



#### CANTERBURY CHRIST CHURCH UNIVERSITY

# Experimental investigation of Earth-air ventilation system in low-energy buildings

Professor Abdullahi Ahmed (PhD, CEng. MCIBSE. FHEA) Director of Engineering and Built Environment

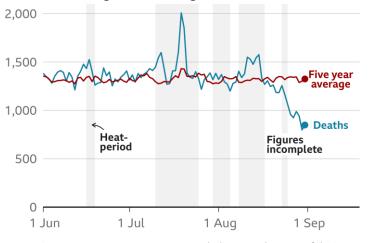




### **Climate Change Impact**

#### More deaths seen during periods of high heat

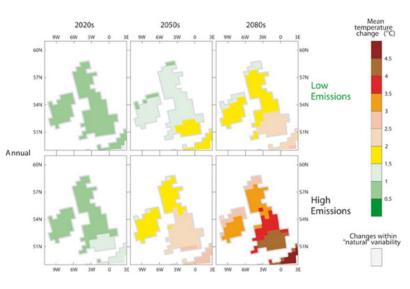
Heat-periods, daily deaths and five-year average deaths, 1 June to 31 August 2022, England and Wales



Note: Five-year average covers 2016-21 excluding 2020 because of the impact of the coronavirus pandemic on deaths. Data for late August is incomplete

Source: ONS

ВВС



₩ UK Parliament
Committees
<u>UK Parliament</u> > <u>Business</u> > <u>Committees</u> > <u>Environmental Audit Committee</u> > News Article

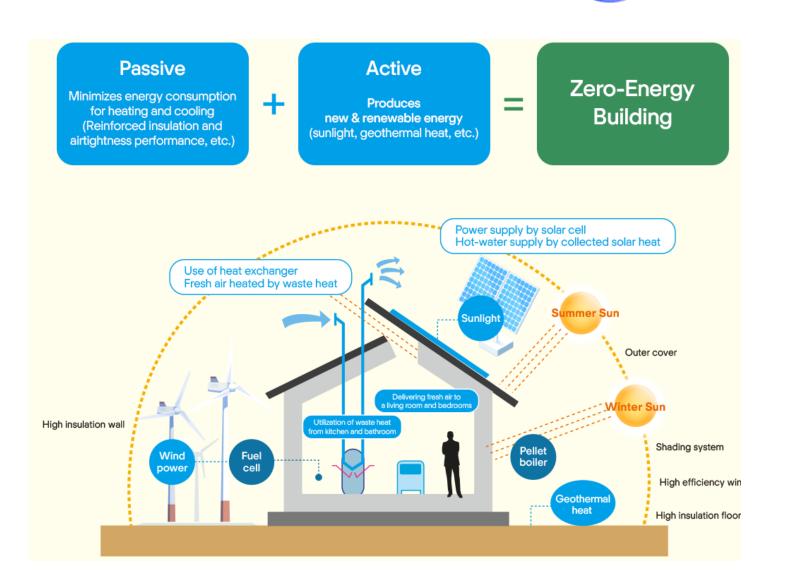
#### Heat-related deaths set to treble by 2050 unless Govt acts

26 July 2018





Achieving Net Zero Buildings

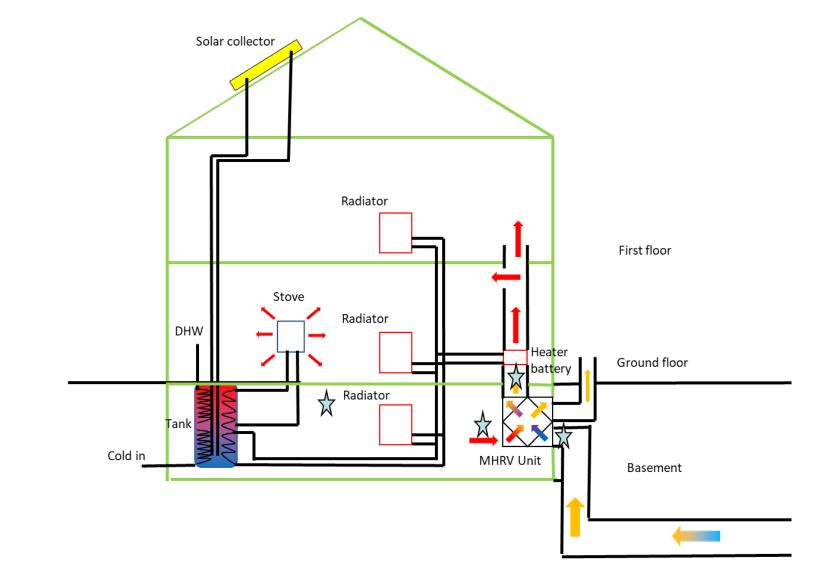


Canterbury Christ Church

University







- Building Energy Strategy
- Solar thermal Systems
- Biomass heating systems
- Mechanical Ventilation and Heat Recovery System
- Earth-Air heat exchanger
- Highly insulated thermal storage store;
- Rain-Water Harvesting System;

Ground heat exchan





- Exposed concrete slab Mature trees Fixed solar provide shading shading Adjustable internal blinds Pressurised floor voir Windows open for External Fresh Air Plantroom under stairs pressure relief & temperature intake Natural ventilation 30°C light bypass if required by occupier Ventilation via AHU floor grilles a second s Earthduct min. 70m length / 600mm Diameter Air Temperature at outlet: 24°C
- The Earth-Air Heat Exchanger (EAHX) is a subterranean cooling system that consists of network of pipes buried below the ground surface, through which ventilation air supply is circulated





## Case Study Systems







## Monitoring

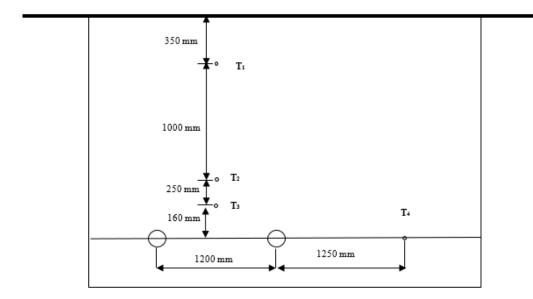


Parameter	Monitoring approach		
External weather conditions: air	Weather station – Mounted horizontally on a post attached the solar chimney. The		
temperature, relative humidity, wind speed	weather station has been located at high level above the building to minimise the risk of		
and direction, solar radiation, rainfall	over-shading by the building and surrounding vegetation.		
	Pyranometer – Mounted on the same vertical post as the weather station.		
Soil temperature	4 K-type Thermocouples were used at different locations in the surrounding soil both		
	vertically and horizontally to establish soil temperature variation with depth and horizontal		
	distance from the pipe surface. The horizontal distance between the parallel pipes has		
	been shown to be the main cause of thermal interference.		
Inlet and Outlet air temperature	2 K-type thermocouples were used at both the inlet and outlet of the ducts shaded from		
	direct solar gain to give heat transfer effectiveness of the earth-duct for heating and		
	cooling ventilation air.		



### Monitoring



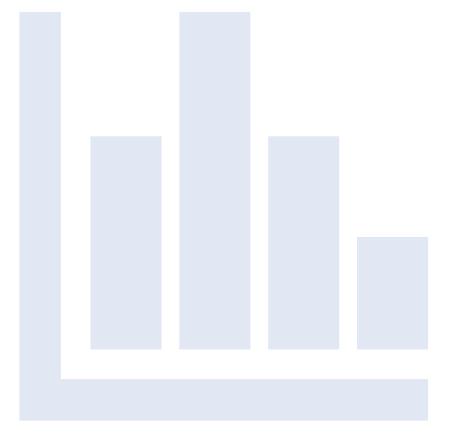


Parameters	Speed Setting 1	Speed setting 2	Speed setting 3
	(00:00 - 07:00 am)	(07:00am -23:59pm)	(party mode)
Air velocity (m/s)	1.4	2.5	3
Volumetric flow rate (m3/h)	200	350	450
Estimated pressure loss	6	21	29
(duct) (Pa)			
Estimated pressure loss (air	8.5 Pa	30	40Pa
intake to MVHR) (Pa)			





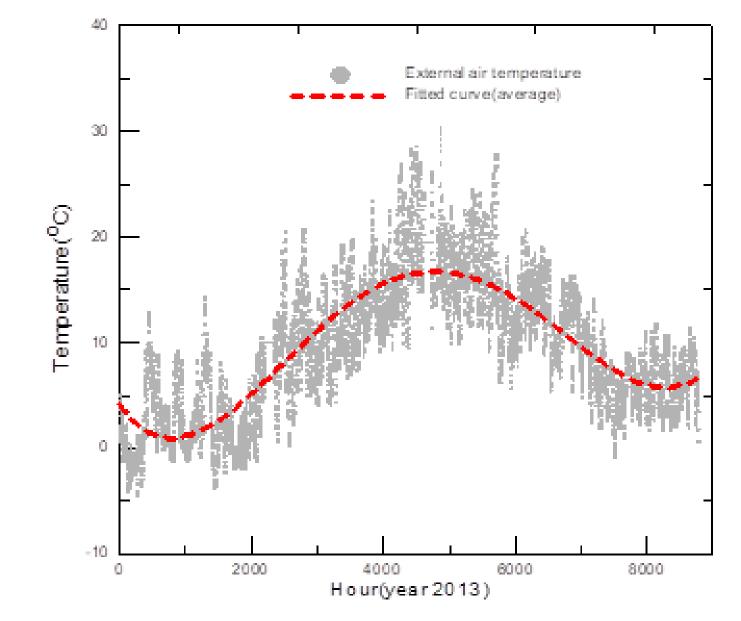
# Results and Analysis







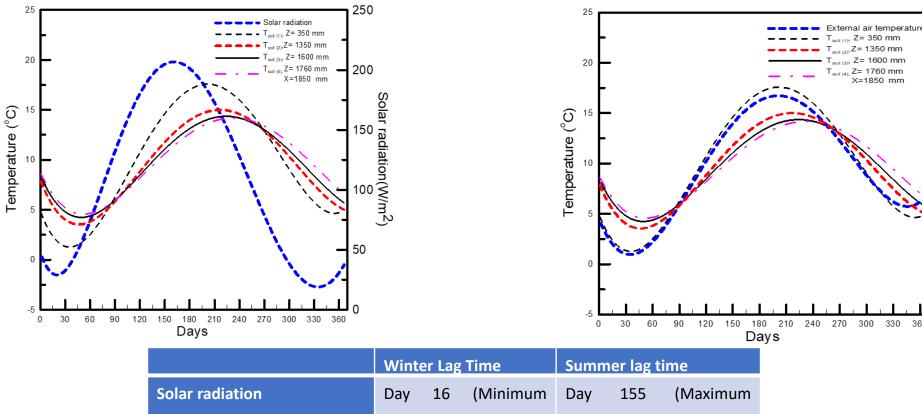
# External air temperature





# Dynamic annual changes in daily average soil temperature at various depths





winter temperature)

16

30

30

Soil temperature (350mm)

Soil temperature (1600 mm)

Soil temperature (1760 mm)

summer temperature)

40

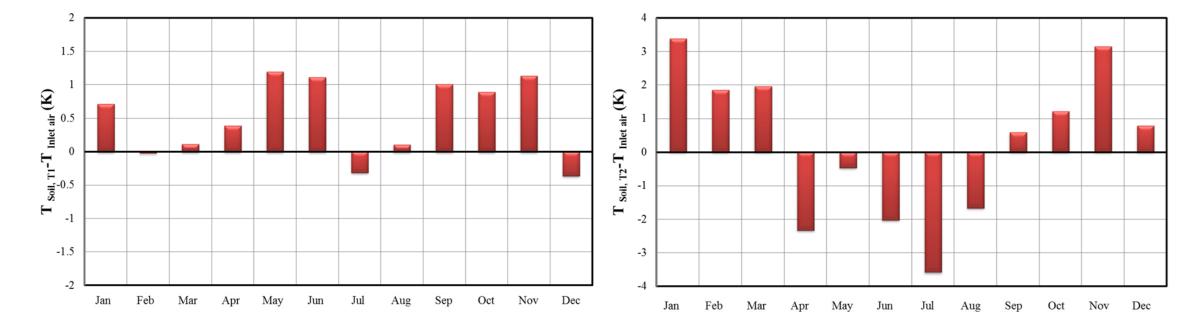
70

70



### Monthly average thermal potential





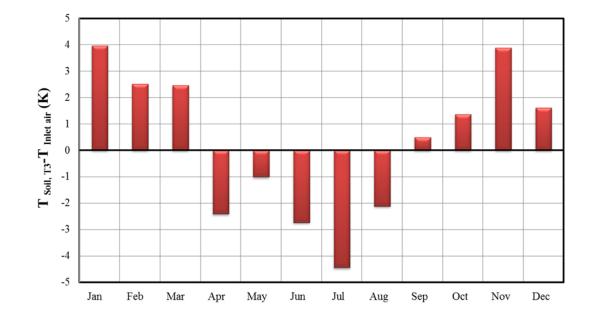
Monthly average thermal potential of ETAHE system at 350mm depth

Monthly average thermal potential of ETAHE system 1600mm depth

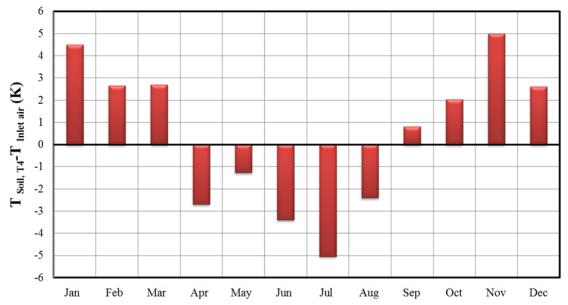


# Monthly average thermal potential of ETAHE





Monthly average thermal potential of ETAHE at 1760mm depth (600mm from duct surface)

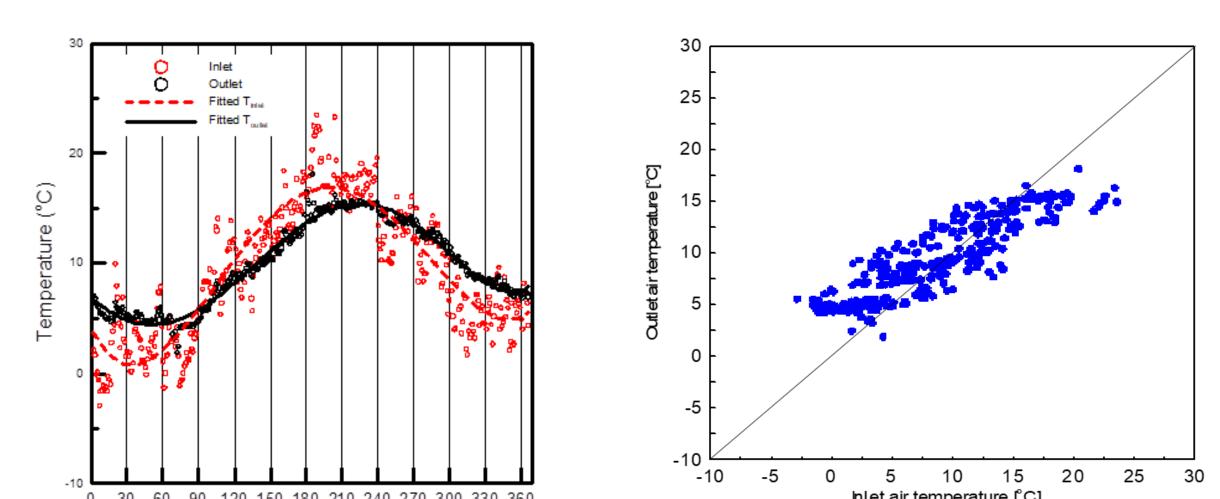


Monthly average thermal potential of ETAHE at 1760mm depth (1850 from duct surface)





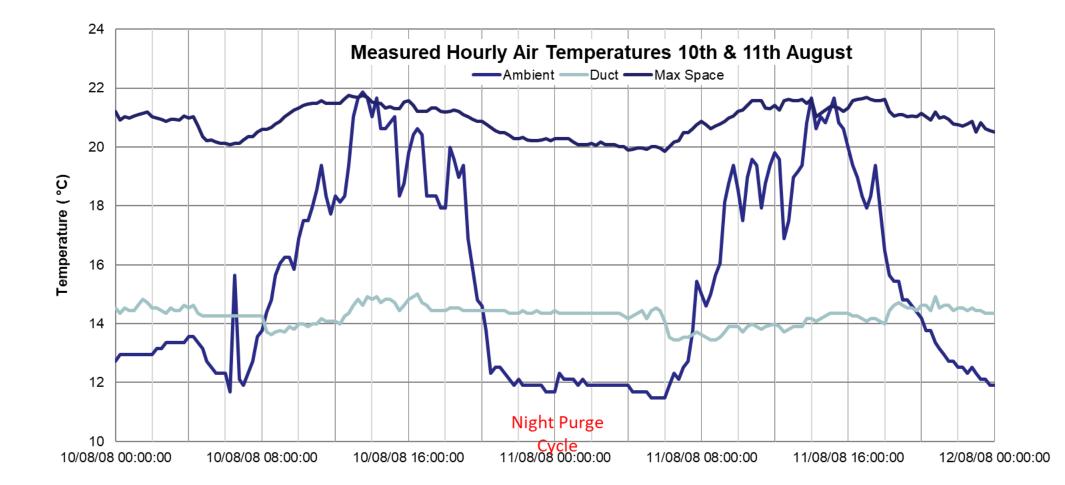
# Relationship between inlet temperature and outlet temperature





## Night Purge potential







## Conclusion





#### **Technical Issues**

Depth is critical – below 1 meter for reasonable soil-air temperature difference;

Reduce the risk of frost on MVHR system;

Avoid temperature stratification – soil temperature increase + drying near the pipe;

Effective integration with other heating and ventilation system



#### **Non-technical**

Cleaning and Cover – dust/rodent;

Control strategy