

Executive Summary

This project centres around the mechanical and electrical design of an existing teaching building at the University of Reading.

Prior to the project, occupancy evaluation surveys conducted by the University revealed dissatisfaction with the thermal comfort and poor indoor air quality of the building.

The aim of this project was to design mechanical and electrical services strategy that would maintain a high level of indoor environmental quality whilst falling within the energy benchmarks.

This report first examines the role of the indoor environment on students' learning and health with a further examination of indoor air quality, the recommendations on ventilation rates and the strategies available to the designer in reaching them.

Taking into consideration the constraints resulting from the existing building and requirements for a healthy learning environment a mechanical ventilation approach was selected.

A model simulation has been constructed in order to determine the heating and cooling loads of both the existing and refurbished buildings. Carbon emissions have been calculated and various renewable technologies assessed to find the most suitable and cost-effective solution for the project.

After several energy-saving steps and with the inclusion of solar photovoltaics the proposed model has resulted in a 37% improvement on the target emission rates for a University Campus building.

The final model loads show a 304% improvement in heating and 195% improvement in cooling over the benchmark figures.

This project has successively shown that it is possible to deliver a building of high indoor environmental quality whilst meeting strict energy targets.

Table of Contents

1. INTRODUCTION	6
1.1 BUILDING SUMMARY	6
1.2 AIMS AND OBJECTIVES.....	7
2. LITERATURE REVIEW	8
2.1 INDOOR ENVIRONMENTAL QUALITY (IEQ)	8
2.2 NATURAL VENTILATION.....	10
2.3 MECHANICAL VENTILATION	12
2.4 HYBRID VENTILATION.....	12
2.5 CONCLUSIONS	13
3. DESIGN CRITERIA	14
3.1 EXTERNAL DESIGN CRITERIA	14
3.2 INTERNAL DESIGN CRITERIA.....	14
3.2.1 Temperature	15
3.2.2 Ventilation.....	16
3.2.3 Acoustics	16
3.2.4 Lighting.....	17
3.3 INTERNAL GAINS.....	17
4. BENCHMARKING.....	18
5. BUILDING SIMULATION.....	20
5.1 GEOMETRY AND LOCATION.....	20
5.2 MODEL 1 - BASEMODEL.....	21
5.2.1 Constructions and Profiles.....	21
5.2.2 Thermal Templates.....	22
5.2.3 Systems.....	23
5.3 MODEL 2 – FABRIC UPGRADES.....	23
5.4 MODEL 3 – SYSTEM UPGRADE.....	24
5.5 MODEL 4 – RENEWABLES.....	24
5.6 BUILDING LOAD CALCULATION.....	25
6. BUILDING SERVICES SYSTEMS DESIGN	28
6.1 MECHANICAL & ELECTRICAL SERVICES SYSTEMS - CONCEPT DESIGN.....	28
6.1.1 Domestic Water Services.....	28
6.1.2 Lighting	28
6.1.3 Small Power and LV	28
6.1.4 Fire Alarm	29
6.2 MECHANICAL SERVICES SYSTEMS - DEVELOPED DESIGN.....	30
6.2.1 Heating & Cooling	30
6.2.2 Ventilation.....	31
7. RENEWABLES.....	34
7.3 PHOTOVOLTAICS	34
7.4 HEAT PUMPS	36
7.5 SOLAR HOT WATER.....	36
8. CONCLUSIONS	37
9. REFERENCES	38
10. APPENDICES.....	39
Appendix 1 – Drawing Issue Register	
Appendix 2 – Drawings	
Appendix 3 – CIBSE TM46 Benchmark Adjustment	
Appendix 4 – Apache System Inputs	
Appendix 5 – Final Model BRUKL Report	
Appendix 6 – Fabric Details Upgrade	

Appendix 7 – PV Simple
 Payback Appendix 8 –
 Heating and Cooling Loads
 Appendix 9 – Duct Sizing
 Appendix 10 – Ventilation
 Calculations Appendix 11 –
 Air Conditioning Schedule

Table 1- BB 101 Carbon dioxide level guidelines.....	9
Table 2- External design criteria	14
Table 3- Internal design criteria - Temperature.....	15
Table 4- Internal design criteria - Ventilation Rates	16
Table 5 - Internal design criteria - Noise Ratings	16
Table 6 - Internal design criteria - Lighting	17
Table 7 - Internal gains	17
Table 8 - Total heating and cooling load comparison to benchmark.....	18
Table 9 - CIBSE TM46 - Benchmark Data.....	19
Table 13 - Fabric Parameters	21
Table 15 - Internal Gains.....	22
Table 16 - Fabric parameters comparison	23
Table 13 - Heating and Cooling Load at each step.....	25
Table 14- Total energy use at each step	25
Table 15- Monthly and Total Carbon Emission at each step.....	26
Table 16 - Indoor unit selections	30
Table 17- Ventilation plant selections.....	31
Table 18 - VAV Box Selections.....	32
Table 19- PV Payback Comparison	35
Figure 1- Google maps view of the University building.....	6
Figure 2- Final BRUKL Report - Energy & CO2 Emissions Summary	19
Figure 3- 3D Model of building in IES	20
Figure 4- Weather Station Distance	20
Figure 5- Weather Station Altitude Difference	21
Figure 6- Daily and Weekly occupancy profile.....	22
Figure 7- Final Model BRUKL Report - Fabric performance.....	23
Figure 8- Electricity Generators input - IES.....	24
Figure 9- Building Energy Use vs Benchmark.....	25
Figure 10- Carbon emissions as a percentage of the Base Model	26