performance standards	314
Truss roof	180	Building regulations (TGD L 2011)	316
Thermal resistance of high-slope roofs	183	Passivhaus standard	322
Roof coverings	185	Revision exercises	329
Low-slope roof structures	189	Chapter 25 Airtightness	330
Green roofs	196	Airtightness standards	331
Revision exercises	197	Airtightness and energy loss	331
Chapter 17 Windows and Doors	198	Permeability testing	332
Functions	199	Calculations	335
Performance criteria	199	Revision exercises	335
Fenestration	200	Chapter 26 Ventilation	336
Designing windows for maximum thermal performance	203	Ventilation control	337
Building regulations standard windows	210	Function of ventilation	338
Passivhaus standard windows	213	Air quality	338
Door design	215	Air change rate	339
Building regulations standard doors	216	Mechanical heat recovery ventilation	340
Passivhaus standard doors	217	Revision exercises	350
Revision exercises	218	Chapter 27 Electrical Energy	351
Chapter 18 Internal Elements	219	Electricity generation	352
Upper floors	220	Distribution of electricity in the home	357
Stairs	225	Safety	365
Internal walls	229	Micro-generation	369
Internal doors	232	Smart metering	376
Revision exercises	234	Revision exercises	377
Chapter 19 Structural Systems – Drawings and Details	235	Chapter 28 Water Supply	378
Section 3 Design: Comfort and Low Energy	263	Water intake	379
Chapter 20 Healthy Indoor Environment	265	Water distribution	379
Comfort factors	266	Cold water supply	380
Revision exercises	270	Hot water supply: building regulations standard	382
Chapter 21 Passive Design	271	Hot water supply: Passivhaus standard	391
Solar principles	272	Revision exercises	395
Passive design	279	Chapter 29 Drainage	396
Revision exercises	286	Above-ground pipework	397
Chapter 22 Natural Light	287	Below-ground pipework	398
Standard sky	288	On-site wastewater treatment	400
Daylight factor	288	Revision exercises	406
Revision exercises	292	Chapter 30 Sound	407
Chapter 23 Heat Energy	293	Sound energy	408
Principles	294	Sound insulation	410
Thermal properties of construction materials	295	Revision exercises	413
Thermal transmittance (U-value) calculations	299	Index	414
Rate, amount and cost of energy loss calculations	308		
Revision exercises	312		

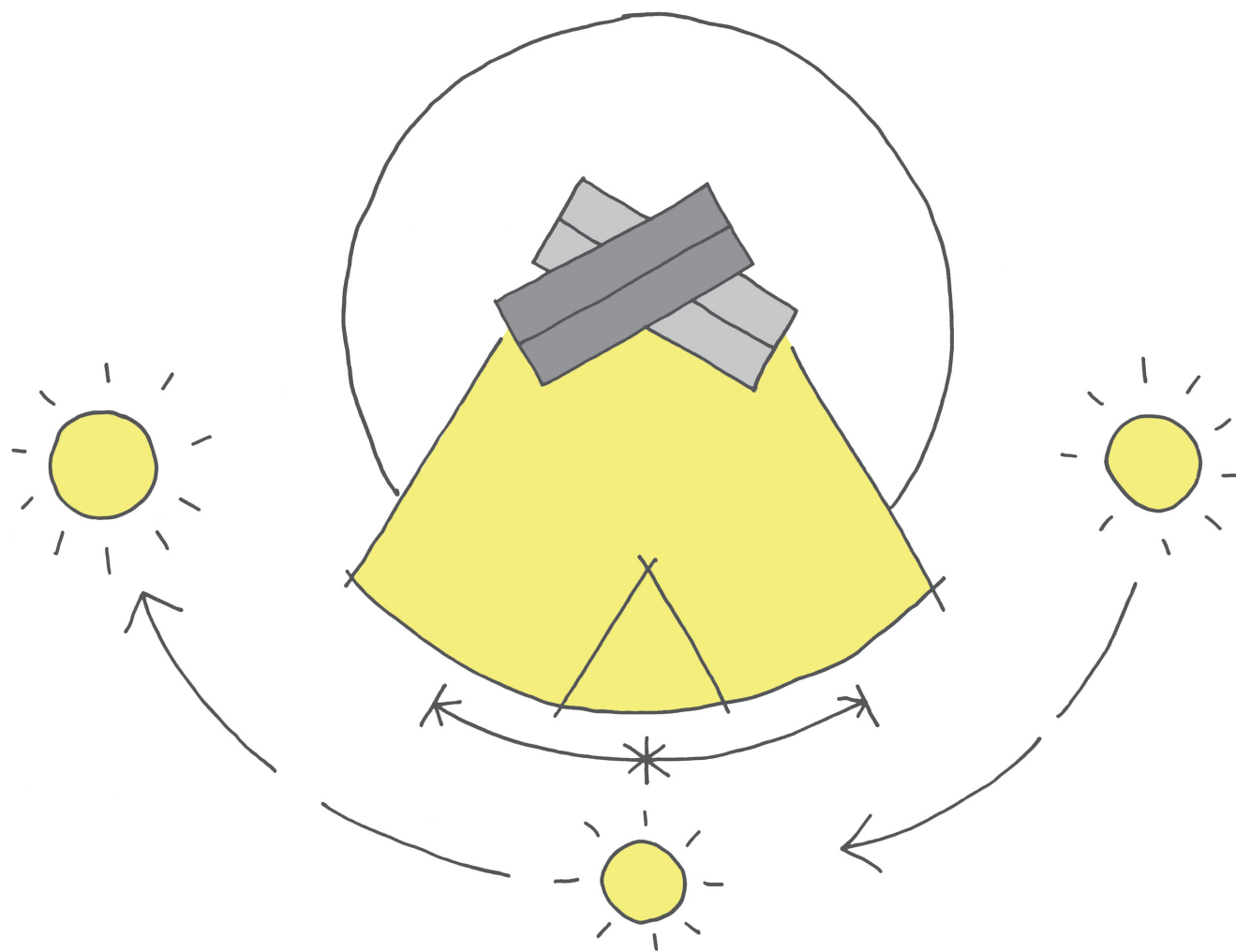




21

CHAPTER

Passive Design



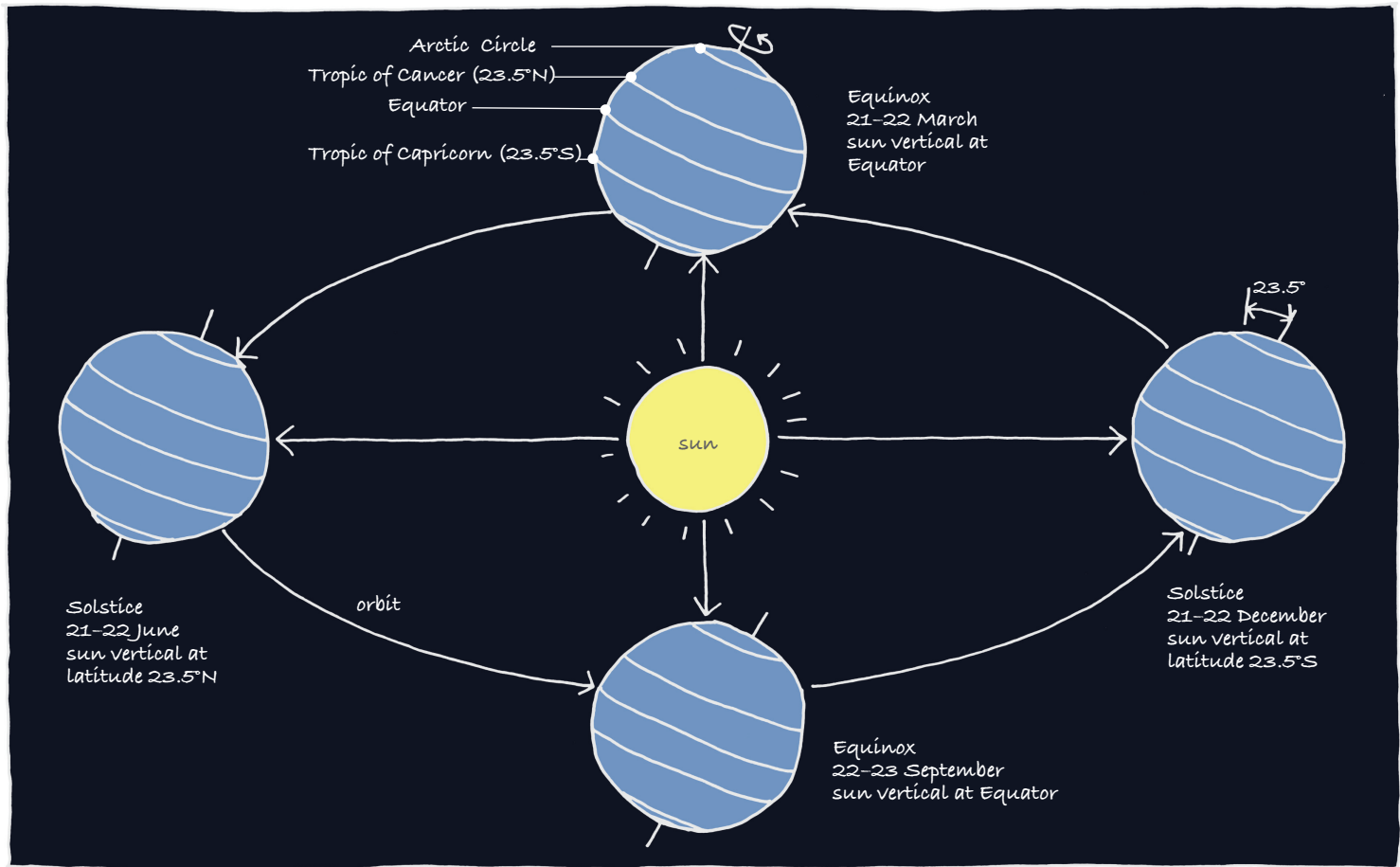
Solar principles

The design of low-energy housing is based on the concept of solar gain – capturing radiant energy from the sun to provide space heating, water heating and lighting.

When designing homes that capture the sun’s energy, it is essential to understand the movement of the sun in the sky and how this changes with the seasons.

Earth’s orbit

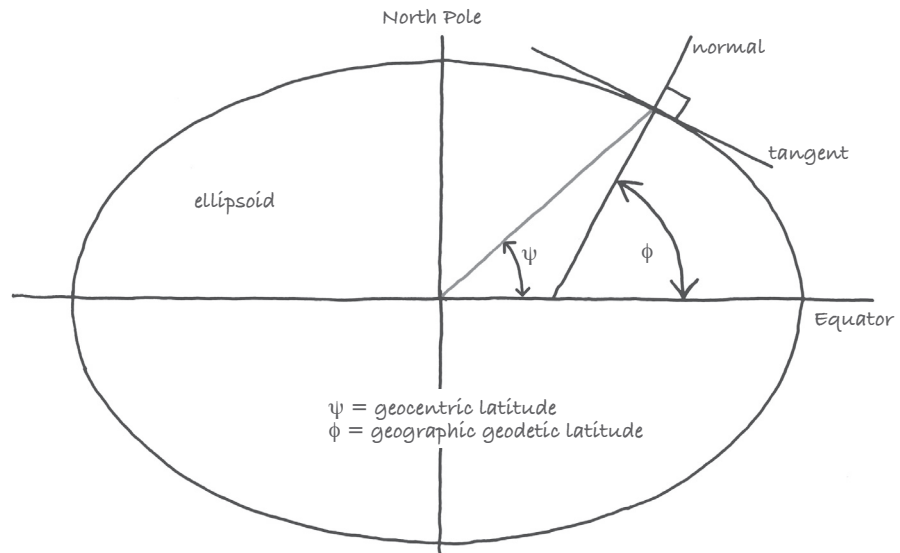
A year is the time taken for the earth to complete one orbit of the sun. The axis of the earth is tilted by 23.5° with respect to the plane that passes through the sun and the Equator. This tilt causes the change in radiation, length of day, and climate between summer and winter. If there were no tilt, there would be uniform climatic conditions throughout the year (i.e. no seasons). The intensity of radiation from the sun also varies with the season of the year. The angle at which radiation from the sun falls on a surface changes as the relative tilt and orbit of the earth around the sun changes.



21.01 The earth’s orbit: the earth rotates about the sun once per year; it rotates on its axis (towards the east, or anti-clockwise) once every 24 hours; the axis is tilted at an angle of 23.5°. Seasons depend on position in orbit.

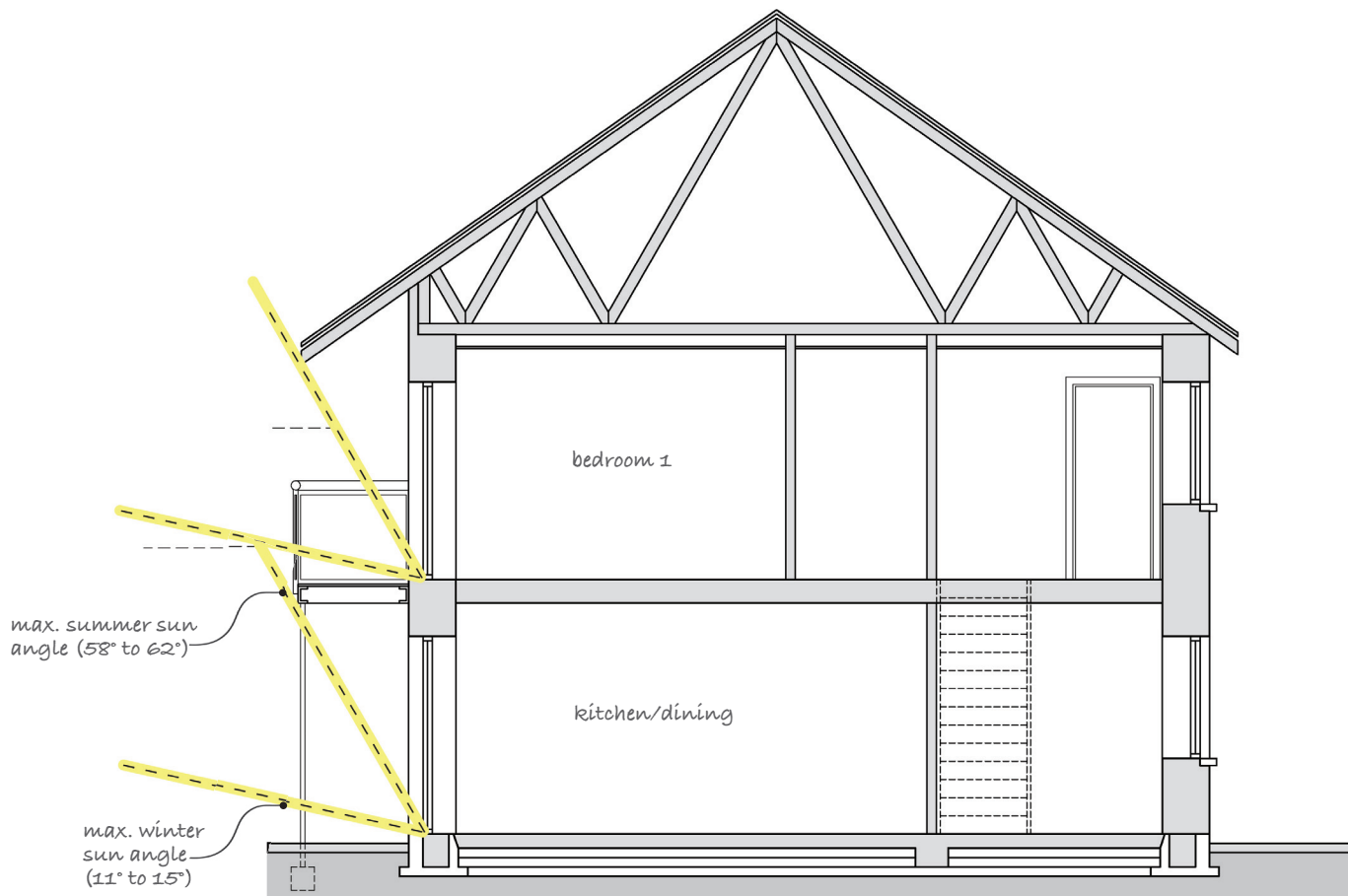
Latitude

Geographical latitude ϕ is a measure of the position of a point on the earth's surface above (north of) or below (south of) the Equator.

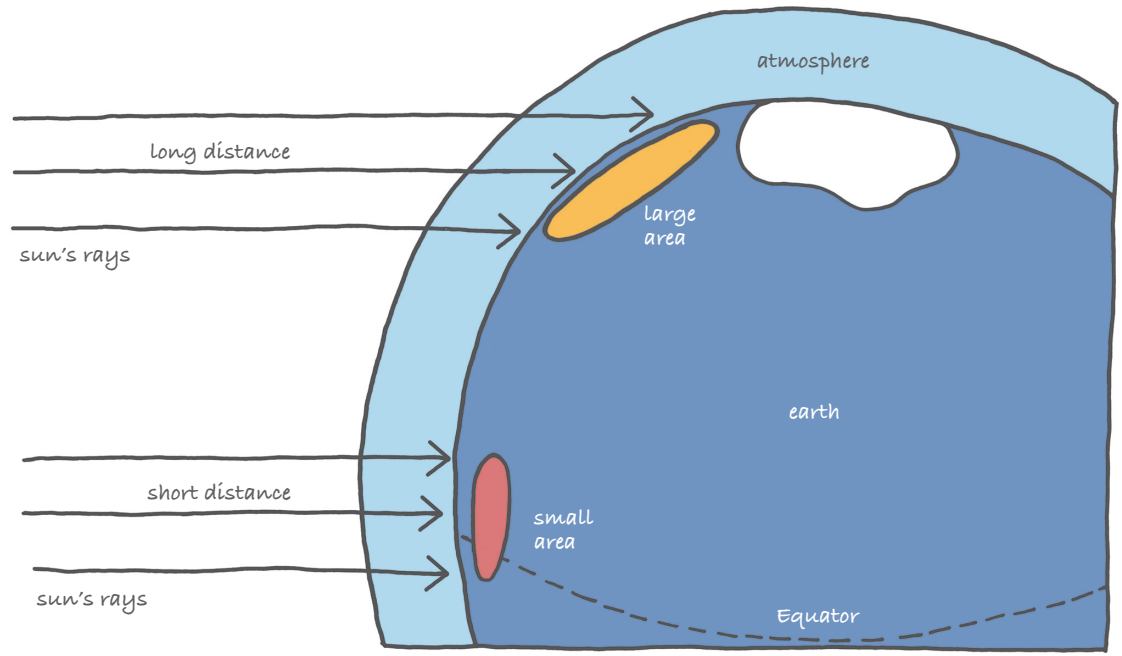


21.02 Latitude: the earth is an ellipsoid (flattened at the poles).

The radiation from the sun is at its most intense when it falls on the earth's surface at an angle of 90° to the surface – this happens at the Equator. The intensity of solar radiation decreases as latitude increases and the angle at which the solar radiation strikes the earth's surface decreases. This angle, called the altitude or sun angle, varies throughout the year. Ireland's position in the northern hemisphere means that the maximum sun angle ranges from approximately 11° to 15° in winter and from 58° to 62° in summer (depending on location).



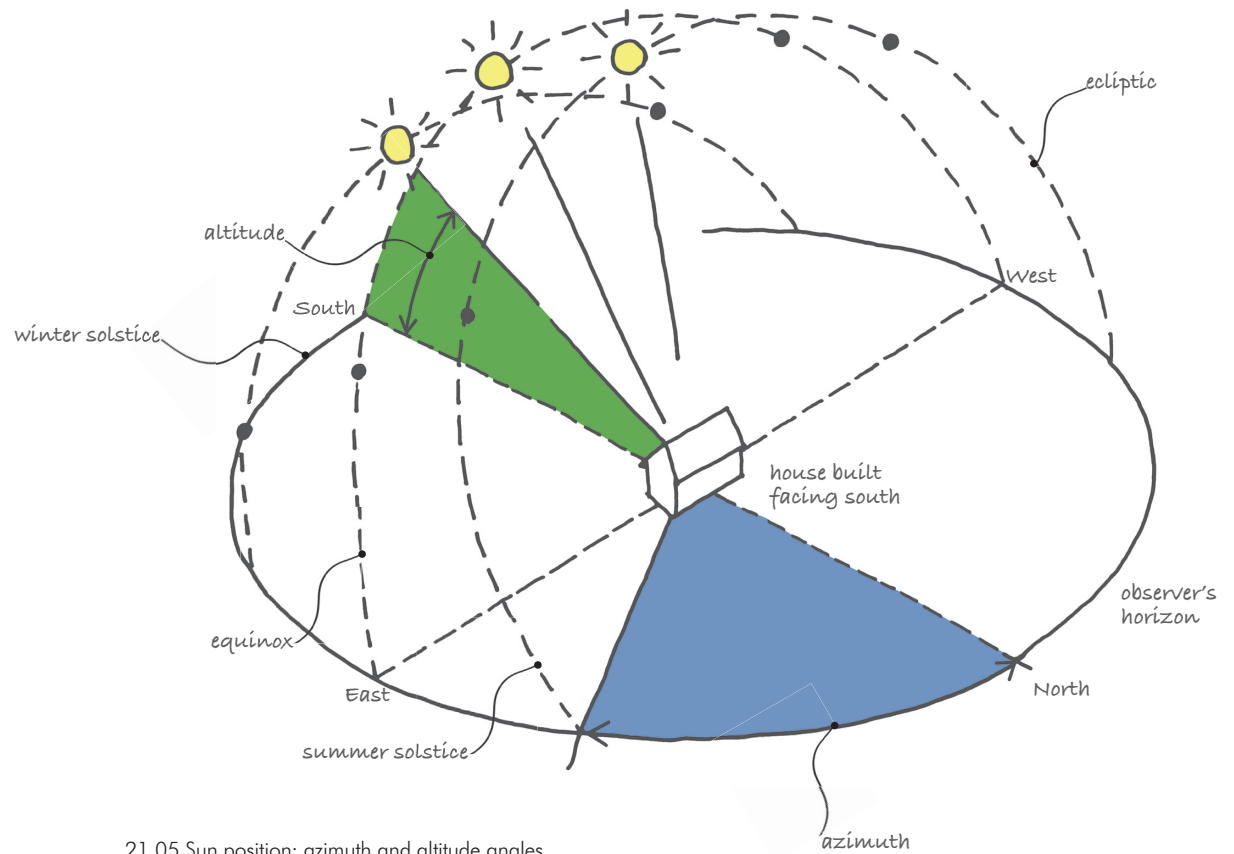
21.03 Maximum sun angle in Ireland varies from winter to summer.



21.04 Latitude: at higher latitudes the sun's energy is spread over a larger area, and is therefore weaker than if the sun is higher overhead and the energy is concentrated on a smaller area.

Sun position

The position of the sun relative to the earth doesn't change. It is because of the earth's orbit around the sun that the sun appears to move in the sky. The ecliptic is the apparent path of the sun in the sky. The position of the sun in the sky is described by two angles: azimuth and altitude.



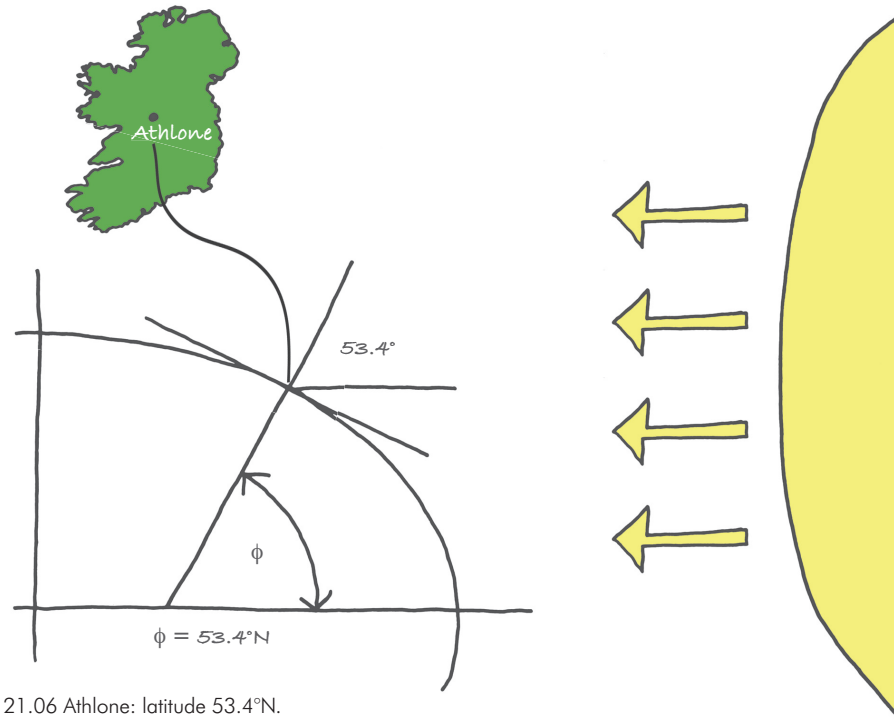
21.05 Sun position: azimuth and altitude angles.

Sun angle

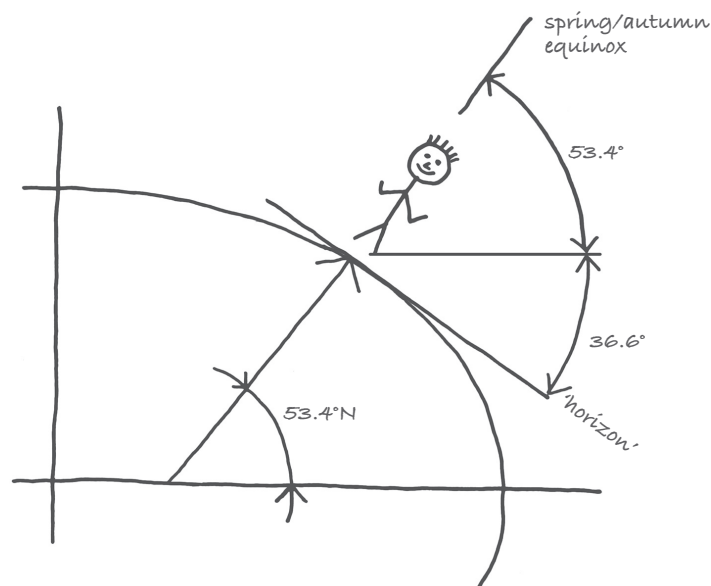
The amount and quality of solar energy we receive in Ireland is influenced by our position on the planet. Ireland's position in the northern hemisphere means that the sun is to the south (over the Equator) – therefore, the south-facing side (façade) of a building receives the most solar energy.

This fact is very important when designing buildings that are going to be primarily heated by the sun's energy (i.e. passive homes). For example, it is important to know the sun angle so that features, such as shading devices, can be included in the design to prevent overheating during the summer. The sun angle is also crucial to the positioning of solar panels to ensure maximum energy gain.

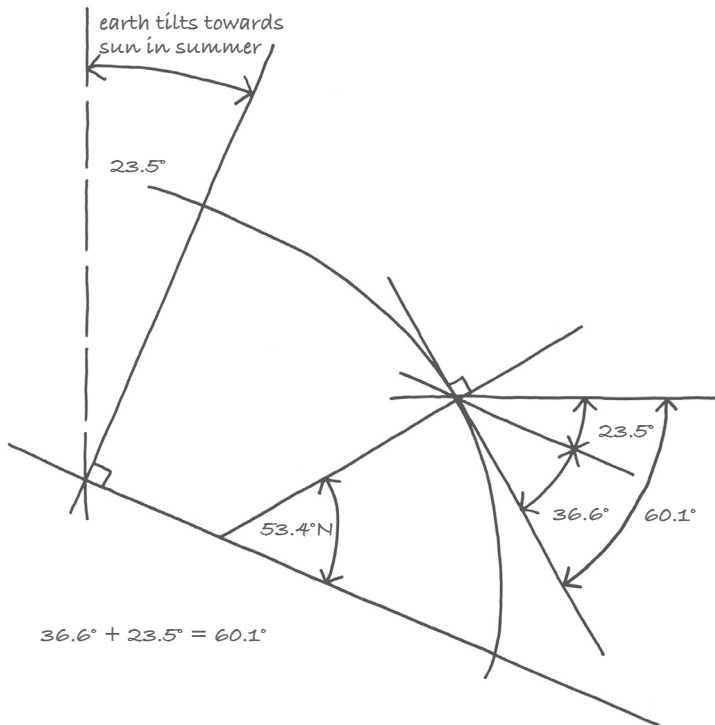
The sun angle varies because the earth is tilted on its axis. In the summer the earth is leaning towards the sun; in winter it leans away from the sun.



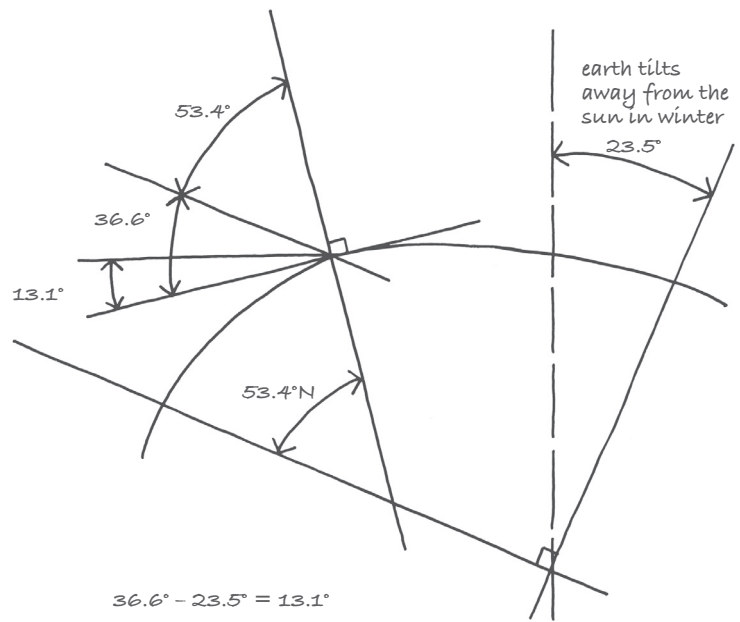
21.06 Athlone: latitude 53.4°N.



21.07 Athlone: maximum sun angle, spring/autumn equinox = 36.6°N.



21.08 Athlone: maximum sun angle, summer solstice = 60.1°N.



21.09 Athlone: maximum sun angle, winter equinox = 13.1°N.

Once the latitude of a site is known (which can be easily found online or by using Google Earth), the maximum sun angle can be calculated using these formulae:

ACTIVITIES

Look up the latitude of your home using the Google Earth app. Calculate the maximum sun angle in summer, winter and at the equinoxes.

season	maximum sun angle
spring/autumn equinox	$90^\circ - \text{latitude} = \text{maximum sun angle}$
summer solstice	$90^\circ - \text{latitude} + 23.5^\circ = \text{maximum sun angle}$
winter solstice	$90^\circ - \text{latitude} - 23.5^\circ = \text{minimum sun angle}$

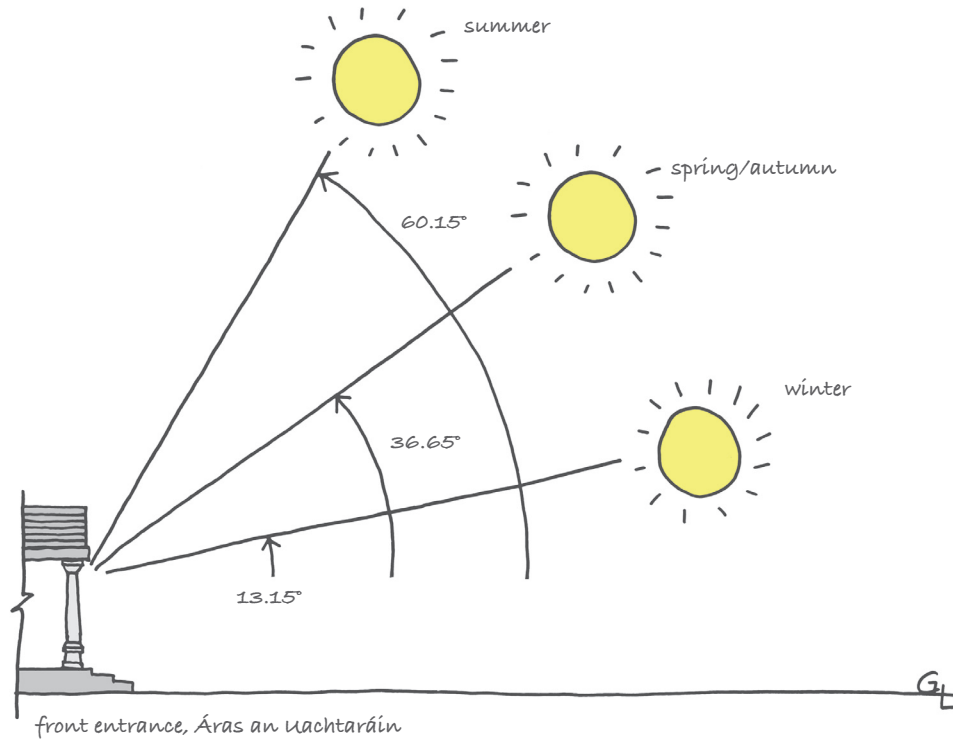
21.10 Maximum sun angle formulae

Worked example

Áras an Uachtaráin in the Phoenix Park, Dublin has a latitude of 53.35 degrees.

season	maximum sun angle
spring/autumn equinox	$90^\circ - 53.35^\circ = 36.65^\circ$
summer solstice	$90^\circ - 53.35^\circ + 23.5^\circ = 60.15^\circ$
winter solstice	$90^\circ - 53.35^\circ - 23.5^\circ = 13.15^\circ$

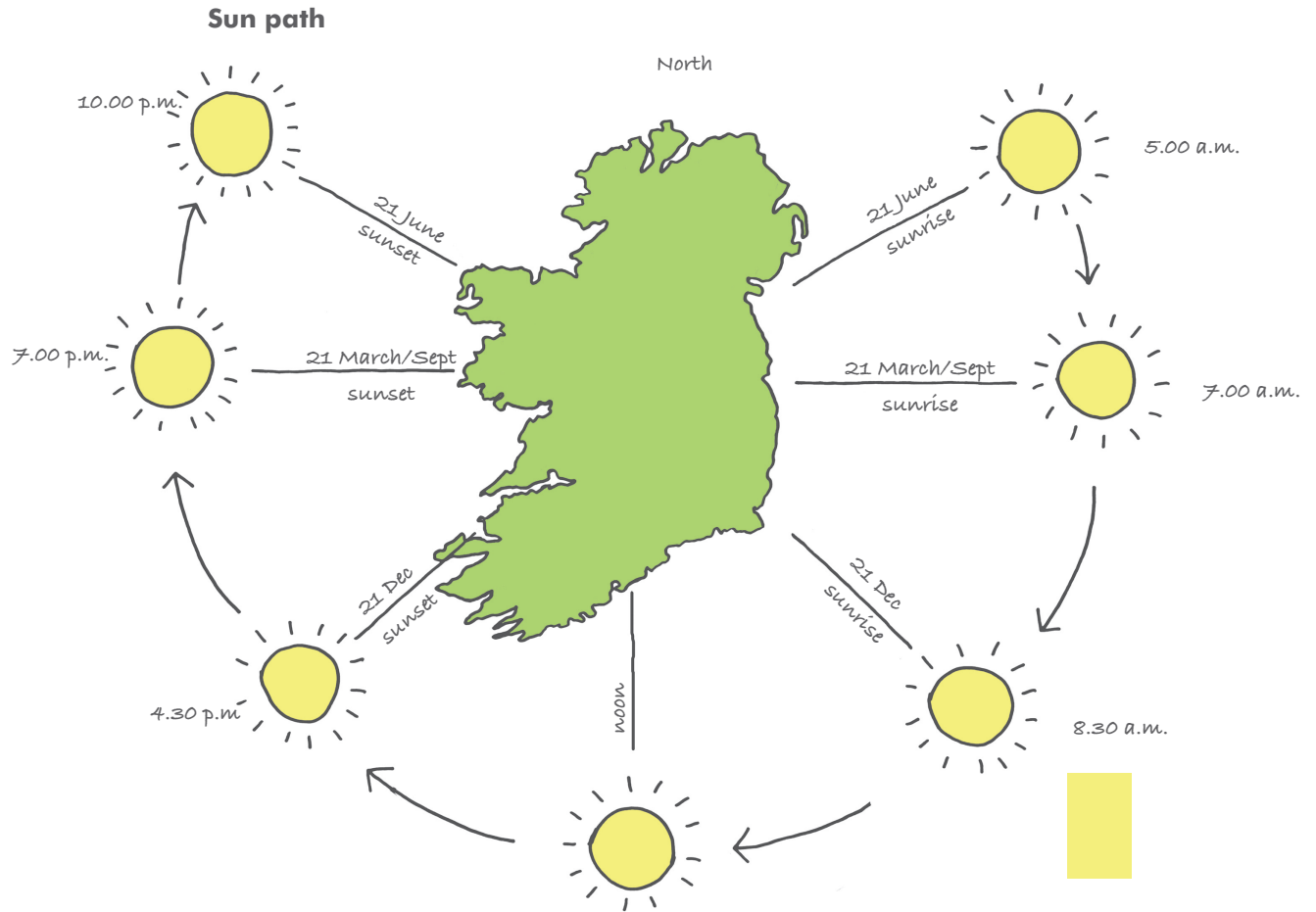
21.11 Maximum sun angle example.



21.12 Maximum sun angle at Áras an Uachtaráin for each season.

	latitude	summer	spring/autumn	winter
Malin Head	55.39	58.11	34.61	11.11
Donegal	54.65	58.85	35.35	11.85
Athlone	53.42	60.08	36.58	13.08
Dublin	53.35	60.15	36.65	13.15
Galway	53.27	60.23	36.73	13.23
Limerick	52.66	60.84	37.34	13.84
Waterford	52.26	61.24	37.74	14.24
Cork	51.90	61.60	38.10	14.60
Mizen Head	51.45	62.05	38.55	15.05

21.13 Maximum sun angles at various locations throughout the year. Athlone, being in the middle of Ireland, has the average values.



21.14 Simplified sunpath diagram showing approximate time and azimuth angle of sunrise and sunset in Ireland.

The position of the sun can be plotted using a sunpath diagram. This diagram provides an accurate picture of the sun's position when viewed from a particular point on earth at various times of the year.

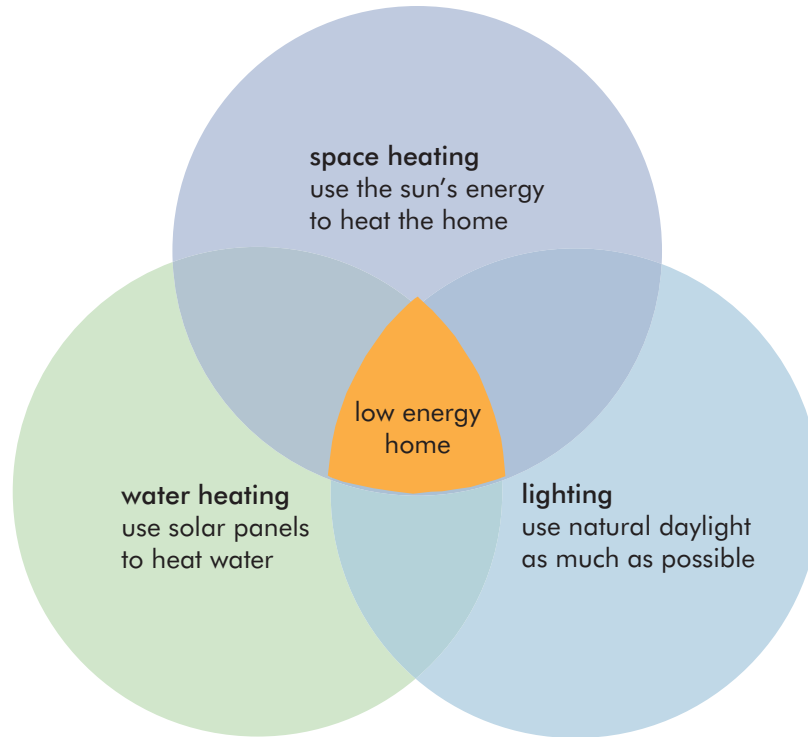
KEY PRINCIPLES

Simple facts about the sun's movement:

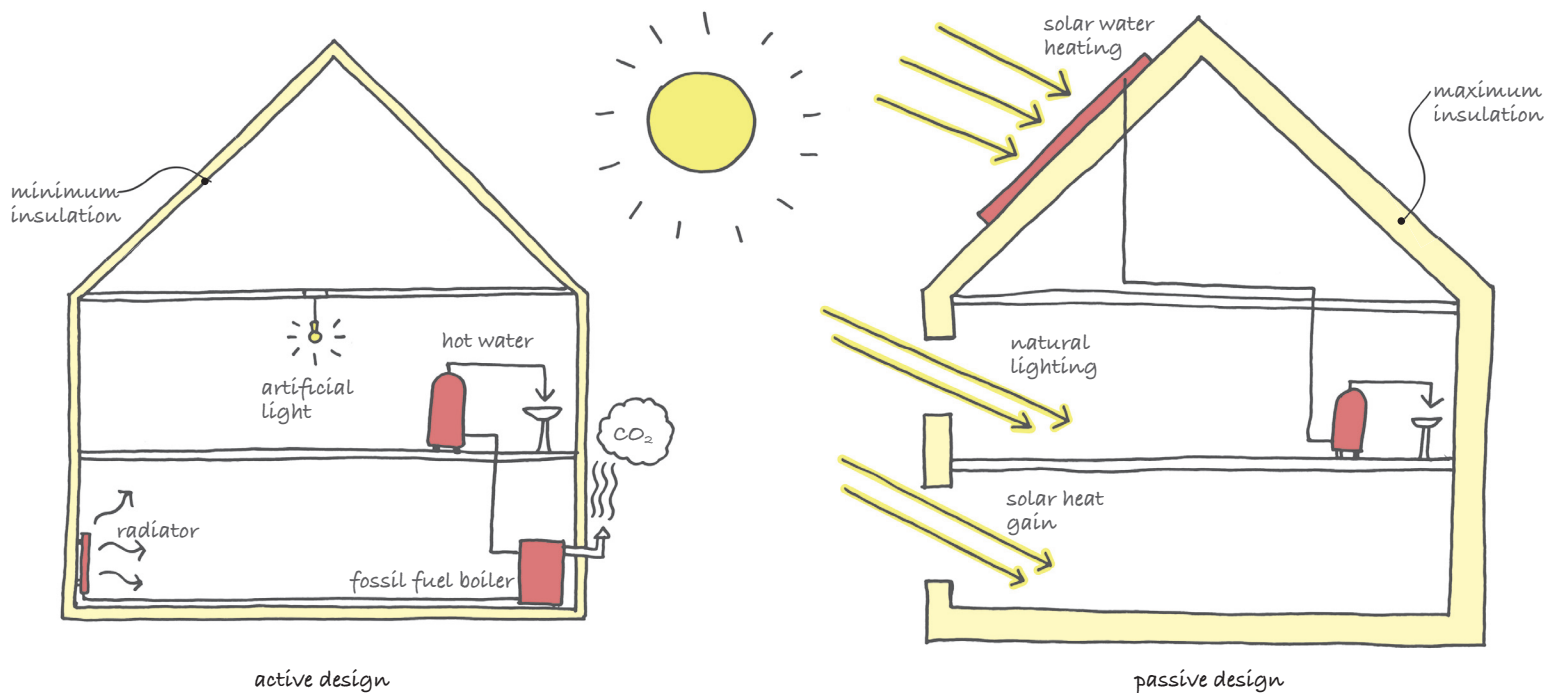
- the sun rises (morning) in the east and sets (evening) in the west
- the sun is approximately due south at noon
- the sun is higher in the sky in summer than in winter
- summer days are long; winter days are short.

Passive design

Passive design is a general term used to describe a way of designing buildings that uses sunlight to provide heat and light. Unlike active design, which relies on burning fuels to produce energy to provide space heating, water heating and lighting, passive design uses energy from the sun to do this. Almost every home built in Ireland over the last century was based on active design. These homes waste a lot of energy in providing a comfortable indoor environment. Creating sustainable homes means shifting from an active to a passive approach.



21.15 Passive design: low energy homes use solar gain to provide space heating, water heating and lighting.



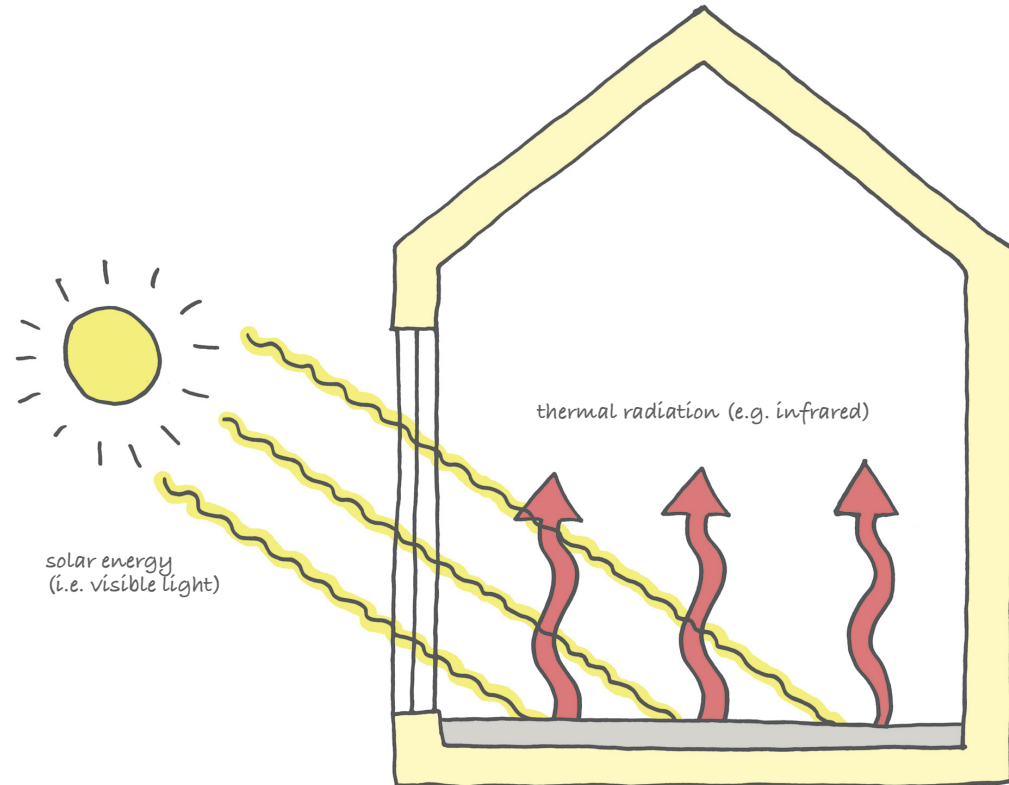
21.16 Active design (high energy consumption and high CO₂ emissions) versus passive design (low energy consumption and low CO₂ emissions).

Solar gain

Solar gain (also called solar heat gain) is a term used to describe the increase in temperature in a space or material that results from solar radiation.

The amount of solar gain increases with the strength of the sun, and with the ability of the material to absorb the radiation. Dark-coloured, rough-textured objects absorb solar radiant energy more readily than light-coloured, shiny objects. When an object is struck by sunlight it absorbs the solar energy (i.e. visible light plus a small amount of ultraviolet light) from the sunlight and later radiates this energy as infrared radiation.

When this happens in a building with low-e glazing the glass traps the energy (i.e. infrared radiation) inside. This is essentially the greenhouse effect. The application of low-emissivity coatings to the glazing makes the glass transparent to the visible light but not to the infrared radiation.



21.17 Solar gain: radiant energy from the sun warms the indoor spaces.

KEY PRINCIPLES

Homes designed to optimise solar gain have three features:

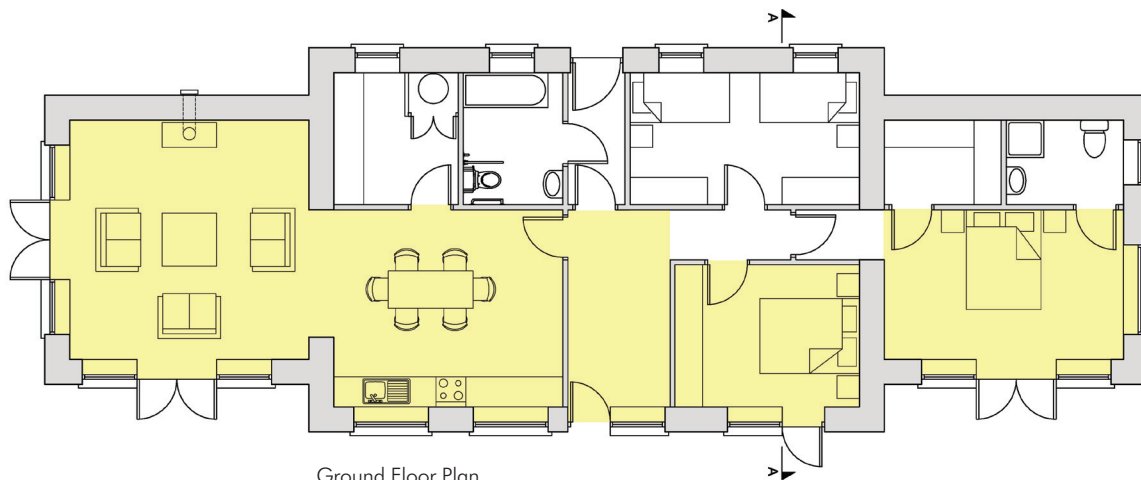
- a façade that faces south
- lots of glazing in the south-facing façade
- an interior layout that positions the main living spaces on the south side of the building.



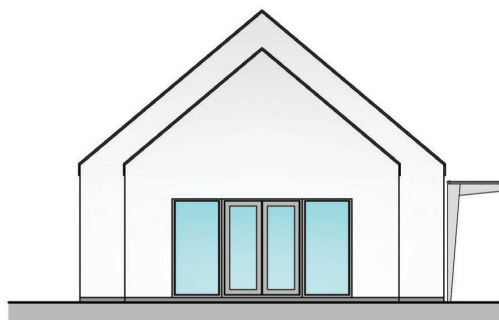
South Elevation



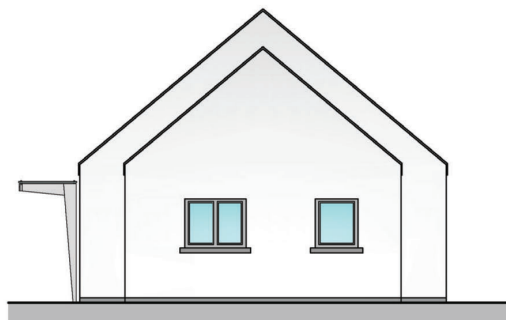
North Elevation



Ground Floor Plan



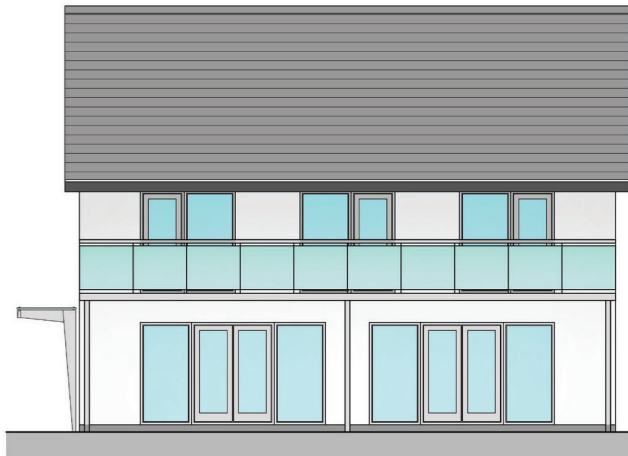
West Elevation



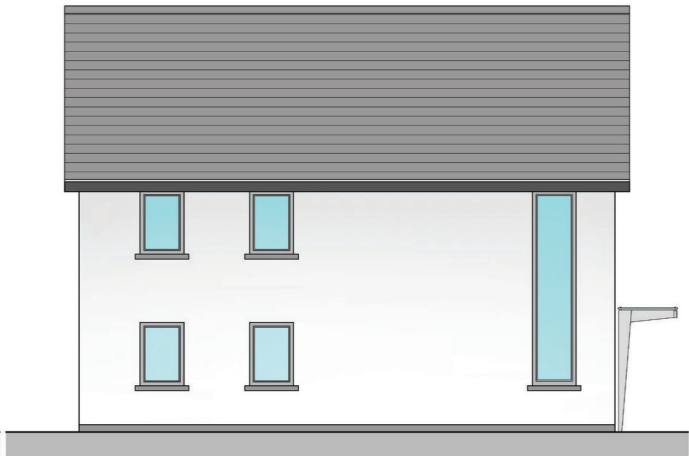
East Elevation

21.18 Single-storey house: orientation, glazing and interior layout combine to optimise solar gain.

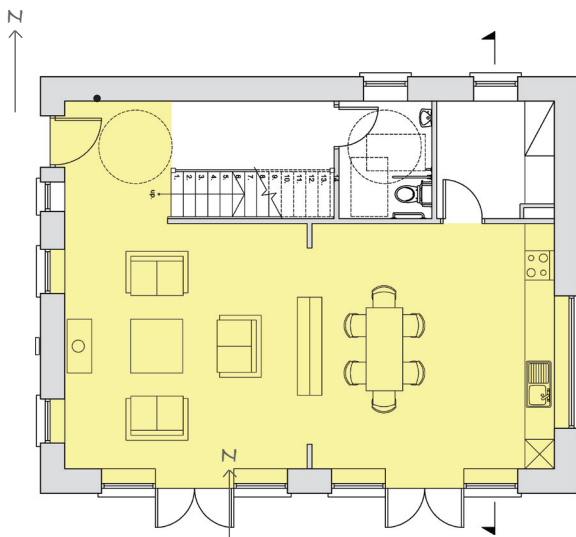




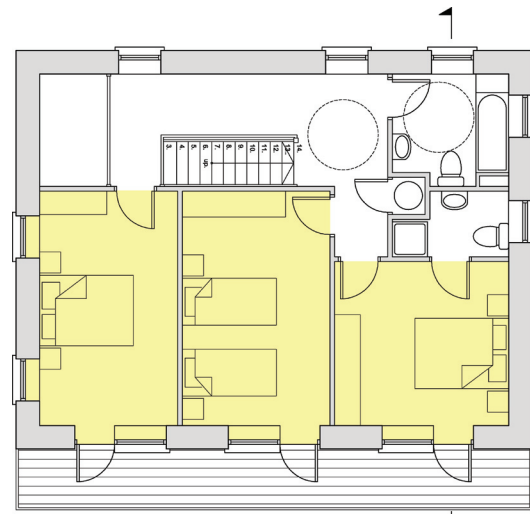
South Elevation



North Elevation



Ground Floor Plan



First Floor Plan



West Elevation

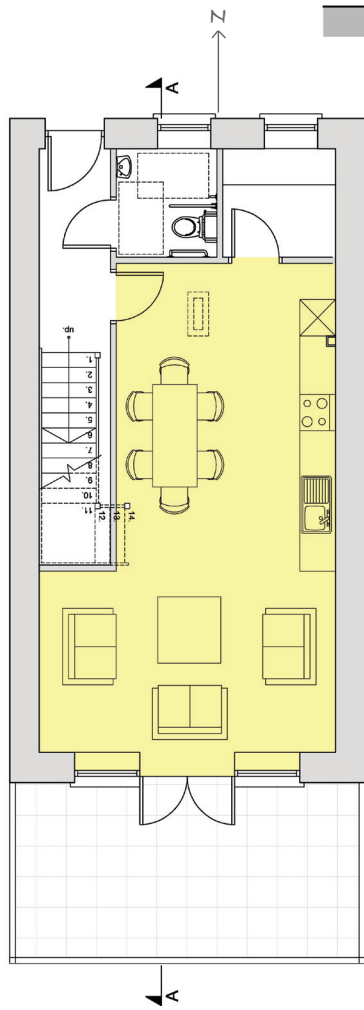


East Elevation

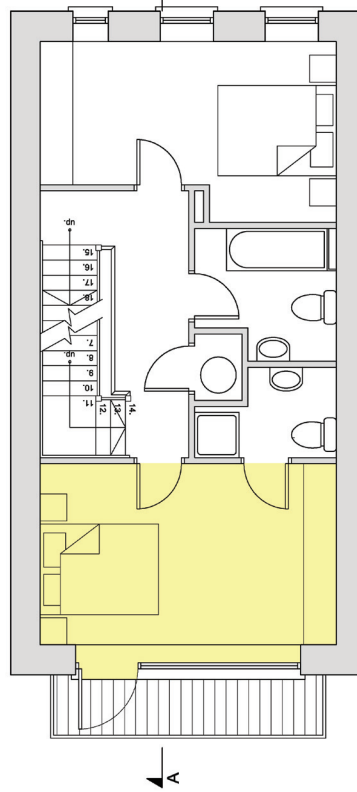
21.19 Two-storey house: orientation, glazing and interior layout combine to optimise solar gain.



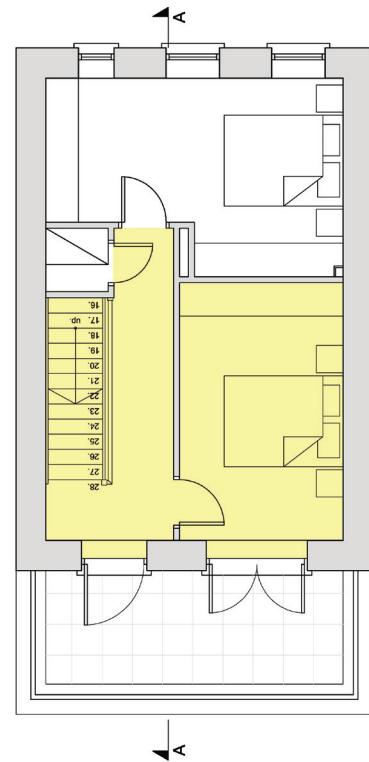
South Elevation



Ground Floor Plan



First Floor Plan



Second Floor Plan

21.20 Three-storey house: orientation, glazing and interior layout combine to optimise solar gain.

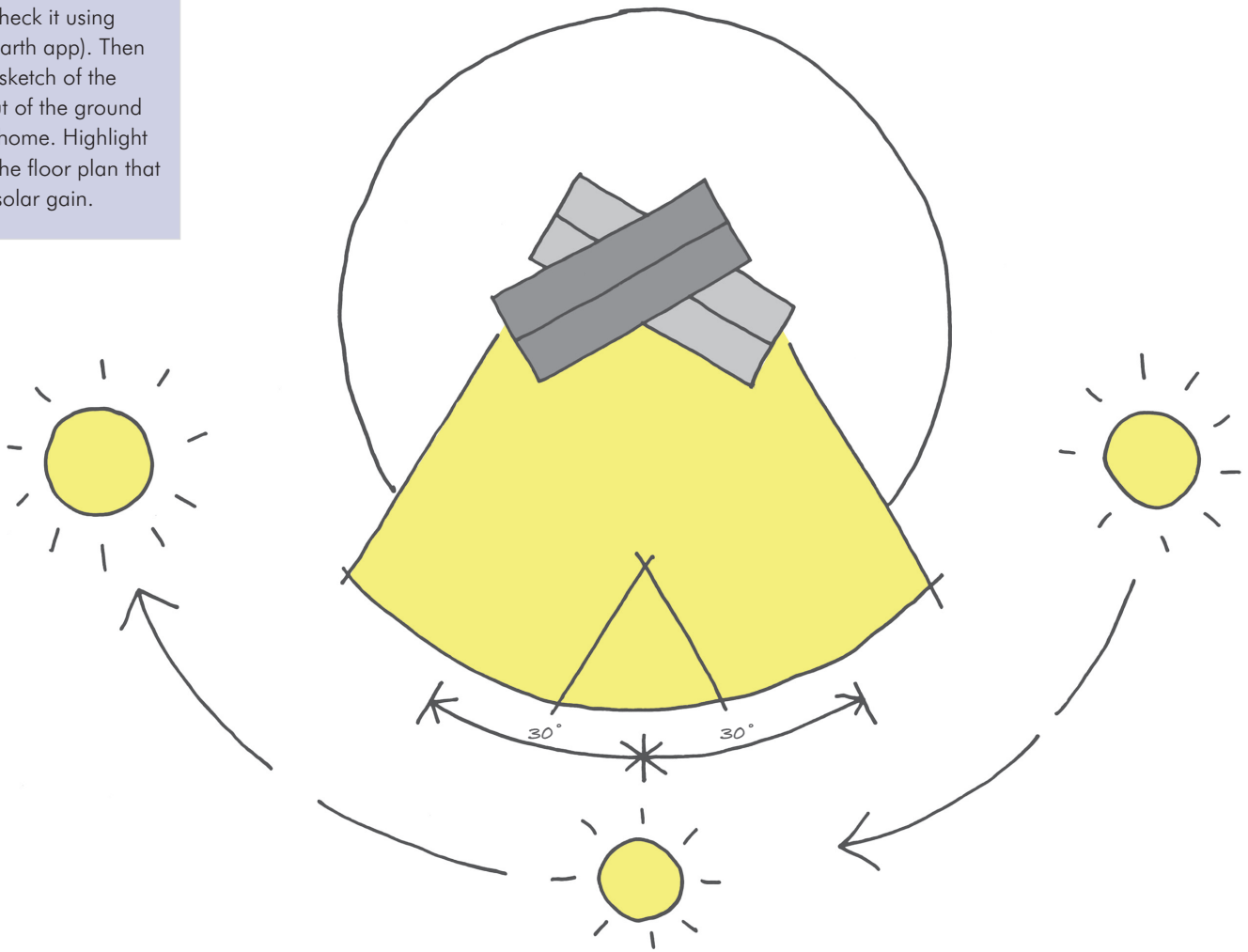


ACTIVITIES

Sketch the orientation of your home (check it using the Google Earth app). Then make a neat sketch of the internal layout of the ground floor of your home. Highlight the areas of the floor plan that benefit from solar gain.

Orientation

A passive house should be oriented within 30° of south. This orientation will maximise solar gain as the sun tracks across the sky. This is especially important during the cold winter months when the sun angle is low and the daylight hours are reduced.

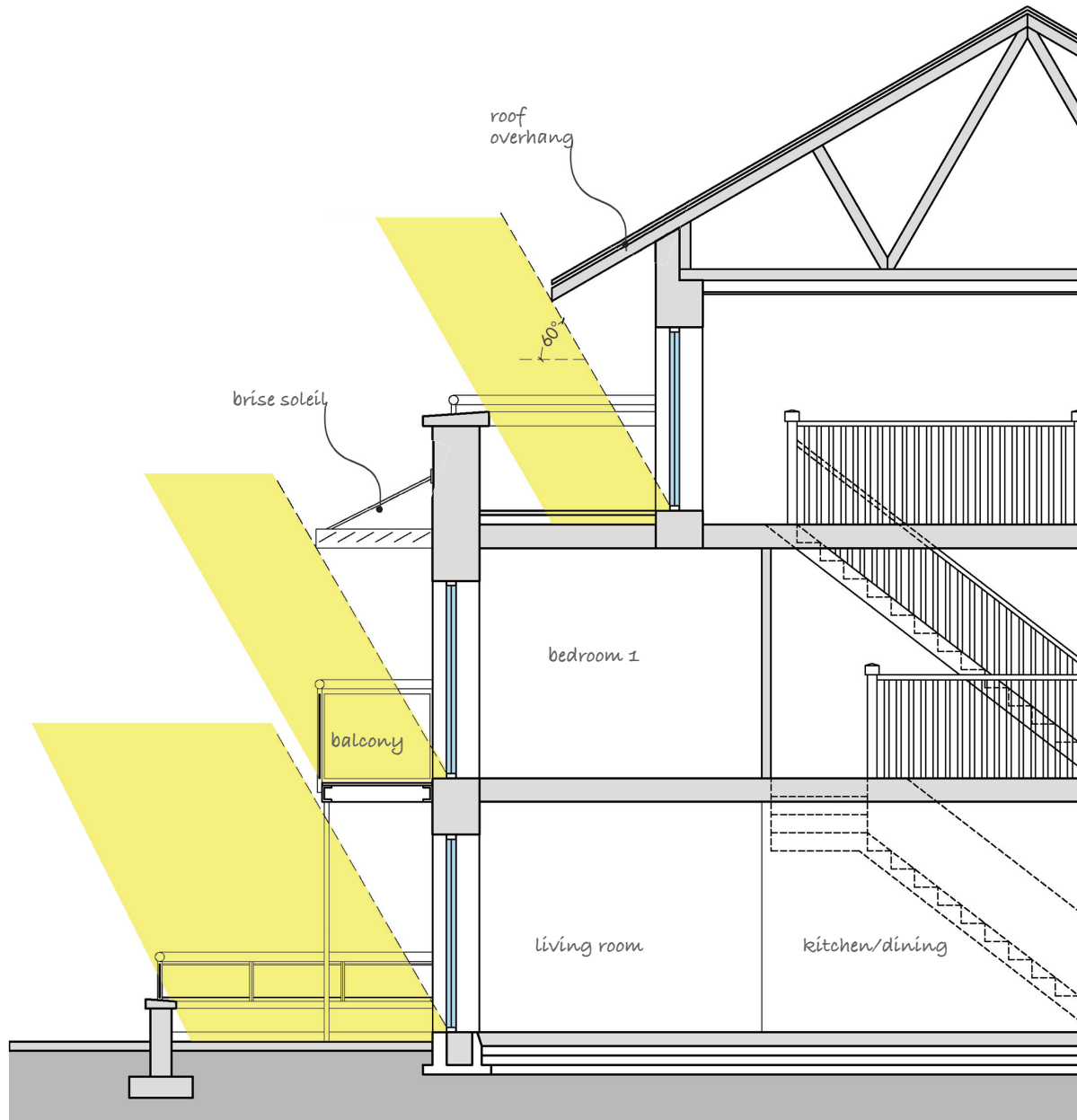


21.21 Orientation: the glazed façade should be oriented to within 30° of south.

Overheating and shading devices

Buildings that are designed to harness solar energy have the potential to overheat in the summer. This issue is addressed at the design stage. For example, if a building is being designed to the Passivhaus standard, a software tool called the Passivhaus Planning Package allows the designer to accurately calculate whether the building will overheat and to design preventative measures.

Shading devices are used to control solar gain through south-facing glazing during the summer. Permanent shading devices (e.g. brise soleils) that do not require adjustment by the occupant are preferable to those that do (e.g. shutters). Automated adjustable shading devices (e.g. blinds) are also used but these can be expensive and require regular maintenance. Planting (e.g. birch trees) can be used to the east and west. However, planting does not work on the south side of a building because the sun angle is too high. High thermal insulation of the building fabric also helps to keep the building cool during summer.



21.22 Shading devices: roof overhangs, brise soleils and balconies are commonly used to prevent overheating. Note: 60° is the average maximum sun angle in Ireland (see Chapter 20).



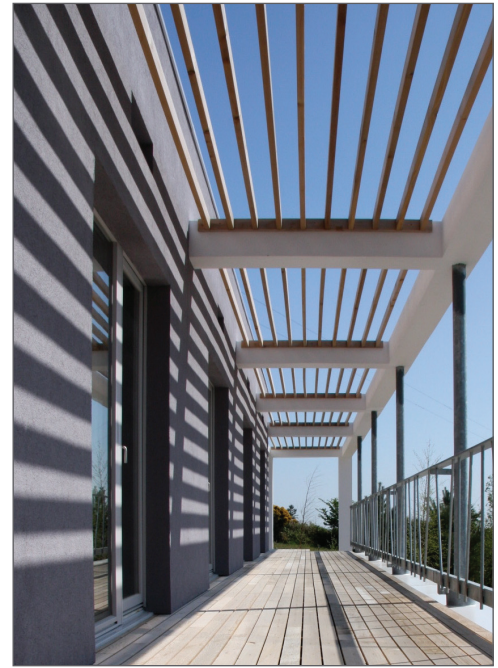
21.23 Shading devices: notice the shadow cast by the roof overhang on this home by Scandinavian Homes of Co. Galway.



21.24 Shading devices: roof overhangs and balconies are both used in this house, built by Cyril Mannion in Athenry, Co. Galway.



21.25 Shading devices: notice the striped shadow pattern cast by the brise soleil on the first floor façade on this house in Co. Wicklow.



21.26 Shading devices: the brise soleil significantly reduces solar gain, preventing overheating.

REVISION EXERCISES

- 1 Describe the influence that a site's latitude has on solar gain.
- 2 Explain, using neat freehand sketches, how the earth's axis tilt has an effect on sun angle during summer.
- 3 Calculate the maximum sun angle during summer and winter at your home's location. (Hint: look up your home's latitude using the Google Earth app.)
- 4 Explain, using neat freehand sketches, the features of a home designed to optimise solar gain.
- 5 Show, using neat freehand sketches, how you would redesign the ground floor of your home to optimise solar gain. (Note: show before and after floor plans and indicate the direction of North.)