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A SUMMARY ASSESSMENT OF THE CAPENHURST HOME

by J. B. Siviour and A. E. Mould

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SUMMARY

This report presents a short technical description of the ECRC Energy Efficient House (the Capenhurst home) specification, omitting the detail and worked examples of the full Design Guide. It is intended for use as a reference by the knowledgeable designer who already has experience of the detailed design and construction requirements of the Capenhurst home specification.

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FIGURES 1-7

1. INTRODUCTION

This note summarizes the information given in detail in the Capenhurst home design guide[1]. It applies to the Energy Efficient House specification developed by ECRC having:

(a) a well insulated structure, including double glazing;
(b) controlled ventilation with a relatively airtight 'shell' and mechanical ventilation with heat recovery;
(c) off-peak space and water heating.

The design process is to consider the whole house first for insulation and heating, and to set out the ventilation system in principle. At this stage the design can be offered to the customer. If he continues to be interested, details can be worked out, including the structure, insulation and room by room design of the heating and ventilation systems.

2. INSULATION AND U-VALUES

2.1 General Requirements

The table below shows the U-values and insulation thicknesses required in typical constructions to meet the specification overall.

		U-value W/m^2K	Typical insulation thickness mm
roof		0.25	160
walls	masonry	0.35	100
	timber frame	0.35	115
floor	timber suspended	0.35	75
	solid concrete	0.35	50
windows and external doors		3.0	double glazed

Any of these U-values may be up to 25% greater, provided that others are decreased so that the total heat loss for the house remains the same. For example, a masonry wall with a 75mm fibre filled cavity or a standard 89mm insulated timber frame wall both have U-values of about 0.43 W/m^2K and both would be acceptable. Methods of recovering the higher heat loss would be to substitute low emissivity double glazing having a U-value of 2.0 W/m^2K for some of the ordinary double glazing, or to have more loft and floor insulation as required.

2.2 Practical Application and Imperfections

Ideally the insulation would be continuous, but this is not possible because of necessary penetrations and imperfect design and construction.

The necessary penetrations will be known at the design stage and can be minimized and allowed for in the calculations. Some examples are:

- Windows and external doors. Their combined area is limited to a maximum of 15% of the perimeter wall area, and wood or plastic frames should be used and not metal, even metal with a thermal break.

- Cavity closing around windows and doors. Materials of relatively low thermal conductivity should be used such as insulating block, wood or plastic extrusion, not brick or ordinary concrete block. Lintels should be insulated and not have metal directly crossing the wall.

- Masonry cavity wall. The insulation should be down to the dpm level. The preferred material is blown fibre but even this has a higher thermal conductivity in practice than usually used ($\simeq$ = 0.05 c.f. 0.04 W/m^2K). Other materials have been found to be even less effective in practice because of air movement within the insulation.

- Structural timber, e.g. joists and wall studs must be treated as thermal bridging in the U-value calculations.

Imperfections in building are generally air gaps or insulation missing. Examples are:

- Missing areas of blown fibre in a cavity wall due to poor installation. Hole pattern should be to B.S. 6232.

- Gaps between adjacent layers of batts or blankets.

- Insulation omitted, especially from narrow gaps between joists and walls.

- Uneven thickness, and thickness less than specified.

- Loft and wall insulation not joining at eaves.

Poor design and application can permit gross air leakage and cold air flow on the warm side of the insulation, e.g.

- behind dry lined plasterboard. A solution is to perimeter seal at floor, ceiling and internal and external walls.

- cavities with board insulation. It is almost impossible to achieve close contact between the insulating board and the inner leaf of the wall and between board and board.

3. TEMPERATURES

3.1 Internal Temperatures

Internal temperatures depend on a number of factors including people's preference, clothing, cost of heating and occupancy. Preferred temperatures are generally in the ranges:

sitting	20-25°C
light work	15-20°C
sleeping in bed	14-19°C
unoccupied	14-17°C

In energy efficient houses constraints on the running cost for heating are largely removed, and temperatures will tend towards the warm end of the ranges. The unoccupied house temperatures of 14-17°C means that no part of the house will feel cold on occasional short occupation. This house temperature will allow rapid warm-up when needed and minimize the risk of condensation.

The specification gives the following temperatures for heating system sizing:

living rooms	22°C
dining room	22°C
bathroom	22°C
bedrooms	19°C
other areas	17°C

The average whole house temperature generally will be in the range 18-21°C. A working family with significant unoccupied periods would have an average towards the low end, and 'sheltered' accommodation towards the high. As a guide the suggestions are:

working family	18°C
typical family	19°C
retired family	20°C
sheltered accommodation	21°C

3.2 External Temperatures

For design loss calculations the value generally used is -1°C.

For seasonal heating estimates the average varies geographically and with length of heating season.

For a 32 week heating season (end September to early May) the average is about 6°C for much of the U.K. The following table can be used for geographical and exposure variations unless local knowledge is available.

Geography -	General value of average external temperature	6°C
	Coastal areas of South Wales and S.W. England	8°C
	Coastal areas of South and S.E. England	7°C
	North East England, Scotland	5°C

Exposure - In exposed areas reduce external temperature by 1K.

4. VENTILATION RATES

The airtight shell and mechanical ventilation with heat recovery mean that the ventilation heating requirement is well below the 1 to 1.2 ac/h normally allowed for in calculations.

For the whole house the working values are

(a)	infiltration:	fresh air rate	0.35 ac/h
		heating equivalent	0.35
(b)	mechanical:	fresh air rate	0.4 ac/h
		heating equivalent (63% heat recovery)	0.15
(c)	total:	fresh air rate	0.75 ac/h
		heating equivalent	0.5 ac/h

Room requirements are influenced somewhat differently by the mechanical system, since living and bedrooms have fresh air supplies, wet rooms have air extracts, and the hall, landing and stairs have neither. All, of course, have infiltration routes, giving rise to rates which are quite variable. For room heater sizing the following assumptions are made:

living and bedrooms (with air supplies)	heating equivalent	0.75 ac/h
wet rooms (with air extracts)	" "	nil
other areas		0.35 ac/h

The nil for rooms with air extract is because air will be drawn from the rest of the house.

The total for all the rooms added together may exceed the whole house average value, but these values are for sizing the individual room heaters. The whole house will not usually be occupied all at the same time. Detailed consideration of the design of the ventilation system follows in section 10.

5. DESIGN HEAT LOSSES

This is calculated taking:

(a) practical U-values

(b) thermal areas for the walls, floor and roof, which may be obtained by adding 15% to the areas calculated from internal dimensions. The addition allows for the extra effective areas of corners and the areas covered by internal walls and floors.

(c) a net heating requirement of 0.5 ac/h after allowing for the performance of the mechanical system and airtight shell.

(d) an external temperature of -1°C and an internal temperature of between 18 and 21°C as appropriate to the intended use and owners' requirements.

The example house shown in Figures 1 and 2 has internal dimensions of:

	MAIN PART	UTILITY/STUDY
overall width	9.5m	2.7m
overall depth	5.8	5.115
storey height	2.4 (each storey)	2.35

The gross floor area is $124m^2$, and the volume $297m^3$. The other areas are given in the working table below.

TABLE OF DATA FOR DESIGN LOSS CALCULATION (WHOLE HOUSE):

Element	Areas (m^2) Internal	Thermal (A)	U-value W/m^2K	AU W/K
Walls	132.3	152.1	0.35	53.2
Floor	68.9	79.3	0.35	27.8
Roof	68.9	79.3	0.25	19.8
Windows & doors	27.2	27.2	3.0	81.6
Ventilation	½ x 297		1/3	49.5
Total heat loss coefficient				231.9

Taking an internal average temperature of 19°C gives a design day loss (DDL) of 231.9 x 20, that is 4.64 kW.

A yet simpler method of calculating an approximate value uses the following correlation, which has been found to be reasonably accurate for detached dwellings of shape and layout which would be considered typical or normal.

Heat loss coefficient (W/K) = 50 + 1.5 x floor area.

In this example where the floor area is $124m^2$

Heat loss coefficient = 50 + 1.5 x 124 = 236 W/K, and the design day loss is then 4.72 kW, compared with 4.64 kW calculated above.

6. HEATER SIZING - WHOLE HOUSE

For the whole house the storage requirement (as charge acceptance) is calculated using the design day heat loss (DDL). For the geographic areas having the average external temperature of 6°C the calculations are:

For 5% day energy, storage = 60% of DDL over 24 hours
For 10% day energy, storage = 55% of DDL over 24 hours

In the present example where DDL = 4.64 kW, the storage requirement at 5% day energy is 0.6 x 4.64 x 24 = 66.8 kWh.

The effects of external temperature variations have been investigated at ECRC using degree days. Some simplified results are summarized in the following table for the external temperatures given in section 3.2.

TABLE OF STORAGE HEATING REQUIREMENTS AND SEASONAL EXTERNAL TEMPERATURE:

Average outside temperature	Percentage of design day loss for seasonal day energy of		Present Example Storage requirement kWh	
°C	5%	10%	5%	10%
8	52	47	58.0	52.4
7	56	51	62.4	56.8
6	60	55	66.8	61.3
5	64	59	71.3	65.7
4	68	63	75.8	70.2

The change per degree is about 6.5% of the storage requirement. A similar percentage should apply for internal temperature variations. However, if the design day loss DDL is calculated using the different internal temperature, the storage requirement will automatically change, by about 5%, which is sufficiently close for acceptable accuracy.

Variation in free heat, see section 7, also has an effect. Thus a very large house occupied by two people should have 9 kWh more storage than if occupied by 5 people. The calculations based on 60% or 55% are good enough for typical occupancy as marked in the free heat section.

7. FREE HEAT

Free heat contributes towards space heating in all buildings, and is especially significant in energy efficient houses. The sun, metabolic heat and electricity for purposes other than space heating all make a contribution. The table below has been assembled giving typical values. Allowances have been made for losses by, for example, hot water down the drain, water vapour and solar shading by curtains. Of the total, 30% has been assumed to be lost.

TABLE OF USEFUL FREE HEAT

Size \ Occupancy		1 person kWh/day	2 people kWh/day	3 people kWh/day	4 people kWh/day	5 people kWh/day
Very small	40-55m^2	11.0*	14.0*	17.0	-	-
Small	55-70m^2	12.5*	15.5*	18.5*	21.0	23.5
Medium		14.0	17.0	20.0*	22.5*	25.0
Large	95-125m^2	16.0	19.0	22.0	24.5*	27.0*
Very large	125-155m^2	19.0	22.0	25.0	27.5	31.0*

*Denotes typical values for heater sizing.

8. SEASONAL HEATING ESTIMATES

The length of heating season for the energy efficient house is assumed to be 32 weeks from the end of September to early May. (If local knowledge suggests a longer or shorter season it can be used along with the appropriate local average external temperature). The method calculates the average daily loss, allows for free heat, then calculates the seasonal requirement. The following calculation illustrates the method for two cases using the data from preceeding sections.

Occupancy: Typical family, 4 person
House size: Floor area of 124m^2
Locations: general (example 1), and exposed (example 2)

TABLE FOR ESTIMATING SEASONAL HEATING REQUIREMENTS:

Item		(1) average	(2) exposed
average internal temperature	°C	19	19
average external temperature	°C	6	5
average temperature difference	K	13	14
heat loss coefficient (hlc)	W/K	231.9	231.9
average rate of heat loss	kW	3.01	3.25
daily energy loss (gross)	kWh/day	72.4	77.9
size/occupancy for free heat		4P/medium	4P/medium
average free heat	kWh/day	24.5	24.5
daily energy loss (net)		47.9	53.4
seasonal requirement for 32 weeks	kWh	10,730	11,960

9. HEATING SYSTEM DESIGN

9.1 General

The storage heating requirement has already been calculated for the whole house in section 6. In this section calculations for the living room and a bedroom are given in some detail, with a heating system list for the whole house.

The basis is the system used in the ECRC trial houses, comprising a fan storage heater and focal point fire in the living room, with ordinary storage and direct heaters elsewhere.

The parameters for these calculations are listed in the following table:

TABLE OF DATA FOR SIZING ROOM HEATERS

Room	Design Temperatures		Ventilation rate for heating room ac/h	Heater Size	
	Internally °C	Externally °C		Storage % of 24h loss kWh	Direct % of power loss W
Living	22	-1	0.75	85	-
Dining	22	-1	0.75	85	-
Bedrooms	19	-1	0.75	60	-
Kitchen	17	-1	nil	-	200
Bathroom	22	-1	nil	-	towel rail

For some rooms storage or direct may be options to consider. These must be considered carefully, bearing in mind the use as well as the room heat loss.

It is useful to make a summary of the heating system with its options, and to mark on the house plan positions where they may be sited. With the highly insulated envelope the traditional requirement of heaters under the windows is unnecessary. Other points to consider are the usual possibility of interaction between the lounge thermostat and the output from the heaters, and that the hall storage radiator has to provide heat up the stairwell and prevent cold draughts from the front door.

9.2 Living Room

The living room is the most important one to size. Its loss is calculated in a similar manner to that for the whole house. The internal dimensions of the example are:

width	3.65m
depth	5.8m
height	2.4m
volume	50.8m^2

The wall areas have to be worked out knowing the window area. The window area includes any external doors.

TABLE OF LIVING ROOM DESIGN LOSS CALCULATION:

Element	Areas m^2 Internal	Thermal (A)	U-value W/m^{2}K	AU W/K
Walls	24.5	28.2	0.35	9.9
Floor	21.2	24.4	0.35	8.5
Windows	6.9	6.9	3.0	20.7
Ventilation	0.75x50.8	38.1m^3/h	1/3	12.7
Total heat loss coefficient				51.8

Design day heat loss to outside = 51.8 (22 -(-1)) = 1.19 kW

Storage heater charge acceptance 0.85 x 1.19 x 24 = 24.3 kWh

Install 24 kWh storage fan heater, with time clock and thermostat to control the fans.

9.3 Bedroom

A large exposed bedroom might need a small storage heater, instead of a direct heater. As an example, the largest bedroom is used. Its internal dimensions are:

width	3.85m
depth	3.5 m
height	2.4 m
volume	30.0m^3 (allowing for recess)

TABLE OF BEDROOM DESIGN LOSS DATA

Element	Areas m^2 Internal	Thermal (A)	U-value W/m^3K	AU W/K
Wall	15.6	17.9	0.35	6.3
Roof	13.5	15.5	0.25	3.9
Window	2.0	2.0	3.0	6.0
Ventilation	0.75 x 30.0	22.5	1/3	7.5
Total heat loss coefficient				23.7

Design day loss to outside	23.7 (19-(-1)	=	474W
Size of storage heater (option 1)	60% x 474W x 24	-	6.8kW
Size of panel heater (option 2)	200% of 474	-	900W

9.4 Hall and Landing

The hall, and occasionally the landing, accommodate the storage heating not installed elsewhere. The difference must be made using the calculated values of room storage requirements, not the installed heater sizes.

9.5 Summary of the Space Heating System for the Capenhurst home

Lounge — 24 kWh fan storage heater, time clock and room thermostat controlling the fans
Focal point heater, manually controlled

Dining Area — 12 kWh storage heater with automatic charge control

Kitchen Area — Plinth fan heater

Study — option (a) 12 kWh storage heater with automatic charge control
option (b) 900W direct panel heater with integral time clock and thermostat

Utility — 600W direct panel heater with integral time clock and thermostat

Hall/landing	option (a)	18 kWh storage heater with automatic charge control
	option (b)	two storage heaters with automatic charge control
	(i)	18 kWh in the hall,
	(ii)	12 kWh on the landing
Bathroom		Heated towel rail manually controlled
Bedrooms 1&2		900W direct panel heaters with integral time clock and thermostat
Bedrooms 3&4		750W direct panel heaters with integral time clock and thermostat

Note that for study and hall/landing options (a) would be used together, or options (b) would be used together.

10. MECHANICAL VENTILATION

10.1 General

The system works by extracting air from rooms where odours and moisture are produced, principally kitchens and bathrooms, and introducing fresh air into living rooms and bedrooms. By providing a heat exchanger, the incoming fresh air is warmed by the outgoing used air. The heat exchanger efficiency is 60% or more (Figures 3, 4, 5).

The system is designed to work continuously, with user control of volume by switching and giving a choice of approximately 0.3, 0.5 and 0.7 ac/h for the whole house.

10.2 Ventilation Volumes

The design values are:

(i) Extract: A rate of 0.5 ac/h for the whole house is taken, and divided equally for all the exact positions.

(ii) Supply: The rate is 0.9 of the extract (0.45 ac/h), so that the system does not pressurize the house. The volumes to each room with a supply are at the rates of 0.7-0.75 ac/h for each room, to give a total equalling that for the whole house.

These flow rates would be achieved on the intermediate setting, with the user switching to lower and higher rates. In the energy calculations a rate of 0.4 ac/h is used, assuming significant periods of operation on the low setting.

To cater for different house sizes, and pressure drops, fan speeds are adjustable internally in the power unit. Room flow rates are set at each supply or extract terminal. Detailed calculations are necessary, but can only be done after the layout of the system has been designed. It may be best to leave this detail to the equipment supplier, and until after the builder has confirmed his interest. The detailed design procedure is included in the Capenhurst home guide.

10.3 Basic Design and Layout

The first consideration in designing a system is the location of the fan unit. Siting the unit, complete with cooker hood, above the cooker or hob is preferred to remote locations, such as in the loft. The fixing height is generally in line with the upper level of kitchen cupboards. An adjacent power supply is required. In cold weather condensation will occur in the heat exchanger as the outgoing room air is cooled. This condensate can be drained to the back of the sink waste trap by a ½" pipe. If the cooker is remote from a suitable waste, condensation can be run outside to a small soakaway. An overflow pipe is unsuitable because the slow flow of condensate could freeze and block the pipe.

The ductwork is a new service to introduce into the house and cannot be readily routed and hidden like plumbing or cables. Duct routes must be planned. Where ducts run parallel to joists, the ducts can be fixed between them in the intermediate floor thickness, otherwise they must go above or below floors or in the loft. Vertical rises or drops may be routed in built-in cupboards or can be boxed in.

The fresh air and discharge ducts connect an external wall terminal the fan unit and are usually of 125 mm diameter. In winter both of these ducts will carry air which is considerably cooler than room air, therefore they must be both thermally insulated and vapour-sealed on the outside, or problems with condensation on the outer surface of the ducts will ensue. Usually these ducts will run below the ceiling and above the kitchen wall cupboards. This is just possible with the present minimum legal ceiling height of 2300 mm, and a top of cupboard height of 2100 mm. A ceiling height of about 2400 mm is more normal and this height or higher is preferred.

The supply air and extract air ducts for the house are likely to be 125 mm diameter for their main runs with flow rates greater than 30 l/s, thereafter reducing to 100 mm diameter for smaller flow rates. For single branches with small flow rates 80 mm diameter ducting may be used.

Even though fans of high quality are used, it is necessary to incorporate a silencer in the supply duct before it branches off to habitable rooms. This will ensure that the system is virtually inaudible (30 dBA or less) in the bedrooms at intermediate fan speed, and quieter still on the low setting.

Any supply or extract ductwork which passes out to unheated areas of the house must be insulated with 60 mm of fibrous insulation. The ducting must also be draught-sealed to the structure where it passes through.

Supply grilles are usually in the ceiling, although they can be in the walls or floor. Bedroom inlets are usually placed near the door to blow into the room and avoid any possibility of dropping cool air near a bed position. The grilles should be at least 700 mm from walls.

Sometimes the position of inlet grilles is governed by available duct routes between joists. Deflectors are available for use in ceiling grilles if they have to be placed significantly off centre.

Transfer grilles are not usually necessary, as British internal doors are not closely fitting.

Extract grilles should be placed near or above the source of contamination or between the source and door to the rest of the house. In a kitchen, as well as the cooker hood extract, it might be necessary to install an extract grille in the ceiling, e.g. above a built-in oven.

Utility rooms present problems in deciding how much moisture is likely to be released. A tumble dryer vented directly into the room would need a 125 mm extract duct. The dryer could be connected to the extract system by a special fitting or it might be discharged directly into the outside air.

11. AIRTIGHTNESS

A relatively airtight house is required so that the uncontrolled ventilation, or infiltration, is less than generally required. The mechanical ventilation system, operated by the user, can then control the rate and place of ventilation as required.

To achieve the airtightness draughtstripping or sealing is needed in a number of general areas:

- all opening windows and external doors
- between walls and the frames of windows and external doors
- where pipes and ducts pass through the walls, floor and ceiling
- all gaps associated with suspended ground floors
- all gaps associated with plasterboard on ceilings and walls

It is generally accepted that the infiltration over a heating season is about one-twentieth of the air leakage under a pressure test at 50Pa. So for a leakage of 7 ac/h the infiltration will be about 0.35 ac/h.

12. AIR PRESSURE TEST

The test will measure the flow and pressure characteristics of the house. The specification requires that the leakage is not greater than 7 ac/h when the inside to outside pressure difference is 50 Pa (50 Pascals, 5 mm water gauge). The apparatus for the test is shown in Figure 6. It comprises a calibrated variable speed fan, a meter to measure air flow through it and a manometer to measure pressure difference between inside and outside the house.

A panel is fitted and sealed in the open doorway of an external door. The door itself does not have to be removed. The fan is fitted to a hole in the panel and the air flow meter and manometer set up. A 240V 10A electricity supply is required to power the fan motor.

All openings not part of the building structure must be sealed off for the test. This includes the mechanical ventilation system which can be sealed at the external terminal.

Weather variables, particularly wind speed and direction, and sheltering, can have significant effect. The test pressure of 50 Pa is in fact low enough that wind-generated pressure differences can increase or decrease the flow through the fan, depending on the relative directions. High wind speeds combined with a degree of sheltering can give a buffeting wind and result in a very variable flow rate reading. For a reliable result wind speeds should be less than force 3 (see table) and preferably less than force 2.

<u>THE BEAUFORT SCALE</u>

Force	Description	Specifications for use on land	Mean speed m/s
0	Calm	Calm; smoke rises vertically.	0.0
1	Light air	Direction of wind shown by smoke but not by wind vanes.	0.8
2	Light breeze	Wind felt on face; leaves rustle; ordinary vane moved by wind.	2.4
3	Gentle breeze	Leaves and small twigs in constant motion; wind extends light flag.	4.3
4	Moderate breeze	Raises dust and loose paper; small branches are moved.	6.7
5	Fresh breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters.	9.3

*Equivalent speed at 10 m above ground.

If windspeeds are higher, the test could still be used to identify whether a house was particularly airtight or particularly leaky.

For a house which fails, then a smoke puffer can be used inside the house to identify where leaks are occurring and give an indication of their significance. It may be possible to seal some leaks, even temporarily, and the effect on flow and pressure difference evaluated immediately. This is particularly useful when a builder is on site and can take immediate remedial action.

There are a number of other factors which can influence leakage of a house, and the value measured. The test method does not include leakage area of the door and frame in which the equipment is positioned. If at all possible, the apparatus should be fitted in the external doorway which, by inspection, has the best fitting door for minimum leakage.

The fan can be used to pressurize by blowing into the house, or de-pressurise by blowing out, and the result can be different. De-pressurization will make outward opening windows press more firmly on their frames and draughtstripping, but can tend to open up the gap around inward opening doors.

The leakage characteristic of a house will vary during its lifetime. The initial drying-out, if it causes shrinkage and wider gaps, will increase leakage. Some ECRC measurements show such increases in the range 1 to 2 ac/h, but carpeting and decoration will decrease it. It is therefore suggested that testing should be carried out immediately on completion, and before the house is furnished. Houses just passing could fail if retested later.

Results are, of course, subject to the accuracy of the equipment. A set of good equipment which is well looked after should have repeatability from test to test of ±2%. Accuracy from one set of good equipment to another should be within ±5%.

13. WATER HEATING IN PRINCIPLE

The water heating for Capenhurst home follows the EC DOM9 quite closely. Capacity ranges from 120 litre tank for one person household to 210 litre tank for 4/5 person household. The cylinders should be factory insulated. Petal jackets have gaps and are poorly insulated at the dome, which in practice means they permit twice the loss of those factory insulated, i.e. around 5 kWh/day instead of about 2½ kWh/day.

Pipe runs should be short (Fig. 7) to minimise the amount of hot water left in the dead legs but this is governed very much by the house layout. The branches to hand basins and kitchen sink should be fitted as close as possible to the outlet from the hot water cylinder to minimise the length of 22 mm diameter pipe, and the amount of hot water left in the dead legs after draw-off at these positions. A handbasin in the remote W.C. may be best provided with a direct acting electric water heater, possibly of the time-controlled spray type, so that only a cold supply is needed.

The major improvement in the Capenhurst home is in the hot water pipe insulation. All the hot water pipes must be insulated using pipe insulation at least 12 mm thick. The insulation must be bound or glued to eliminate air gaps and consequent air movement heat loss. This treatment will be needed circumferentially and longitudinally for slit material. Material which shrinks in service must be compressed in length when installed to allow for this.

Typically the insulation will more than halve the rate of heat loss compared with a bare pipe. At 50°C bare pipe losses would be reduced from about 30 W/m run to 12 W/m.

Generally, on average, half of the hot water taken from the tank is not useful because of pipework losses from bare pipes. By insulating the pipes the loss is around 25%, depending on the intermittancy of the pattern of use. This is a significant improvement in the system efficiency.

Insulated pipework should not be used to reduce the size of the storage cylinder. ECRC measurements suggest that in houses with electric water heating, more hot water would be used if more was available. The day rate element and run down timer was essential but there is some reluctance to use it. Shower units should follow present practice of being direct acting.

Larger houses, especially with two bathrooms, may need a hot water supply even larger than 210 litre. The hot water service should not be to a lower standard than the other improvements given by the Capenhurst home specifications. At present consideration is being given to the use of two cylinders as an alternative to one, but full investigation has yet to be made.

14. INSTRUCTION AND GUIDANCE FOR HOUSEHOLDERS

People vary in how they operate their houses, and often do not really know how to do so, because they have never been told or even given written instructions as for household equipment. An Energy Efficient House has the potential to perform very much better than ordinary houses. Householders should therefore be given some simple guidance as detailed in the Capenhurst home guide, and encouraged to try variations to suit their own needs.

15. BENEFITS AND COSTS

The main benefits are increased comfort and convenience, and freedom from financial constraints on heating. Dampness and odours are removed, and heating costs are half those for similar conditions in a similar house to Building Regulations.

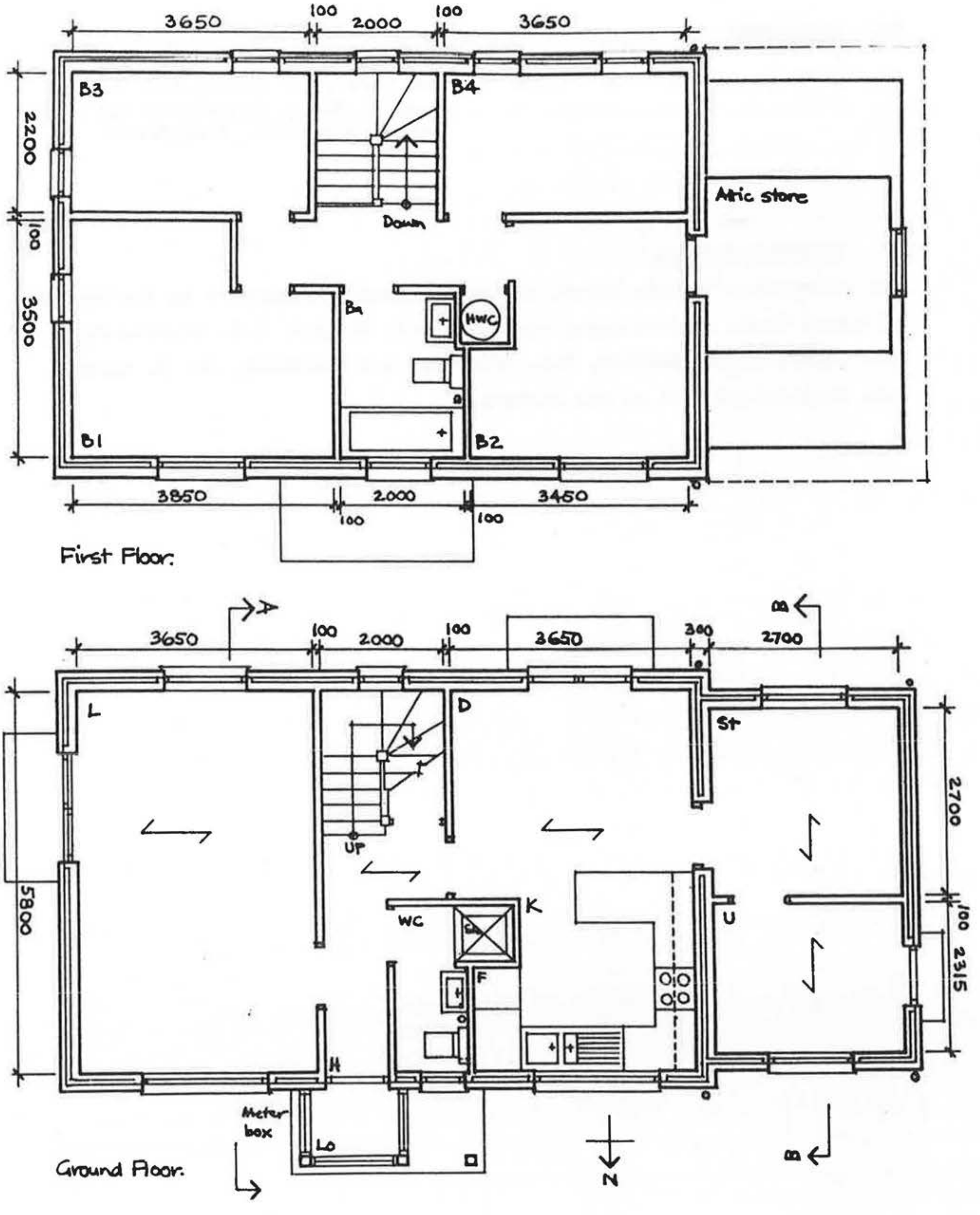
Typically the extra costs would be £2,000-£3,000, compared with a house to current Building Regulations.

16. REFERENCES

[1] A. E. Mould and J. B. Siviour — The Capenhurst Energy Efficient House - Design principles and worked examples. ECRC/M2229

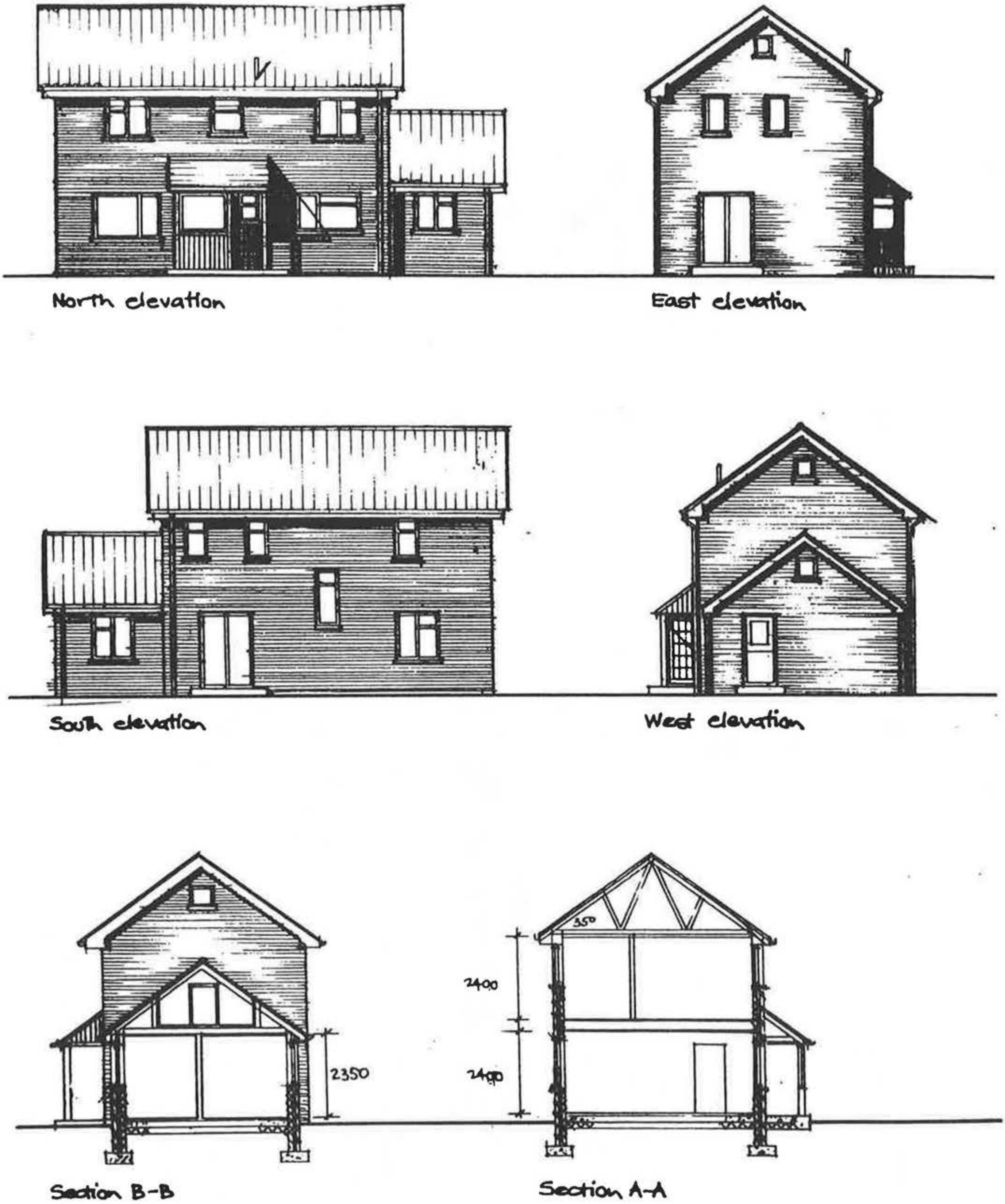
17. ACKNOWLEDGEMENTS

The information in this report has been assembled from work by the Energy Efficient House project group including D.J. Dickson, L.R. Dowdeswell, E.B. Edwards, J.P. Edwards, D.A. McIntyre, A.R. Marchant, Mrs C. Mason, F.R. Stephen, as well as the authors.



Electricity Council Research Centre Capenhurst, Chester CH1 6ES [051-339 4181]	EXERCISE CAPENHURST HOME	Scale Date 21xi86	Dwg. no. 86\T3

Figure 1



Electricity Council Research Centre Capenhurst, Chester CH1 6ES 051-339 4181	EXERCISE CAPENHURST HOME	Scale Date 28/1/86	Dwg. no 86\T4

Figure 2

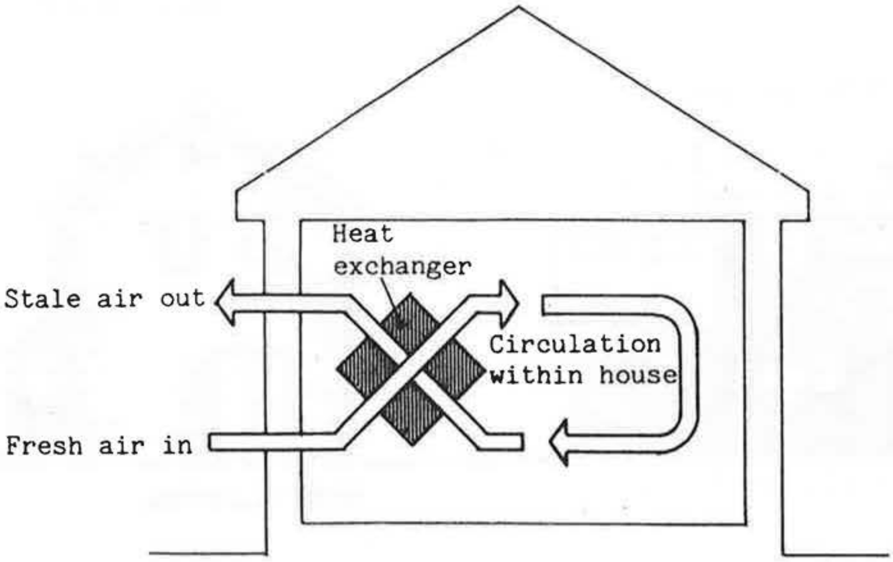


Fig. 3 Principle of ventilation + heat recovery system.

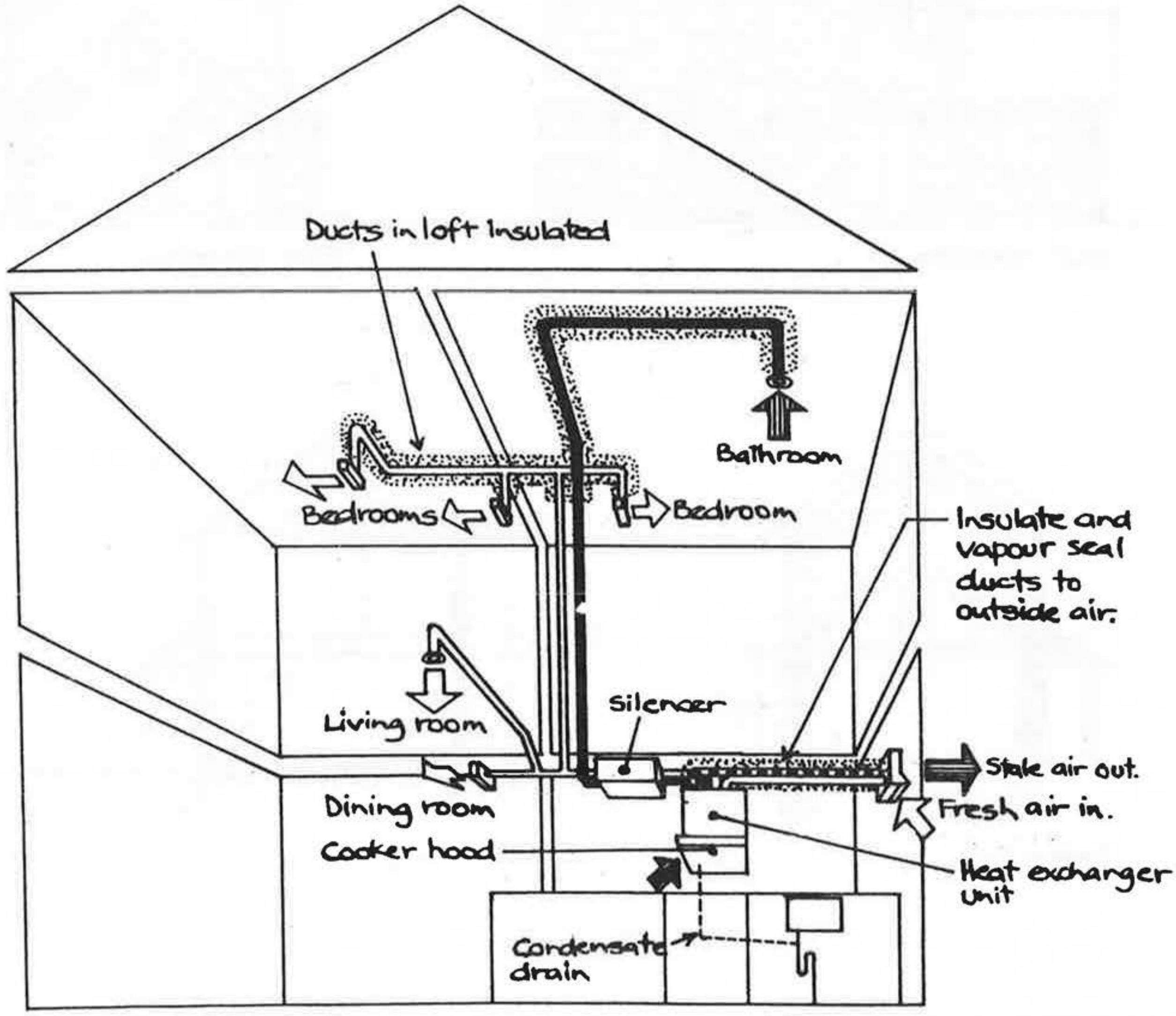


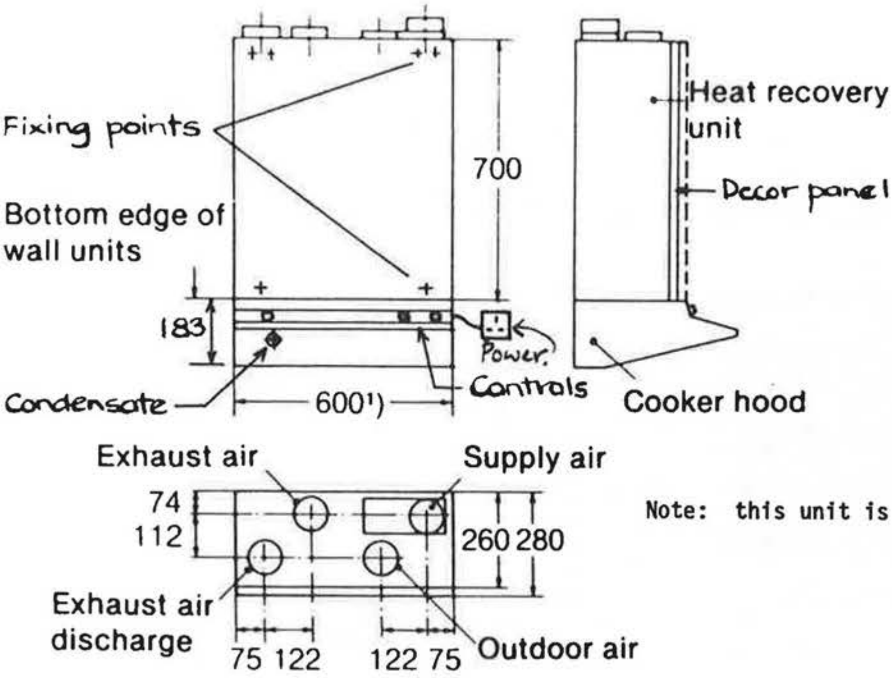
Fig. 4 Layout of a typical ventilation + heat recovery system.

Dimensions

ACF Heat recovery unit

ECRC/M2230

(All dimensions in mm)



Note: this unit is not handed.

1) Width of the heat recovery unit, including the hinges and the locking decive of the inspection door.

The connection spigots are 100 mm dia. female. The above dimensions apply only to the heat recovery unit.

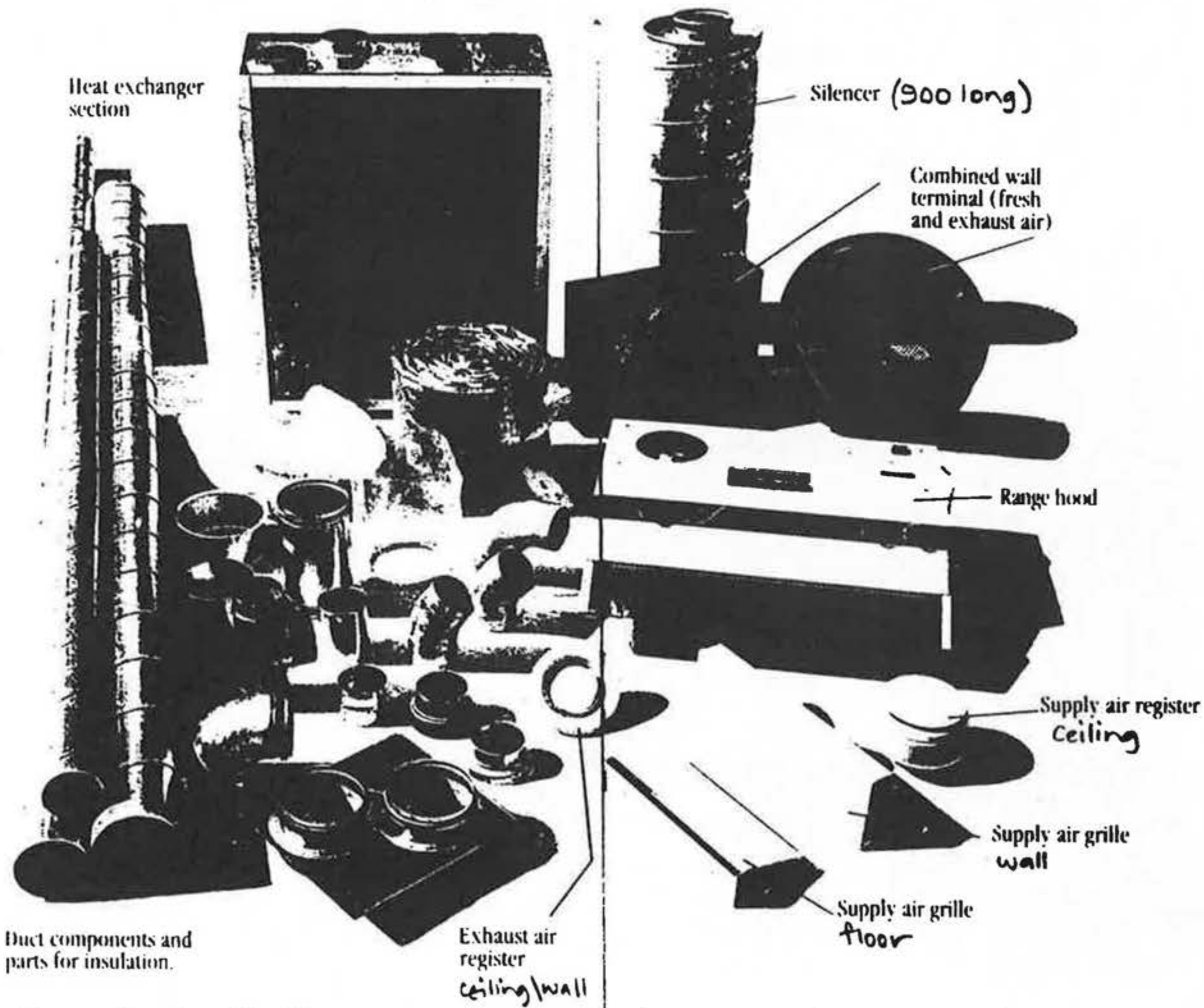


Figure 5 Ventilation system components (courtesy of Bahco Ltd.)

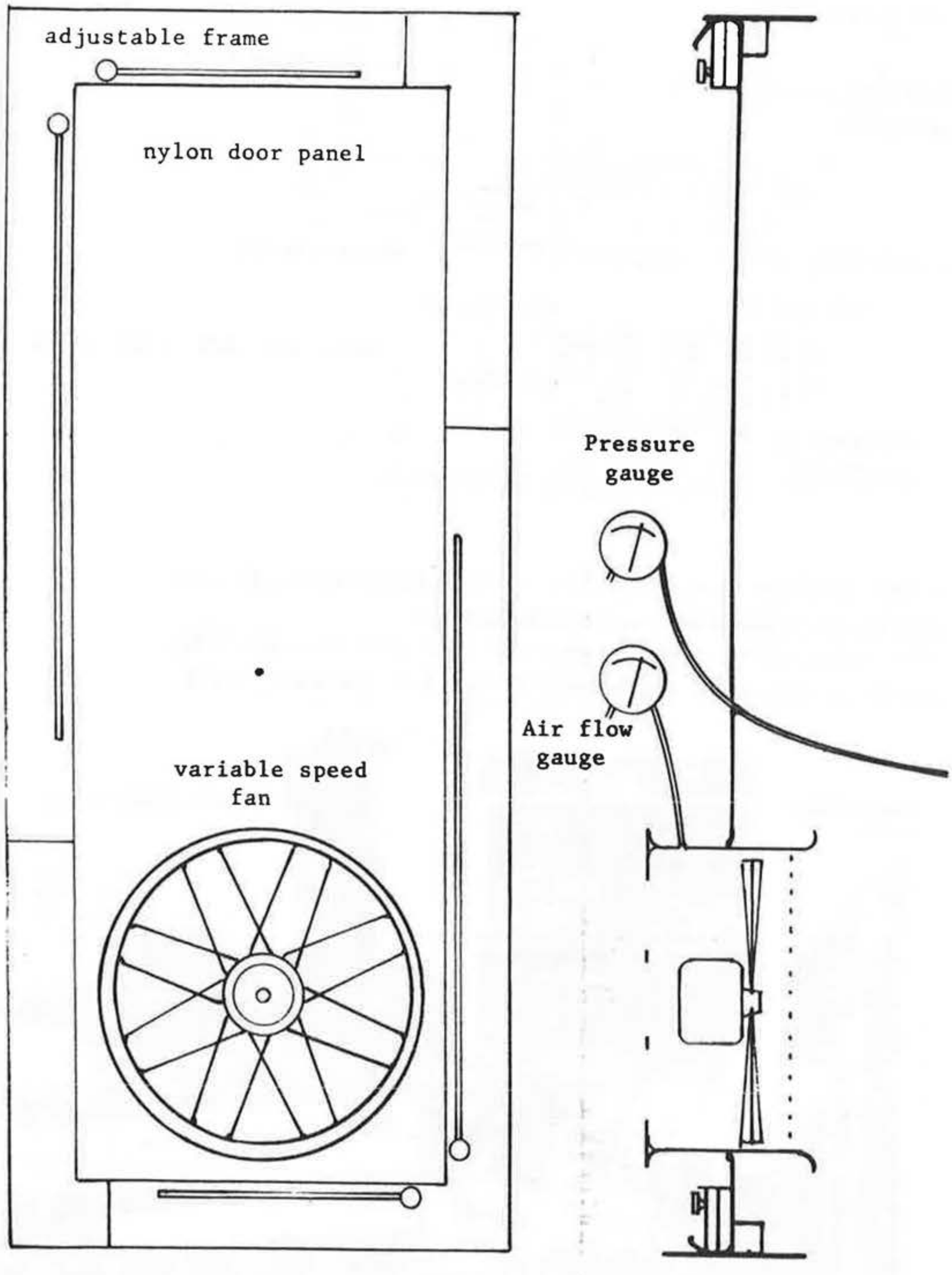


Figure 6 Fan pressurization equipment for measuring house leakage

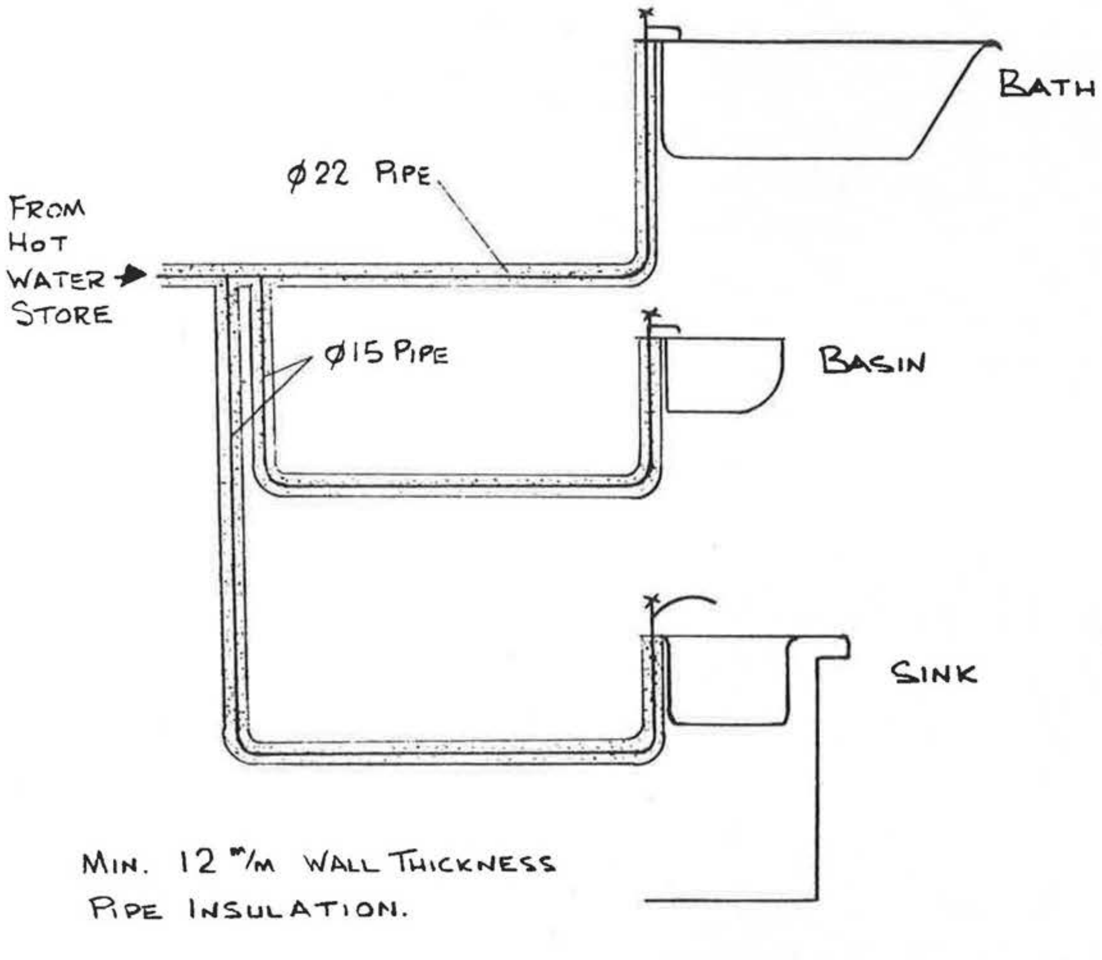


FIGURE 7 EFFICIENT HOT WATER DISTRIBUTION

• SHORT PIPERUNS • ALL INSULATED

The hot water store would be to the E7 specification, which includes rectangular and cylindrical combination units. The bottom element is supplied from the off-peak only, and the top element is connected to the 24 hour supply via a run down timer.