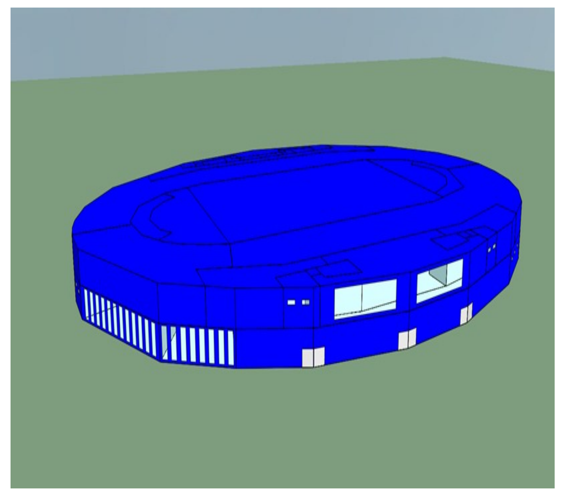
The National Velodrome & Badminton Centre with a Thermal Labyrinth Integrated

Description of the Building



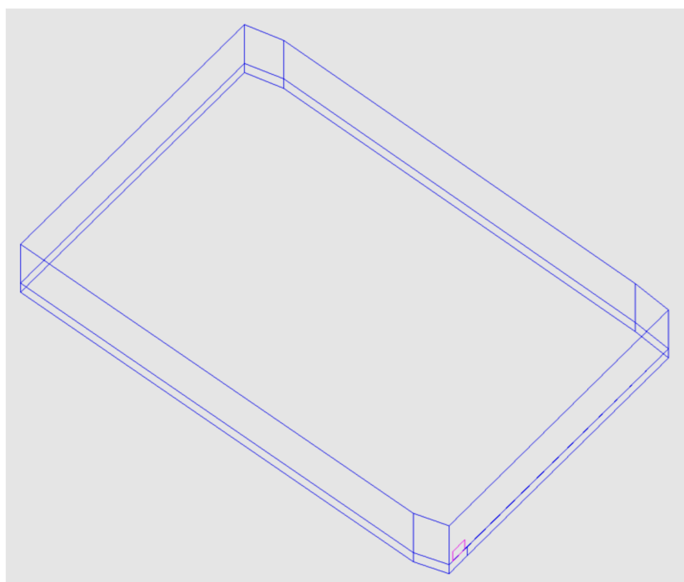
The National Velodrome and Badminton Centre is located within the National Sports campus in Abbotstown, Dublin 15. The external design conditions for Dublin, Ireland were taken from the ASHRAE design weather database. The outdoor winter temperature is -1.2°C and the outdoor summer temperature is 22°C. The building height is 8.5m high and has a total floor area of 13,200m^2. The building consists of two levels, and will provide modern facilities for athletes, spectators, coaches, officials and clubs. It will not only be used for training purposes but to also host major sporting events. The track and infield may be used as a multi-sports area .i.e. a badminton court, basketball court or a volley-ball court.

Function of IES

The objective of this project is to take a section of the final year project building and apply sustainable design techniques to it using the IES software and evaluate possible design improvements. The specific area of interest is to improve the design of the infield through use of a thermal labyrinth. The infield is a large open space with a volume of 17,975m^3 that requires 18°C for training and competition purposes. The room sensible heat gain in the infield is massive at 73291.72W which is mainly due to the high lighting load which equates to 31.6 W/m^2. If the labyrinth proves to be a success, free cooling of the infield in the summer can be achieved, decreasing the cooling demand on the chillers. In addition to this, the labyrinth will pre-heat the air in the winter, reducing the heating demand on the heat pumps.

Analysis

Microflow will be used to do a CFD simulation of the airflow going through 3 different labyrinth options and a conclusion will be reached on whether the labyrinth can free cool the infield to 18°C in summer and pre-heat the air to 18°C in the winter. A basement is added, as shown on the right, for the underground labyrinth to connect into to allow the labyrinth cooled or heated airflow travel through the basement and up into the infield through ceiling grilles. The method to ventilate, cool and heat the infield through the thermal labyrinth is displacement ventilation.



Option 1: Labyrinth 2m below Ground Level

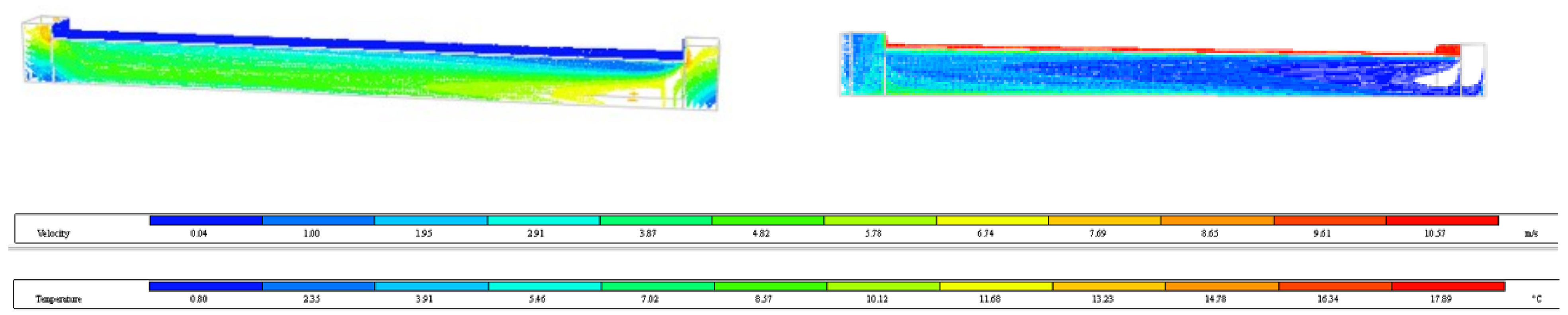
The 1st labyrinth tested is 2m below the ground where the soil ranges between 5°C and 15°C.

Velocity Profile

The desirable velocity through the exhaust is 6m/s. As seen below the velocity is 6.74m/s which is a little high.

Temperature Profile

The temperature is raised from -1.2°C to 4°C. The air is preheated but there is room for improvement.



Option 2: Labyrinth 4m below Ground Level

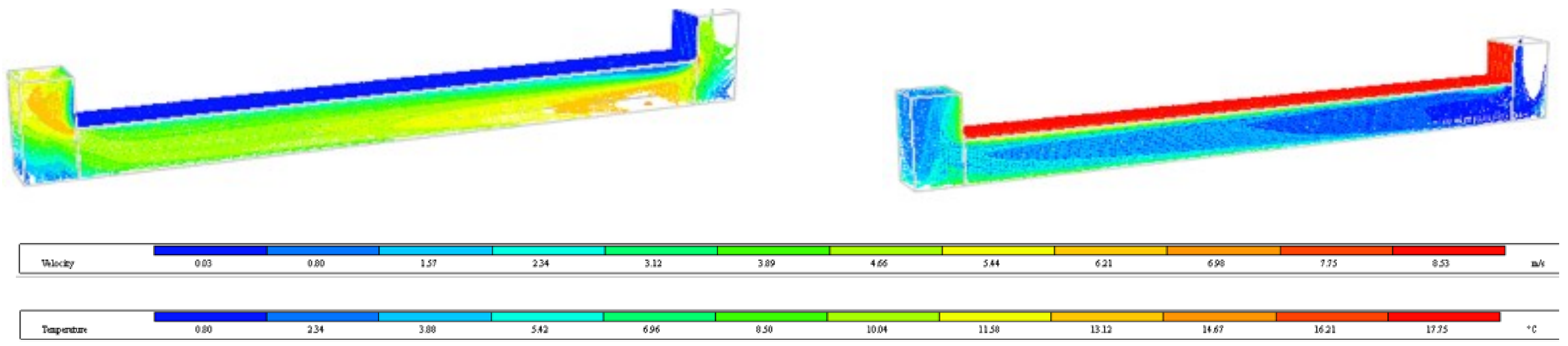
The 2nd labyrinth tested is 4m below the ground where the soil ranges between 8°C & 12°C, and this labyrinth is shorter in length.

Velocity Profile

The velocity is approximately 5.44m/s exiting the exhaust which is desirable.

Temperature Profile

Temperature is raised from -1.2°C to 4°C again. No change from the previous option, there is still room for improvement.



Option 3: Labyrinth 4m below Ground Level Incorporating Bends

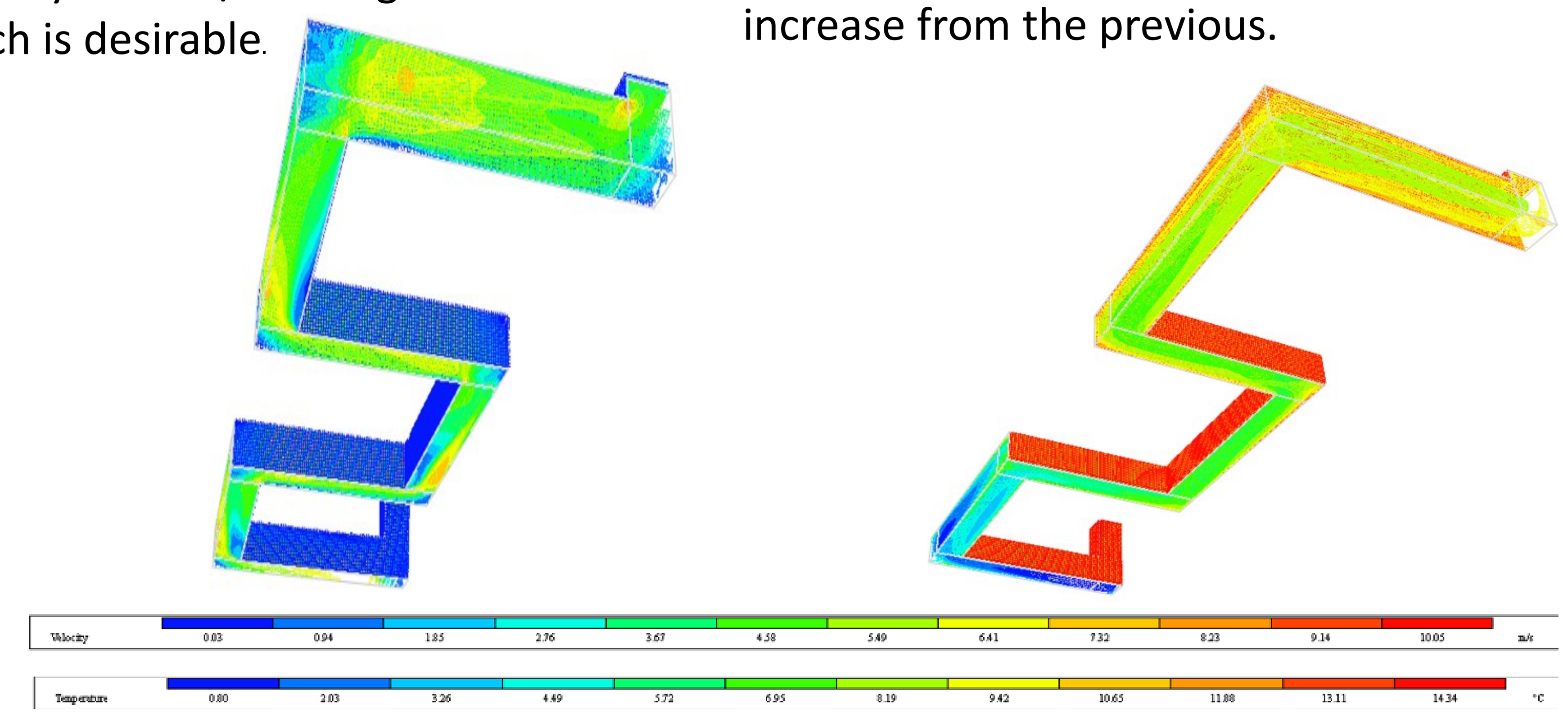
Like option 2, this is constructed 4m below the ground where the soil ranges between 8°C & 12°C, but this labyrinth incorporates bends to create air turbulence for improved heat transfer.

Winter Velocity Profile

Velocity is 5.5m/s exiting the exhaust which is desirable.

Winter Temperature Profile

Temperature is raised from -1.2°C to 10°C, huge increase from the previous.

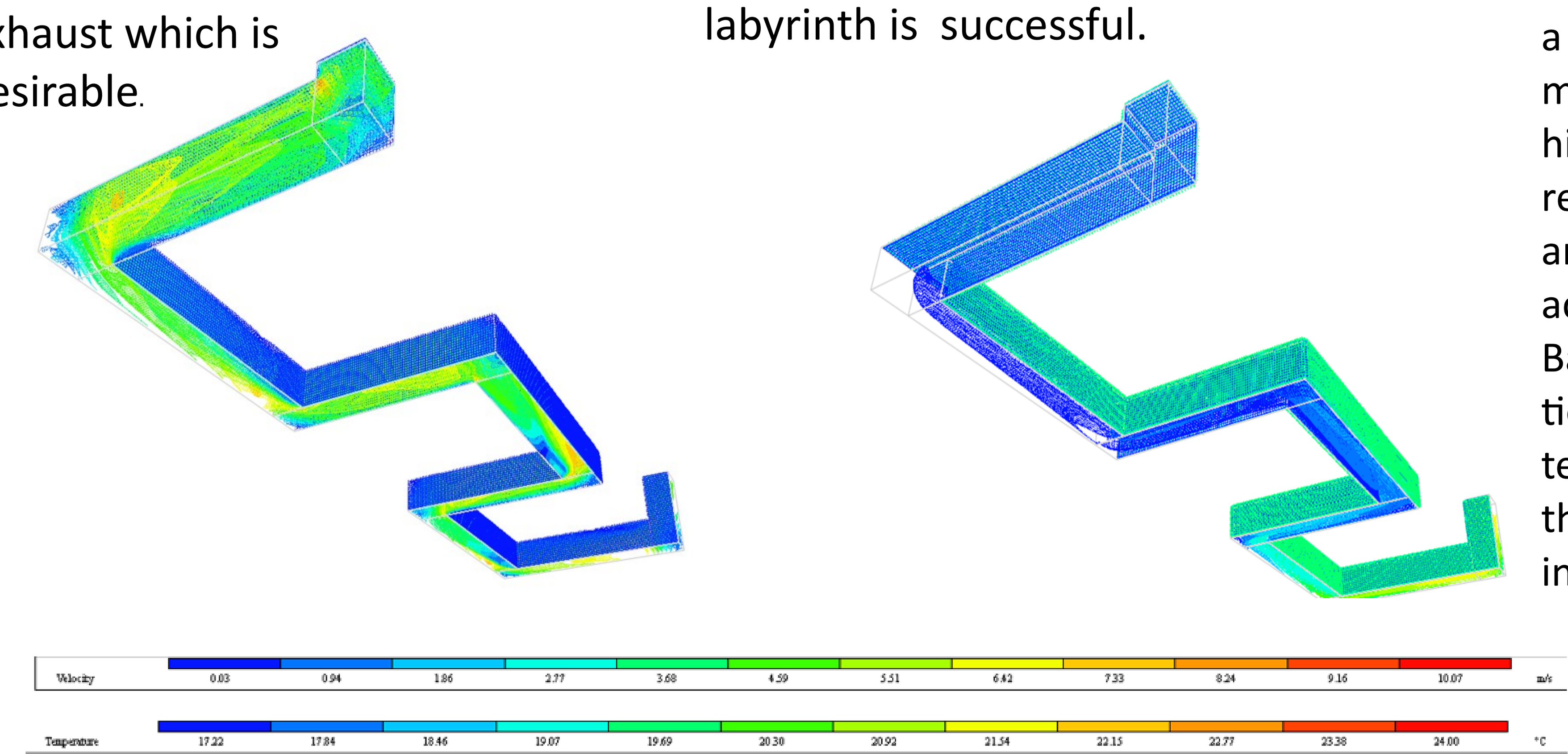


Summer Velocity Profile

Velocity is 5.51m/s exiting the exhaust which is desirable.

Summer Temperature Profile

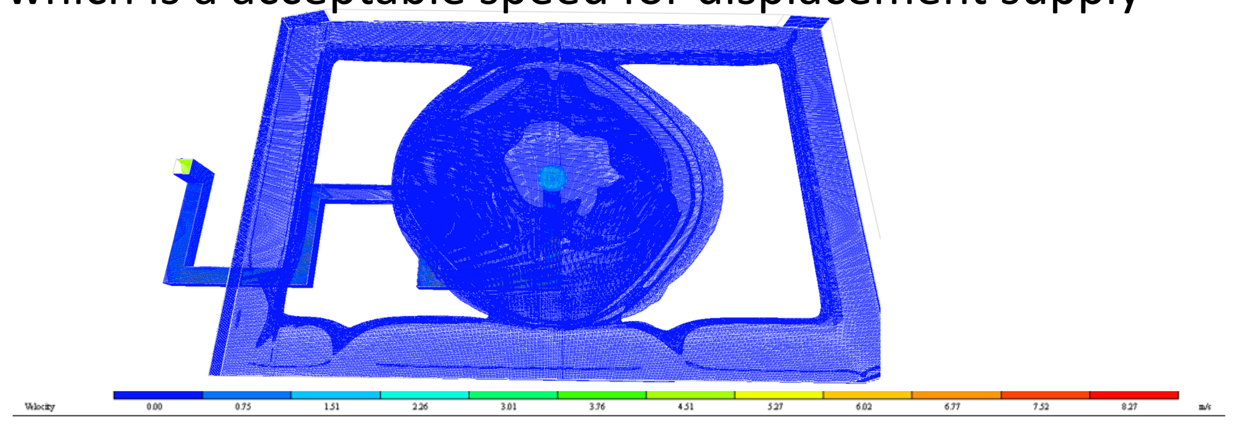
Temperature is cooled from 22°C to 17°C, labyrinth is successful.



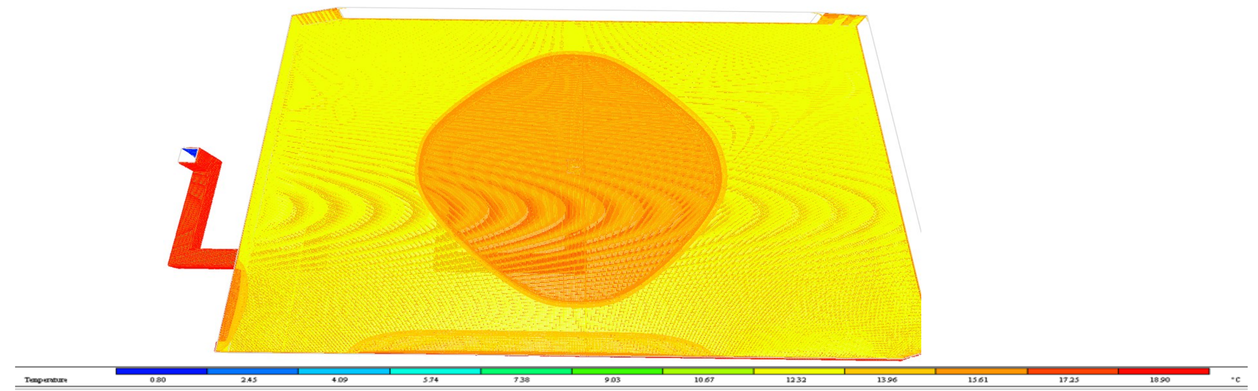
Results

Labyrinth Supply to Infield

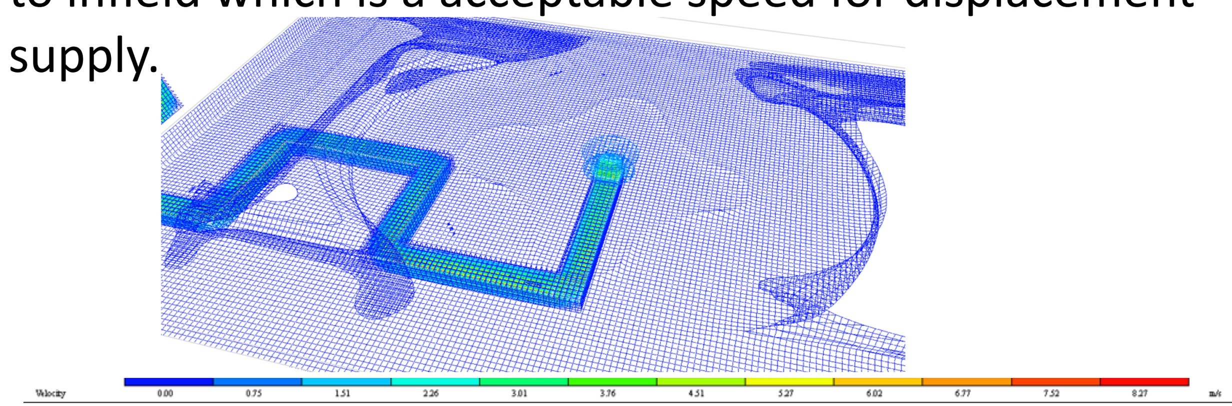
Winter Velocity Profile: Velocity is below 0.75m/s to infield which is a acceptable speed for displacement supply



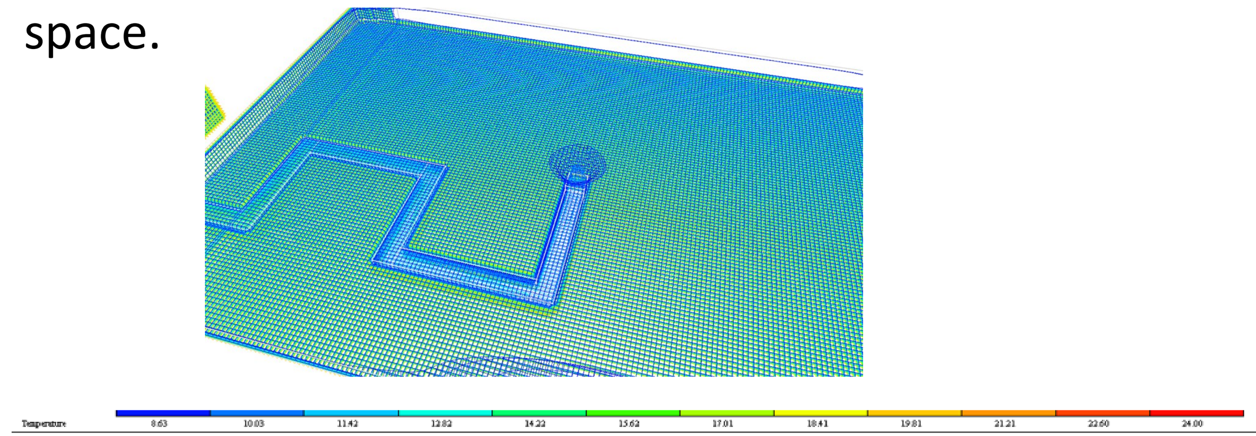
Winter Temperature Profile: Temperature is 15.6°C Mechanical heating only required to bring the space up 2°C to reach desired temperature of 18°C.



Summer Velocity Profile: Velocity is again below 0.75m/s to infield which is a acceptable speed for displacement supply.



Summer Temperature Profile: Temperature is 10°C entering the infield conveying the labyrinths ability to cool the space.



Conclusion

In conclusion, the labyrinth design incorporating bends of 4m depth is the most effective option. The labyrinth brings the infield BER to 0.98, band B3. SBEM calculated the infield to use 281.86kWh/m^2 /yr. This is a substantial drop in energy use from before which was 436.32kWh/m^2 /yr. This proves how effective this design change is. The previous high carbon emissions for the infield of 85.80kg CO_2/year is also reduced to 55.42kg CO_2/year. This new improved energy performance and reduced CO_2 confirms the addition of the thermal labyrinth achieves a low carbon and sustainable building design for the National Badminton and Velodrome Centre. Thus, the objective of taking a section of the final year project building and applying sustainable design techniques to it using the IES software was achieved. The addition of the labyrinth brought a significant design improvement, thus it will be included as a low innovative technology for my final year project.

	Primary Energy Use (kWh/m²/yr)	Carbon Emissions (kgCO2/m²/yr)	Building Energy Rating
Actual	281.86	55.42	0.98
Notional	286.39	54.88	Band
Indicator	0.98	1.01	B3

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