The Potential Influence that Crosswinds have on ACC Performance

A Computational Fluid Dynamics Approach

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ACC Users Group
Pueblo, CO

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2. Non Standard Installations
3. Technology Introduction
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R&D of turbomachinery components and auxiliaries

1. Siemens
   a. Low No_x
   b. Advanced mechanical (Switzerland)
2. Innovative Uniform combustion technology
3. Advanced aerodynamics and cooling schemes.
4. Next generation use of efficient systems for combustion operation

CPS (Switzerland)

1. "Subcontract" work for CPS (CH) in our area of expertise

Various

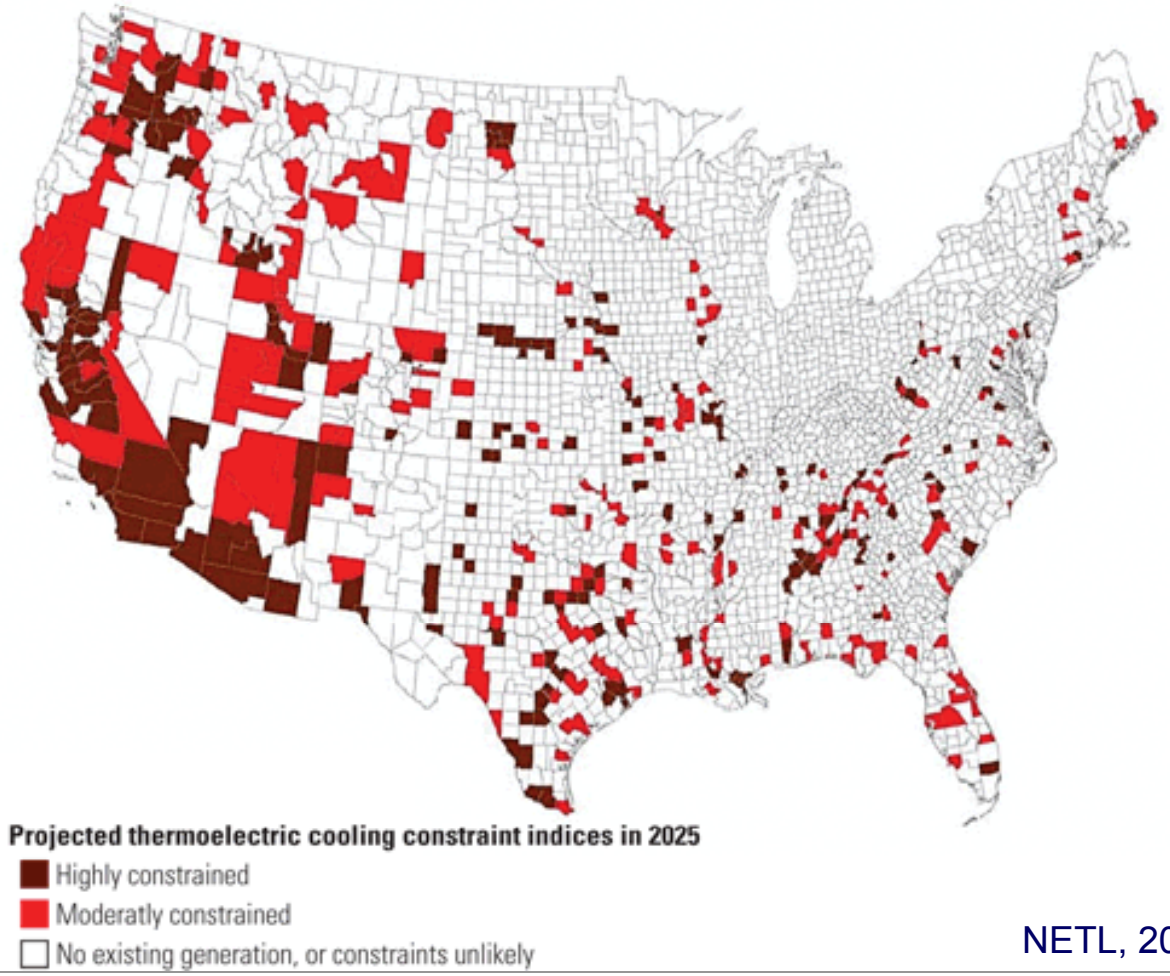
1. Various Customer base
   A. Due diligence audits
   B. R&D advances for Global Clients

Outline

- Challenges facing ACC's
- Technique to investigate these issues
- Case Study Description
- Results - Case 1

The Need for Air Cooled Condensers

Thermoelectric Cooling Constraint is based on the Water Supply Sustainability Index (WSSI) Index. Highly constrained areas have a WSSI index of 3 or greater.



NETL, 2006

Air Cooled Condensers

- Reasons for reduced Heat Transfer in ACC's include:
  - Air Recirculation
  - Distorted Inlet Flow Conditions
  - Hot Air Plumes from Surrounding Heat Sources
  - Degradation of Fan Performance
- New installation considerations (Customer Responsibility):
  - Local Buildings
  - Environmental Wind
  - Terrain
  - Environmental and Ecological restrictions
  - ***Upstream Heat Sources***

Location Location Location!!!

- Computational Fluid Dynamics (CFD)
  - Scale Model that shows physical fluid interactions
  - Investigation
    - Identify Current Problems
    - Predict Future Problems

Case Study using CFD

- Investigation of Steam Power Plant Extension in Asia:
  - Currently using Wet Cooling Towers
  - Extension uses 4 ACC units on SE part of plot.

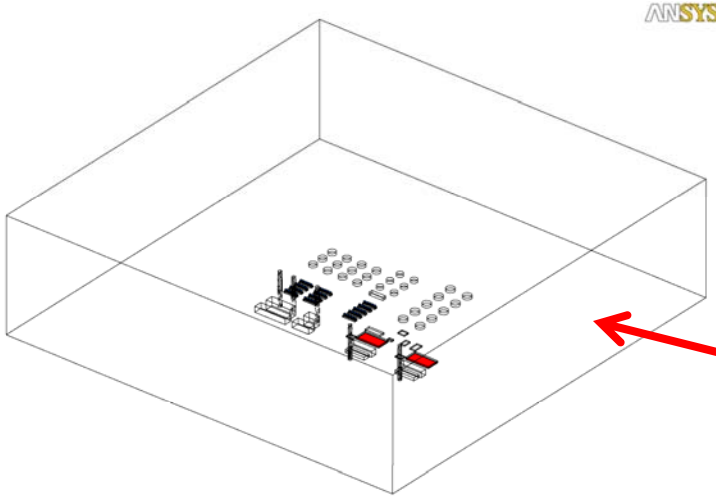
- Concerns
  - Crosswind directions & speeds **force the exhaust of the cooling towers** to recirculate into the inlet of the ACCs?

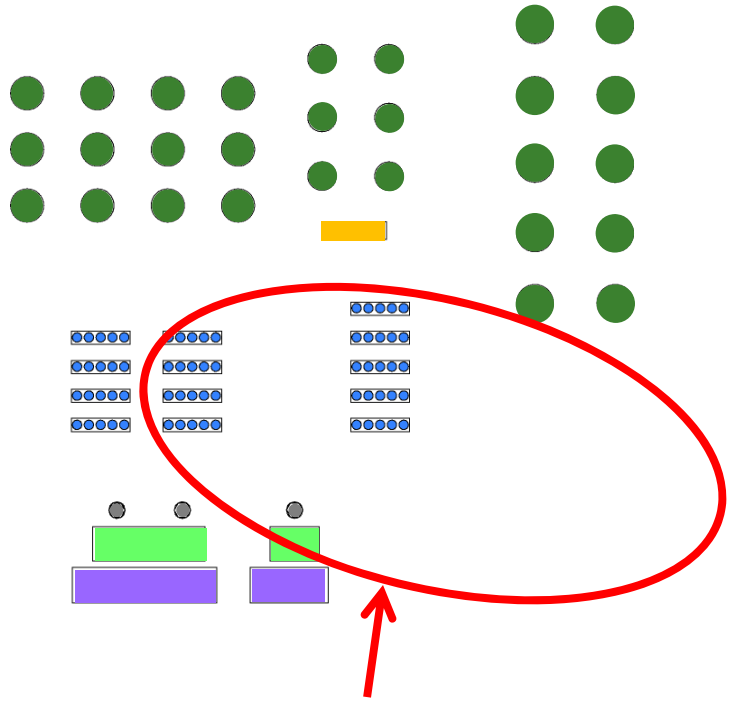
- Objective
  - Study crosswind approach angles and speeds to see the impact of the cooling tower exhaust on the ACC Units.

Plant Layout and Computational Domain

Important Physical Features:

- Oil Tanks
- H2 Plant
- Wet Cooling Towers
- Stacks
- Boilers
- Turbine Hall
- Water Treatment Plant
- Diesel Room
- Auxiliary Cooling
- Air Cooled Condensers
- Misc Units





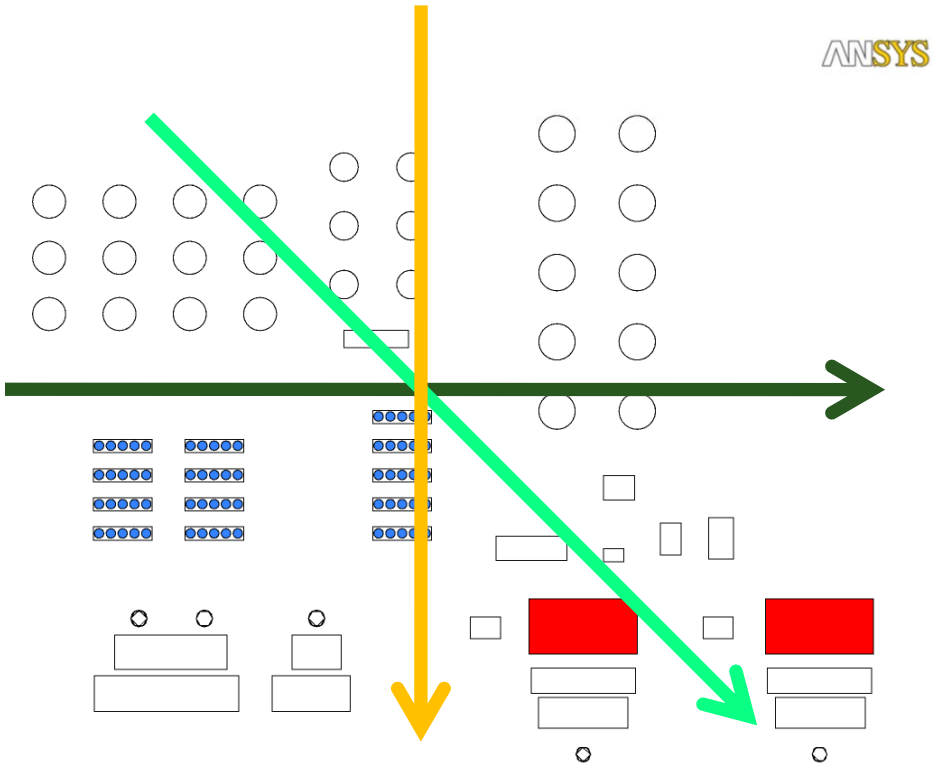
Compact Domain

-Focus on small region

-Lower Computational Cost

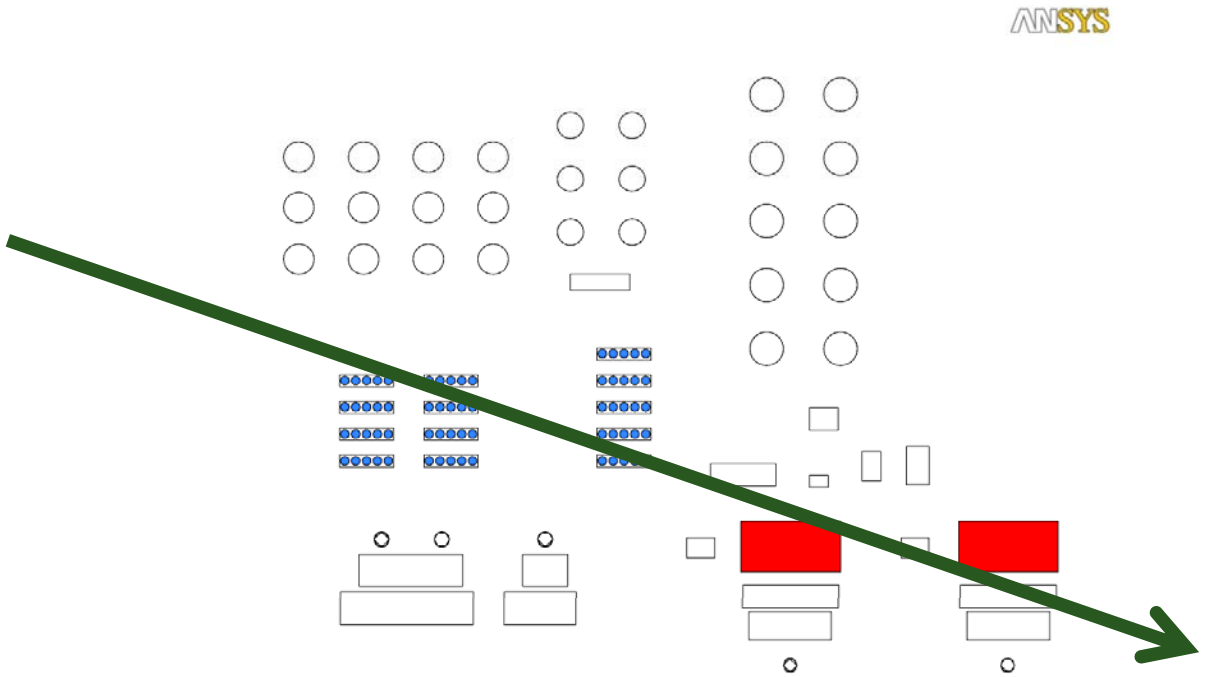
Crosswind Approach Angle

- Original plan to test 3 Angles of Approach
  - From the North
  - North West
  - West



Crosswind Approach Angle

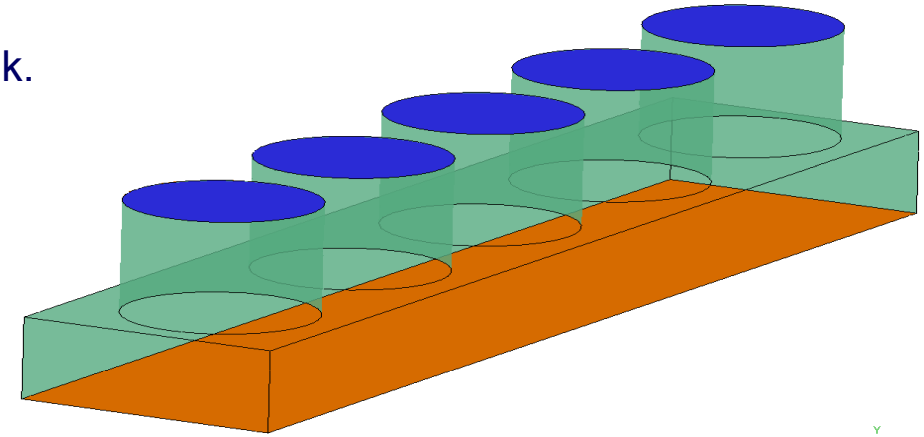
- One Approach Angle will represent the *Critical Winds*
  - Case 1: Design point:
    - 10 mph at 33 ft
    - 18 Degrees North of West



Key Geometries

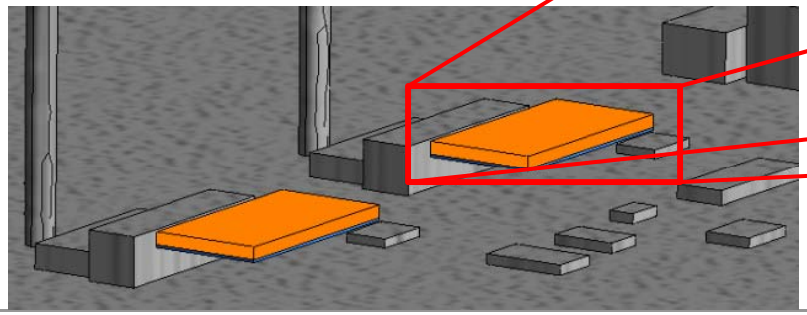
Wet Cooling Towers

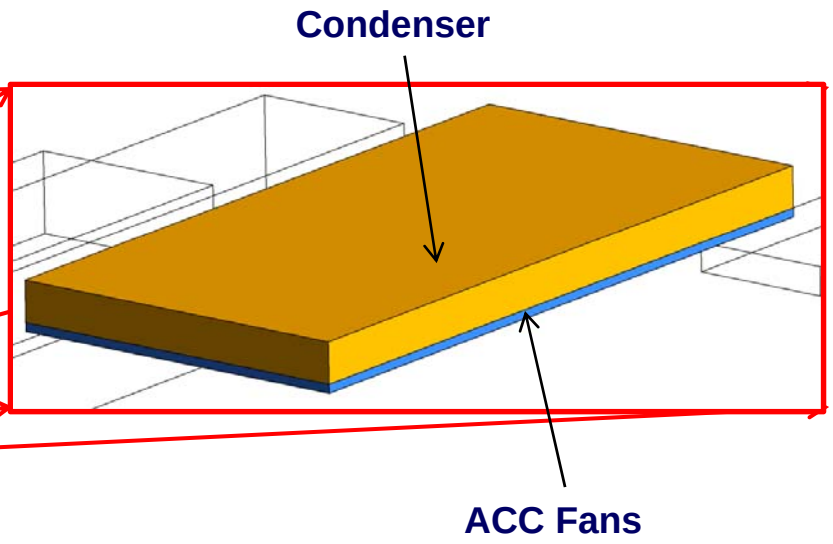
- Modeled as a voided cavity with a Mass & Momentum source and Mass sink.
- Prescribed
  - Mass Flow
  - Heat Duty



Air Cooled Condensers

- Separate domains:
  - Lower domain: Fan
  - Upper domain: Condenser
- Each block represents 2 ACC units, 72 cells total.





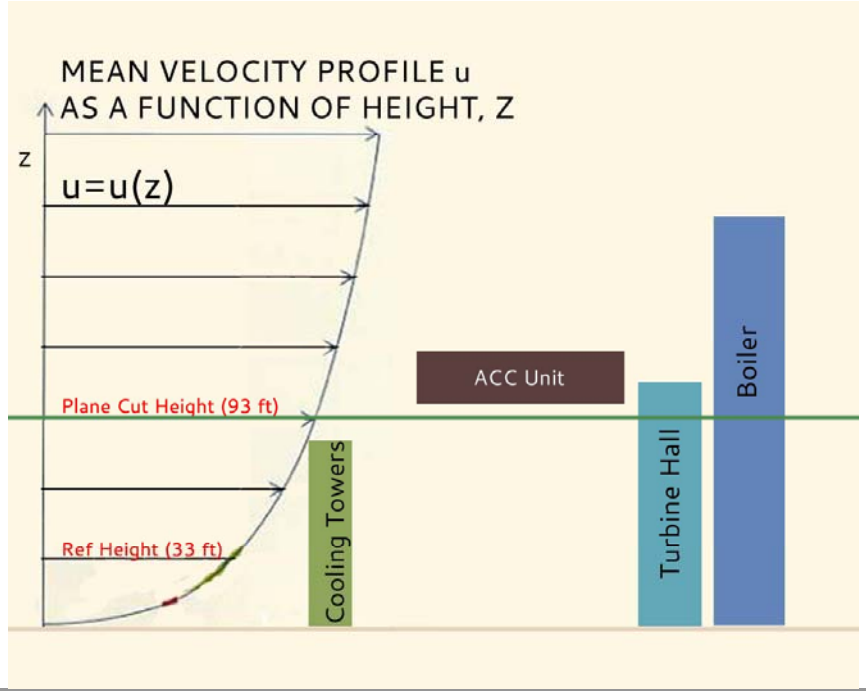
Cross Wind Velocity

Modeled using *Wind Profile Power Law* (From 18 degrees above West)

$$u_x = u_r(z_x/z_r)^{\alpha}$$

Where:

z_x = Height
z_r = $Height_{Ref}$ = **33 [ft]**
u_x = Velocity @ z_x
u_r = Velocity @ z_r
α = Coef that describes the stability of the atmosphere = 1/7 (neutral stability)



Case 1

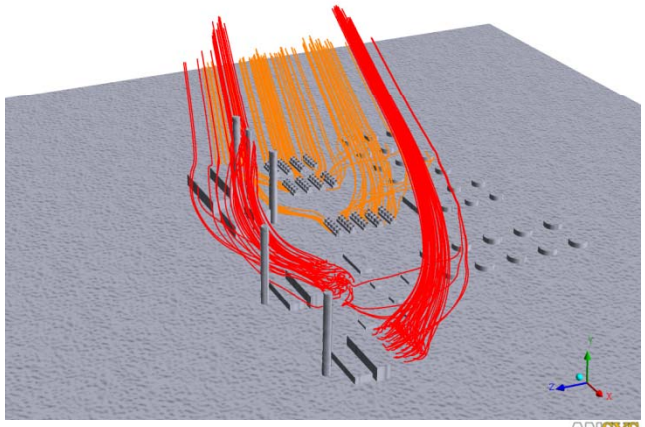
Crosswind

10 mph at 33 ft

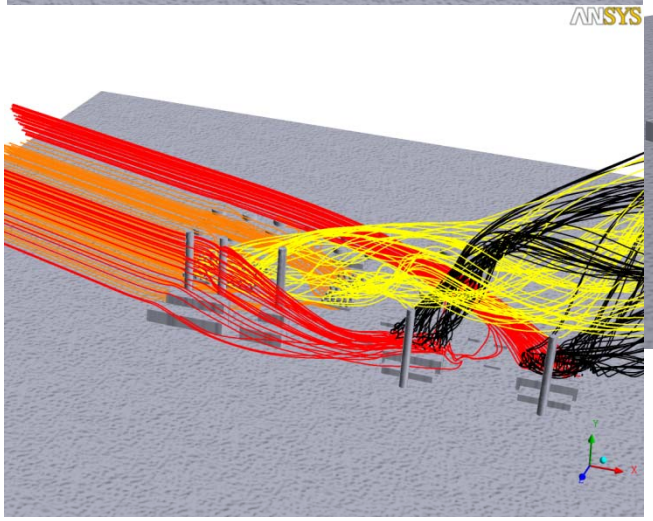
18 Degrees North of West

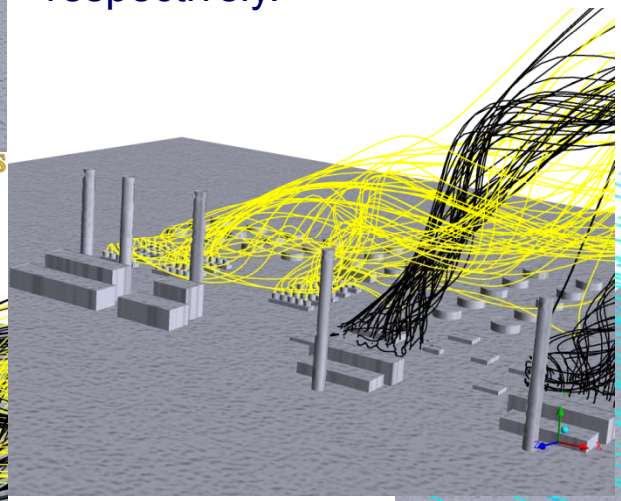
Full Plant

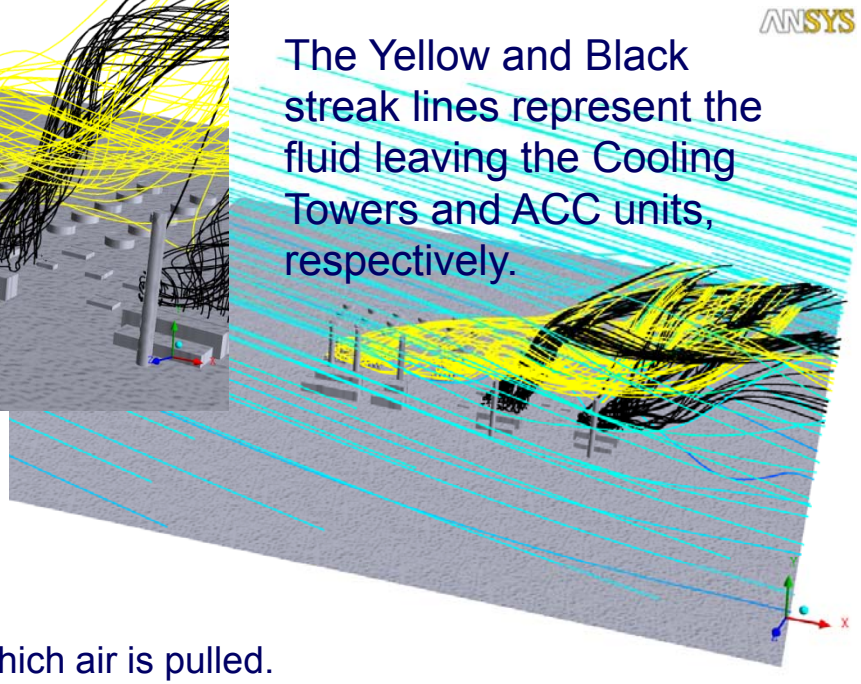
Streak Lines
Red: ACC Source Mass Flow
Orange: Cooling Tower Source Mass Flow



The Orange and Red streak lines represent the fluid approaching the Cooling Towers and ACC units, respectively.







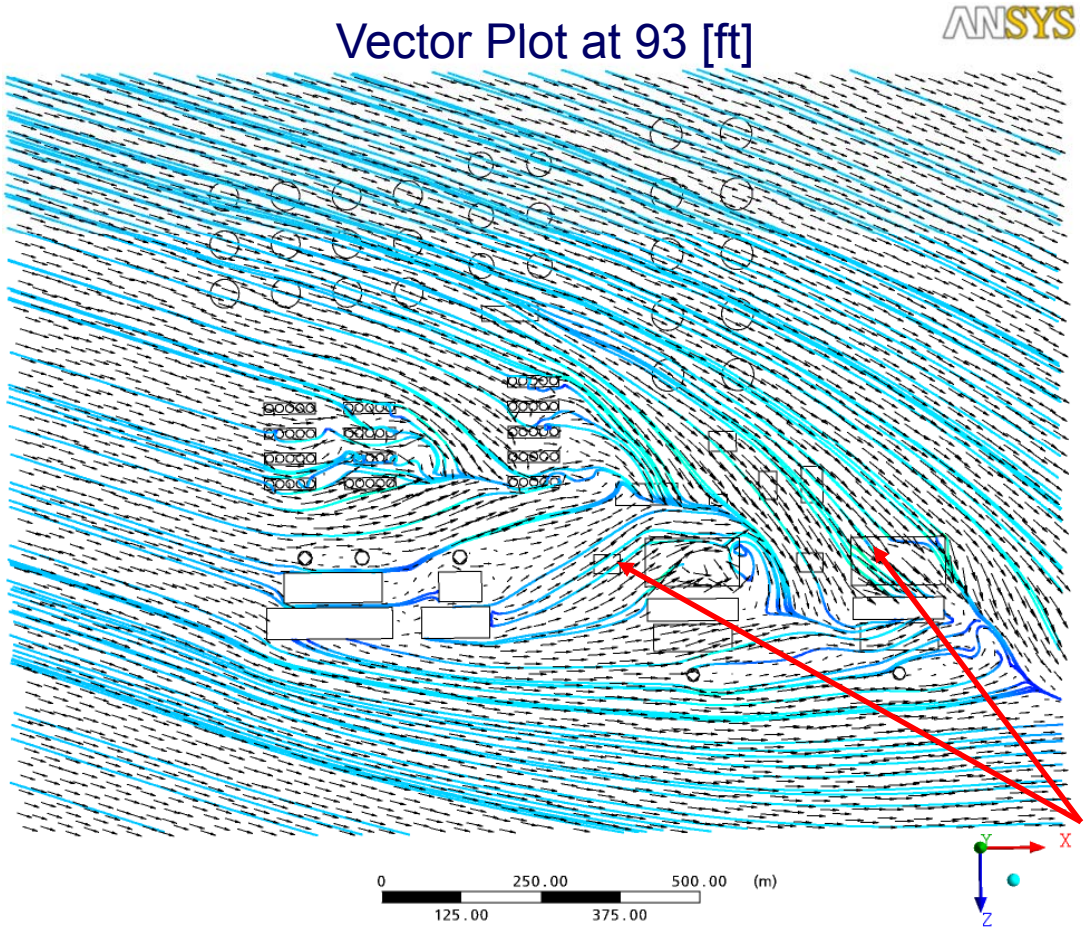
The Yellow and Black streak lines represent the fluid leaving the Cooling Towers and ACC units, respectively.

ACC Units and Cooling Towers have distinct regimes from which air is pulled.

Full Plant

Streak Lines – Flow Path

Velocity Vectors



Different Mass Flow Approach Directions

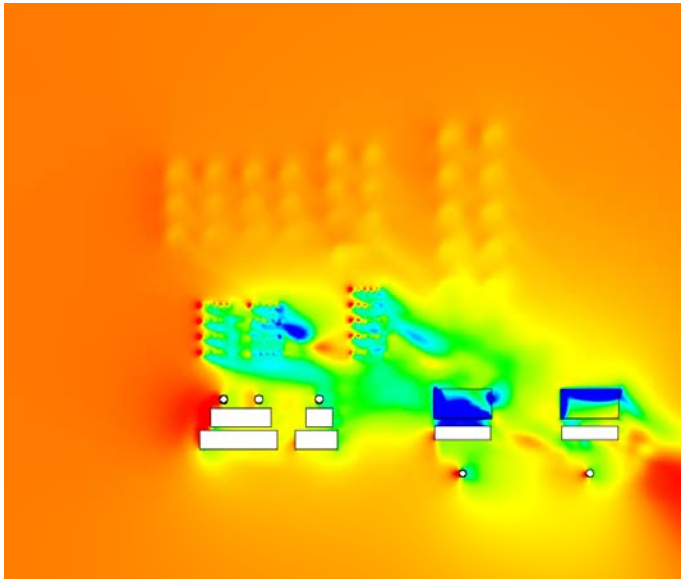
Cooling Towers

Immediate region South East of the Cooling Towers experiences a lower pressure due:

High temperature exhaust Mass being directed to the ACC Units.

Low Pressure Region at 93 [ft]

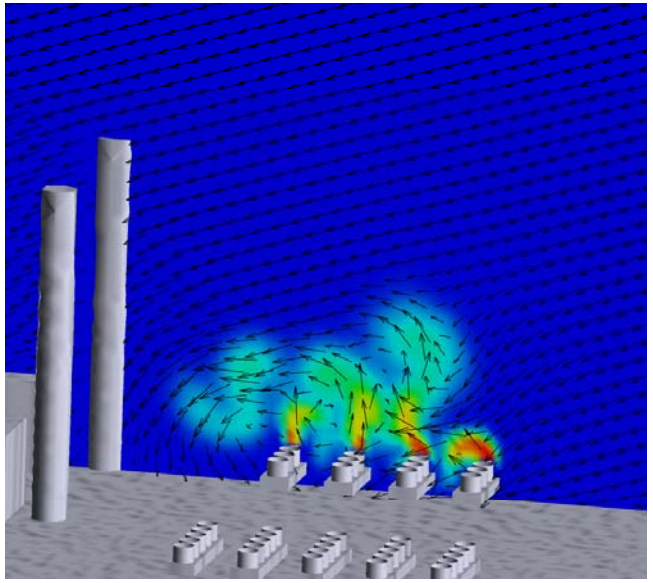
High Pressure



Low Pressure

Flow exiting the Cooling Towers can get drawn back in to the base of the towers.

Cooling Towers: small regions of recirculation around inlets.



High Temps

Low Temps

Air Cooled Condensers

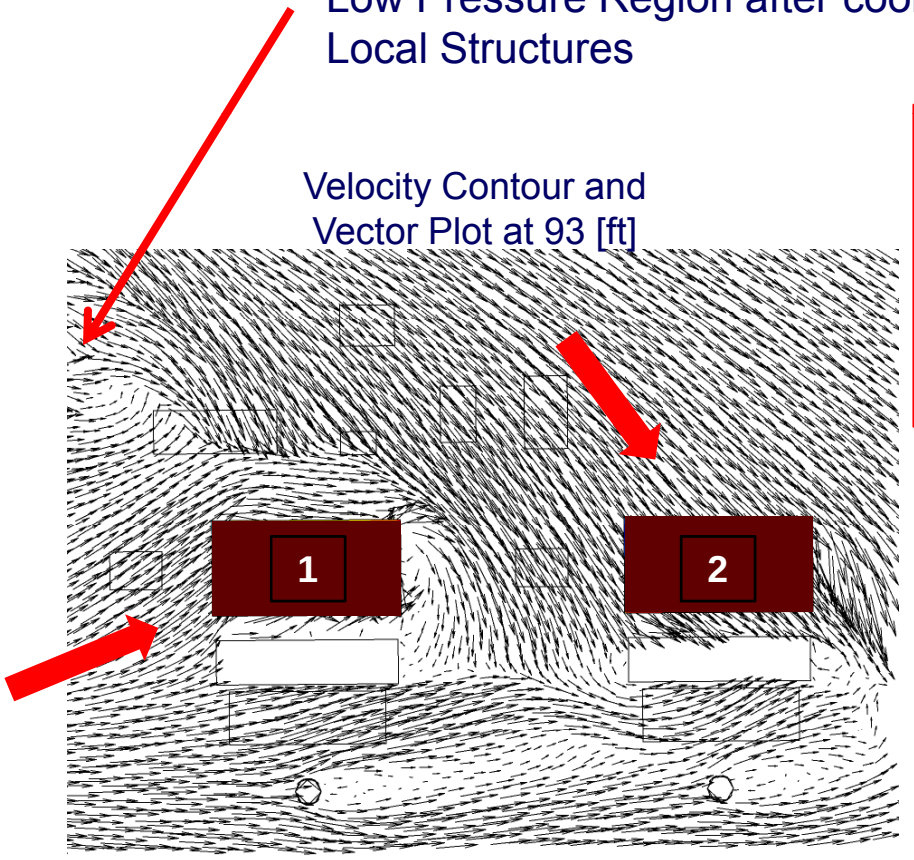
Non uniform velocity distribution influenced by:

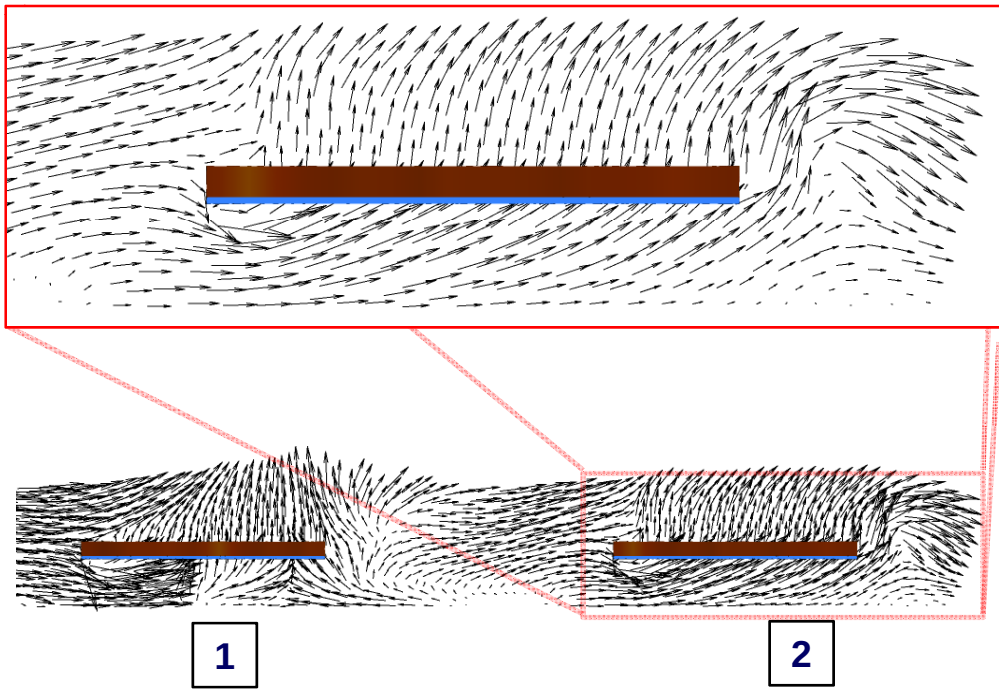
- Local structures around ACCs
- Sharp change in flow direction at ACC leading edges.

Flow approaches each ACC Unit from different side due to:

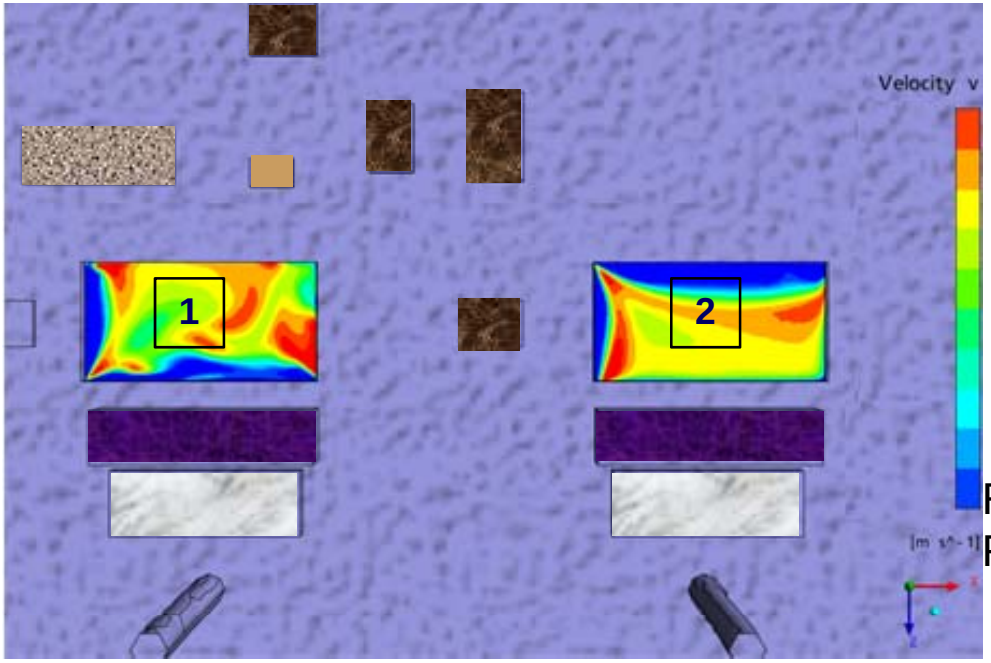
- Low Pressure Region after cooling towers(LP)
- Local Structures

Velocity Contour and
Vector Plot at 93 [ft]





Normal Velocities

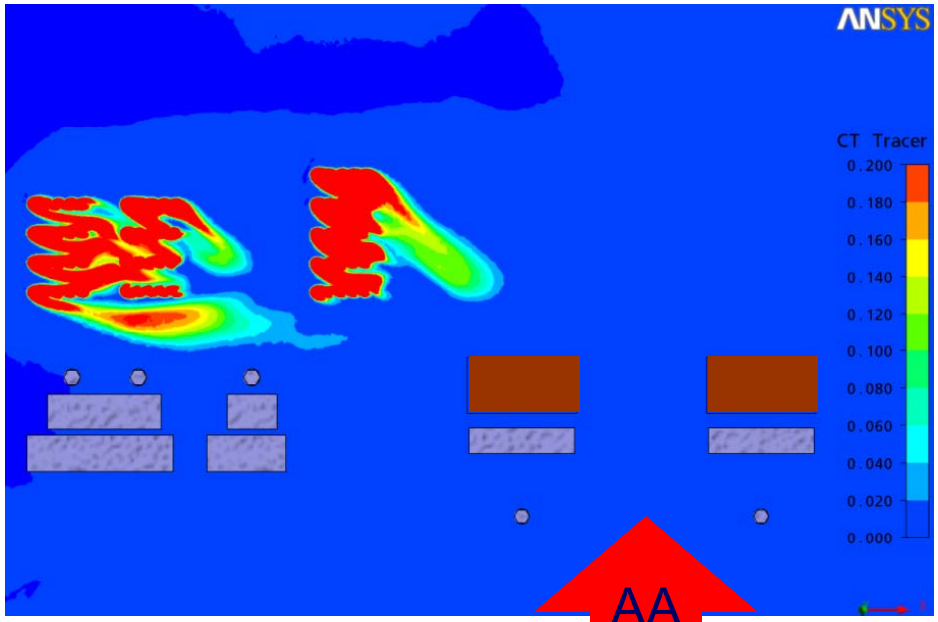


Best Performance

Reduced Performance

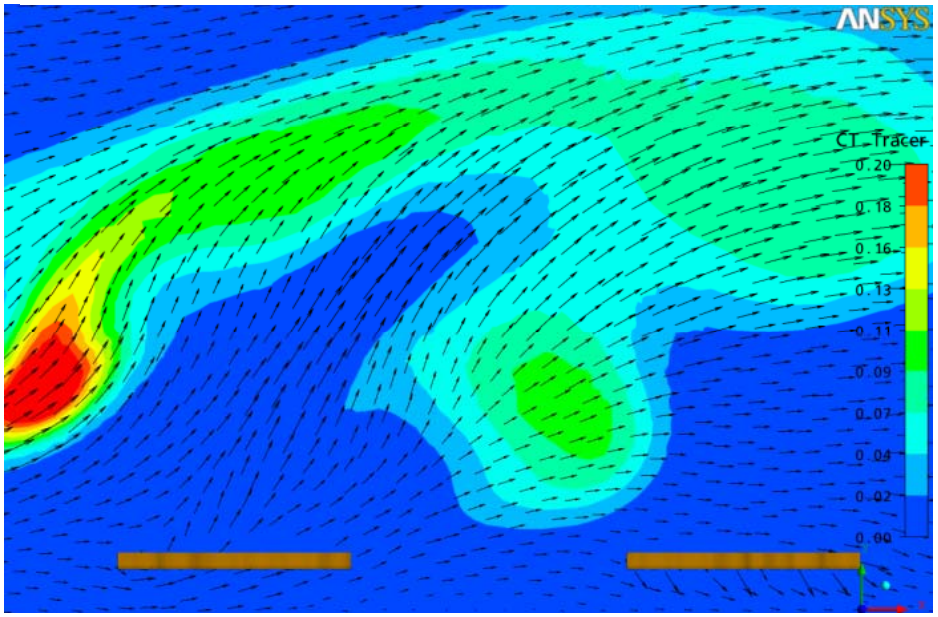
Cooling Tower Tracer

Contour Plot at 93 [ft]



Plan view

Contour Plot Facing North



View on AA

Tracer particles were emitted from the Wet Cooling Towers and tracked.

Contour plot shows regions where Cooling Tower exhaust is in high density.

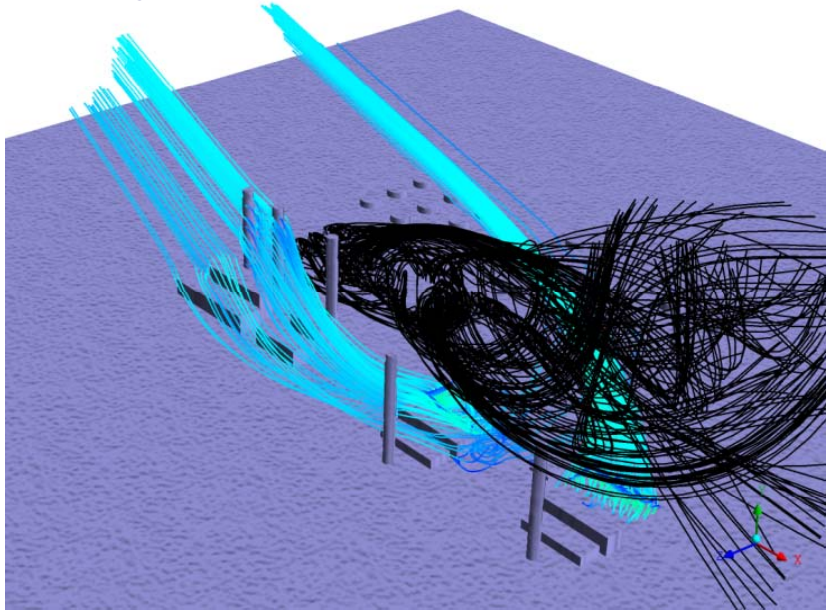
Cooling Towers

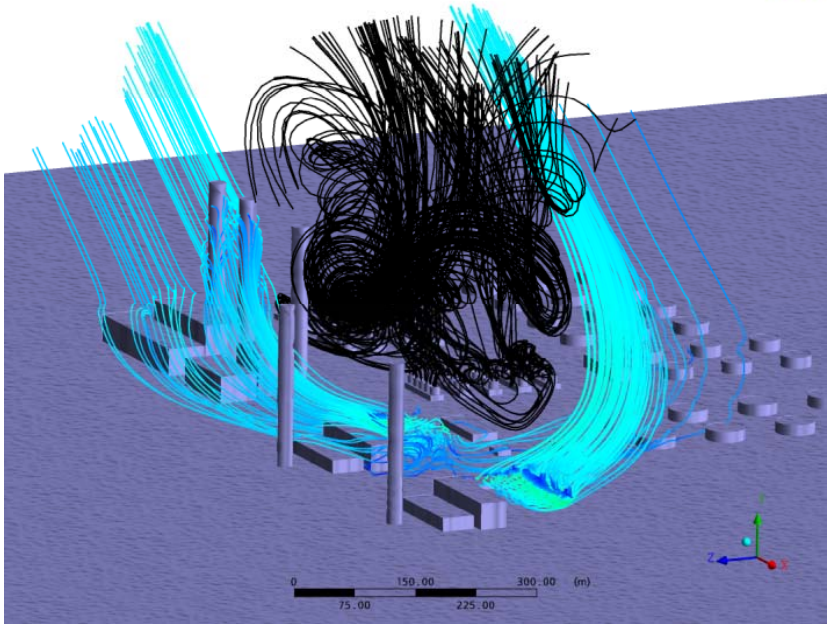
ACC mass flow originates from around the Cooling Towers due to:

- Low pressure zone
- Buoyant cooling tower exhaust

Stacks/Turbine Halls next to ACC Units, STRONG impact on flow
Oil Tanks and other structures, LOW impact on flow

ACC Source Flow
Cooling Tower Exhaust





Case 1: Conclusions

- The Flow approaching the ACC units is not intuitive.
- Confirmed that there is no influence of the Wet Cooling Tower Exhaust on the ACC units.
- Design and Layout are acceptable under Design Conditions.
- What was expected to be the worst case, may not be.