Advanced simulation of air currents can result in more habitable cities

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Credit: AI-generated image (disclaimer)

Densely packed housing makes urban areas vulnerable to overheating, pollution and dangerous wind gusts. The effects of climate change can aggravate these problems, but we can also work to prevent them. This can be done by simulating microclimates.

Cities and urban areas are characterized by high population densities and widespread man-made environments. In city centers this means surfaces covered with concrete and asphalt, less vegetation, more air pollution, and large, densely-packed buildings that reduce both air circulation and access to daylight.

At the same time, and especially in coastal areas, extremely high wind velocities can develop between tall buildings due to airflow channeling effects. This can make pedestrian walkways and cycle paths dangerous and unsafe, especially for vulnerable groups.

Climate change can make cities unbearable to live in

The impact of climate change may be reinforcing the negative effects of densely-packed housing, and many places in the world are at risk of becoming uninhabitable. Europe is probably not the most severely affected, but even here the effects of climate change, such as heat waves , droughts and flooding, represent a threat to both infrastructure and human life. The European heatwave of 2003 claimed more than 70,000 lives. The summer of 2022 was the hottest ever experienced in Europe, with more than 20,000 people dying as a direct result of the heat.

For this reason, it is increasingly important to reduce the impact of extreme heat in urban areas, especially in southern Europe, but also in Norway. In Oslo, in particular, and in the southern parts of Østlandet county, we can expect to experience heat waves in the future. This is why we must do what we can to create habitable conditions in our cities, and in urban buildings, when temperatures increase to levels that we are not used to. We must begin during the planning phase of a construction process.

Advanced simulations deliver more accurate airflow

calculations

So, how can urban planners take a warmer climate into account? Advanced simulation tools such as Computational Fluid Dynamics (CFD) are able to calculate air movements in a variety of environments. This can be done as early as during the planning phase of larger building projects, and as part of the overall urban planning process.

In brief, CFD offers a method of calculating the movement of fluids, including liquids and gases such as air. In recent decades, there has been a boom in the use of such methods, in step with the increase in power of modern computers. In the last 15 to 20 years, the method has also been applied in studies of microclimates. Microclimates represent climatic conditions that develop at scales of less than two kilometers, and for which in the past we based our investigations on measurements and observations.

Trondheim study demonstrates the effect of different measures

Studies of the microclimate at Gløshaugen in Trondheim have demonstrated the effect of the use of various building materials, as well as the impact that the volume of vegetation and natural environments had on local climatic conditions, and how these factors impacted on the energy consumption of buildings and the thermal comfort of people outdoors.

The simulations also showed that the cumulative evaporation from lawns and trees can reduce the air temperature by several degrees (up to 2.4°C at Gløshaugen), and thus reduce the need for cooling the buildings in summer.

These results can be used to look into different scenarios for urban design or to calculate future urban climates. Having said this, it is difficult to give general recommendations because the systems are highly location-specific, and measures must take into account all the relevant factors that influence the microclimate in a given situation.

Multiple applications

CFD can also be used to make high resolution calculations of wind conditions, such as turbulence and wind speed. In this way, it will be possible to identify sites where urban wind turbines for local renewable energy generation can be profitably located. Moreover, the dispersion of harmful emissions and pollution can be simulated in areas such as heavily trafficked roads, industrial plants, and also in the aftermath of accidents and fires.

In other words, CFD is able to deliver useful information to inform construction projects, urban planning and architecture, which in the past has been inaccessible in terms of level of resolution, precision and the speed that we are seeing today.

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