

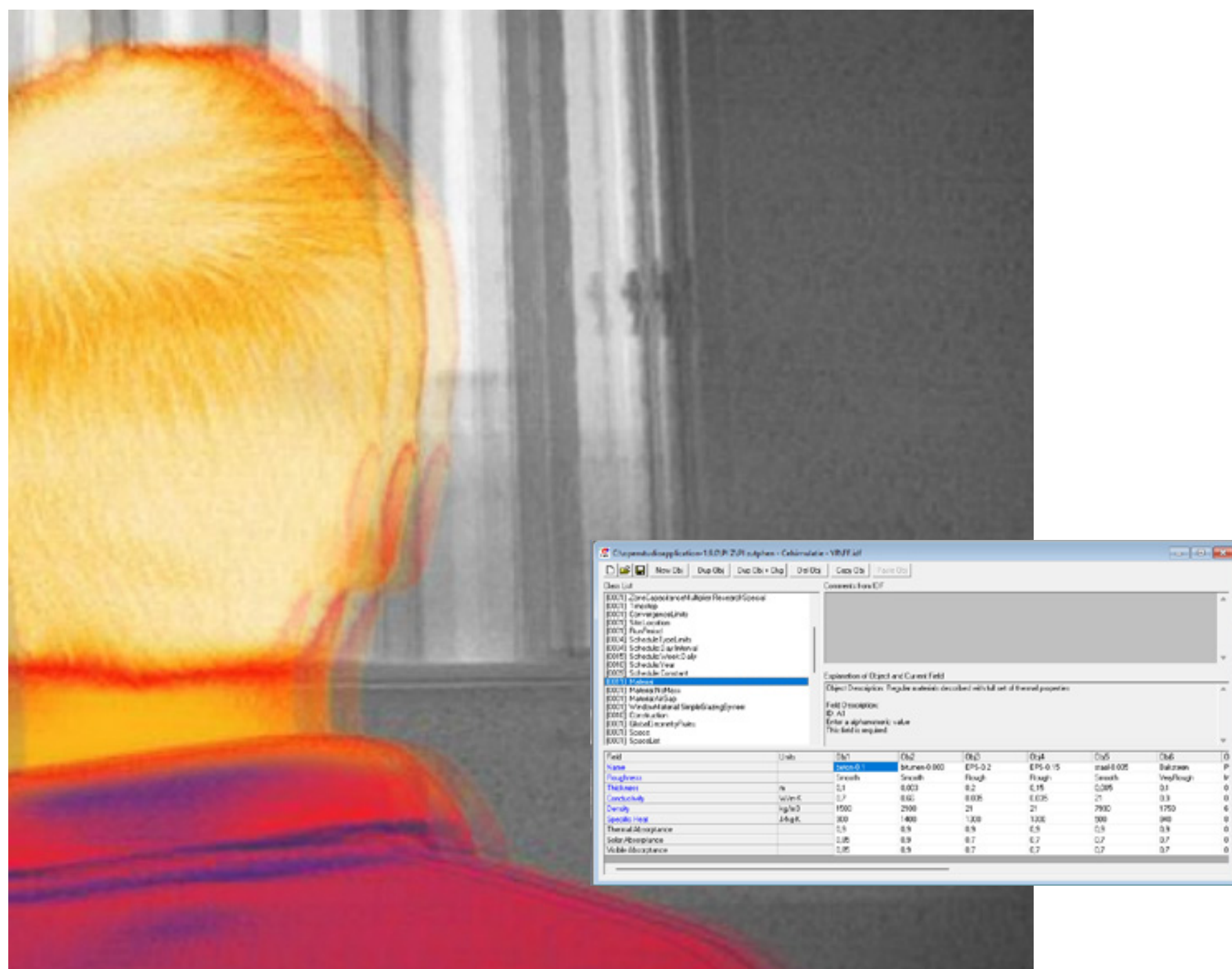
# Cooling down detainees and their prison cells

## Introduction

Detainees in Dutch Penitentiary Institutions (prisons) are locked up in cells for more than 15 hours a day. In cells, temperatures during summer months can rise up to 27 degrees and warmer, even at night.

Heat stress is the state in which the human body is too hot. It cannot dissipate heat as much as is needed to keep the core body on the right temperature. Where slight heat stress causes sleep deprivation and frustration, longer exposure to moderate or extreme heat stress could cause dehydration and even death.

Detainees experience heat stress, affecting in lower mental, psychological and physical wellbeing. These effects negatively influence the safety of the penitentiary institution. A solution is required.



## Computer simulation

Renovations of penitentiary institutions are planned to tackle this problem. These start in 2030. This study focuses on what measures can be taken to reduce heat stress before that time.

To gain valuable insights of different measures, and their heat stress reducing capacity, this thesis focuses on setting up a computer simulation of a prison cell in penitentiary institution Zutphen. The software, EnergyPlus, can simulate heat flows and predict indoor temperatures based on internal and external heat flows, in and out of the cell.

By gathering data on building materials, detainee activities and specs of the ventilation system, the simulation predicts the effect of architectural measures that can be taken. This leads to a roadmap to effectively reduce heat stress in cells. With further iterating this computer simulation, more measures can be tested, and renovation plans can be made effectively.

## Process

This study is conducted as follows.

First, heat stress was researched Online. What is this phenomenon and what are the effects? This was connected with existing and new studies within different penitentiary institutions within the Netherlands. A visit to penitentiary institution Zutphen was made, where detainees and other stakeholder were interviewed on heat stress experiences, current actions taken to reduce heat stress, and regulations and prison policy.

Then, with available data and calculations of ventilation, metabolic heat and solar radiation a SANKEY model was made to identify the relation and sizes of different heat flows in cells. This led to identifying different solution spaces. These are used for ideation.

A computer simulation was set up. This simulation shows all heat flows through the cell and detainee. The perceived temperature and heat stress is calculated. Validation of the simulation is done using other similar studies.

Simultaneously, ideation is connected with stakeholder interviews to find measures that fit the design criteria of this project. These measures are modeled into the simulation, and outcome data is compared to the current situation. This way, the impact of measures is tested. These results are validated and discussed.

Lastly, the outcomes were discussed with stakeholders. New insights of prison personnel and the client company led to an iteration of action points, visualised in a road map to effectively reduce heat stress.

Kees Dik

**Comparing heat stress reducing measures for implementation within penitentiary institutions**

Integrated Product Design

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Dienst Justitiële Inrichtingen  
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