



# Design of Thermal System for Cooling of Server Rooms in Critical and Emergency Situations with PCM

ME 491 RESEARCH PROJECT PRESENTATION

BİLAL ÇAKIR 20170307011

KEREM ÖZMEN 20170307013

UNDER THE SUPERVISION OF PROF. DR. TARIK BAYKARA



# Presentation flow

1. Introduction
2. Features of paraffin wax
3. Project parameters and constraints
4. Traditional server cooling systems
5. Advantages and disadvantages of PCM
6. Details of the project



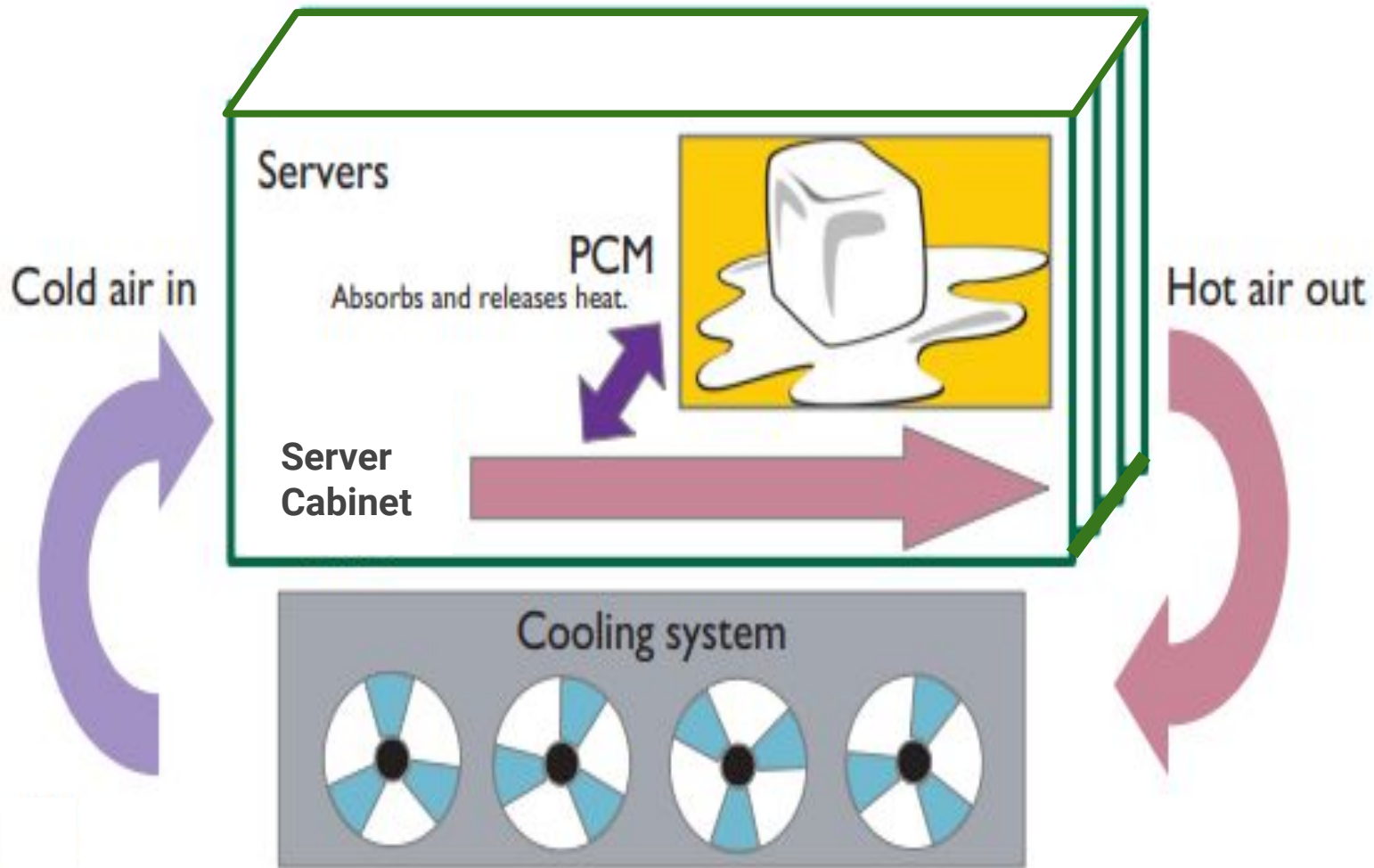
# Introduction

---

Servers should be cooled instantly in critical times. Due to great risk of emergency situations in most dangerous times (*earthquakes, fires, civil wars, etc.*) servers become almost the most important tools for communication.







# Reasons for using PCM

- It is our best choice according to its high thermal energy storage capacity and melting temperature range between  $-9\text{ }^{\circ}\text{C}$  and  $100\text{ }^{\circ}\text{C}$ .
- Cooling with Paraffin-Wax must be chosen from factories, businesses due to its low cost.<sup>(2)</sup>



# PCM material we aim to use



- Solid paraffin wax is preferred for server cabinets' cooling.
- Temperature ranges of 72-76°C, 66-70°C and 59-66°C are good to ensure safe operation of many electronic devices. <sup>(1)</sup>

	2004 publication	2008 publication
Temperature Lower Limit	20 °C	18 °C
Temperature Upper Limit	25 °C	27 °C
Humidity Lower Limit	40 % Relative Humidity (RH)	5.5 Dew Point
Humidity Upper Limit	55 % Relative Humidity (RH)	60 % RH and 15°C Dew Point

*Recommended System Room Temperature and Humidity Values*





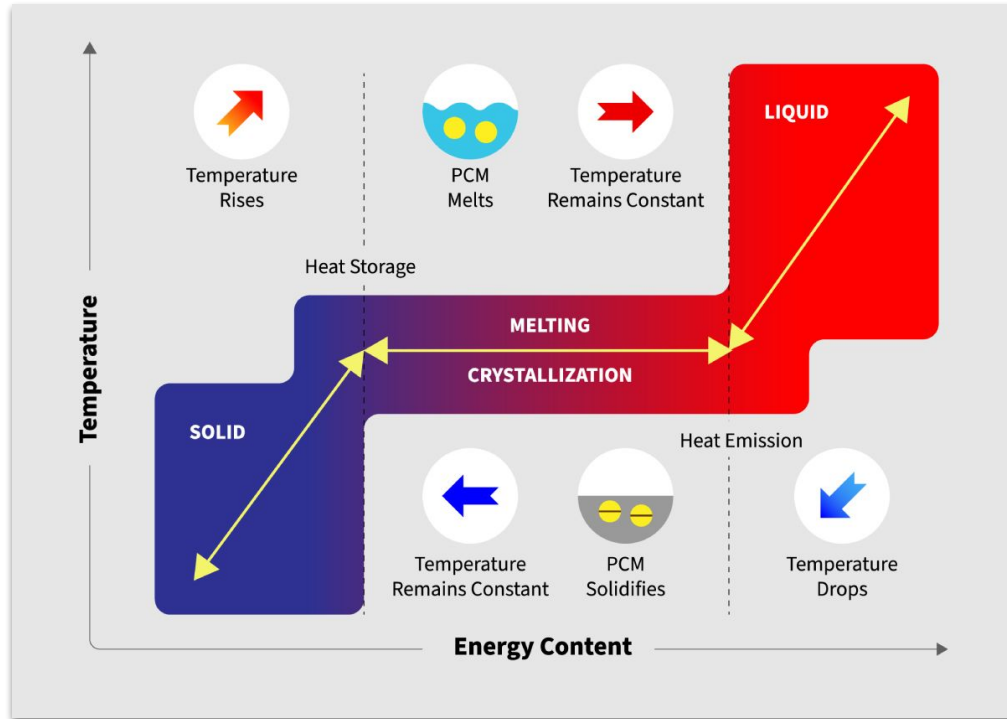
Examples of Paraffins	$C_{36}H_{74}$	$C_{32}H_{66}$	$C_{30}H_{62}$
Density <sub>solid</sub> (kg/m <sup>3</sup> )	857	809	810
Latent Heat (kJ/kg)	223	261	249
T <sub>melt</sub> (°C)	72 to 76	66 to 70	59 to 66

Latent heat must be high since we need the PCM to absorb the heat while the temperature is high due to high processing.

*Comparison of some types of hydrocarbons(Paraffin examples)*



# Working principle of PCM



# Parameters for design

An ideal PCM will have **high heat of fusion**, **high thermal conductivity**, **high specific heat** and **density**, **long term reliability** during repeated cycling.



# Constraints for this project

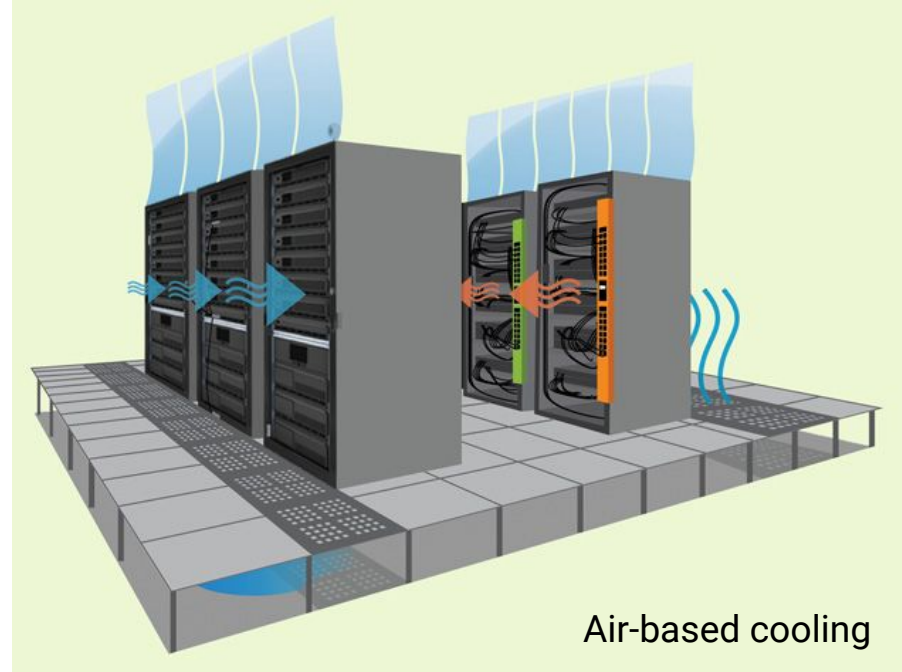
1. Heat of fusion
2. Thermal conductivity of solid and liquid
3. High specific heat and density
4. Long term reliability during repeated cycling
5. Dependable freezing behavior
6. Cost
7. Weight
8. Volume that covers the place(dimensions)
9. Average phase change temperature



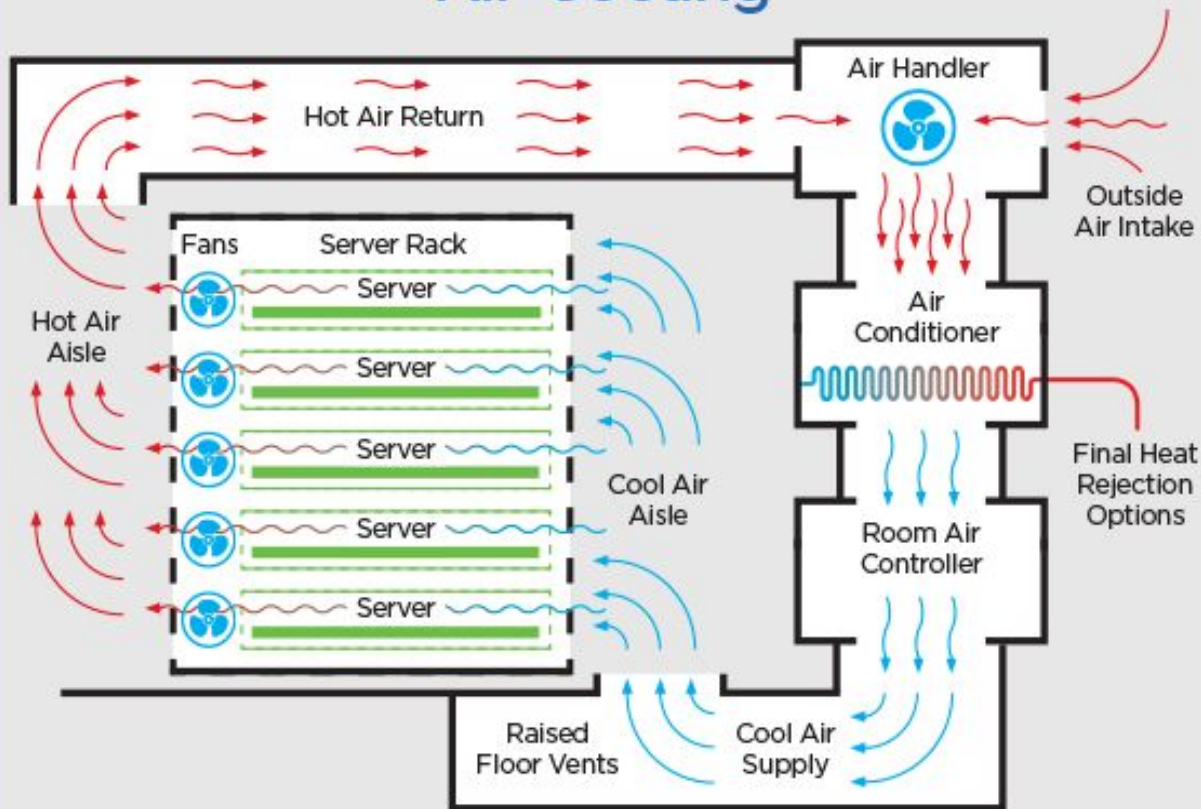
# Server cabinet cooling systems used today

Today, 2 technologies are frequently used for cooling server cabinets.

- Air-based cooling
- Liquid-based cooling

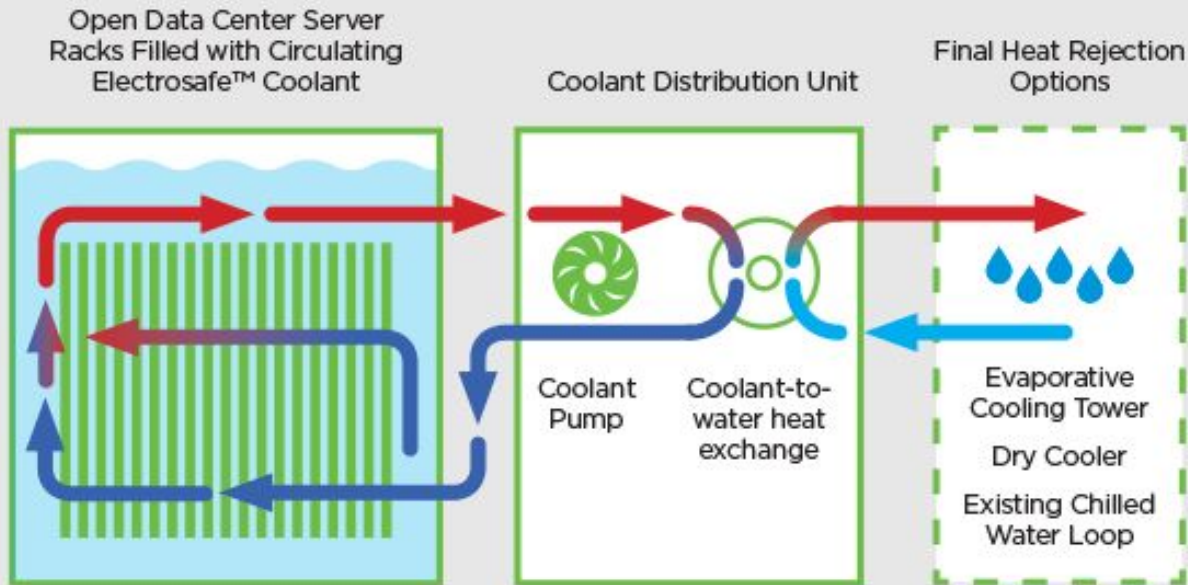


# Air-Cooling





# Single-Phase Liquid Immersion Cooling



Heated coolant exits top of rack. Coolant returns to rack from heat exchanger at user-specified temperature.

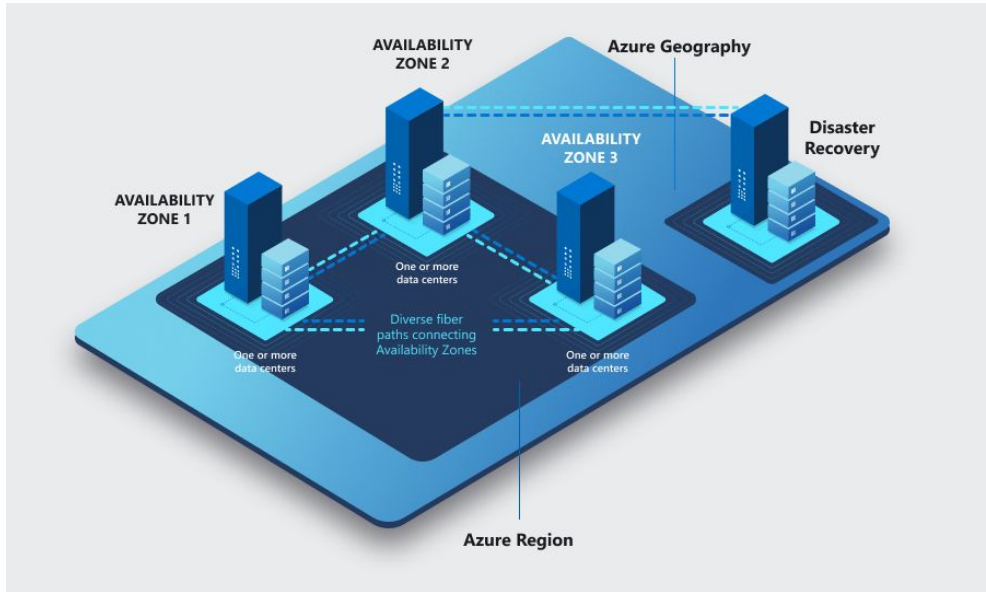


Liquid-based cooling

# Advantages and Disadvantages of Organic PCM

- **High temperature range.**
- **Paraffins have no tendencies to super cool.<sup>(3)</sup>**
- **Stable for more cycles.**
- **No corrosiveness.**
- **Pure paraffins are expensive.**
- **Paraffins are flammable.**
- **High changes in volume during the phase transition.**

# Precautions taken by companies against a disaster scenario



Cloud Computing Companies (Amazon AWS, Microsoft Azure, Google Cloud) are constantly investing in disaster situations.

We can reduce these investment costs by using PCM in server cooling.

# The importance of using the PCM for emergency situations

Internet use is very intense in important social events (for example, the announcement of exam results, starting the university course registrations, flash news). This means that the servers are overworked.

In such special cases, traditional server cooling systems may not be sufficient. PCM helps the servers to run uninterrupted in such emergencies.



# What We Aimed to Achieve in the Second Presentation

- Supply of paraffin wax
- Experimental procedures and writing detailed reports
- Getting inside knowledge from factories that deals with cooling server cabinets





# References

- <sup>1</sup> Advanced Cooling Technologies Inc., “Phase Change Material (PCM) Selection”, <https://www.1-act.com/products/pcm-heat-sinks/pcmselection> (12.01.2021)
- <sup>2</sup> M. Skach, *et al.*, "Thermal Time Shifting: Decreasing Data Center Cooling Costs with Phase-Change Materials" in *IEEE Internet Computing*, vol. 21, no. 04, pp. 34-43, 2017; doi: 10.1109/MIC.2017.2911418
- <sup>3</sup> In Ismaël, . W., & Nova Science Publishers,. (2020). *Phase change materials: Technology and applications.*, Page: 58

