ACC Expansion

Considering the options to add fan modules to the Matimba ACC's.

Hein Goldschagg, ESKOM

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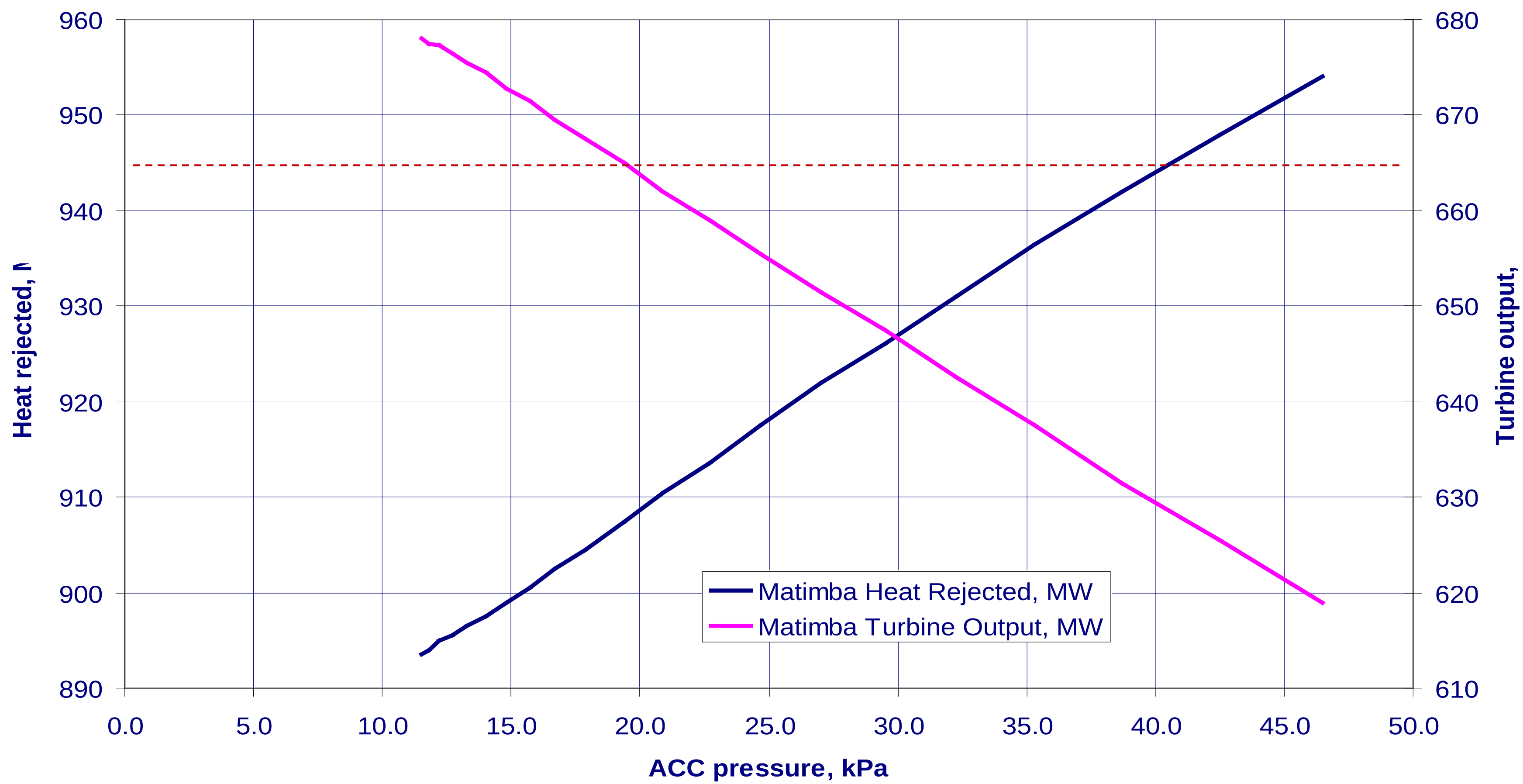
Background

- At the time of its construction, the Matimba was 10 times larger than the largest existing air cooled power station in the world.
- Turbines with air cooled condensers do not have a constant output as the output is directly related to the ambient temperature. The amount of over(winter)/under(summer) ACC capacity is determined by the capital cost and the reserve margin of the grid to compensate for under- capacity
- A station is licenced for a fixed rated output derived from its design points and vacuum related outputs lower than the rated output are considered to be “load losses” by the Grid Control
- The effect of atmospheric ambiences related to temperature, such as adverse wind conditions and inversion were not extensively incorporated in the design of Matimba
- It is therefore an anomaly that the largest ACC in the world was built a bit too compact and small!

Bow-tie curve for ACC

Turbine/ACC characteristic "bow tie" curve



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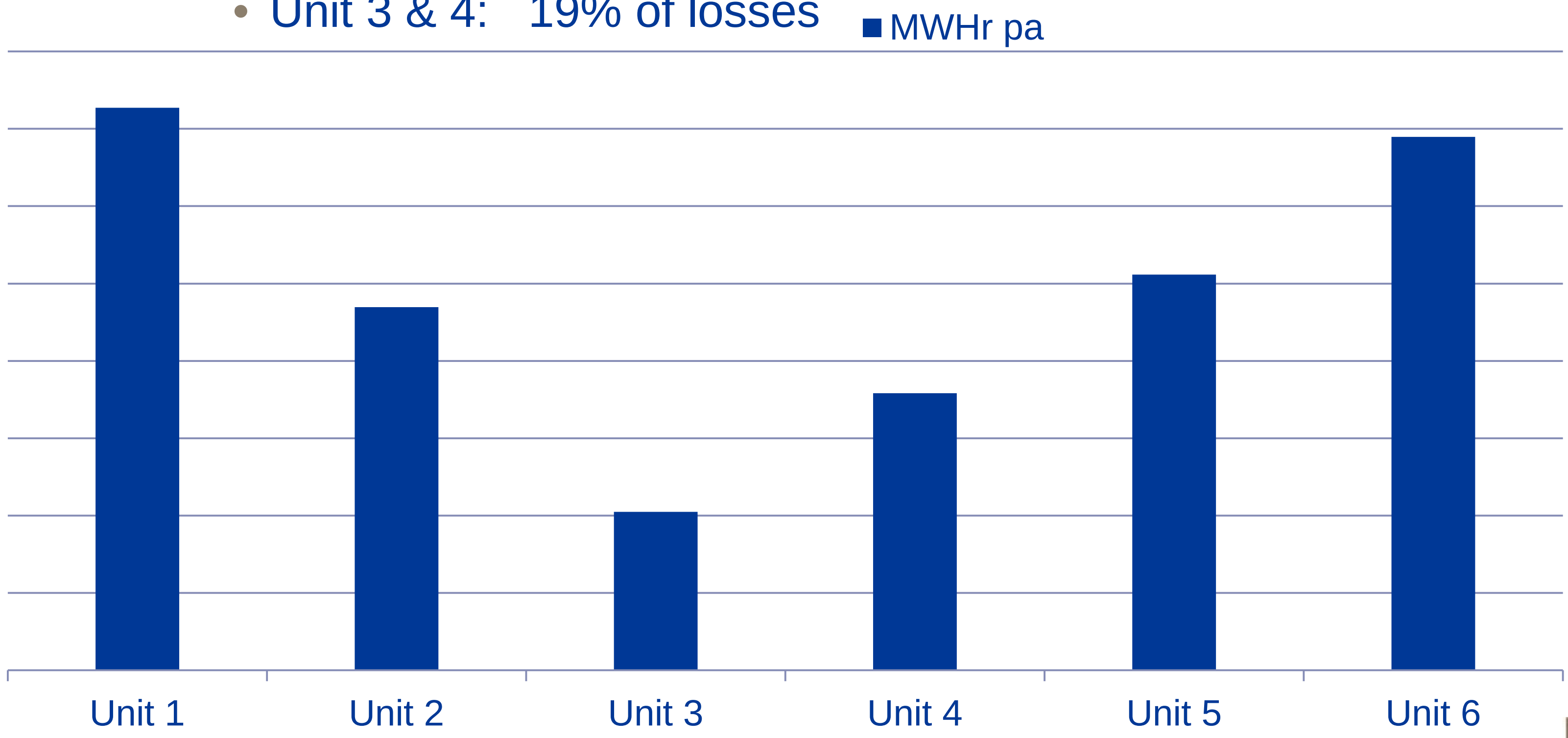
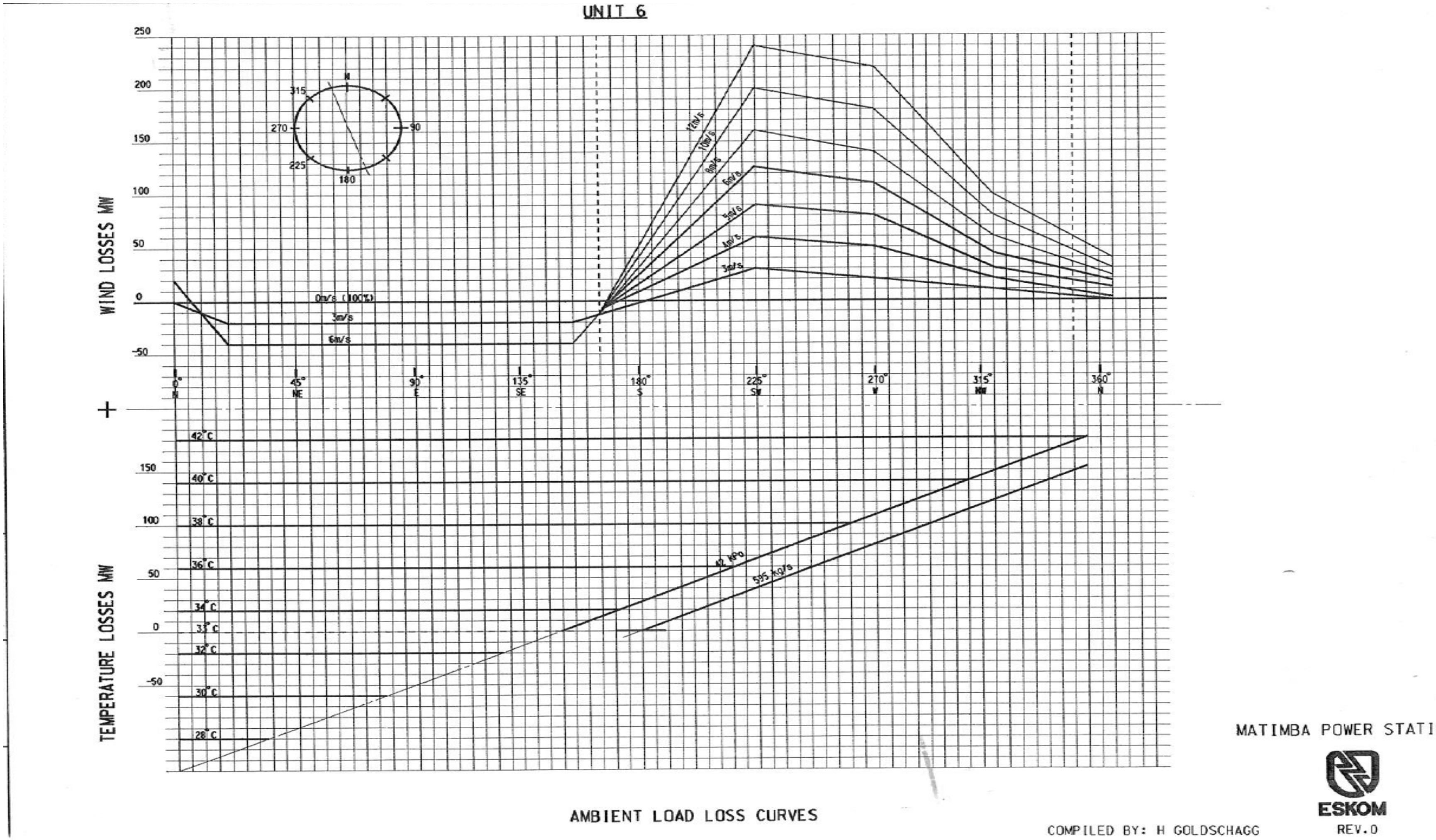
Nature of performance losses

- Averaged annual ACC losses per Unit (18 years data)
  - Unit 1 & 6: 48% of losses
  - Unit 2 & 5: 33% of losses
  - Unit 3 & 4: 19% of losses

The particular pattern is caused by a combination of adverse winds and high temperature



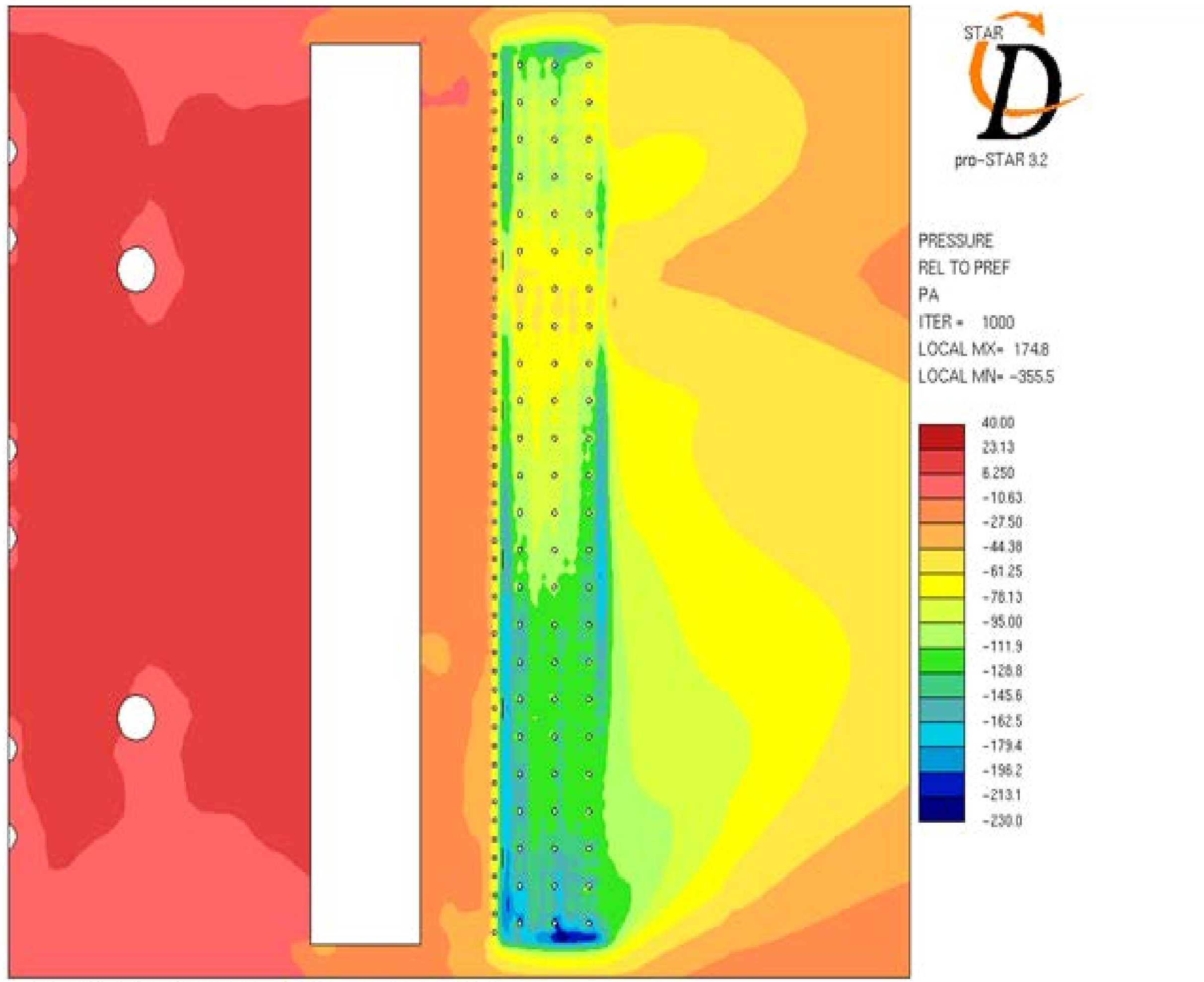
U6 Load loss curves based on observation.
Use to predict output from weather forecasts



CFD pressure field simulation

The CFD pressure field just below the fans indicates a lower fan inlet pressure at Unit 1 and 6. It shows that Unit 2 should be the best performing Unit while that honour belongs to Unit 3 .

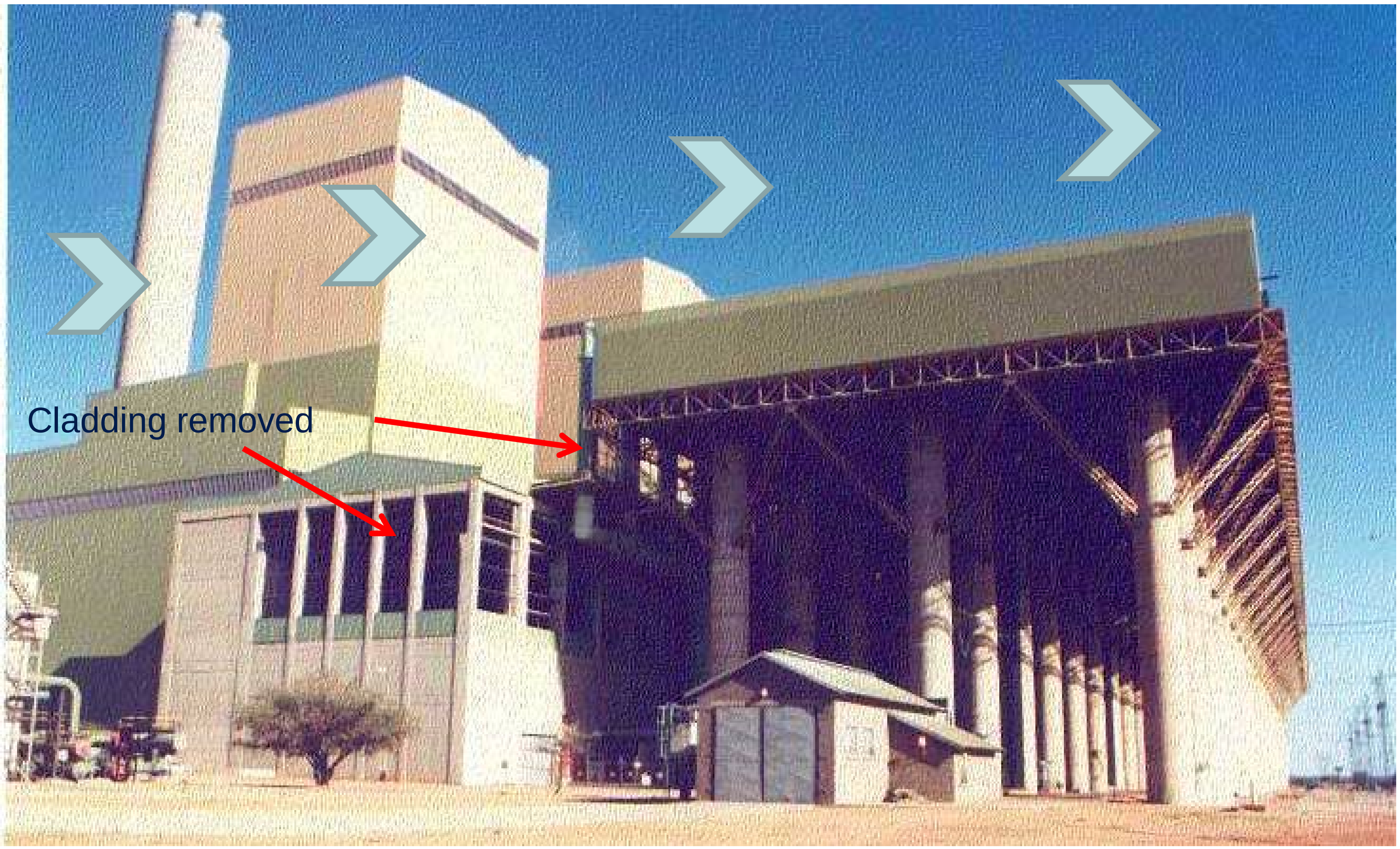
The CFD simulations are run as steady state conditions and at do not cater for the transient .conditions typical with wind. It is a useful tool but can not solely be used to guarantee performance increase expectations.



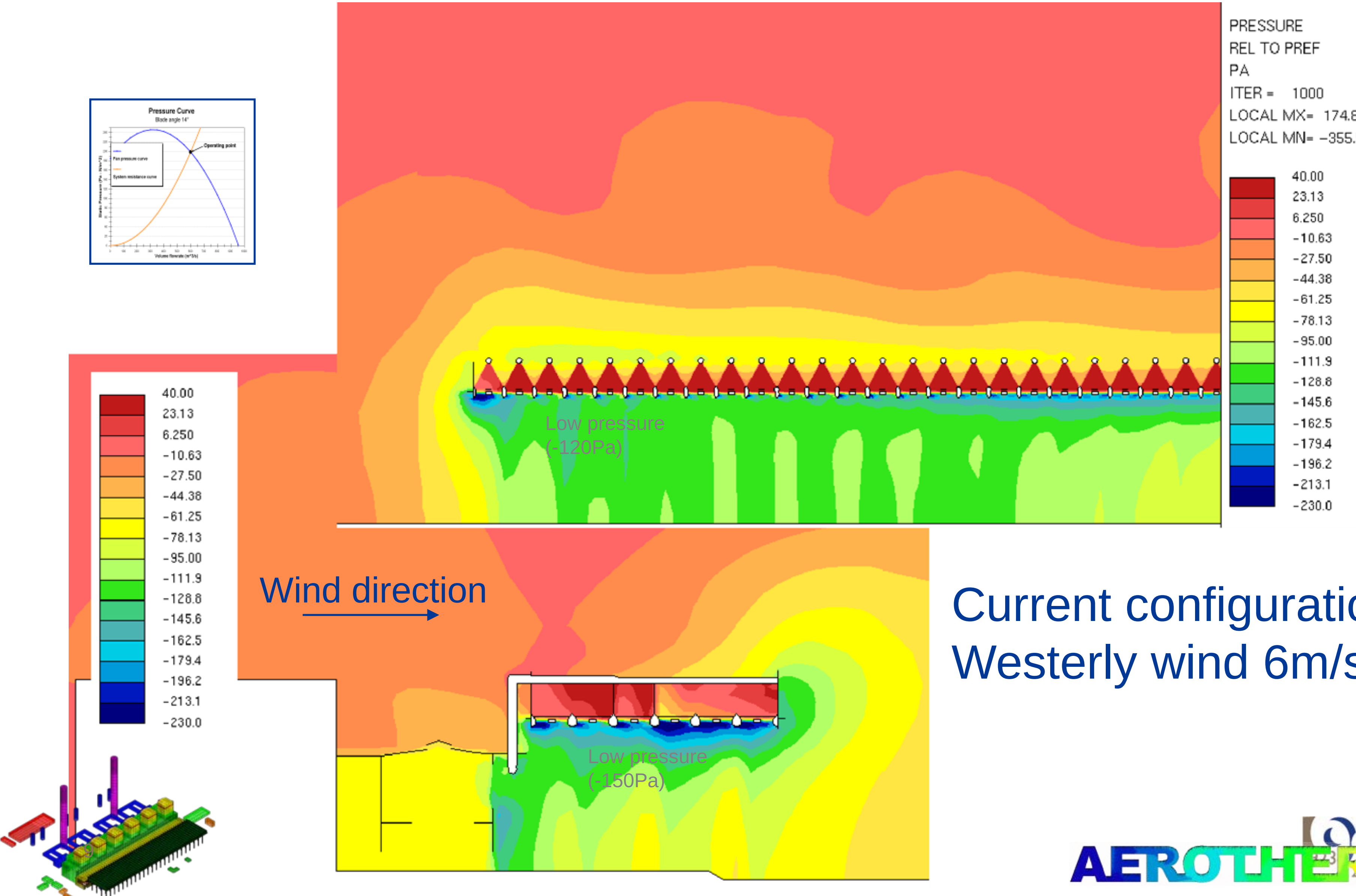
Matimba ACC – Current configuration : Westerly wind 6m/s @ hieght 45m
Section plot 40m above ground level viewed from the top.

Low Cost Options; air flow improvement modifications implemented

Cladding on turbine hall walls and ACC removed to create air passage to U6 fans with westerly winds



Low pressure below U1 and U6 outer fans remain significant.



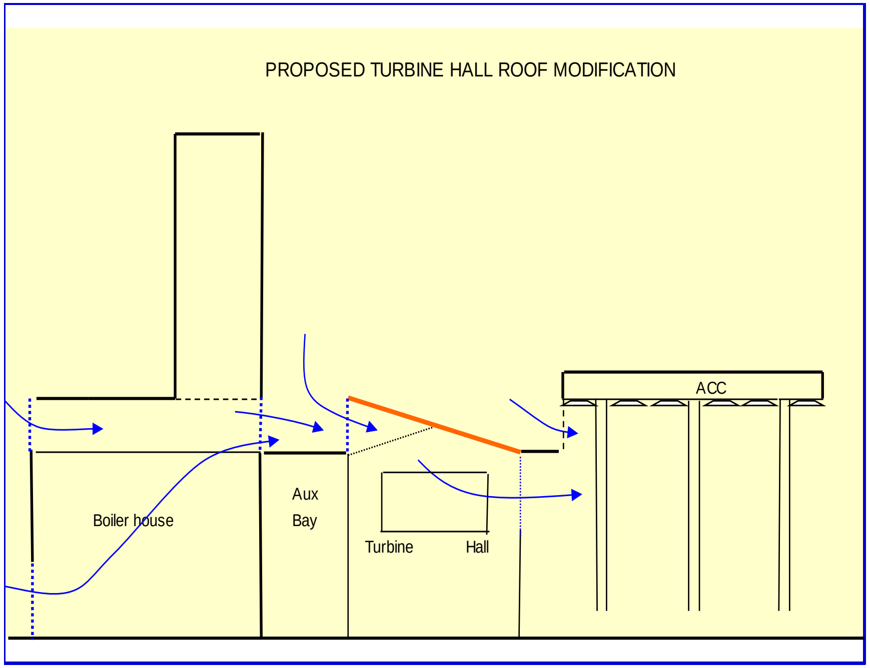
Current configuration
Westerly wind 6m/s

One remaining low cost option

The extent of the modifications already implemented is not sufficient to eradicate wind problems.

An experimental project is initiated to modify the U6 turbine hall roof to create a larger passage for the westerly winds.

The success of the Unit 6 roof modification will determine if the rest of the Units will be modified as well.

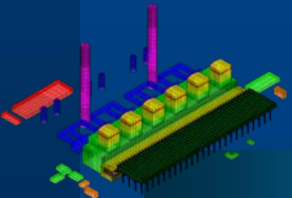


Options for further improvement

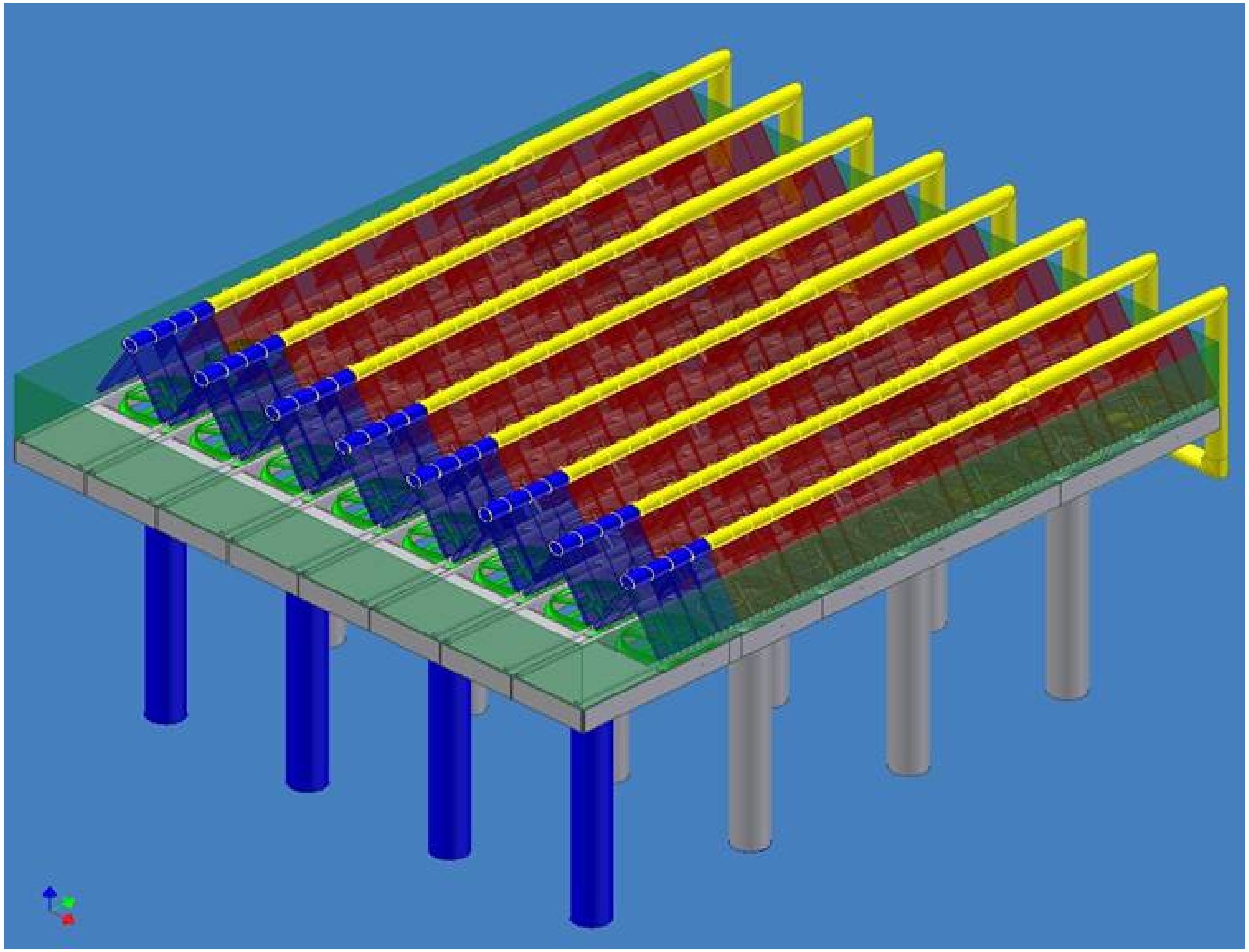
- **Increase the number of fans and heat exchangers:**
  - This gives more mass flow rate due to higher number of fans
  - It also increases heat transfer Area

$$Q = m_a c_{pa} (T_s - T_{a_{in}}) \left[1 - \exp\left(-\frac{UA}{m_a c_{pa}} \right) \right]$$

More fans would result in an even lower pressure under the platform and could therefore cause more hot air recirculation? - Simulate to get indication

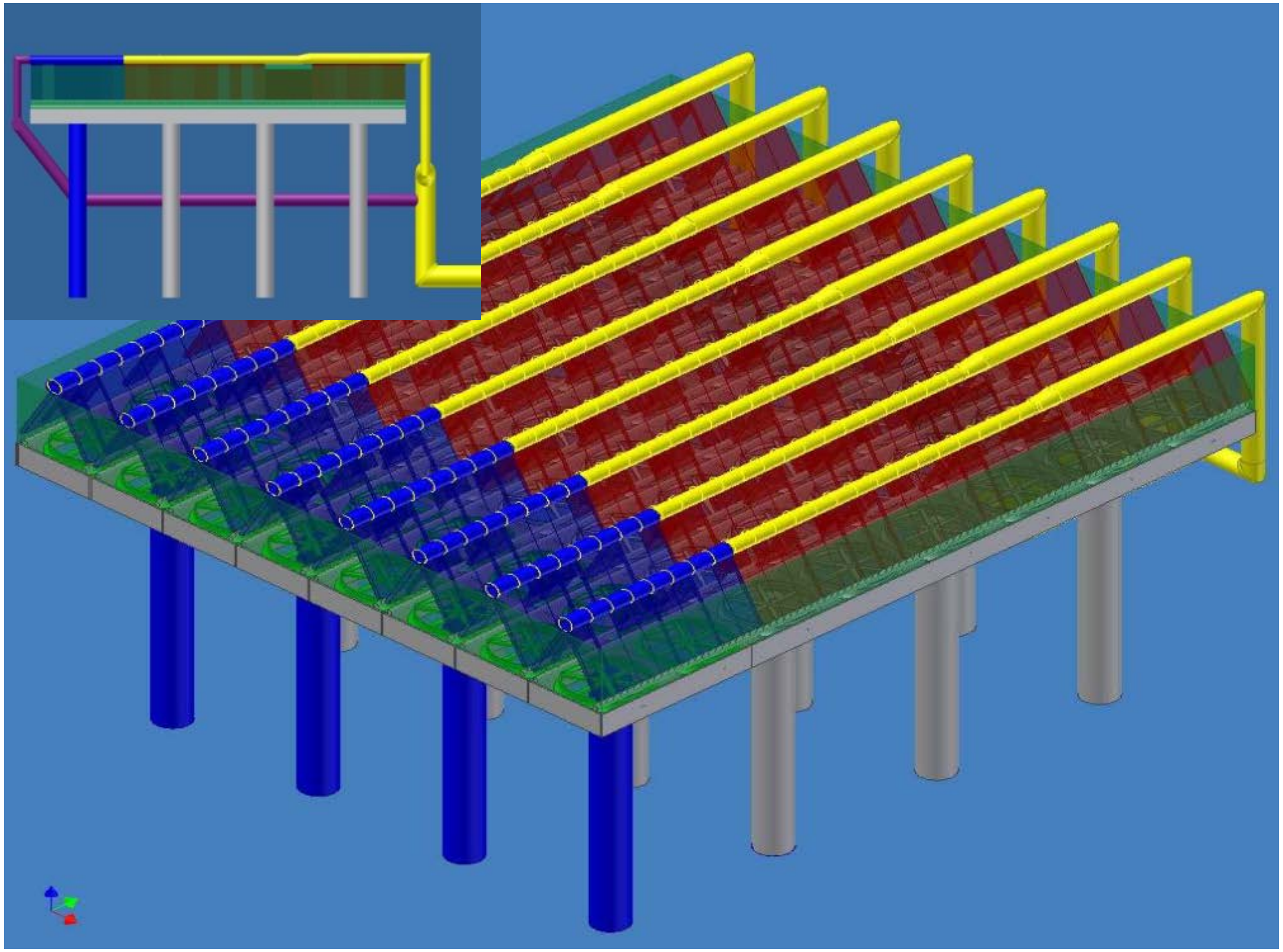


High cost option 1: 8 x additional 9 meter fans



Advantages:
Wide platform overhang inhibits recirculation, and also allow for increased number of bundles per fan
Disadvantages:
Construction works required close and over HV lines.
Additional columns to be constructed

High Cost Option 2: 16 x additional 9m fans added



Advantages: Gives highest MW increase in output

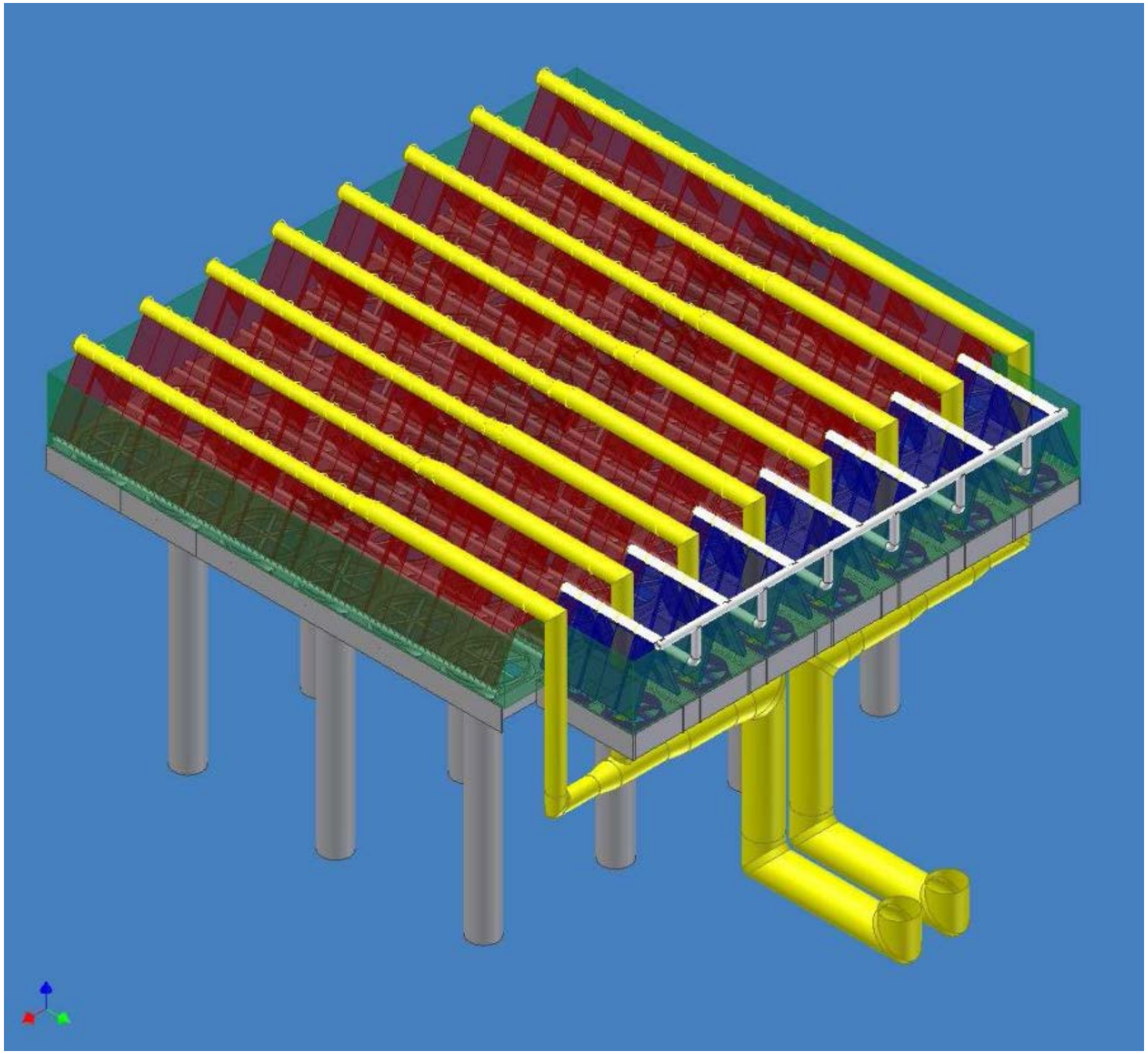
Disadvantages: Requires additional columns, 400kV lines in construction area, additional duct required to prevent very high steam velocities and tube inlet erosion

Construction Obstacle

A major disadvantage of options 1 and 2 is the position of the generator transformers and 400kV lines coming from below the ACC platform. Constructions should ideally take place while the Units remain in operation.

Option 3: 14 Additional 7m fans supported on turbine hall wall

Design checks indicate turbine hall wall can support additional fan modules.
Advantages: No support columns required, short steam ducting, dephlegmators remains in middle of ACC, steam velocities not significantly affected. Construction out of HV line way
Disadvantages: Not accessible with tower crane to construct, maintenance access very restricted



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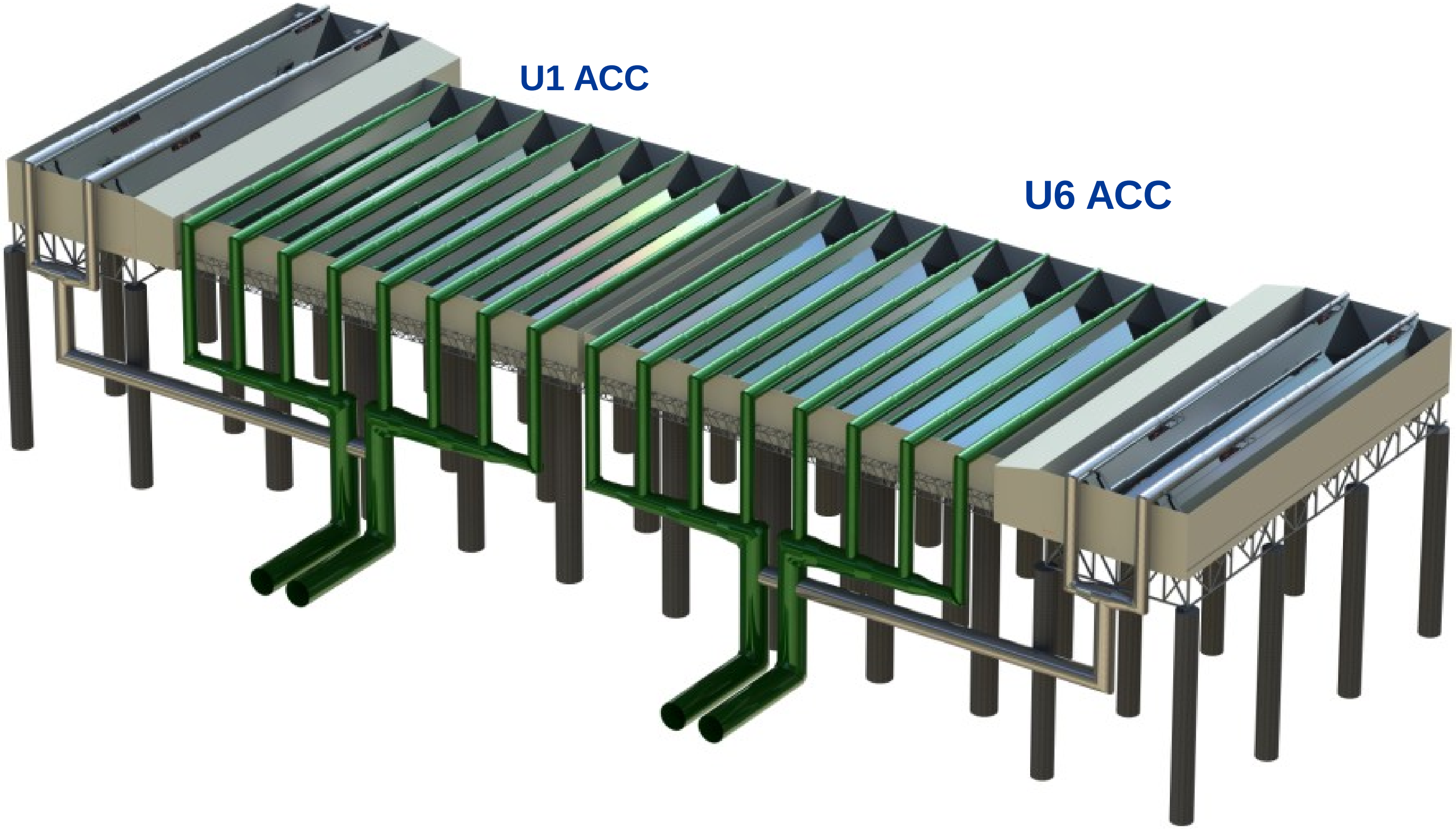
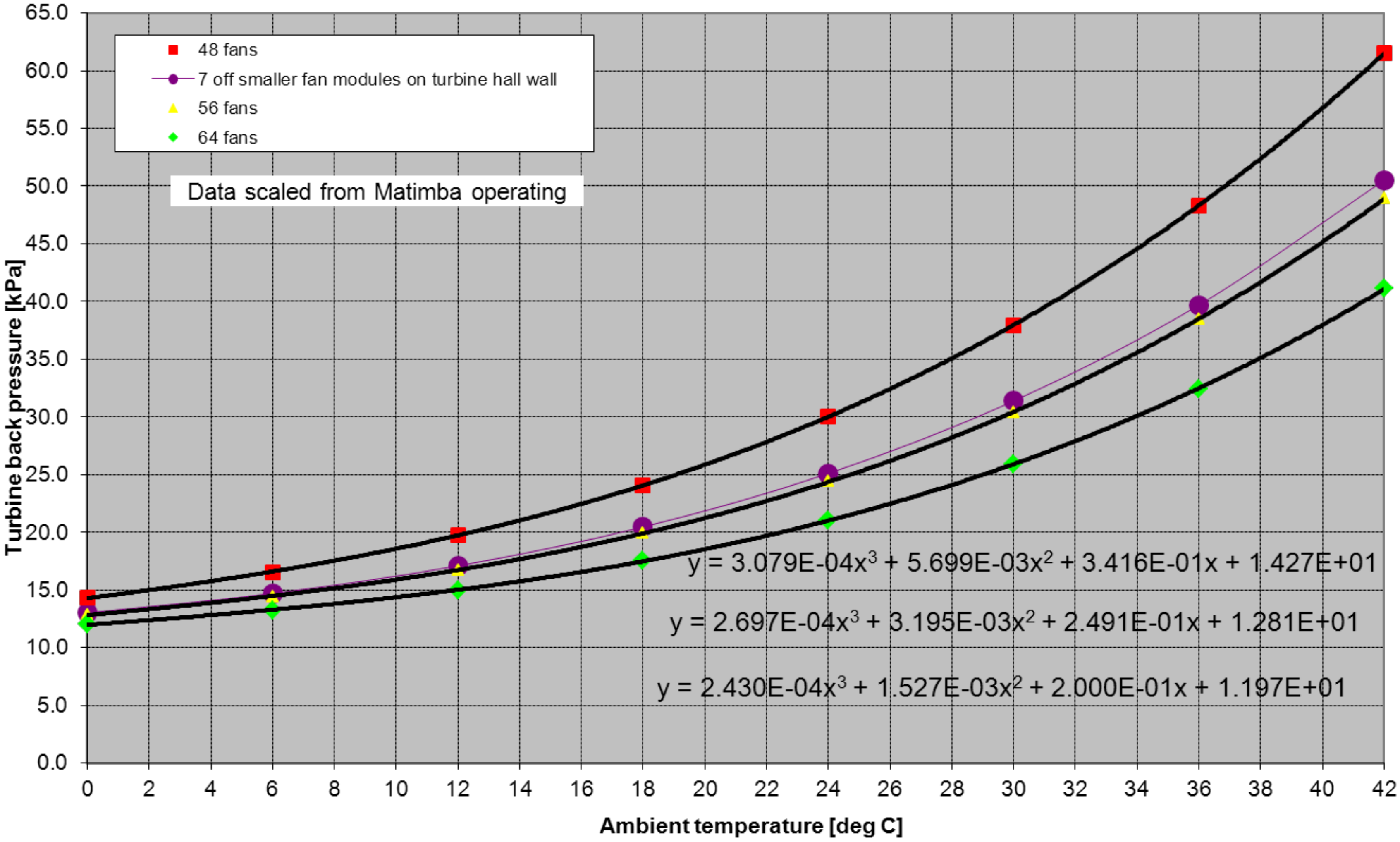
Unit specific Option: Add 12 larger 10m fans to Unit 1 and Unit 6

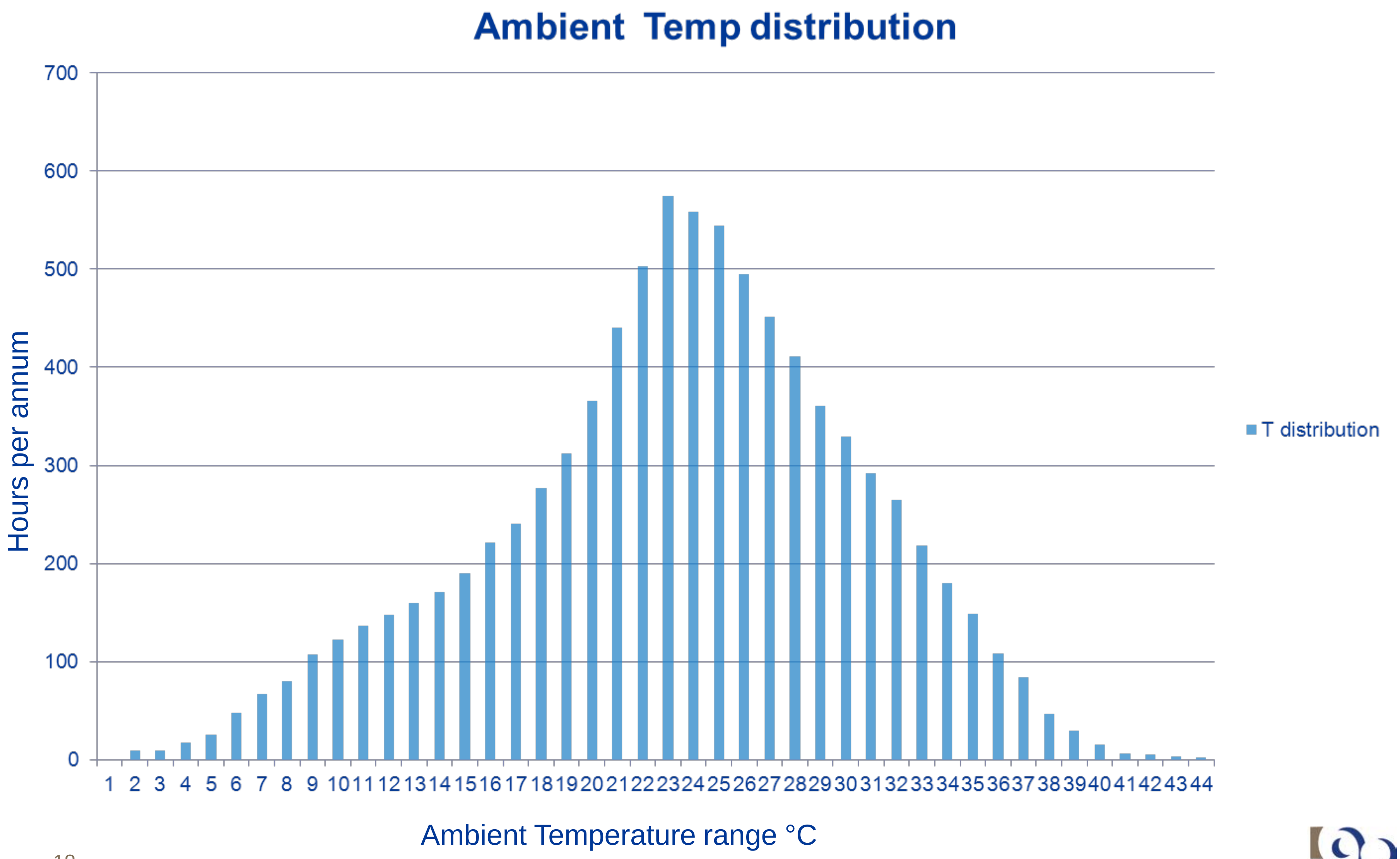
Unit 1 and 6 ACC platforms can be extended to the north and south without interference from the HV equipment. Larger sized fan modules are considered and simulated as the “worst case” that may negatively affect the fan performance of the existing ELF fans



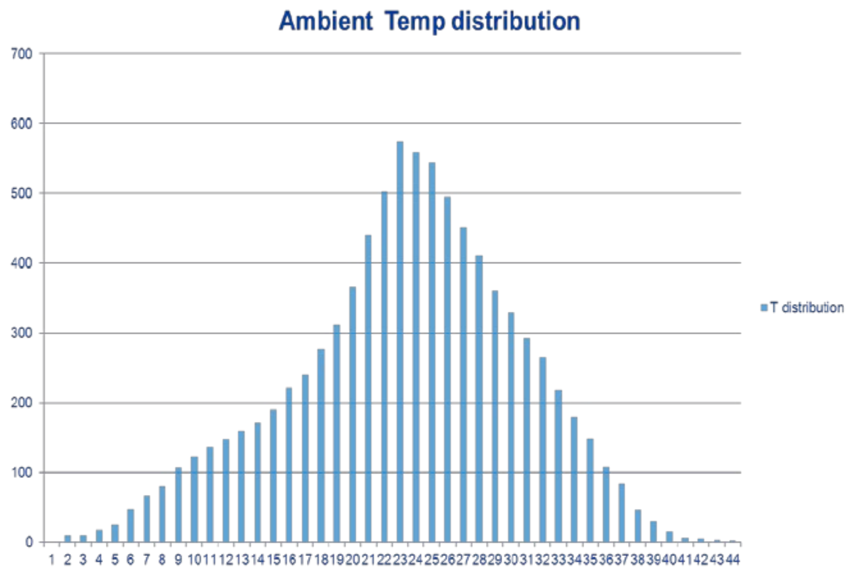
Calculated Back pressure improvement per Option for the ambient temp range (GEA)

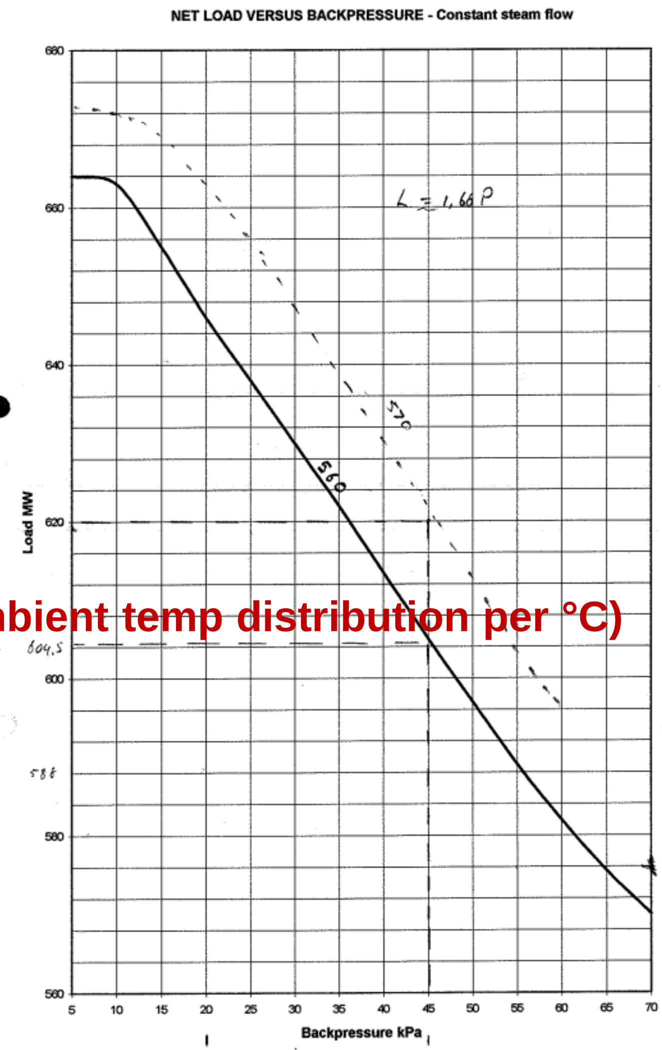


Ambient temperature distribution – hours per annum

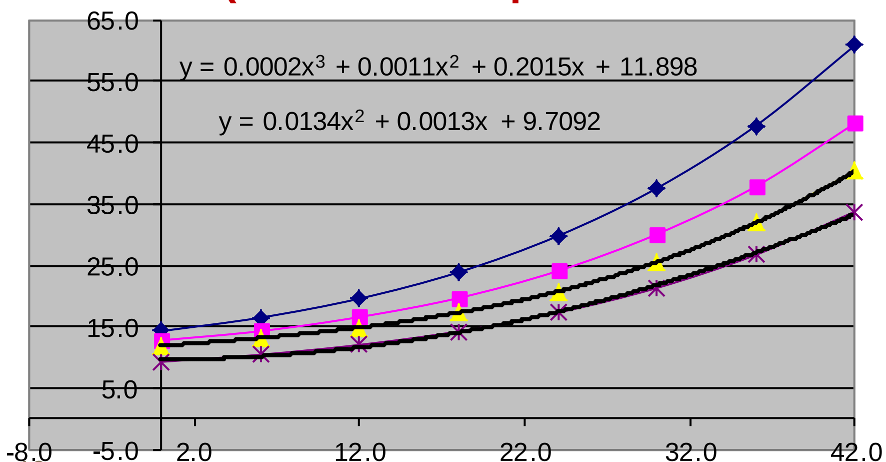


Info required to calculate MWhr Gain at constant steam flow for each option





MWhr = Σ (MW increase per kPa decrease x Ambient temp distribution per °C)



Indicative MWhr gained per option wrt ambient temp distribution profile

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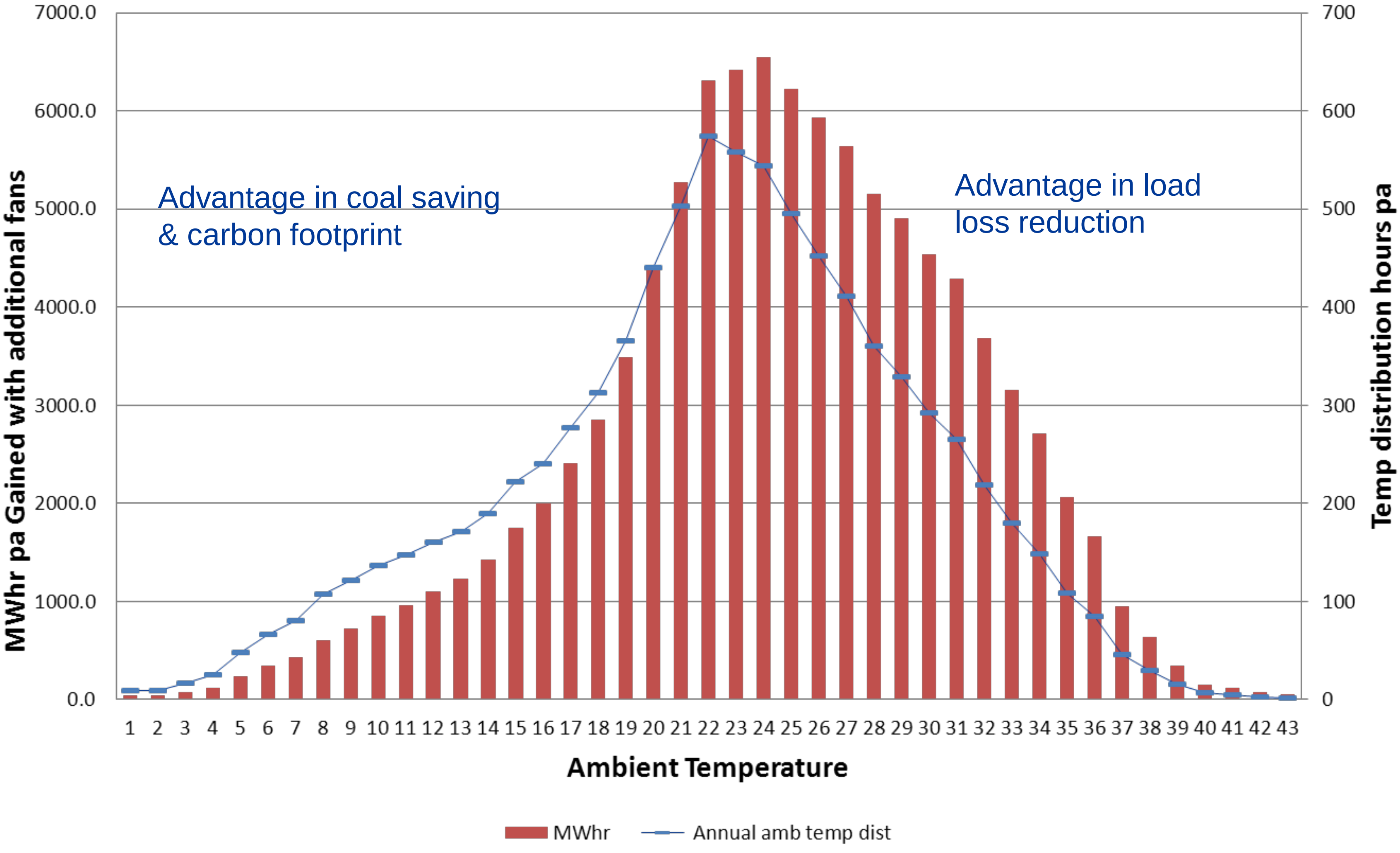

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Evaluation of an ACC enlargement project

- Increasing the size of an ACC includes elements of both efficiency improvement and capacity increase . Environmental aspects such as reduction in carbon footprint is also lately becoming more prominent Economic evaluation of a project to enlarge the ACC depends on how the project is viewed by the utility.

- If the project is considered a capacity increase venture then a levelised cost model may be used to compare the increased capacity with other green fields projects. An environmental assessment will normally be required for a capacity increase project.

- Should the project be considered an efficiency increase project a different economic model is used that compares the cost of generation at different power stations of the utility at normal and peak time to determine the viability of the project

- Ideally the evaluation should consider both aspects but may become quite complex to model.

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THANK YOU