OPEN POSSIBILITIES.

Preparing Meta For Growing Power Demand: Thermal Perspective

OCP GLOBAL SUMMIT

NOVEMBER 9-10, 2021

DCF

Preparing Meta For Growing Power Demand: Thermal Perspective

Manasa Sahini, Data Center Systems Thermal Engineer, Meta

Jayati Athavale, Thermal Engineer, Meta

OPEN PLATINUM™

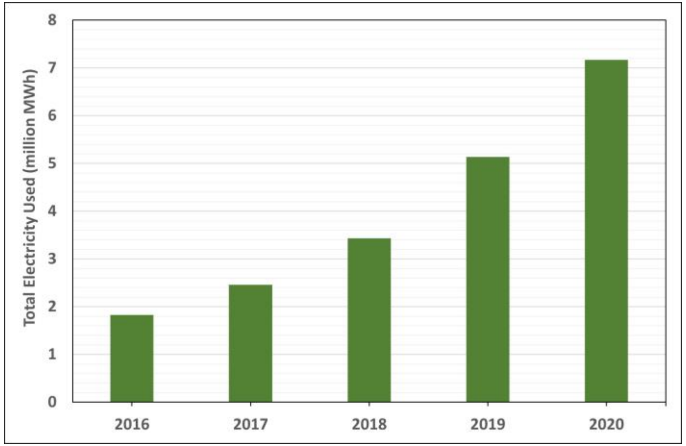
OPEN POSSIBILITIES.

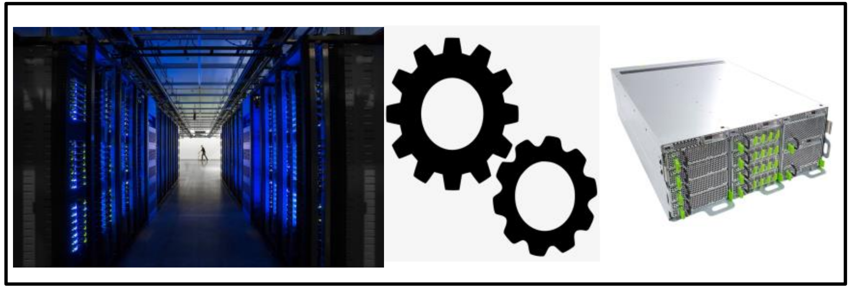
OCP GLOBAL SUMMIT
NOVEMBER 9-10, 2021

Agenda

- Background and Motivation
- Problem Statement
- Aisle Level Evaluation
- Rack Level Evaluation
- Mitigation Strategy

Background and Motivation

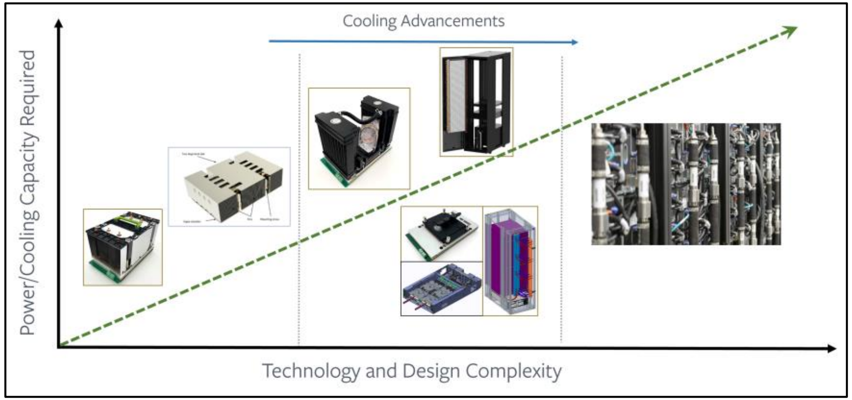




- Meta's IT capacity has grown significantly in the last few years and is likely to continue increasing
- Increasing processor power →increase in rack power density
- It is important to ensure compatibility and safe interoperability of HW and Data Center Facility

Source for graph data: https://sustainability.fb.com/wp-content/uploads/2021/06/2020_FB_Sustainability-Report-1.pdf

Problem Statement



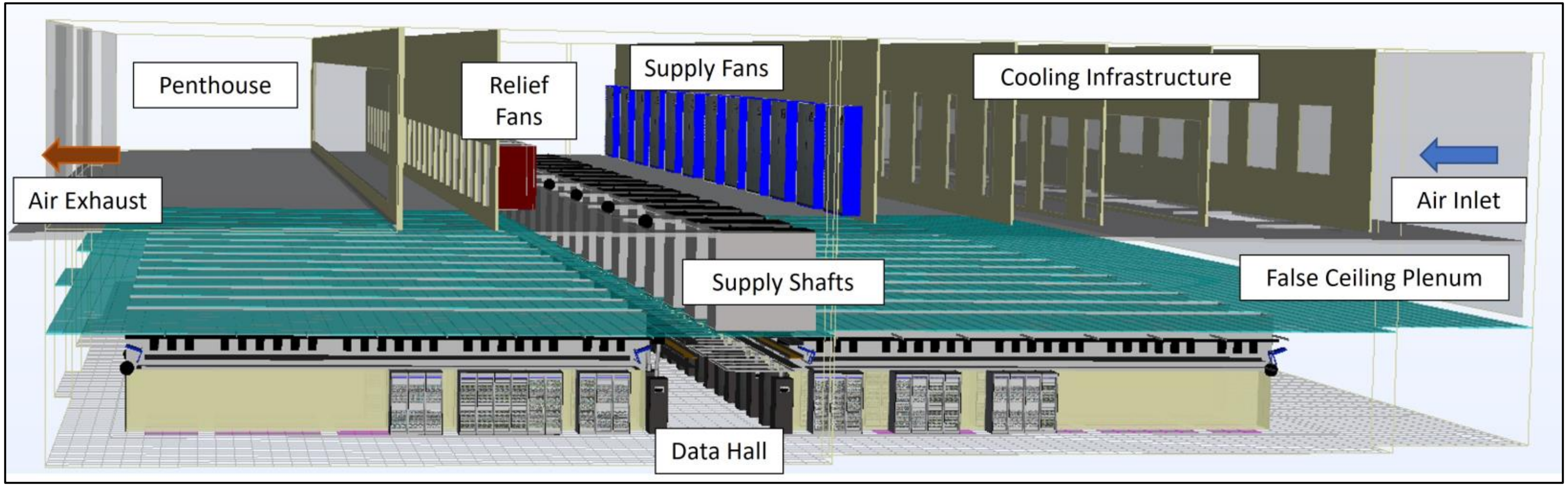
- Assuming same DC envelope-

Higher Rack Power → *Higher Rack Airflow*

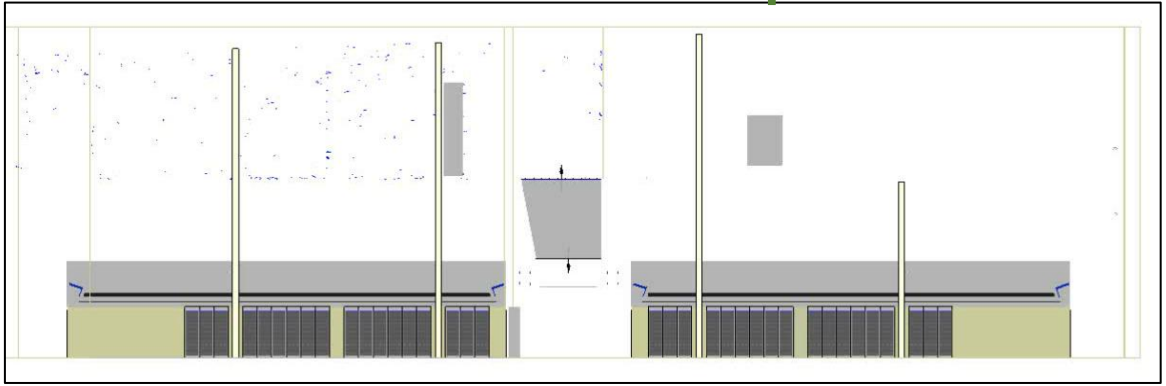
In this study, we focused on:

- Trying to define bounds/constraints for existing DC facilities to support these high airflow racks
- Proposing potential solutions to enable high airflow rack deployment via design and operational changes

Meta Data Center



Data Center Airflow path

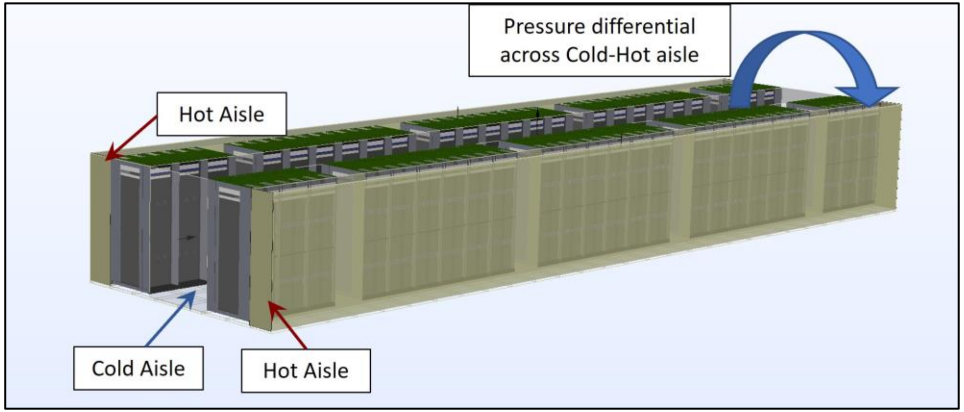


Data center infrastructure is standardized for IT capacity, cooling configuration and rack & containment layout

OCP GLOBAL SUMMIT

NOVEMBER 9-10, 2021

Meta Data Center



- Data center operating envelope is between 65-85F
- In typical operation, a positive pressure differential is maintained across cold aisle to hot aisle

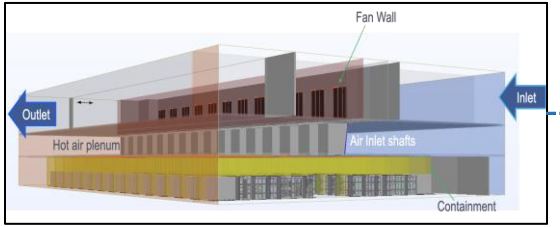
Thermal Risk Assessment

- Thermal risk is determined to be high if analysis shows system inlet temperature > HW design spec

Levels of Evaluation

Power Supported Defined on

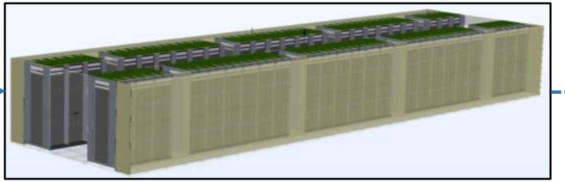
Data Center Level



- Dependent on overall cooling airflow available in data hall

$$Power\ Supported = \frac{Airflow\ Available}{Design\ CFM\ per\ watt}$$

Aisle Level



- Dependent on overall airflow and its distribution in data hall
- Estimated by data hall level CFD analysis

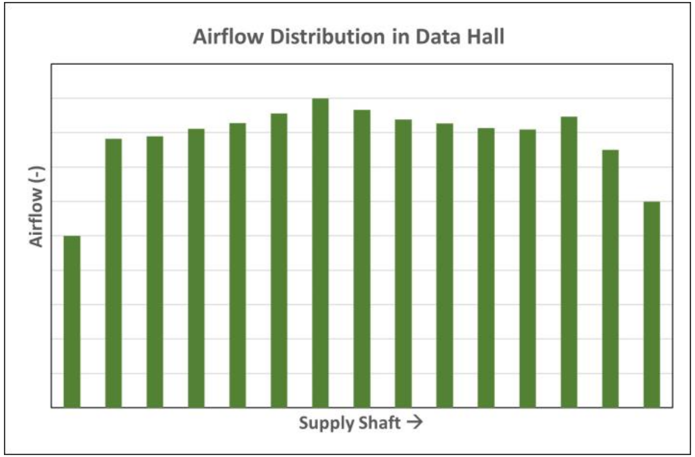
Rack Level

- Dependent on overall airflow, its distribution in data hall and aisle layout
- Estimated by data hall/aisle level CFD analysis and experimental studies

Aisle/Row Level Evaluation

- Goal: Determine IT airflow demand that can be safely supported in data hall cold aisles

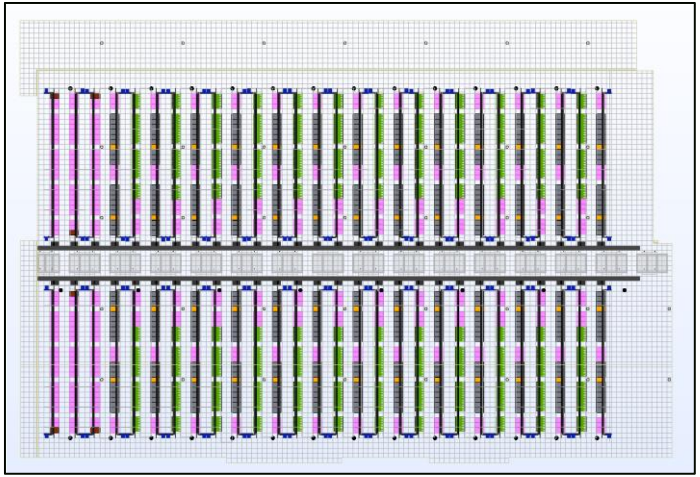
- Allows for more generalized planning; agnostic of rack configuration, CFM/W spec and individual rack power



Aisle/Row Level Evaluation

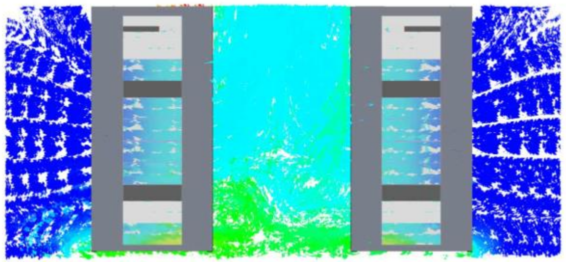
CFD Modeling Considerations

- Simulations considered high end supply temperature and accounted for one fan line-up failure scenario

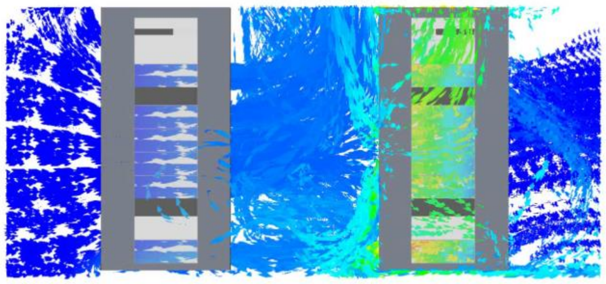


- For generalized guidance, simulation considered racks with worse thermal performance (CFM/W number)
- To remove layout dependence, racks were placed at far end on the aisle
- Pressure based rack bypass has been accounted for in the model

Rack Level Constraint Evaluation



Side view: Normal operation of air flow



High speed operation of airflow

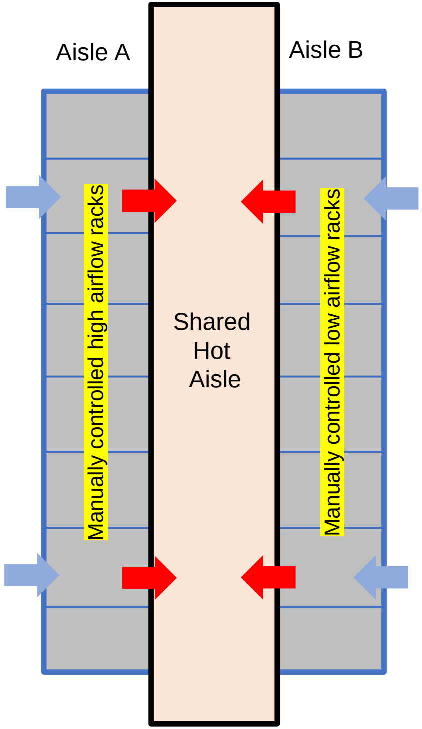
<u>Possible causes</u>:
Recirculation or High back pressure

Recirculation is a phenomena that causes hot air leaks into cold aisle and increases air temperatures of the rack

Higher Recirculation → Higher Thermal Risk

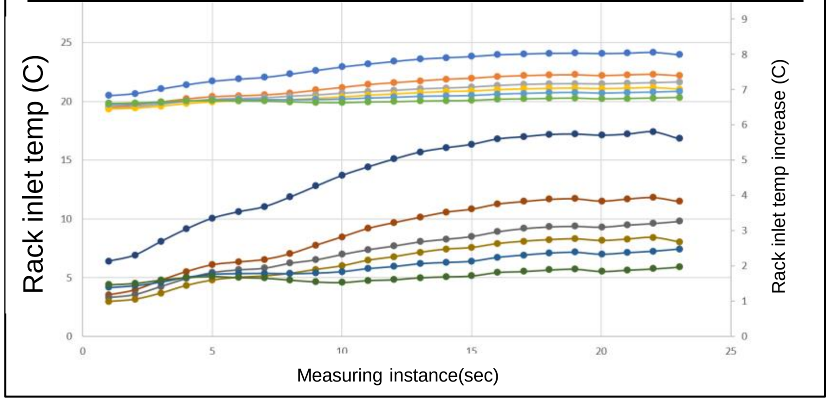
Rack Level Constraint Evaluation

Data center thermal testing



Airflow Scenarios up to 2000-3000 CFM in real-time data center have been tested

Test condition: High Airflow rack[aisle A] : 2300 CFM vs 700 CFM Low Airflow rack [Aisle B]

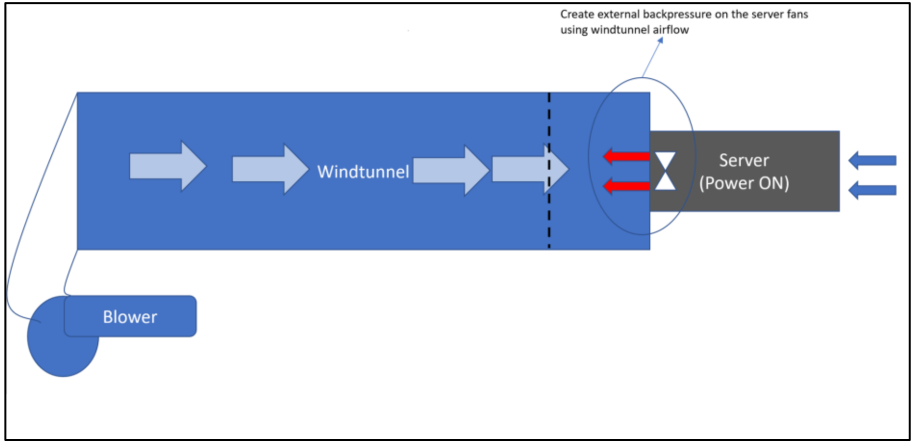


Inlet temperature increase on low airflow rack ~6C

- Inlet temperature increase on low airflow racks is observed
- No impact when both racks are drawing high airflows

Rack Level Constraint Evaluation

Server level testing

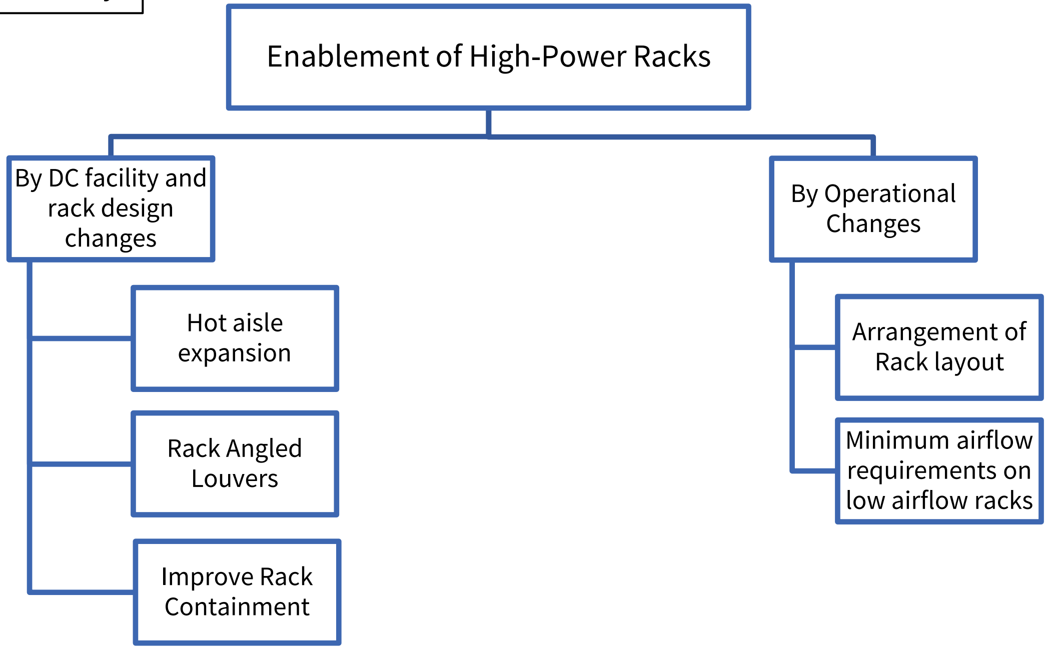


- With increased backpressure, components temperature increase due to reduced airflow intake is observed
- Increase in server inlet temperature is not observed
- Hence, DC level rack temperature increase is external to the server and is caused due to rack-aisle containment gaps and leakages

If left unchecked, this phenomena could cause high thermal risks as well as contribute to operational inefficiencies

Mitigation Strategies

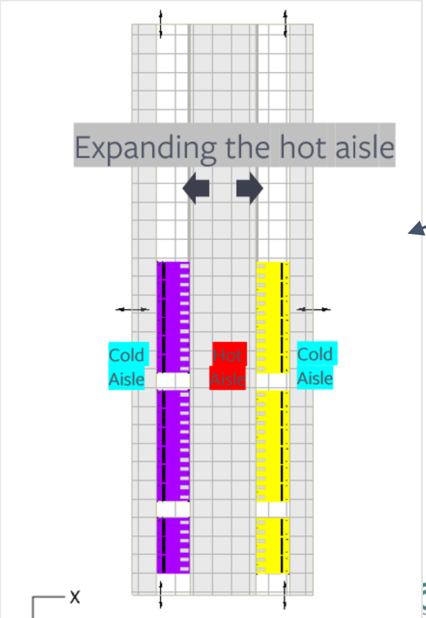
Addressing the risk and inefficiency



Recirculation Mitigation Strategies by Design changes

With current containment spacing, the high CFM TSC racks cause thermal risk issues and resulting ramped up rack fan operating powers.

The current study analyzes different mitigating strategies as follows

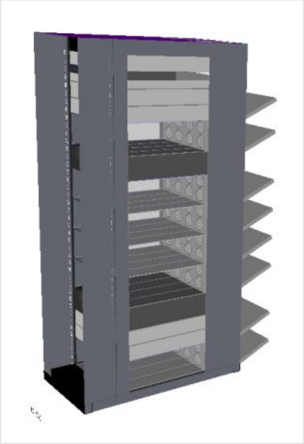


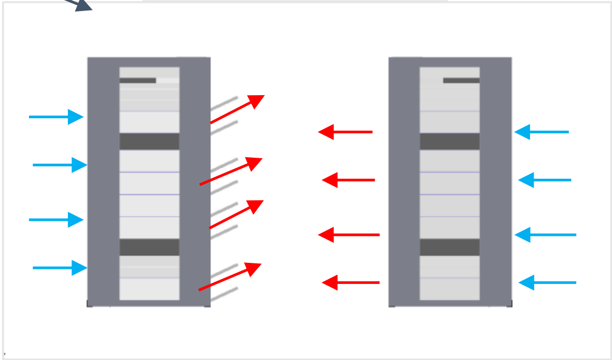
Top view of the racks

1. Hot aisle width expansion

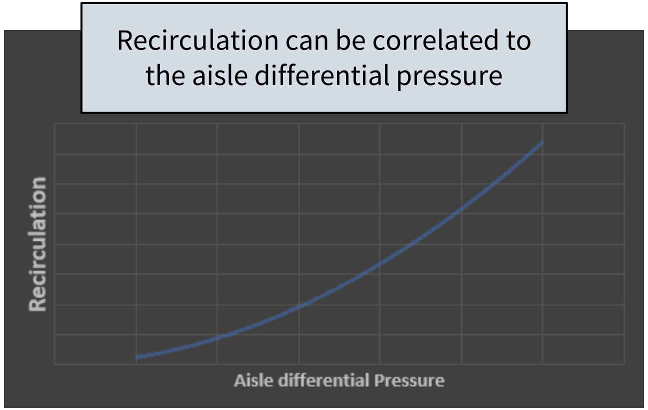
2. Placing angled louvers on the TSC rack

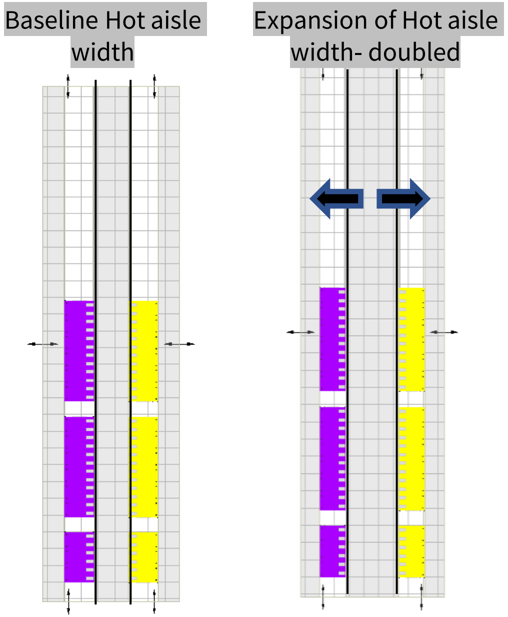
3. Improved Rack containment changes





Impact due to Hot Aisle Expansion





- Defined optimum hot aisle width for rack airflow 3500 cfm
  - Increasing the hot aisle width by 1 ft reduces dP by 10% → Feasible
  - Increasing the hot aisle width by 3 ft reduces dP by 27% → Too wide to implement

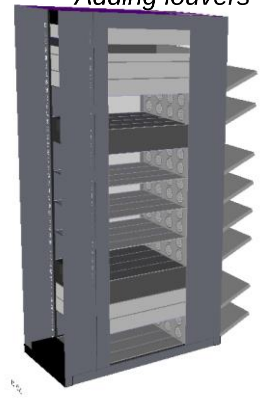
OPEN POSSIBILITIES.

*CFM: cubic ft per min [unit of airflow]
*dP : Differential pressure [pressure difference between hot aisle and cold aisle that causes airflow motion]

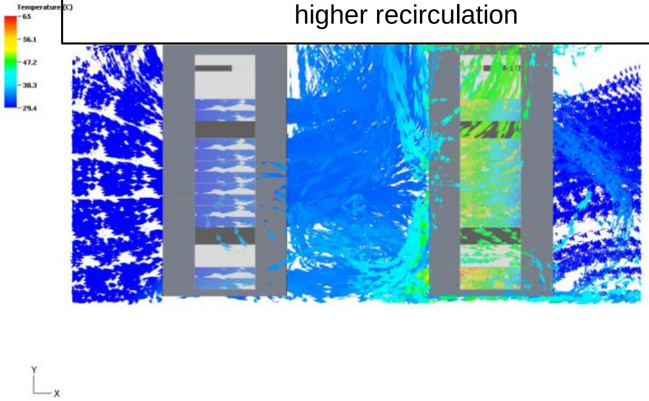
Impact of Angled louvers on Rack

- Adding back-end louvers further reduced dP
  - Reduced the dP by 28%

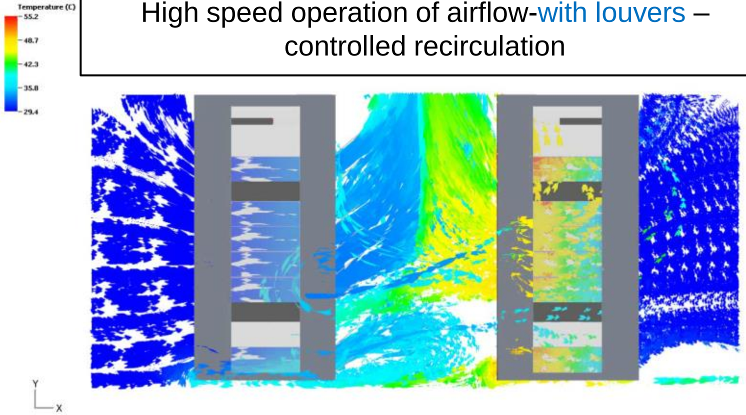
Adding louvers



High speed operation of airflow-without louvers – higher recirculation



High speed operation of airflow-with louvers – controlled recirculation



- A combination of hot aisle width expansion and rack back-end louvers is an optimal solution
  - -Reduced dP by 72%

Recirculation Mitigation Strategies by Operational changes

- Arrange rack layouts such that high power racks can only face other high-power racks
- Develop guidelines for minimum airflow requirements on low power racks to be rear-facing high-power racks

Call to Action

- Above learnings can help Hyperscale data center operators define system level constraints specific to their own data center facilities design
- OCP hardware design community can help enable rack design changes like adding louvers, improving containment such that high thermal risk and operational inefficiencies can be mitigated at data center scale

Contributors

- Systems Engineering team
- Hardware Engineering team
- Strategic Engineering & Design team
- Facilities and site Operations teams

Thank you!