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Open Compute Project
Datacenter Design

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5.10.12

Agenda

1. Introduction
2. Electrical
3. Mechanical
4. Operations
5. Next Steps

Introduction

Facebook Greenfield Datacenter

Goal

- Design and build the most efficient datacenter eco-system possible

Control

- Application
- Server configuration
- Datacenter design

Sites

- Prineville, OR
- Forest City, NC
- Luleå, Sweden


Prineville, OR


Prineville, OR


Prineville, OR
Solar Panels

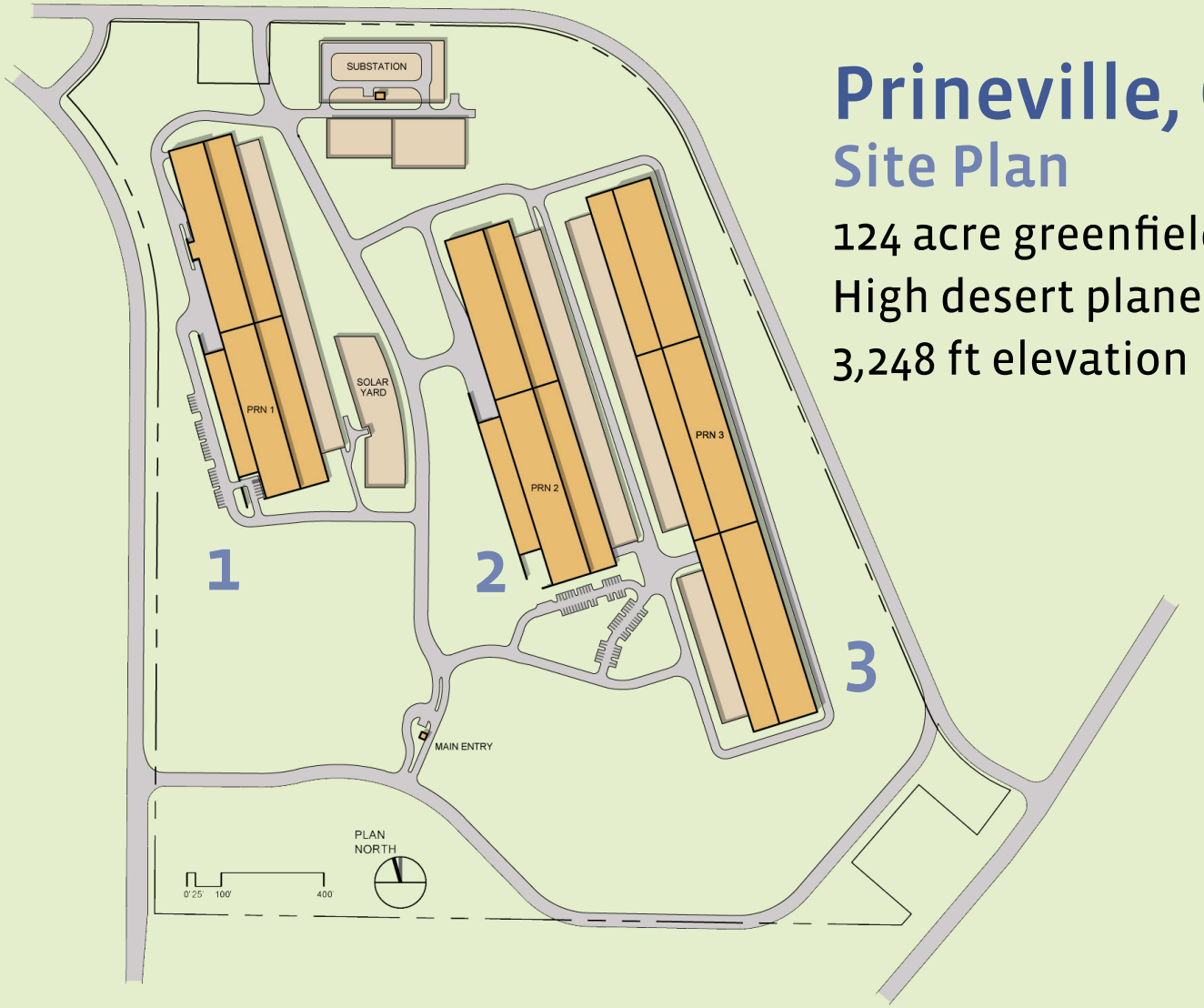
Prineville, OR

Site Plan

124 acre greenfield

High desert plane

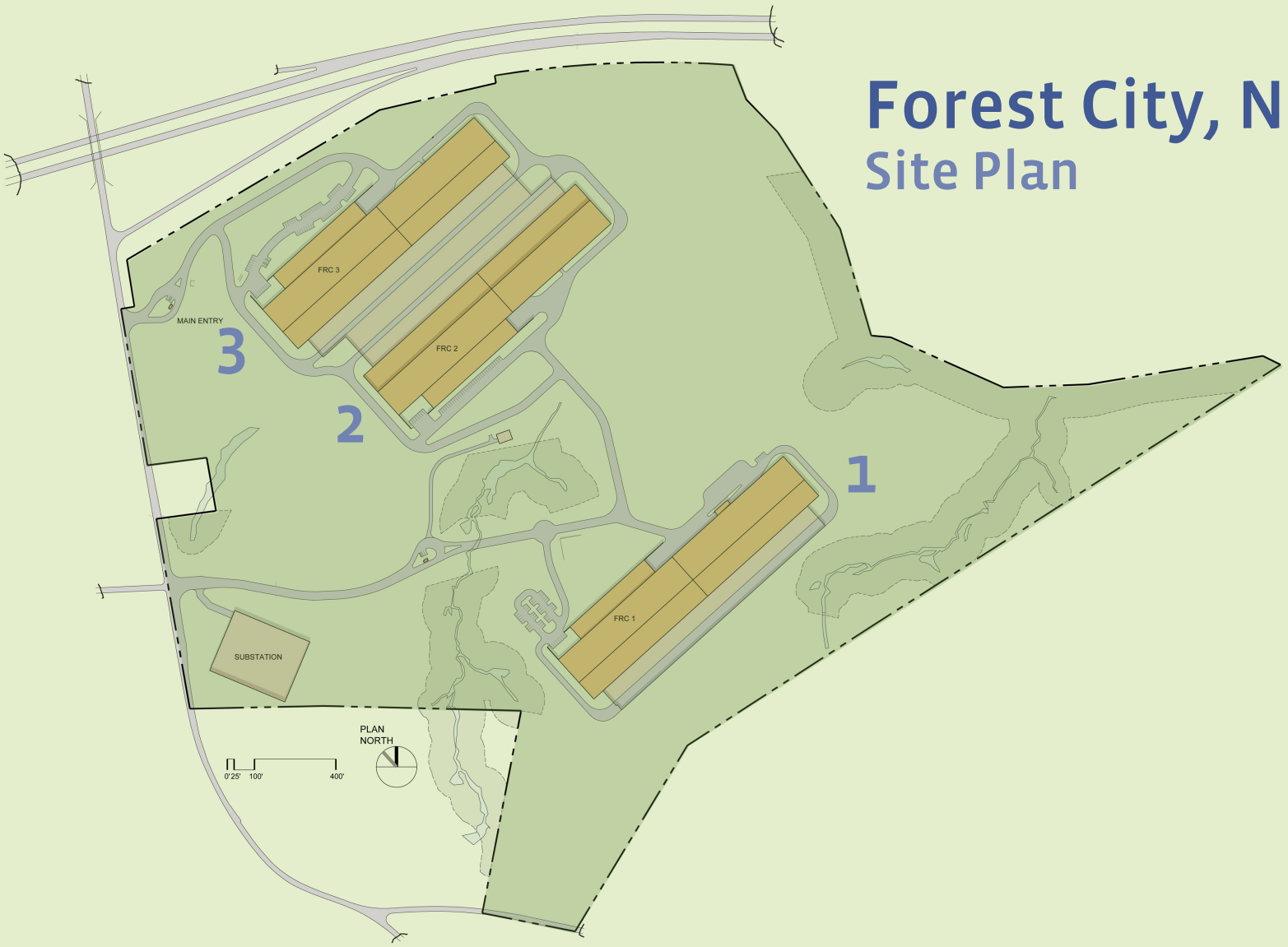
3,248 ft elevation

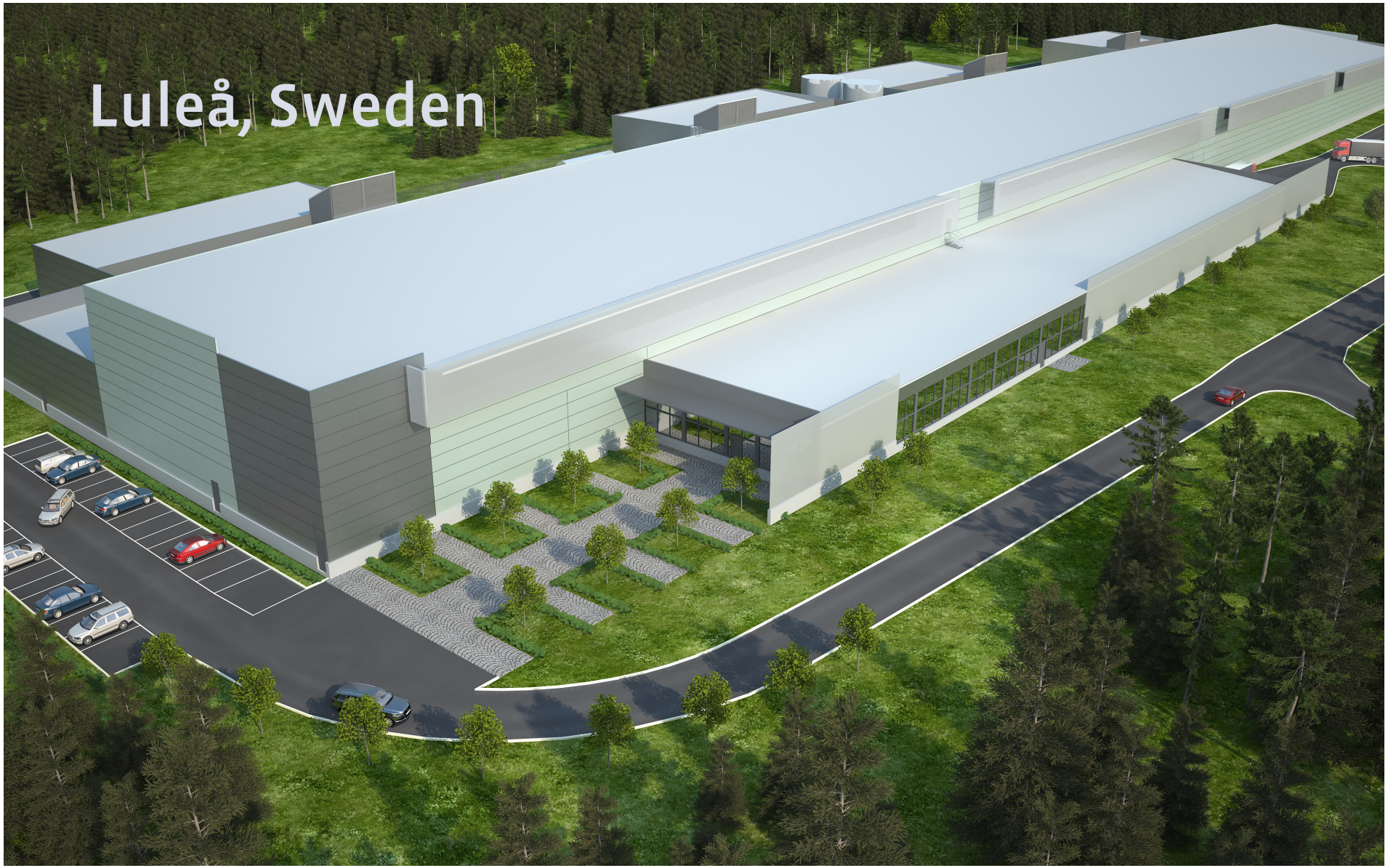



Forest City, NC

Forest City, NC

Site Plan

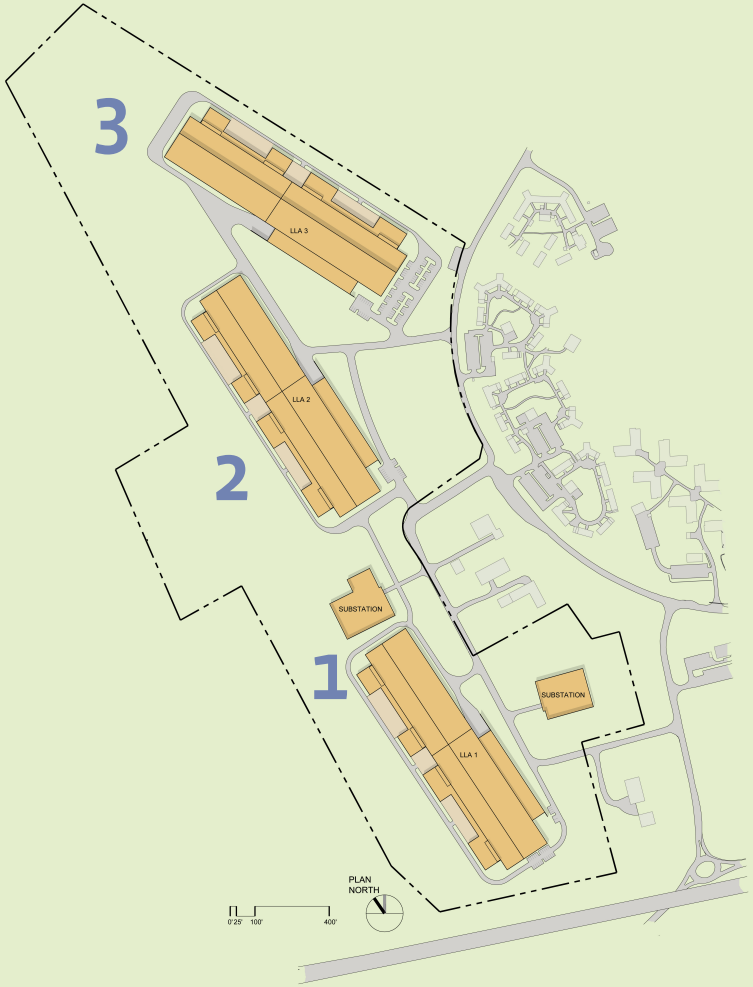



Luleå, Sweden


Luleå, Sweden

Luleå, Sweden

Site Plan

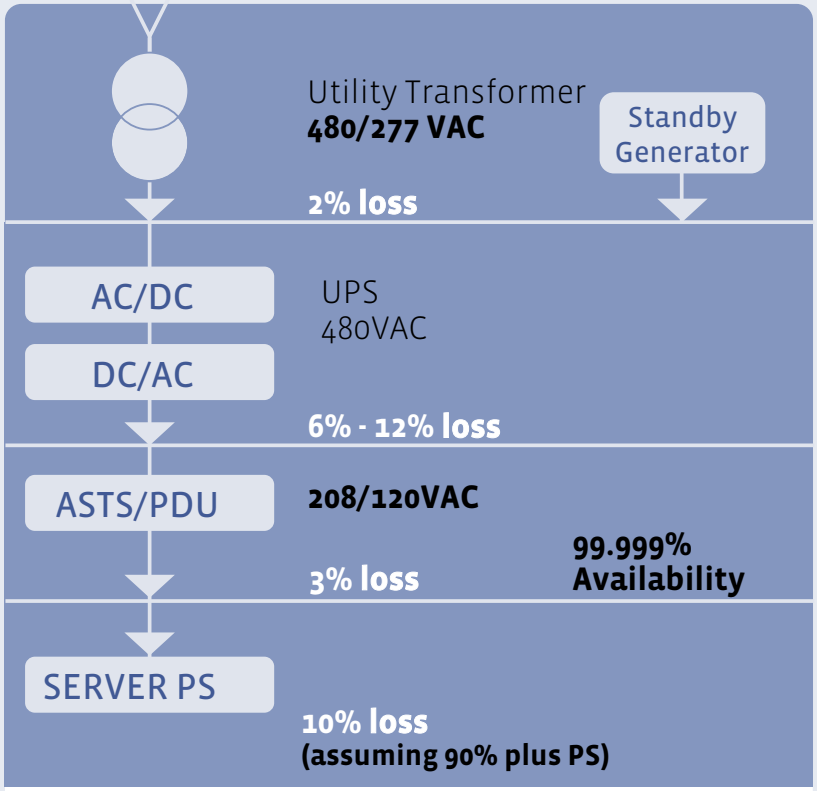


Electrical

Electrical Overview

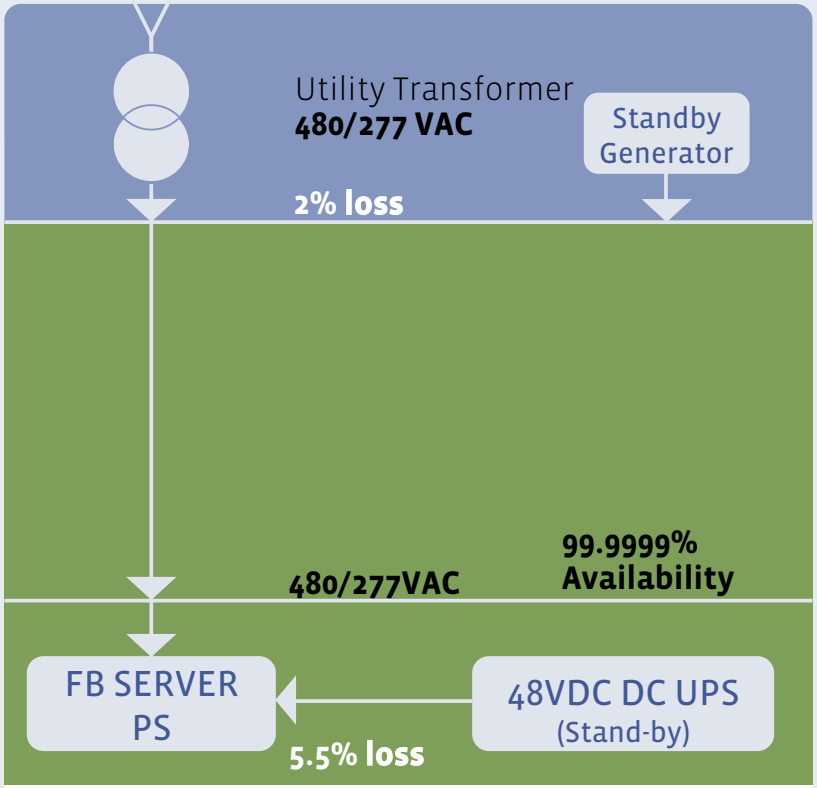
- **Eliminate** 480V to 208V transformation
  - Used 480/277VAC distribution to IT equipment
- **Remove** centralized UPS
  - Implemented 48VDC UPS System
- **Result** a highly efficient electrical system and small failure domain

Typical Power



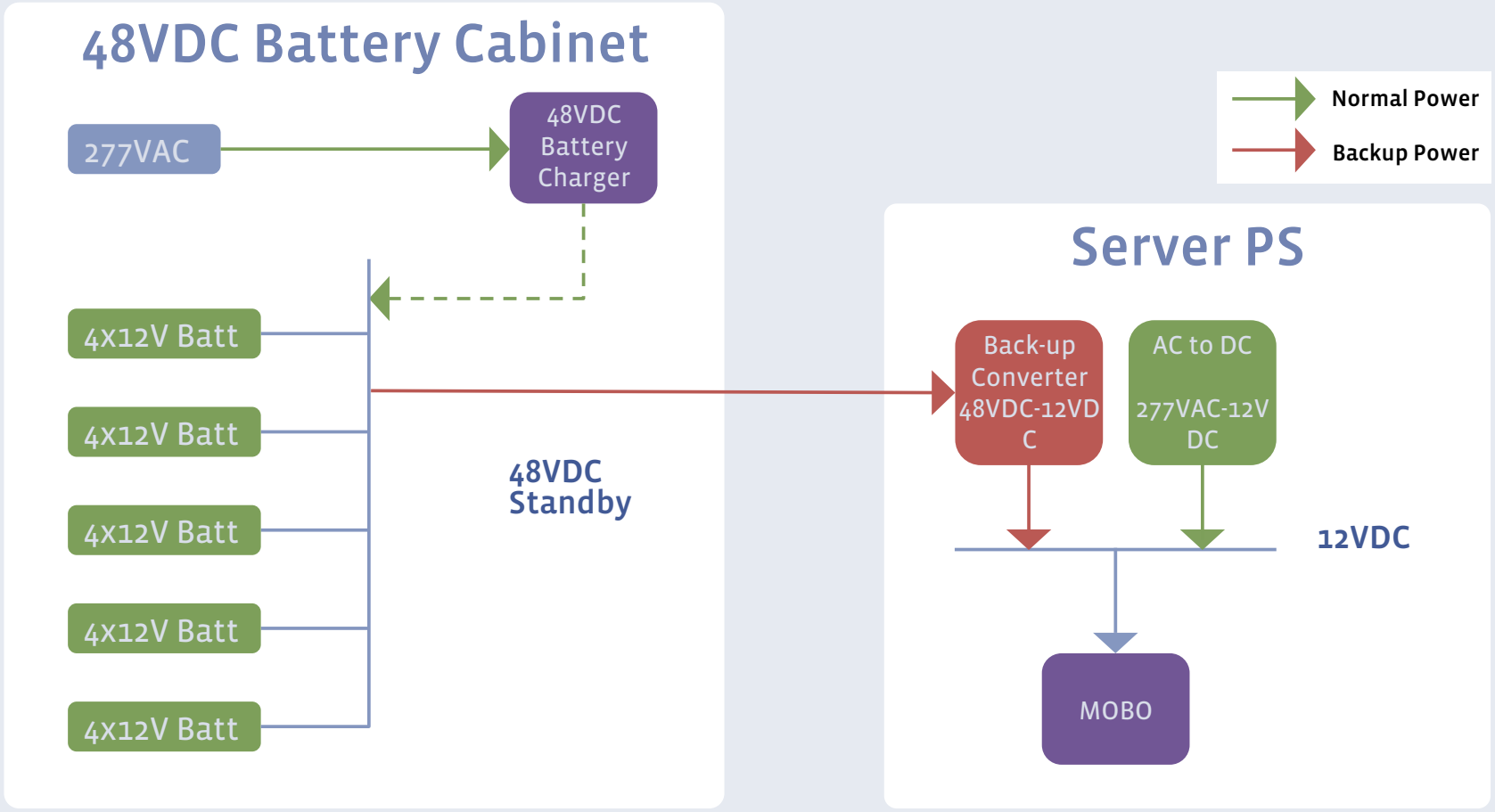
Total loss up to server:
21% to 27%

Prineville Power



Total loss up to server:
7.5%

DC UPS Backup Scheme

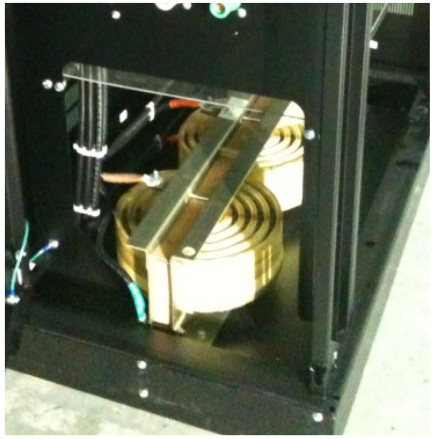


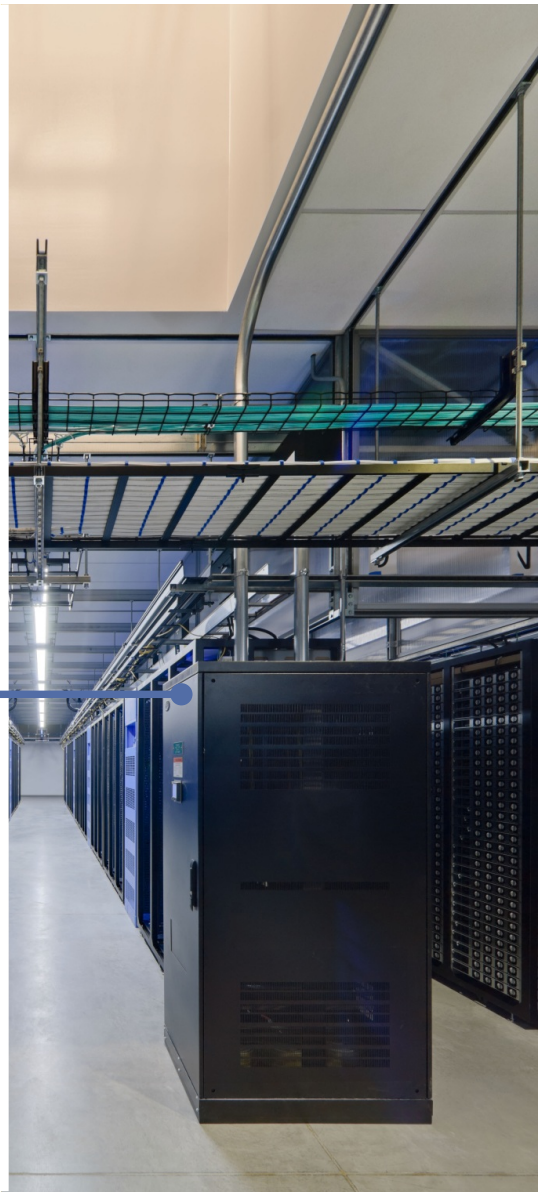
Battery Cabinet

- Custom DC UPS
- 56kW or 85kW
- 480VAC, 3-phase input
- 45 second back-up
- 20 sealed VRLA batteries
- Battery Validation System
- Six 48VDC Output
- Two 50A 48VDC aux outputs

Reactor Power Panel

- Custom Fabricated RPP
  - Delivers 165kW, 480/277V, 3-phase to CAB level
  - Contains Cam-Lock connector for maintenance wrap around
- Line Reactor
  - Reduces short circuit current < 10kA
  - Corrects leading power factor towards unity (3% improvement)
  - Reduces THD for improved electrical system performance (iTHD 2% improvement)
  - Power consumption = 360 Watt



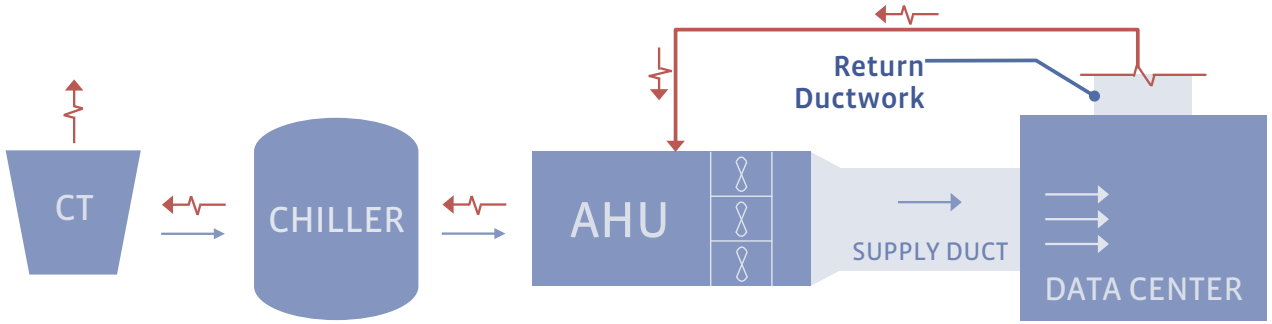


Mechanical

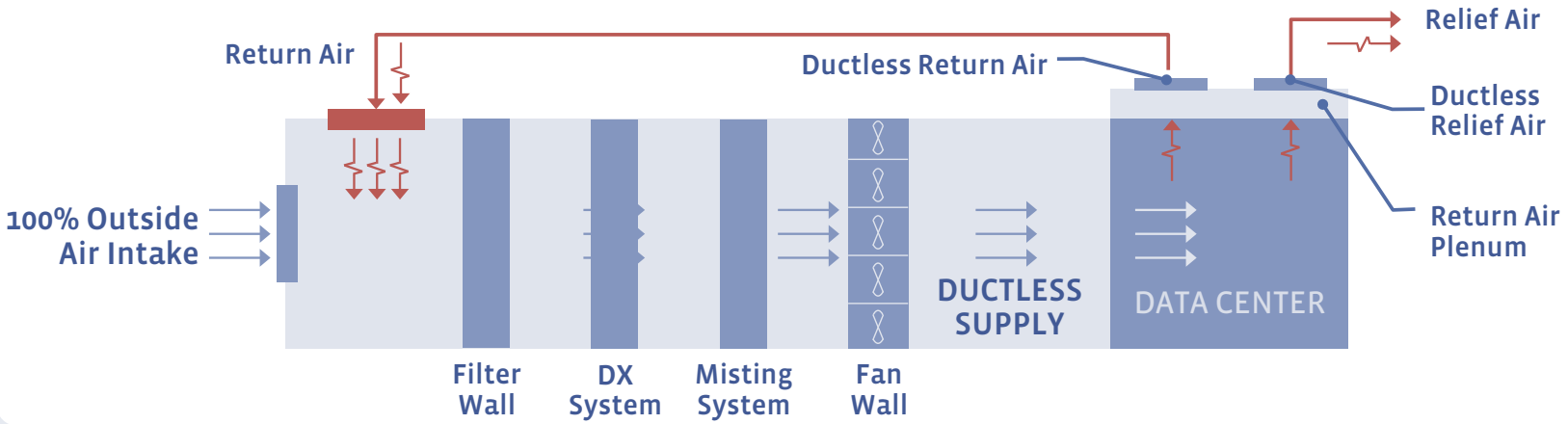
Overview

- **Removed**
  - Centralized chiller plant
  - HVAC ductwork
- **System Basis of Design**
  - ASHRAE Weather Data: N=50 years
  - TC9.9 2008: Recommended Envelopes
- **Built-up penthouse air handling system**
- **Server waste heat is used for office space heating**

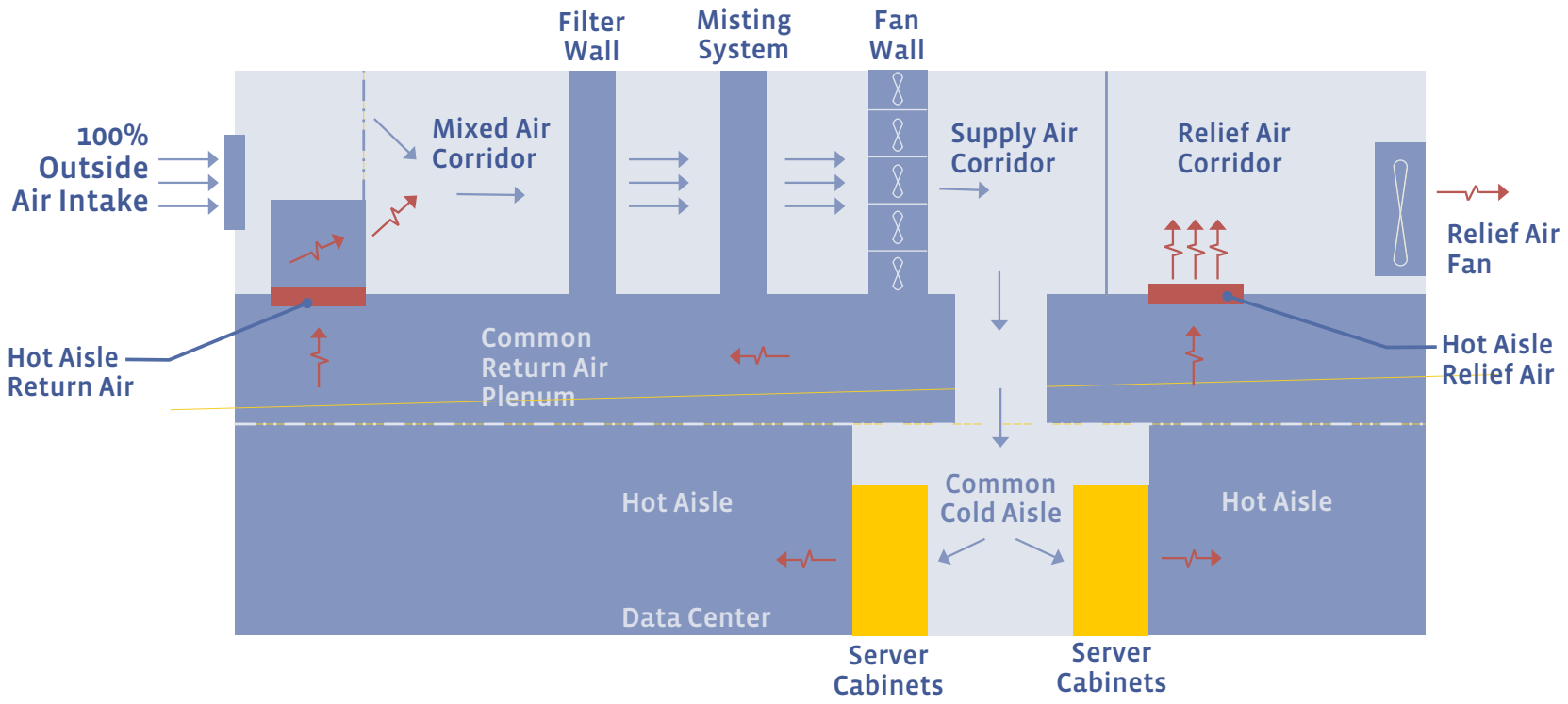
Typical Datacenter Cooling



Potential Datacenter Cooling



PRN1 Datacenter Cooling



Vertical drainable louvers

Outside air intake corridor

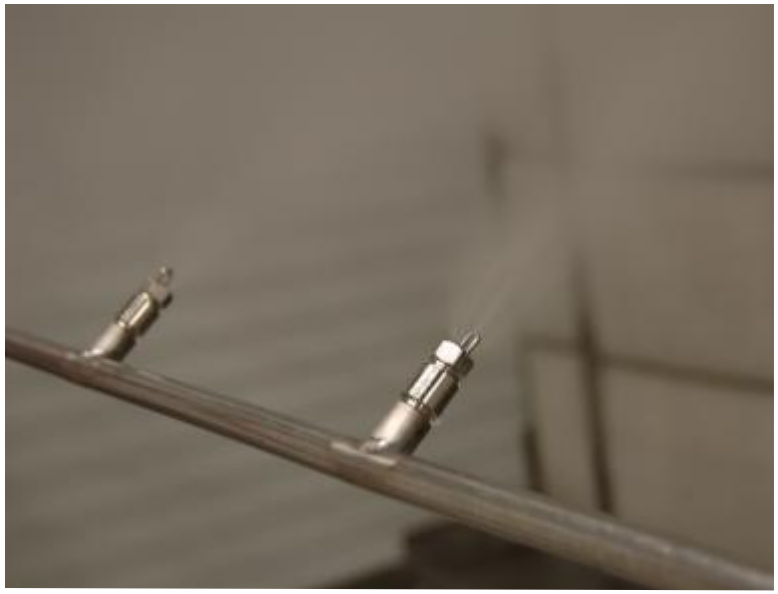

Air mixing section
Evaporative cooling /
humidification corridor

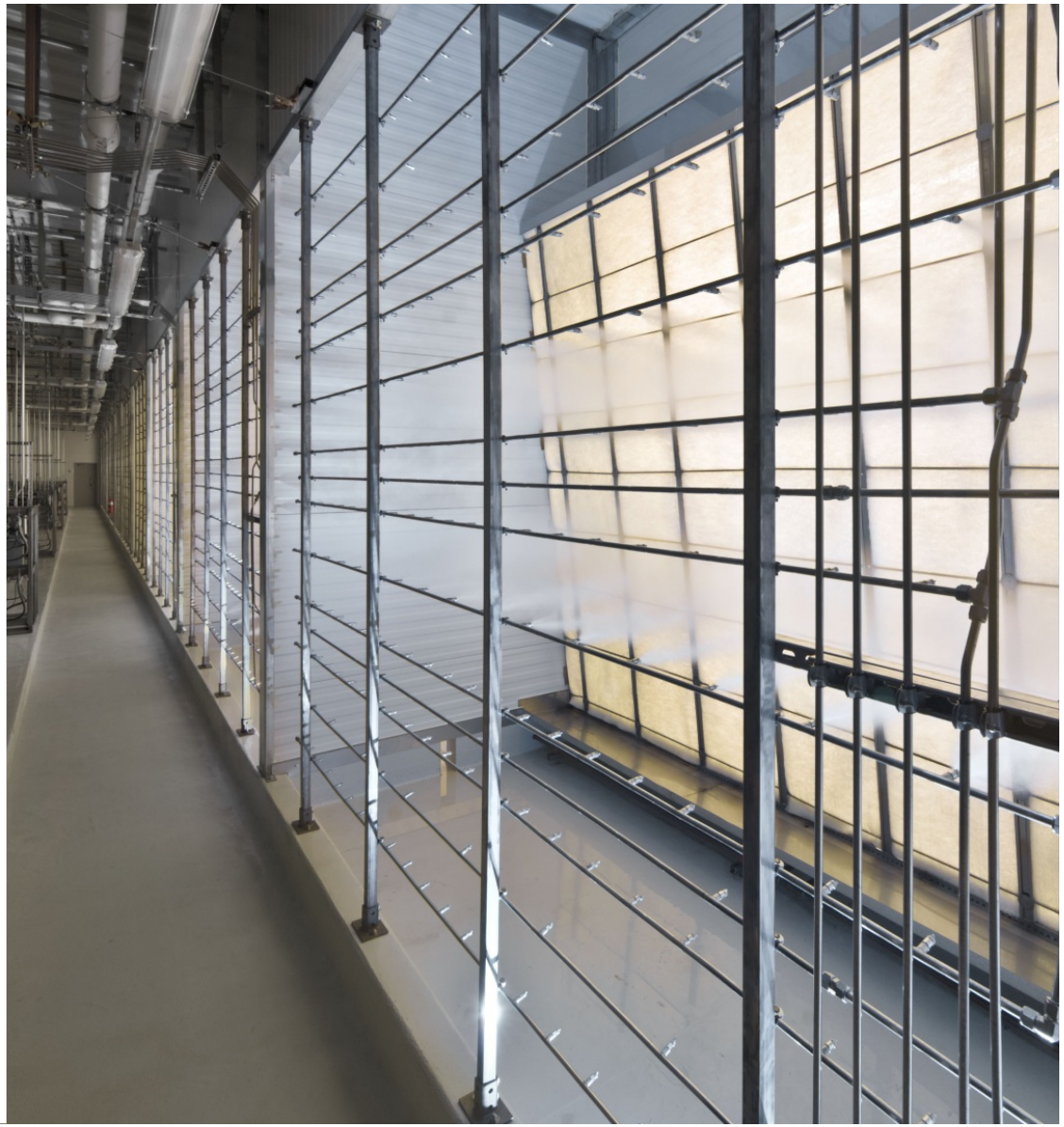
DX Cooling Coil

Forest City Only

- 50 year extreme weather conditions

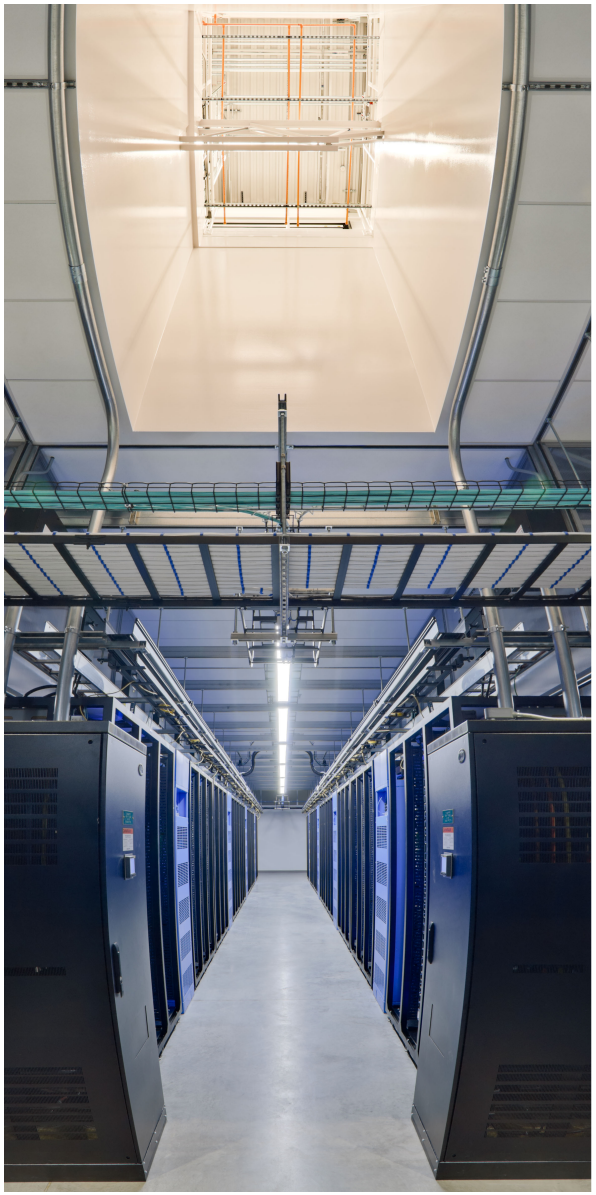

SIEMENS





Fan wall array inlet corridor

Fan array outlet / supply air corridor



Cold aisle pressurization –
ductless supply

Achievements

Prineville

PUE

1.07
full load
verified during
commissioning

WUE

0.31 liters/kWh
calculated value

ENR
Engineering News-Record

National Best Green
Building Project
2011

Operations

In-rush Current with PSU

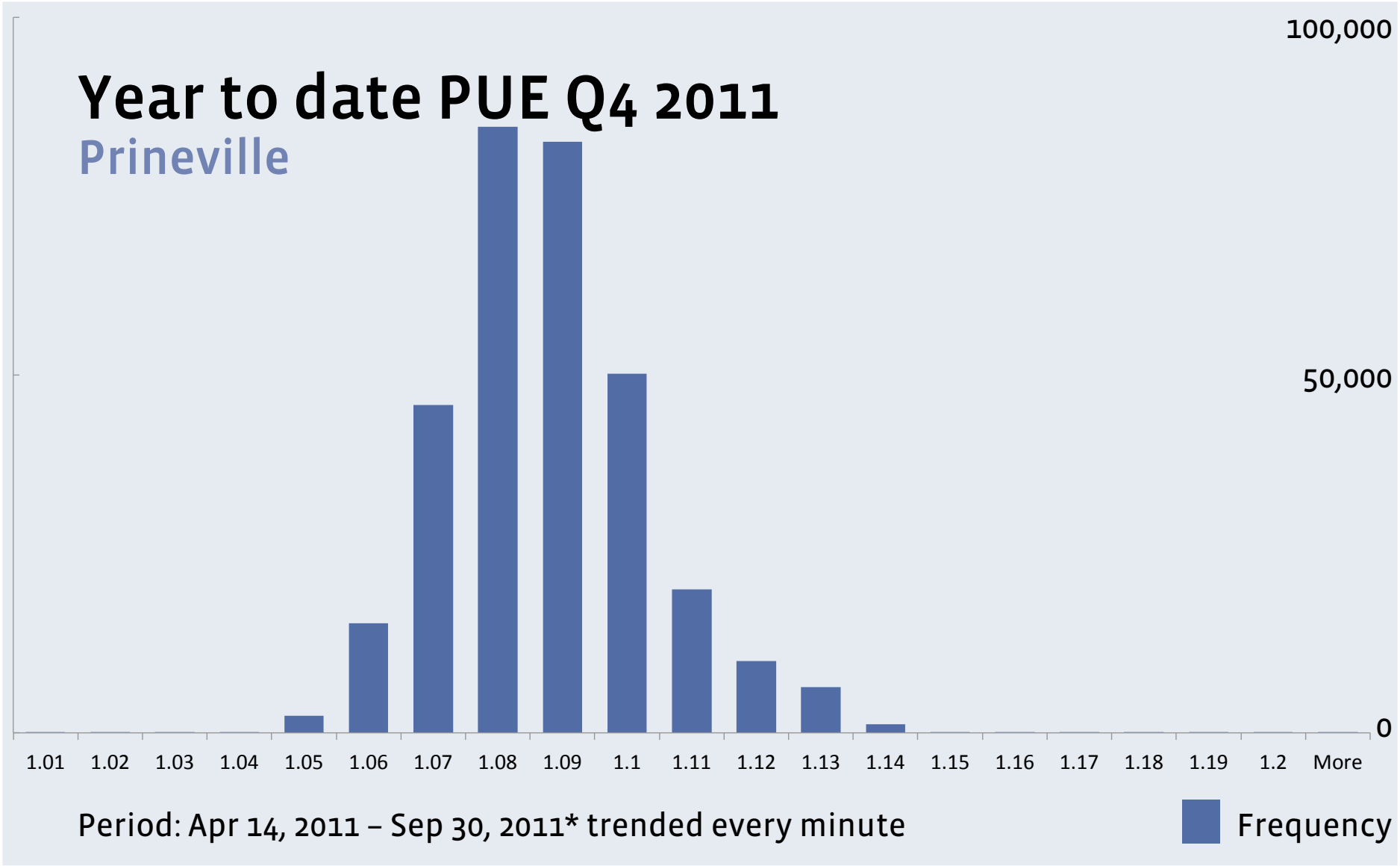
- Higher in-rush current experienced under repeated power outage
- Circuit Breakers see the high in-rush and trip on Ground Fault
- Cause due to PS input capacitor
- Adjusted setting accordingly to resolve issue


In-Row UPS

Controls Optimization

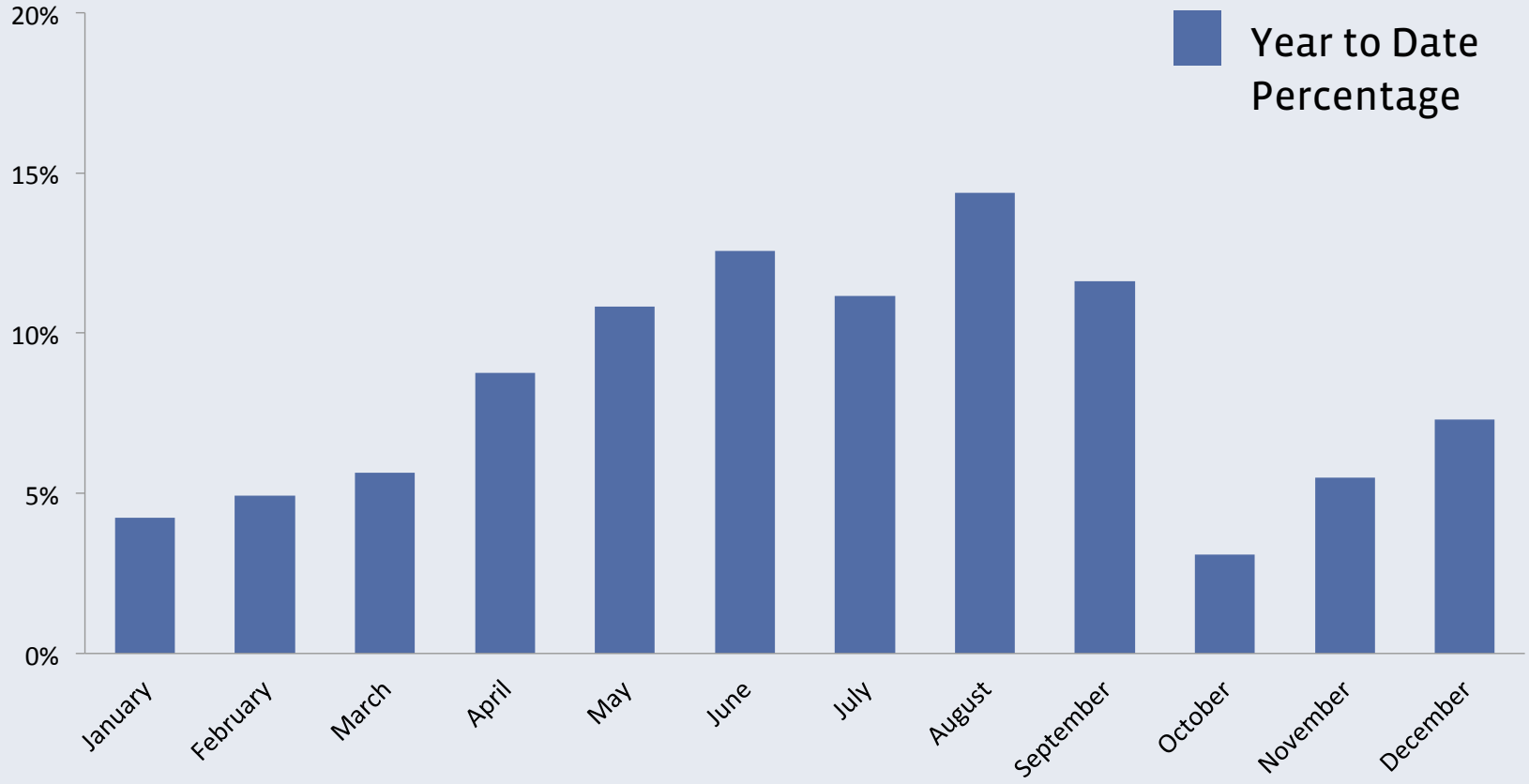
- Controls issues with a 100% OA economization with direct evaporative cooling
  - Error found in the controls sequence
  - Control loop tuning (14) independently controlled AHU line Ups


Perforated target plate


Year to date PUE Q4 2011
Prineville
100,000
50,000
0
1.01
1.02
1.03
1.04
1.05
1.06
1.07
1.08
1.09
1.1
1.11
1.12
1.13
1.14
1.15
1.16
1.17
1.18
1.19
1.2
More
Period: Apr 14, 2011 – Sep 30, 2011* trended every minute
Frequency

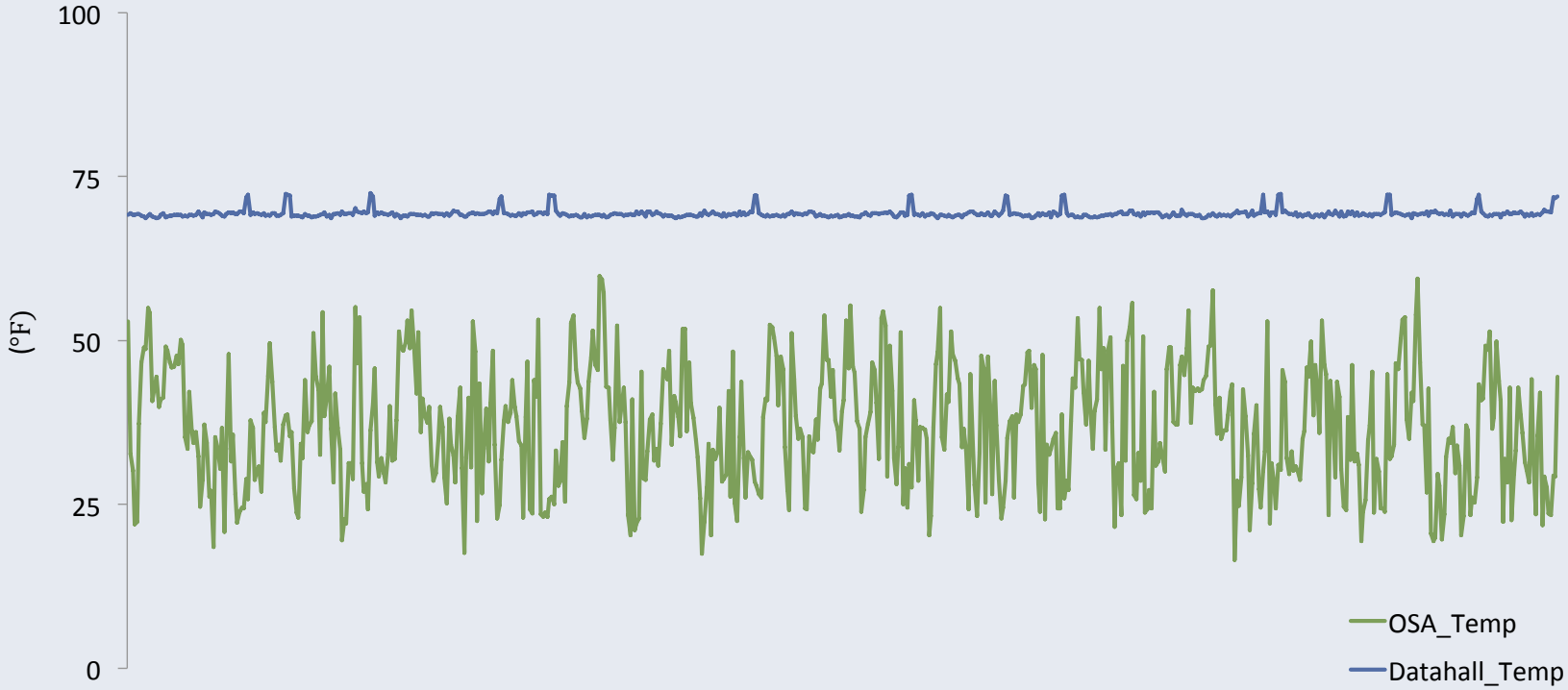
Water Usage

Prineville 1AB



OSA Temperature vs Datahall Temperature

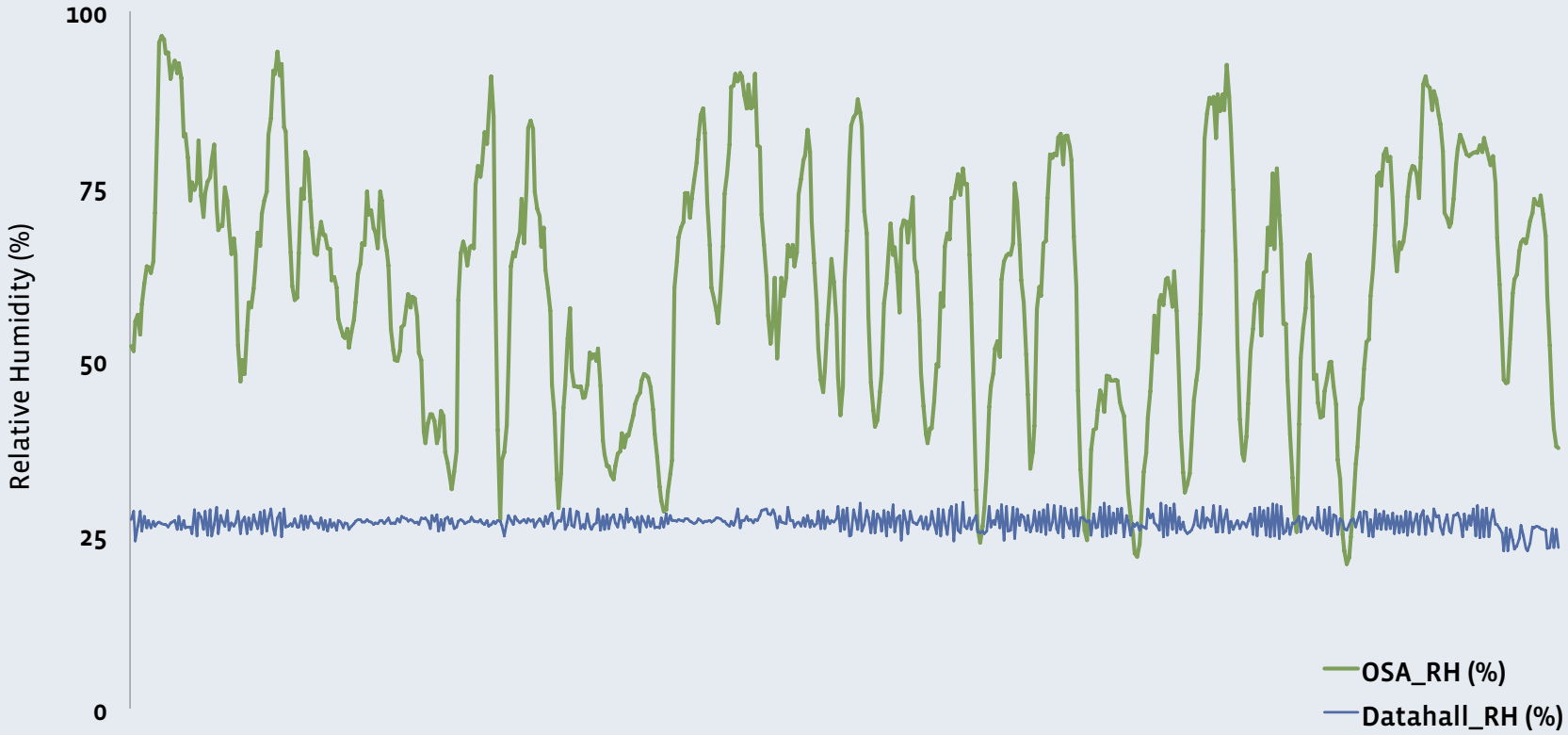
Prineville



November 18, 2011 - December 14, 2011

OSA RH vs Datahall RH

Prineville



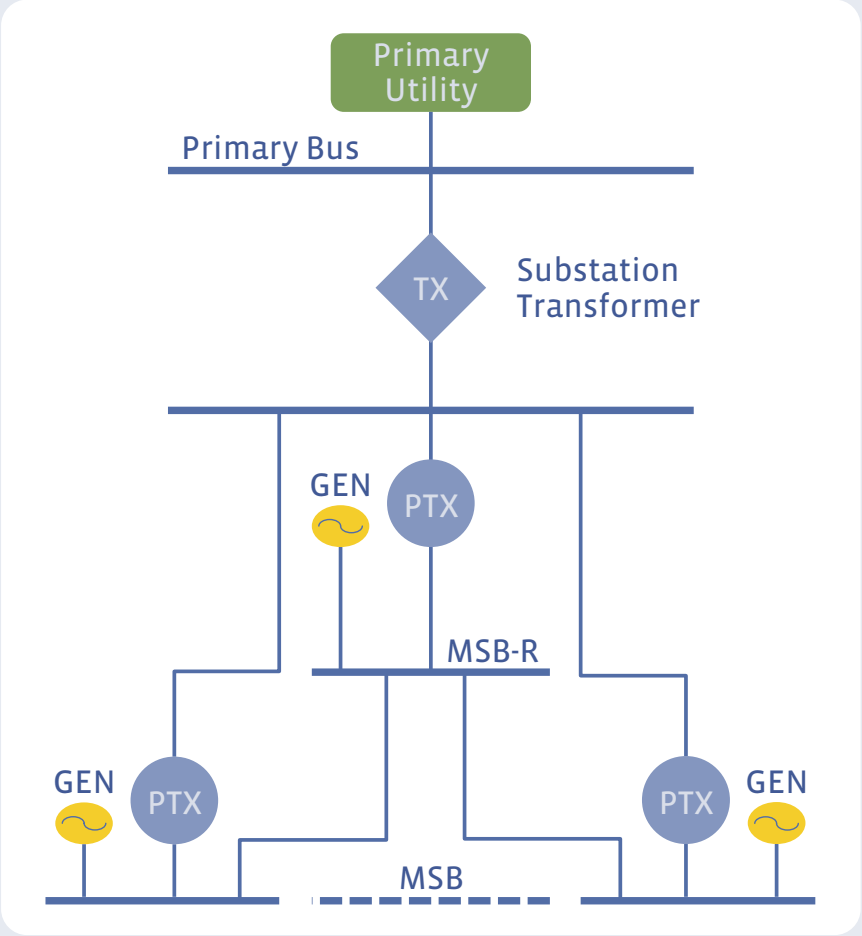
November 18, 2011 - December 14, 2011

Next Steps Electrical

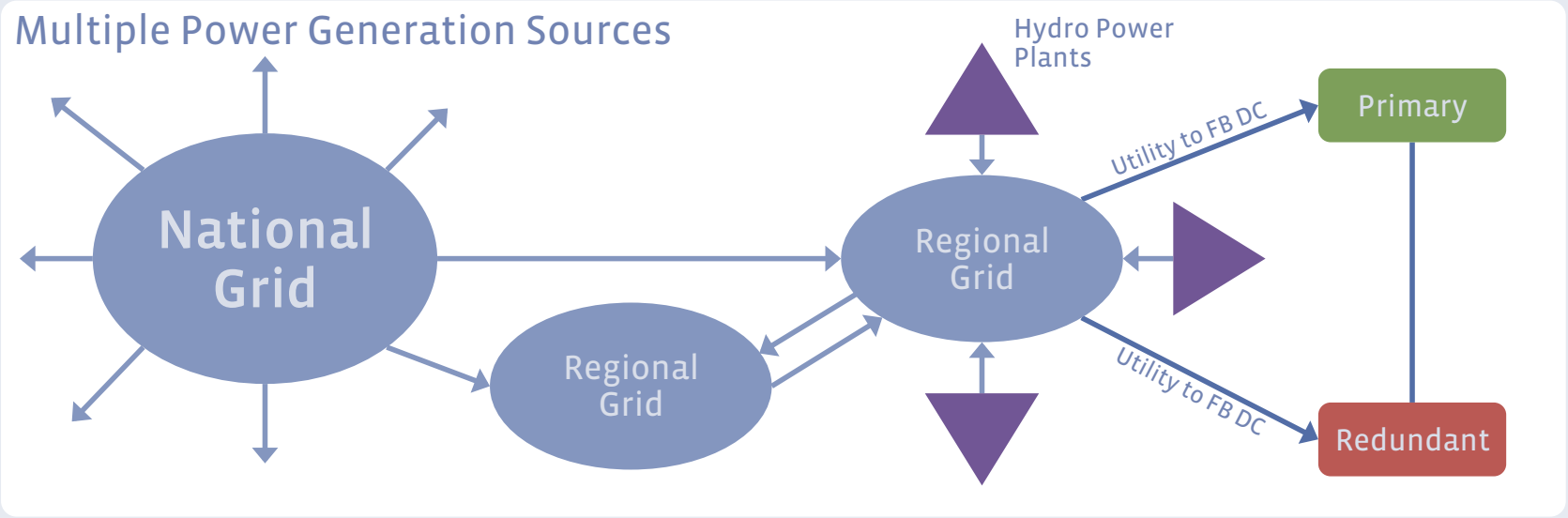
Initial Design

Luleå

- Typical single utility feed
- Standard design with generators



Power Path
Luleå

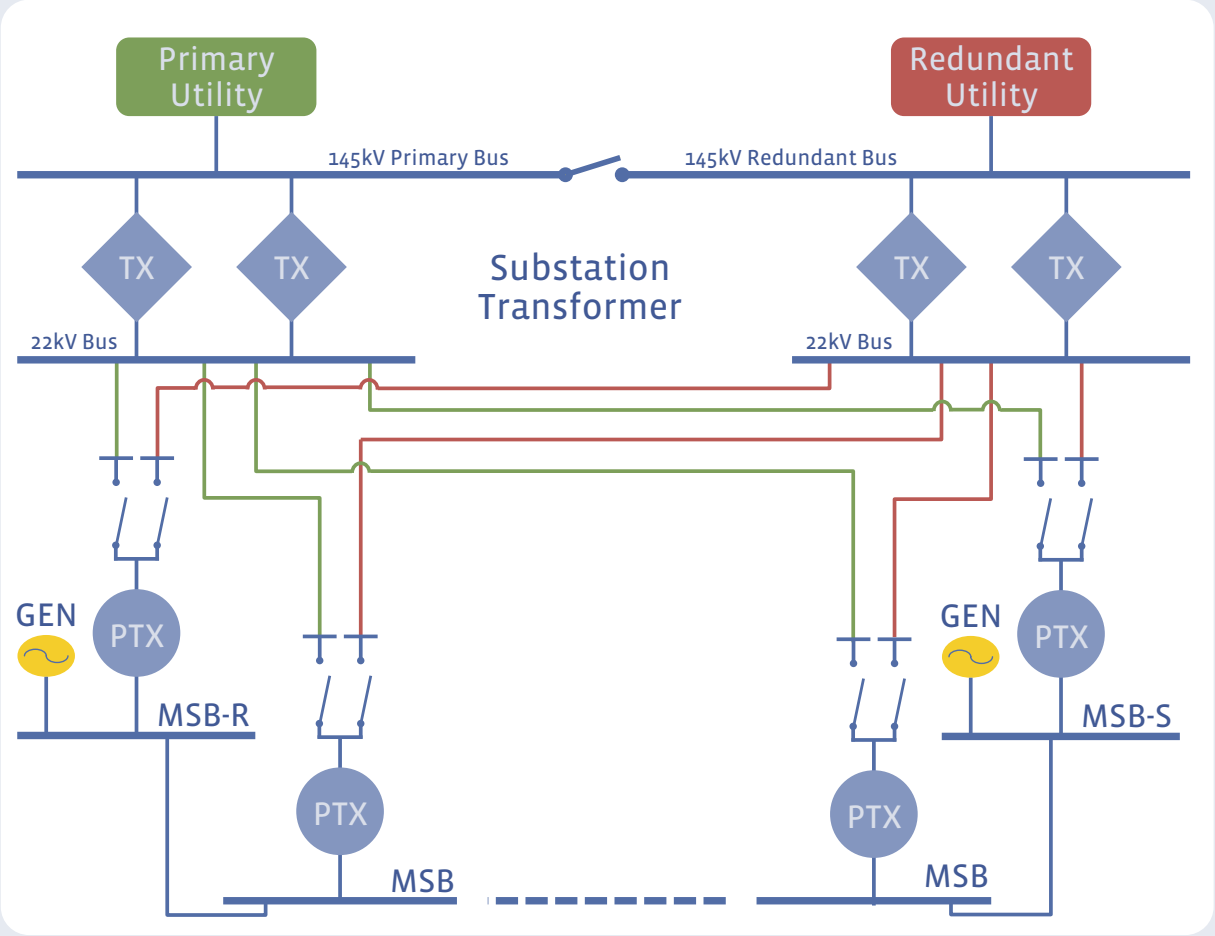


- Robust National Grid with hydro generation
  - No downtime since the 1970's
- 145kV lines to Primary and Redundant Substations from separate source and path

Final Design

Luleå

- Fully redundant system
  - Two separate 145kV utility lines
- 70% Less generators
  - Lower operating costs
    - Less fuel storage
    - Less maintenance



Next Steps Mechanical

Basis of Design Comparison

PRN1A1B	PRN1C1D	FRC1A1B	LLA1A1B
80°F inlet	85°F inlet	85°F inlet	85°F inlet
65% humidity	80% humidity	90% humidity	80% humidity
20°F ΔT	22°F ΔT	22°F ΔT	22°F ΔT

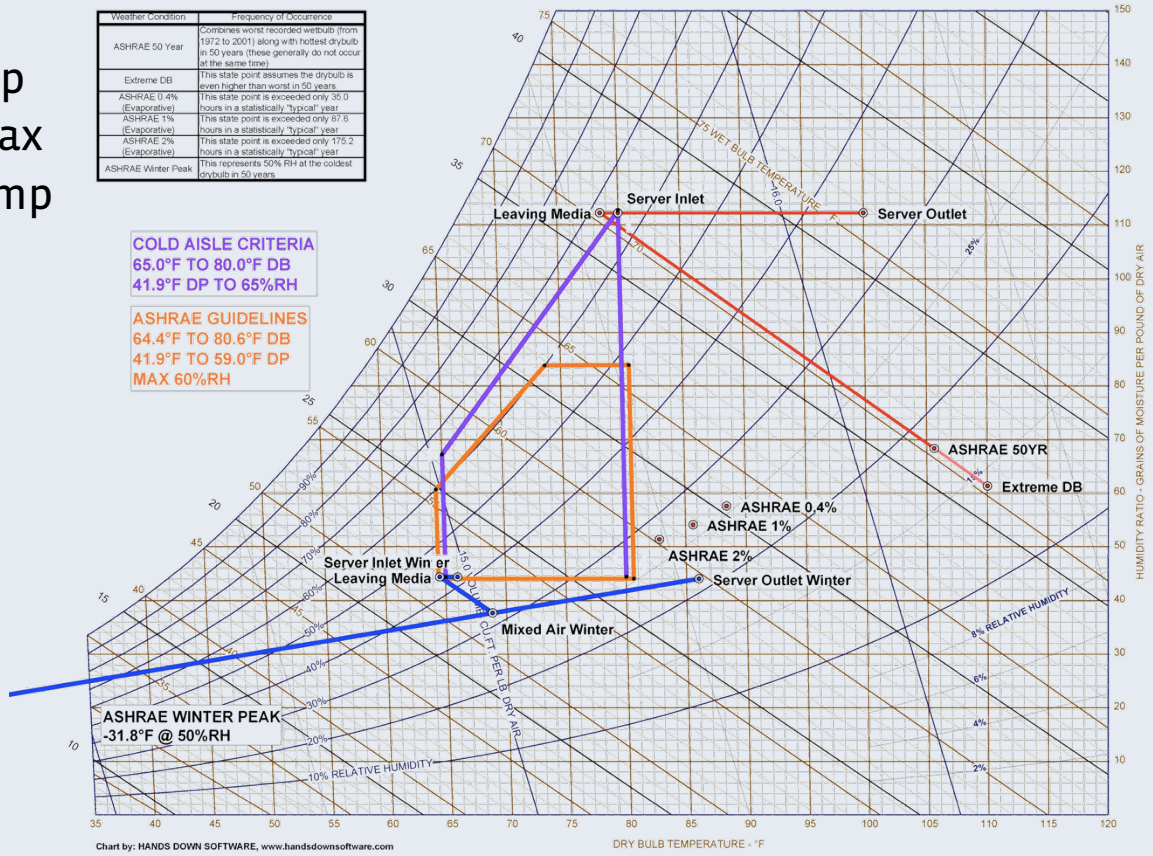
Modifications to Design Parameters

PRN1C1D & FRC1A1B

- Initial design
  - 35°F ΔT for data hall
  - Based on 100% OCP server deployment
- Final design
  - 22°F ΔT for data hall
  - Based on mix of OCP & OEM server deployment
  - Increased (8) AHU line ups to (13) to meet 22°F ΔT

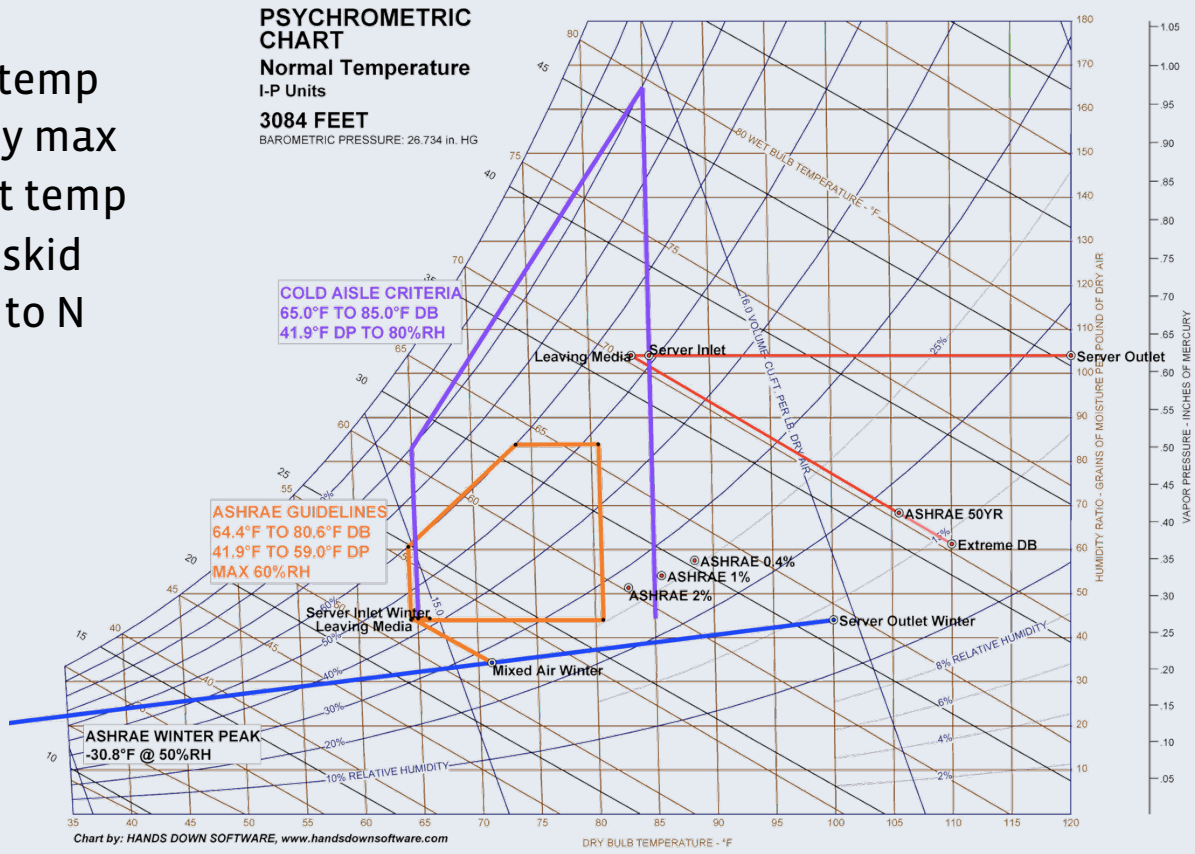
Psychrometric Chart –
PRN1A1B

- **65°F - 80°F** cold aisle temp
- **65%** relative humidity max
- **41.9 °F** min dew point temp
- **Summer**
  - 110°FDB
  - 70.3°FWB
- **Winter**
  - 30.8°FDB
  - 50%RH



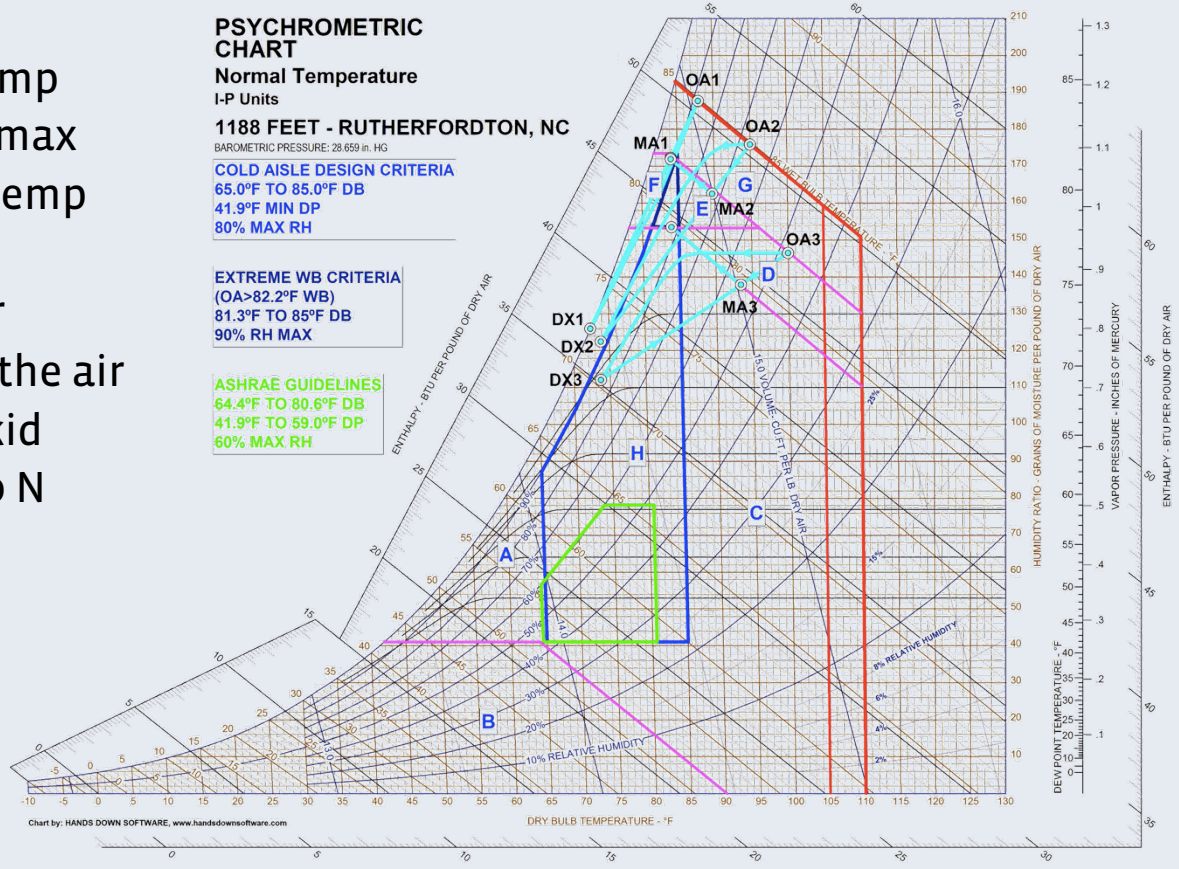
Psychrometric Chart –
PRN1C1D

- **65°F - 85°F** cold aisle temp
- **80%** relative humidity max
- **41.9 °F** min dew point temp
- **Reduced** evap pump skid redundancy from 2N to N
- **Summer**
  - 110°FDB
  - 70.3°FWB
- **Winter**
  - 30.8°FDB
  - 50%RH



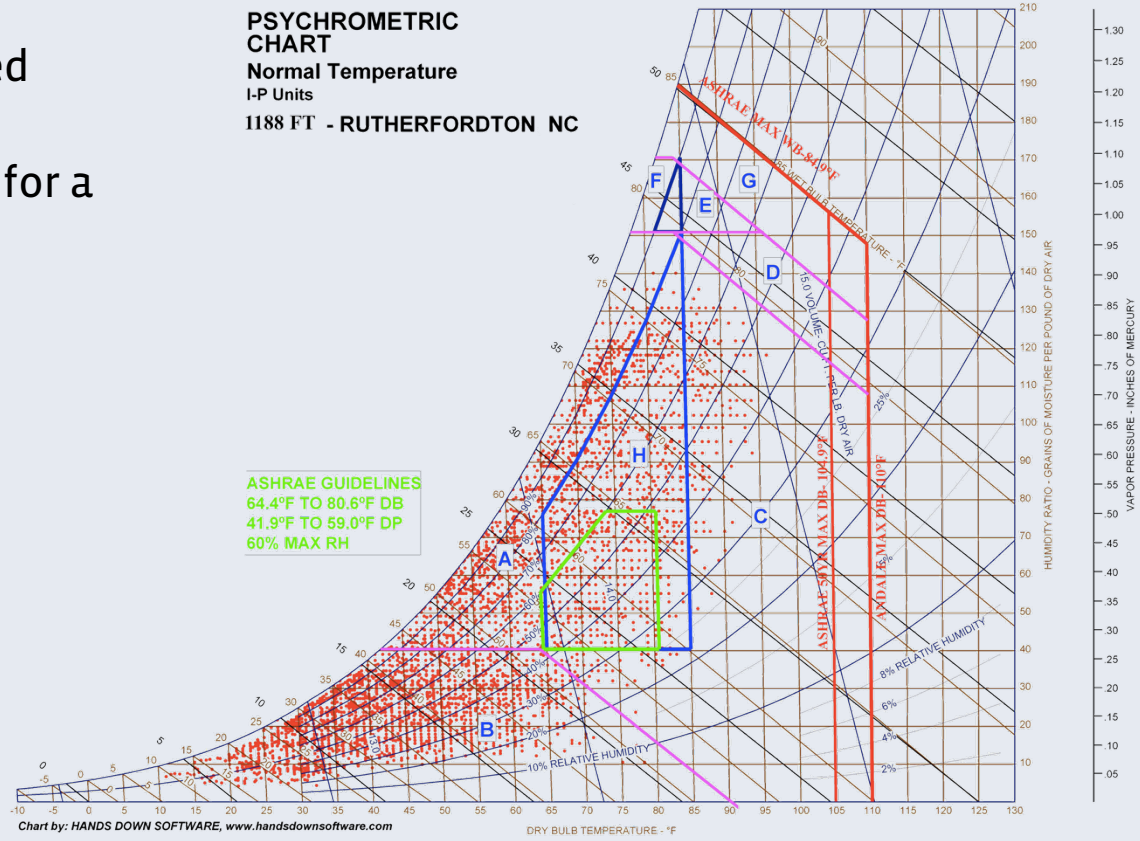
Psychrometric Chart –
FRC1A1B

- **65°F - 85°F** cold aisle temp
- **90%** relative humidity max
- **41.9 °F** min dew point temp
- **DX added**
  - For extreme weather criteria to condition the air
- **Reduced** evap pump skid redundancy from 2N to N
- **Summer**
  - 110°FDB
  - 84.9°FWB
- **Winter**
  - -6.2°FDB
  - 50%RH



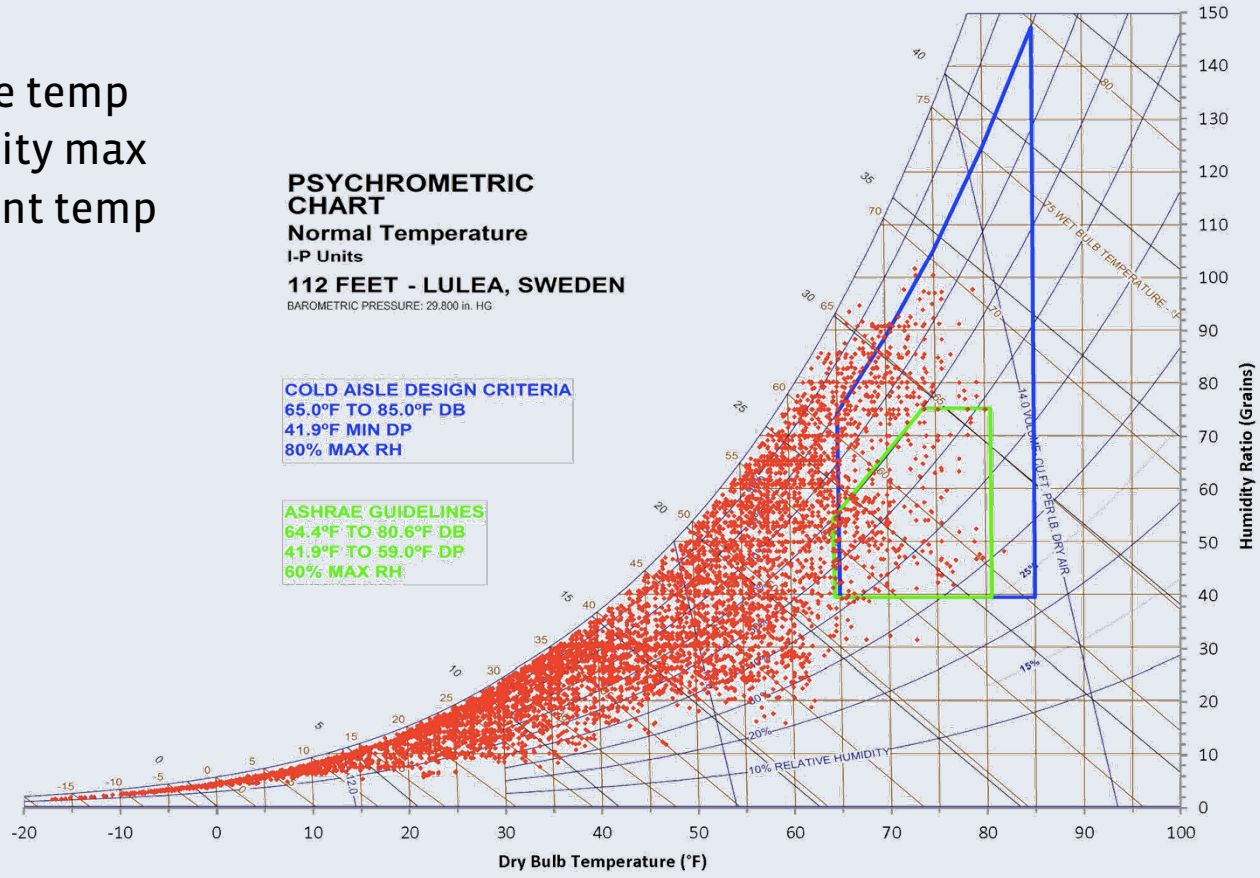
Psychrometric Chart – FRC1A1B

- BIN weather data charted demonstrates that DC cooling is not necessary for a typical year



Psychrometric Chart –
Sweden

- **65°F - 85°F** cold aisle temp
- **80%** relative humidity max
- **41.9 °F** min dew point temp
- **DX** not required
- **Summer**
  - 95.1°FDB
  - 71.2°FWB
- **Winter**
  - -39.1°FDB
  - 50%RH

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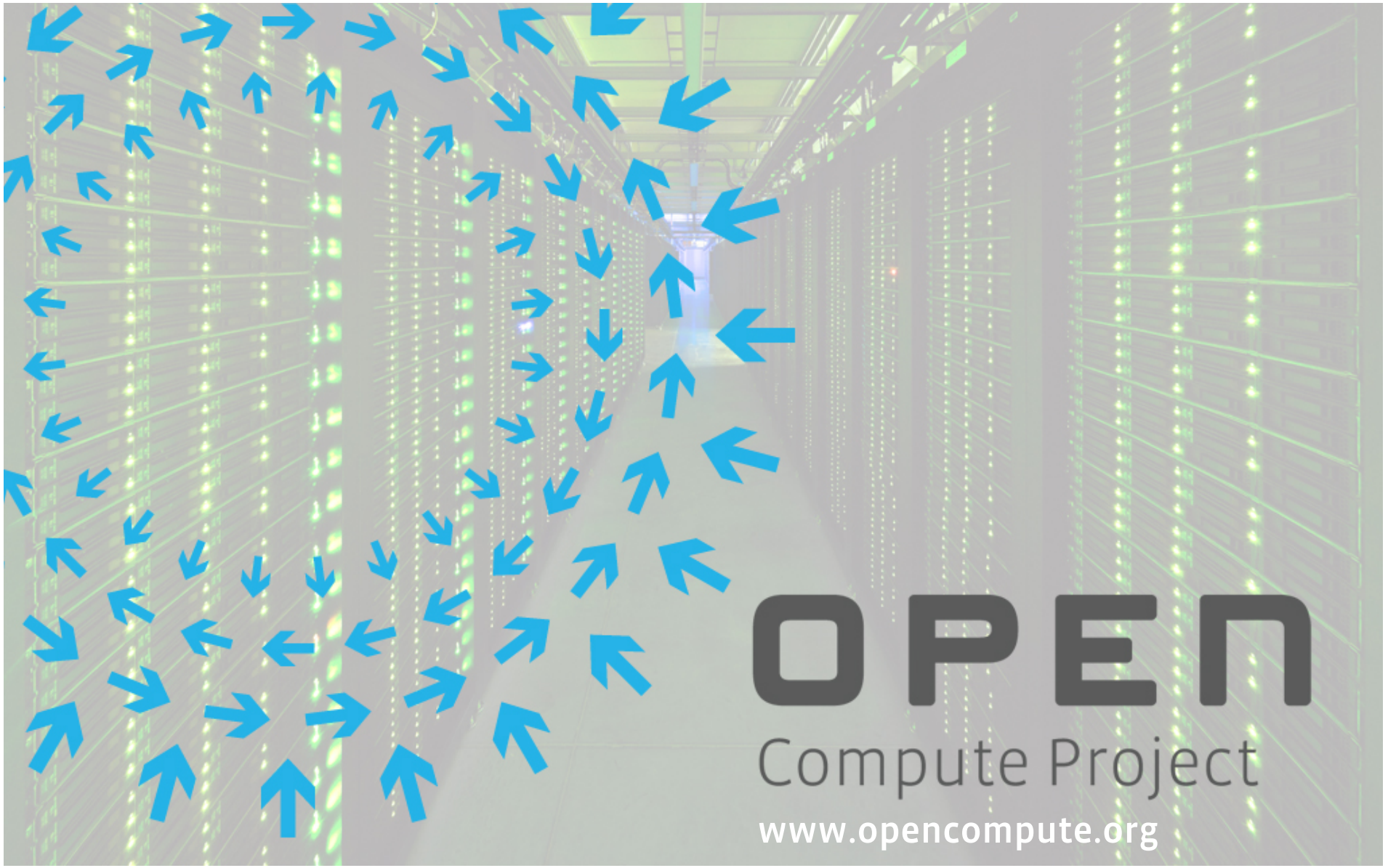
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