Eskom- New coal units and suggestions for further improvement

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- New coal units
- Interaction of ACC platforms
- CFD simulation of new ACC
- Main design characteristics of new ACC
- Future design trends
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New coal units

- Detailed investigations into new coal fired capacity started in 2004.
- Fuel sourced from the same mine which supplies Matimba
- Only dry cooling was considered due to limited water in area
  - Mean annual rainfall is 470 mm (18.5”)
- A life cycle cost comparison was done between the two known dry cooling technologies in South Africa
  - Indirect type (Kendal)
  - Direct type (Matimba)
- Based on available information at the time, direct dry cooling was selected

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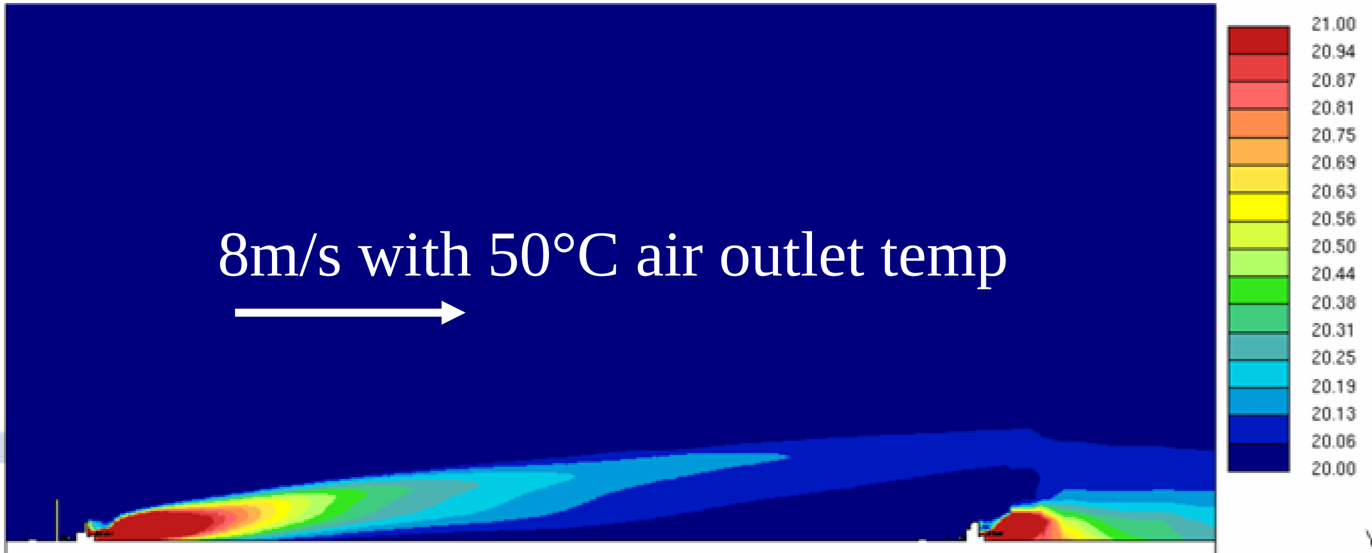
Medupi, 6 x 794 MW

- First supercritical hard coal fired units to be build in South Africa
- Turbine steam conditions: 24.1 MPa/560°C/570 °C

  3495 psi/1040°F/1058°F
- Coal supplied from the same coal mine as Matimba therefore the two stations are located relative close to each other, 6 km (3.7 miles).
- Boiler and turbine contracts awarded in 2007
- ACC included in turbine contract
- **Questions to be answered:**
  - Will the two ACC's affect each other?
  - How to change the ACC enquiry to prevent similar problems experienced at Matimba?
- Initiate a CFD study to investigate various alternatives

Simulation results of 2 adjacent ACC's 6 km apart

No plume or pressure field interaction was found



Temperature contour plots, scale 20 - 21°C

CFD analysis of ACC performance during windy conditions

- **Full numerical analysis of a single axial flow fan**
- **Stage 1: “Test section” conditions**
  - Characterize fan performance numerically in test section conditions
  - Predicted performance characteristics compared to that supplied by fan vendor
- **Stage 2: Fan in A-frame**
  - Full numerical analysis of a single axial flow fan in A-frame
  - Characterize fan performance during normal inlet flow (no wind) conditions with inlet and outlet obstructions including heat exchangers
  - Characterize fan performance with distorted inlet flow conditions
  - Quantify fluctuating forces and bending moments on individual fan blades for fans subject to distorted inlet flow conditions
    - Fan performance correlations obtained by full numerical analysis used in ACC simulation (multiple fans)

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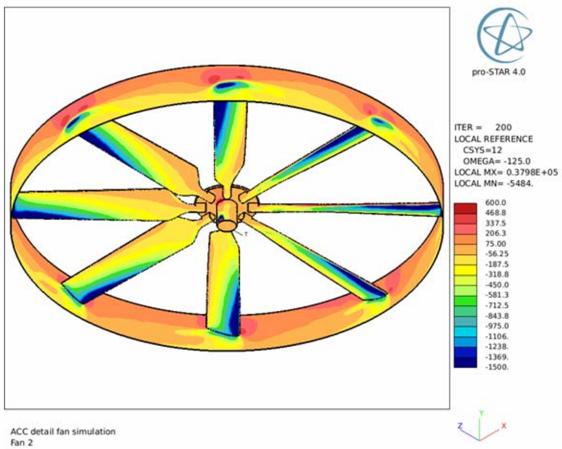
CFD analysis of ACC performance during windy conditions cont.

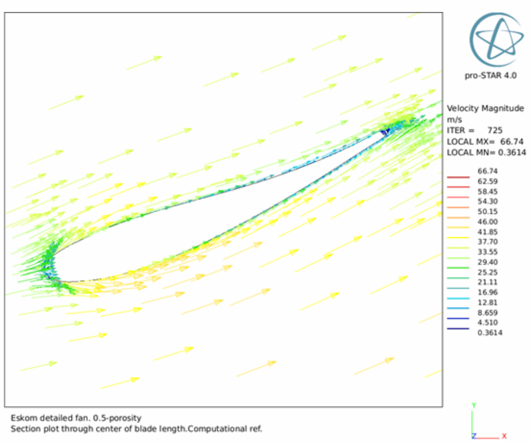
- Study performed for representative ACC (Matimba)
- Include boiler structure and turbine house
- ACC performance determined steady state conditions
- Performance evaluated for different wind directions
- 2 Wind speeds: zero and 9 m/s at 40 m Above Ground Level
- One representative air inlet temperature
- Turbine characteristics, heat rejected vs. LP exhaust pressure, incorporated
- One dimensional model to simulate steam side pressure drop

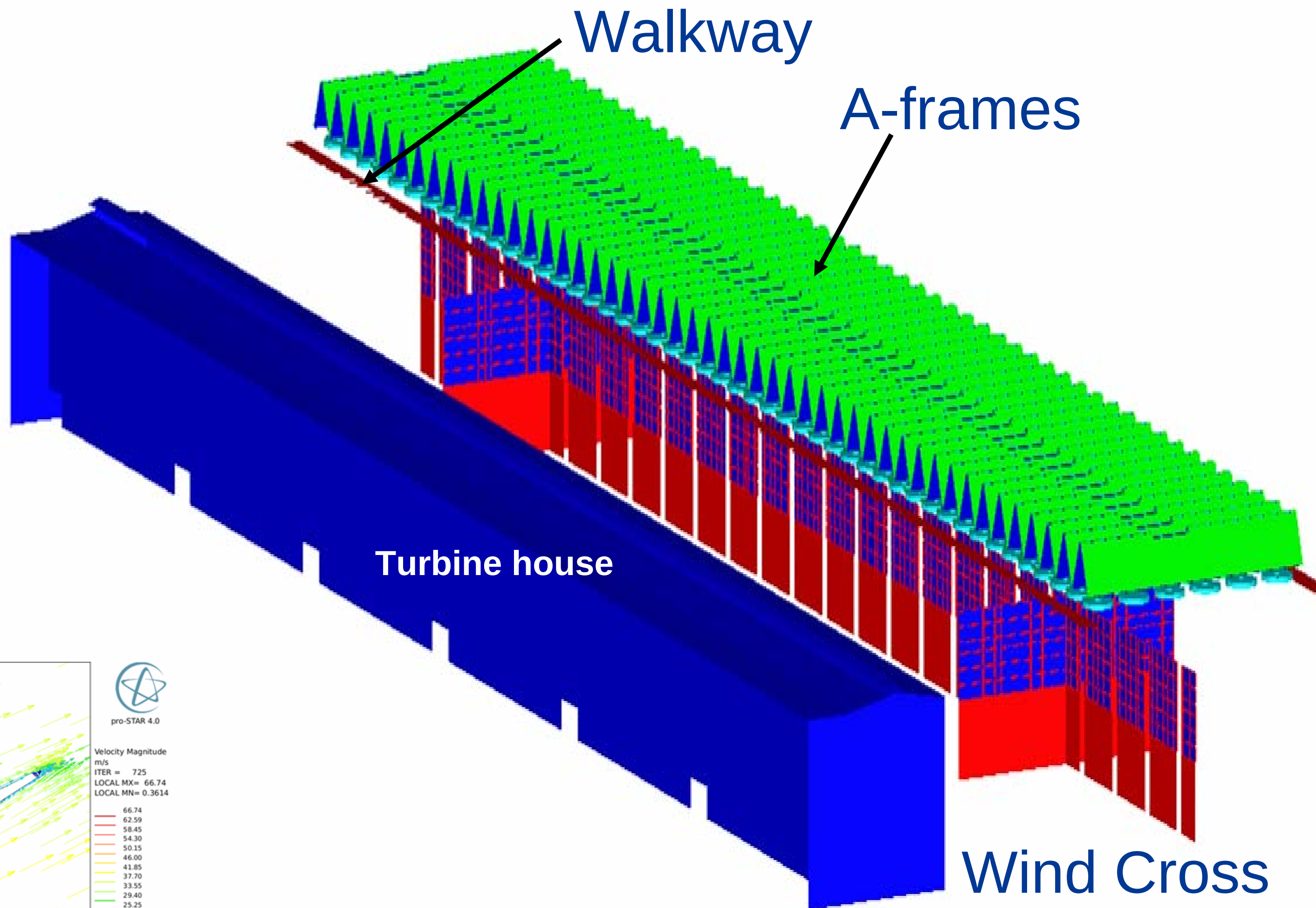
- Objective:
  - Optimum position of ACC relative to turbine house for new project
  - Quantify effect of wind-cross below ACC platform
  - Quantify effect of extended solid walkway around ACC platform
  - Stabilize air flow, and therefore ACC performance, during steady state conditions

CFD model elements (boiler not shown)

Detail fan simulation

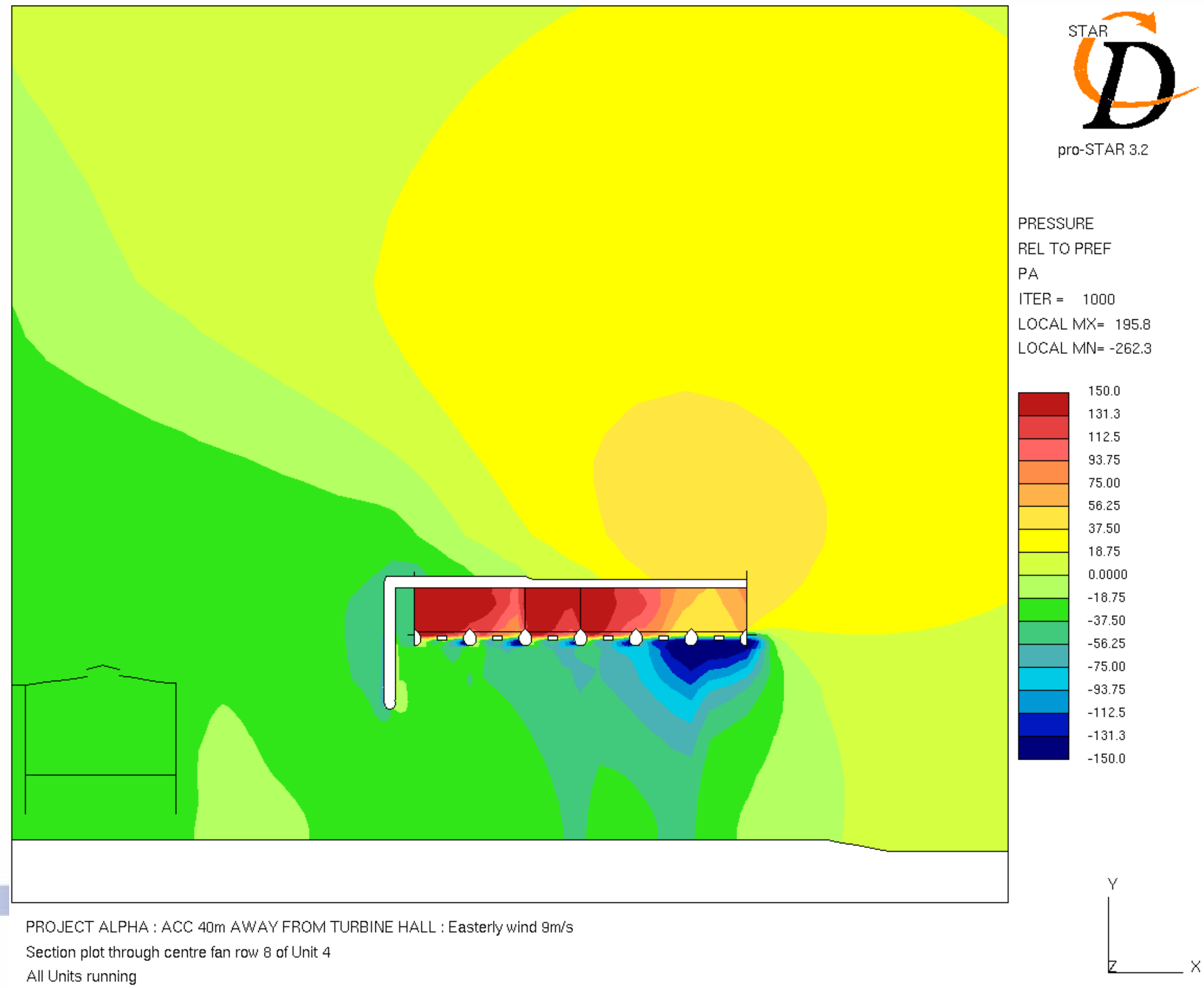






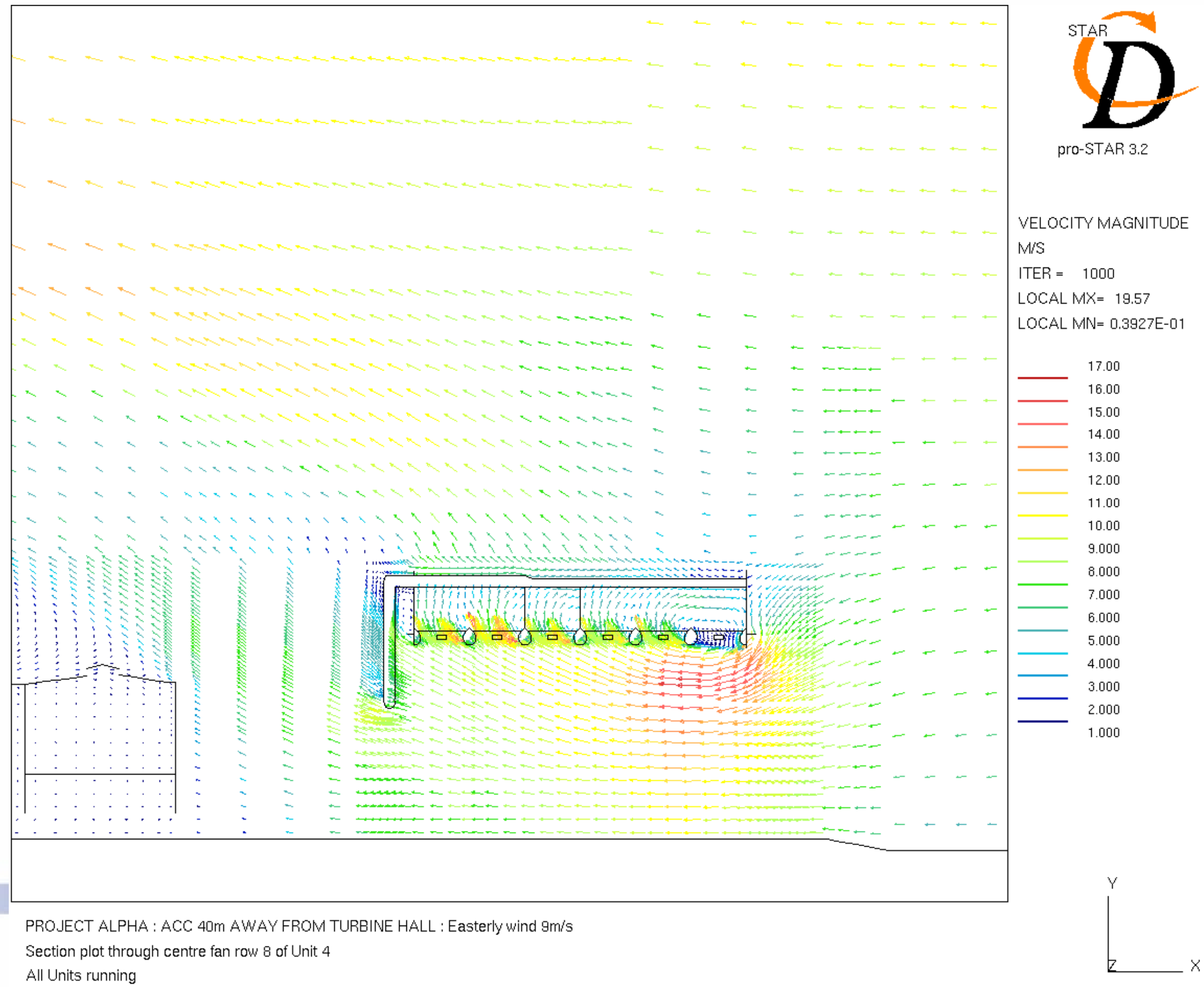
Static pressure contours for 9 m/s wind

- Wind towards boiler
- 40 m distance from turbine
- Positive pressure above platform due wind interaction with plume
- Negative pressure below platform on leading edge due to high air inlet velocity and flow separation

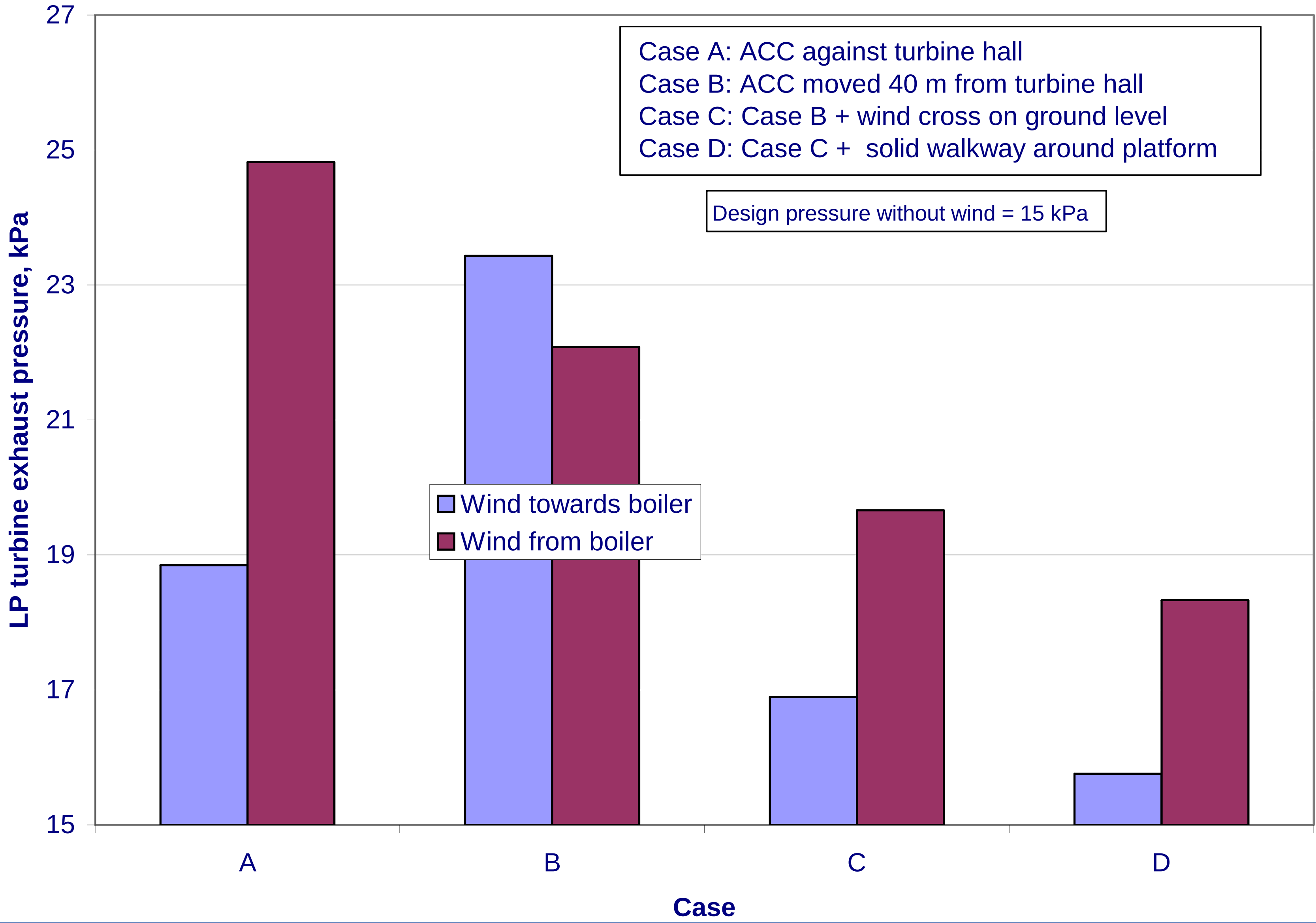


Velocity vectors with 9 m/s wind

- Wind towards boiler
- 40 m distance from turbine
- High velocity below the platform resulting in distorted fan inlet flow conditions



Results of CFD study, 9 m/s wind at 40 m height



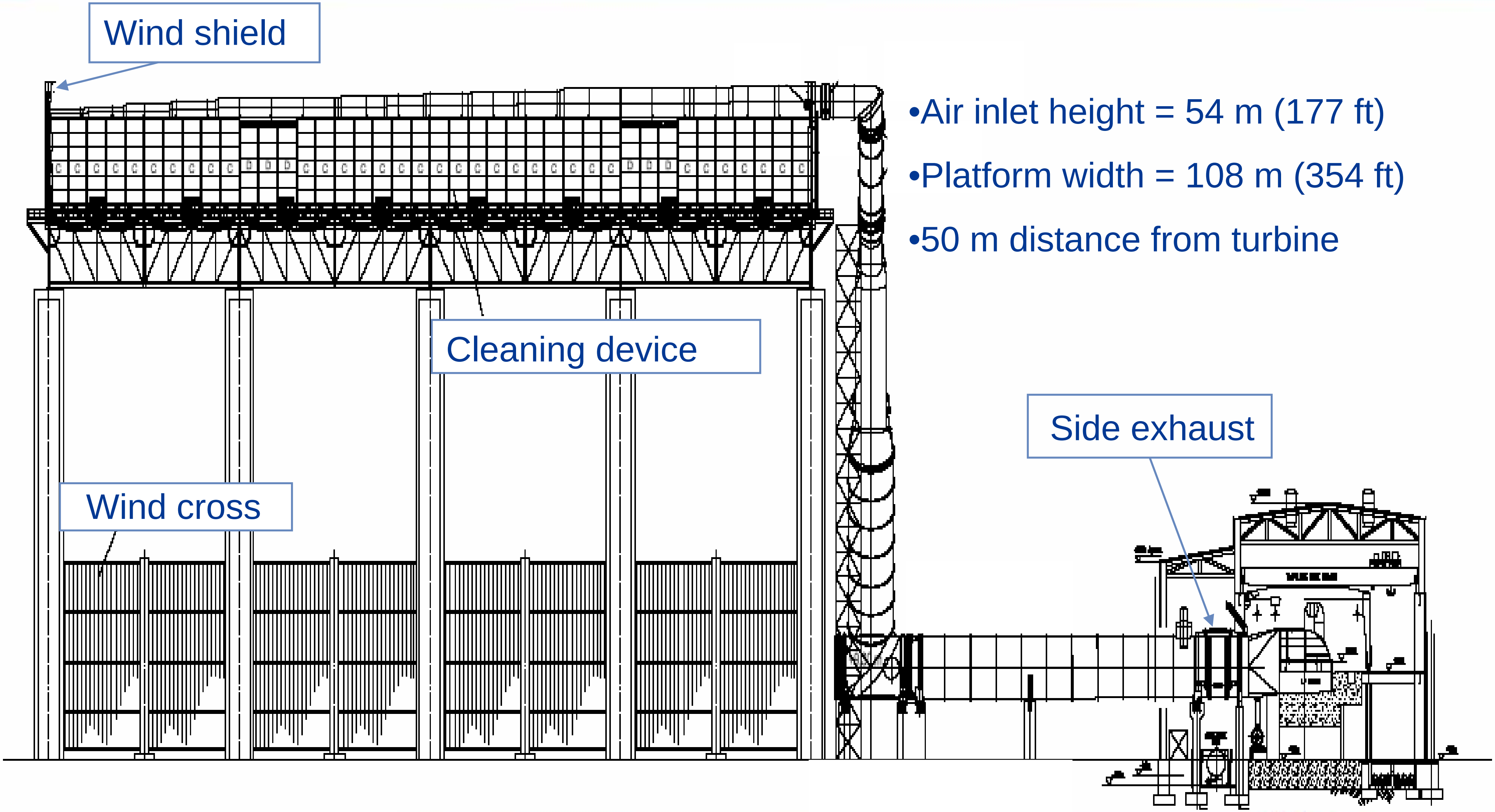
Discussion of CFD results

- Simulated fan performance predictions compare well with that of supplier but more work is required to validate the model
- CFD can be used successfully predict ACC performance, both on air and steam side
- Position of ACC platform and shields etc. does have significant effect on performance
- A thorough understanding of the air flow about the platform is essential to install appropriate corrective measures

Medupi ACC specification

- Minimum distance of 50 m between turbine and boiler
- Solid walkway around ACC platform of minimum width of 2.5 metres
- Wind cross on grade
  - Minimum height equals to a third of plat form inlet height
  - Position and porosity determined by CFD study
- Wind shield provided around the platform
- Design air inlet temperature and wind speed based on weather mast measurements at 40 m Above Ground Level
- 15% additional fan motor power is specified
- Solid partitions between each fan
  - Prevent inlet air recirculation when one fan is out of service

Medupi ACC side view



- Air inlet height = 54 m (177 ft)
- Platform width = 108 m (354 ft)
- 50 m distance from turbine

Medupi ACC

- 6 x 794 MW Output
- Design optimized for range of ambient temperatures
- Average ambient temperature is 23.7°C (74.7°F)
- Back pressure at 23.7 °C is 14.1 kPa (4.2 in Hga)
- Station orientated with prevailing wind direction towards boiler
- **ACC details per unit**
  - 64 fans, 34 ft diameter
  - 8 streets with 8 fans per street

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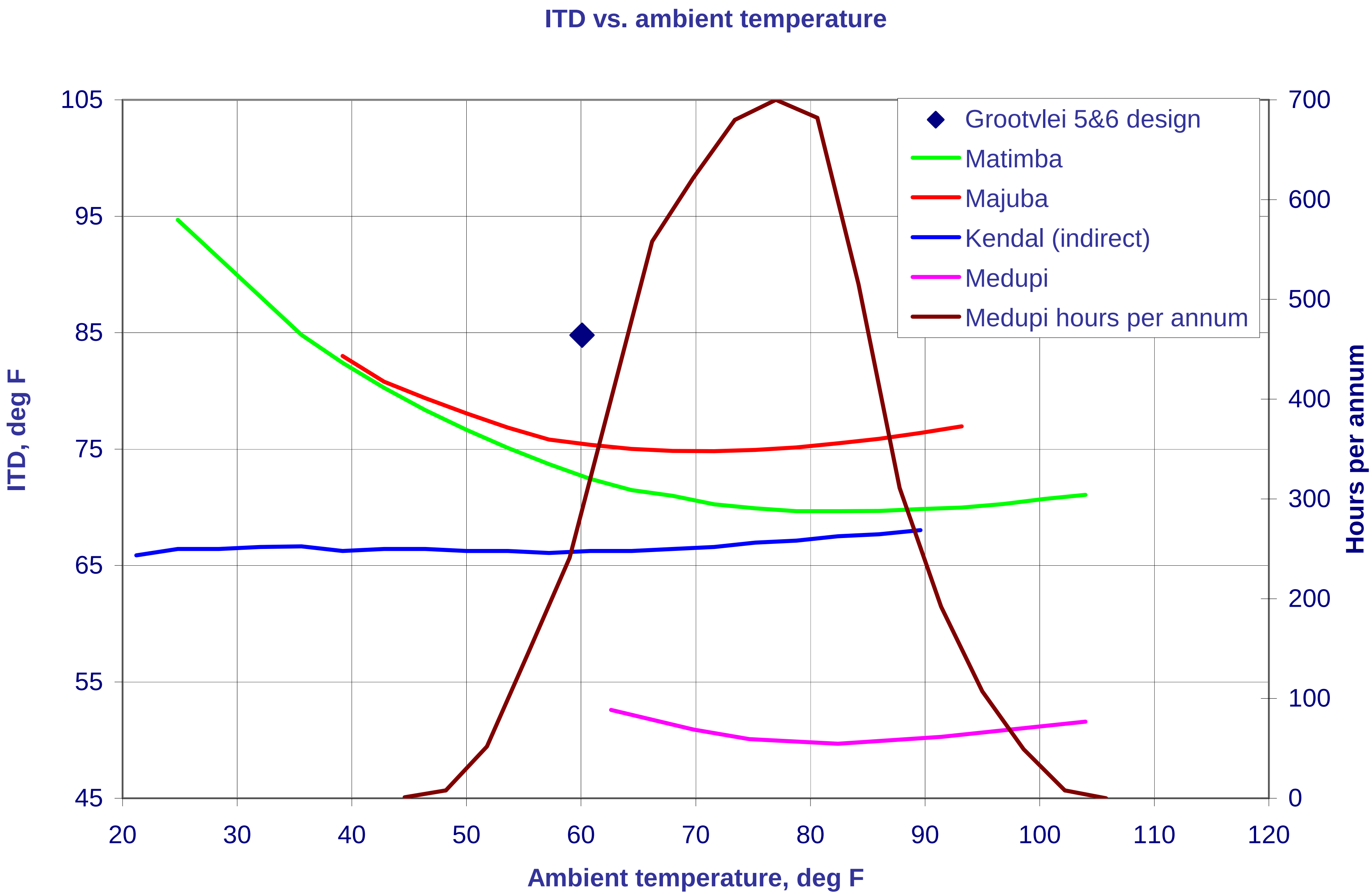
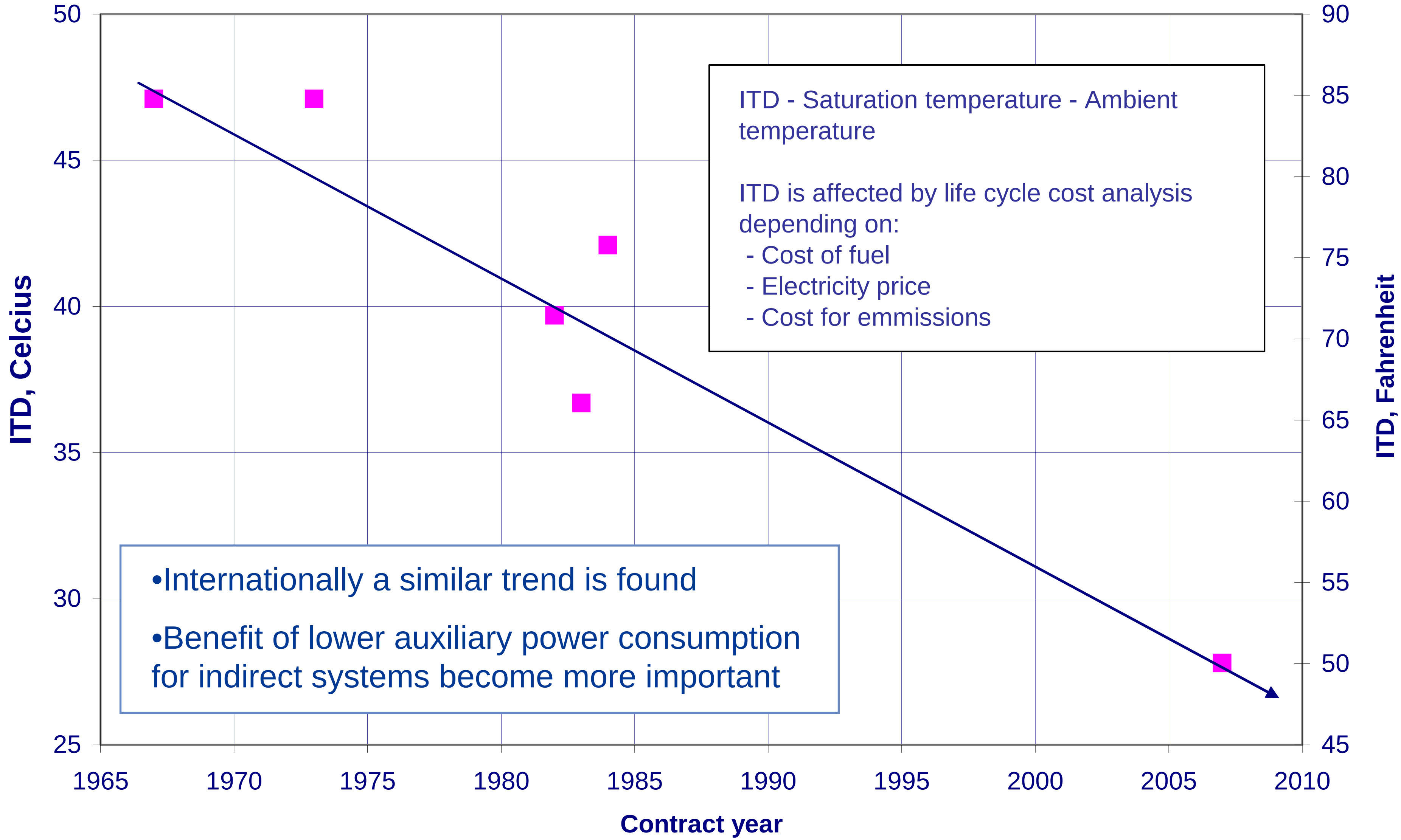
Cooling system ITD, (Saturated Temp – Ambient Temp.)

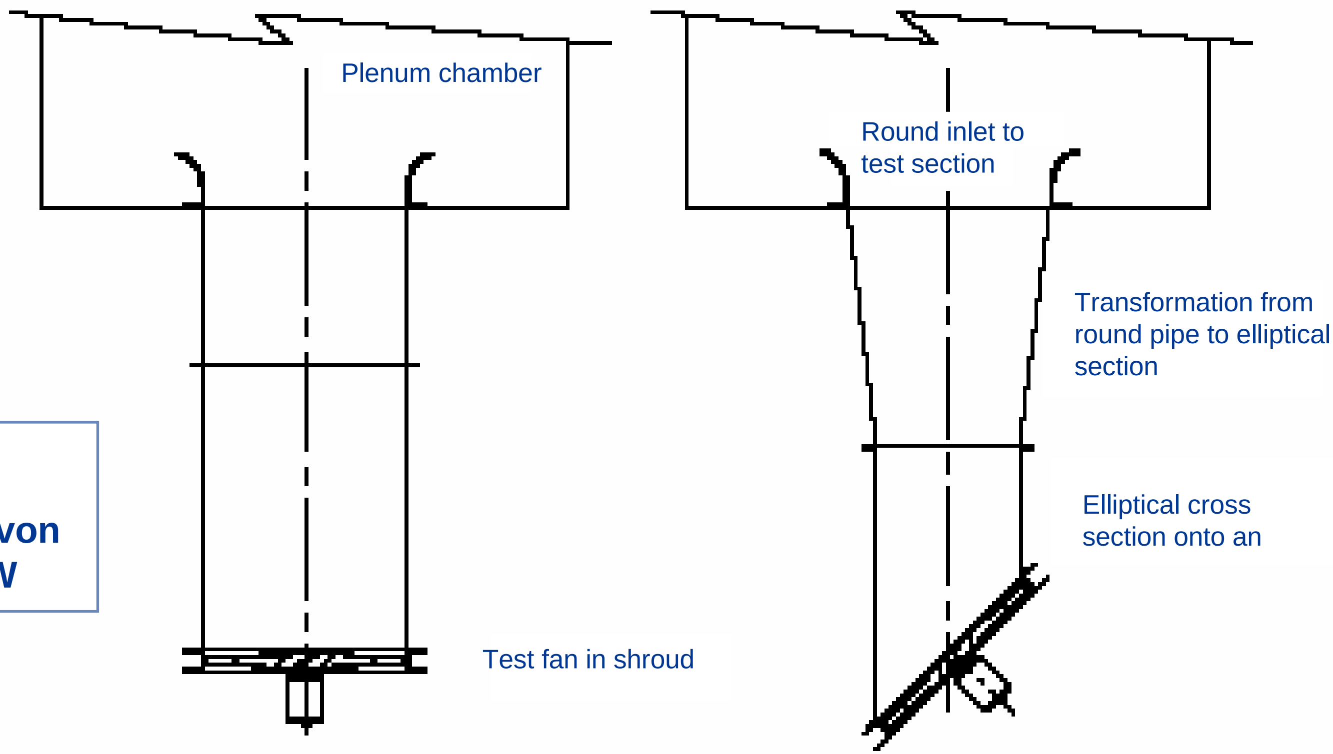


ITD trend over time



Ongoing R&D

- Validation of the numerical analysis of axial flow fans
  - Comparison of numerical results with test section results
  - Test in both ideal and distorted inlet flow conditions
- Correlation of fan performance for application in ACC platform simulation
- Determine appropriate fan pressure margin



Reference:

Stinnes, W.H., von Backström, T.W

Suggestions for further work

- **Performance test code to be re-written**
  - Current code(s) does not recognize for the operational characteristics of an ACC
- **Understanding of axial flow fan performance under distorted conditions**
  - CFD simulations to be validated
  - What is an appropriate fan pressure margin?
- **Ejector sizing**
  - ACC vacuum boundary is orders of magnitude larger than surface condenser and ejector size to be correctly specified
- **Extraction of liquid phase from LP turbine exhaust steam to be considered**
  - Reduction of corrosion on ACC internal surface

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Conclusion

- CFD modeling is an valuable tool to predict ACC performance
  - Approach should be systematic with adequate understanding of sub-components
- ACC performance during windy periods can be improved without need to increase heat transfer area.
- Optimization of ACC should preferably be done before construction starts
- Need for further development work, particularly to validate the axial fan characteristics during distorted inlet flow conditions

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