Alternative Approach To Fan Design For ACCs - Increased Performance Under Adverse Conditions

IAHR 2017

October 2017

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About the ACC

- At the time of construction, the Matimba ACC was **11 times** larger than the largest ACC in operation anywhere in the world.
- 6 units x 665 MW, 48 fans/unit.
- Historic load losses, published, specifically in windy months.
- During 2016, 7 cases of >1000 MW station load loss due to vacuum.
- Usually in afternoon, 30°C+, winds up to 100 km/h.

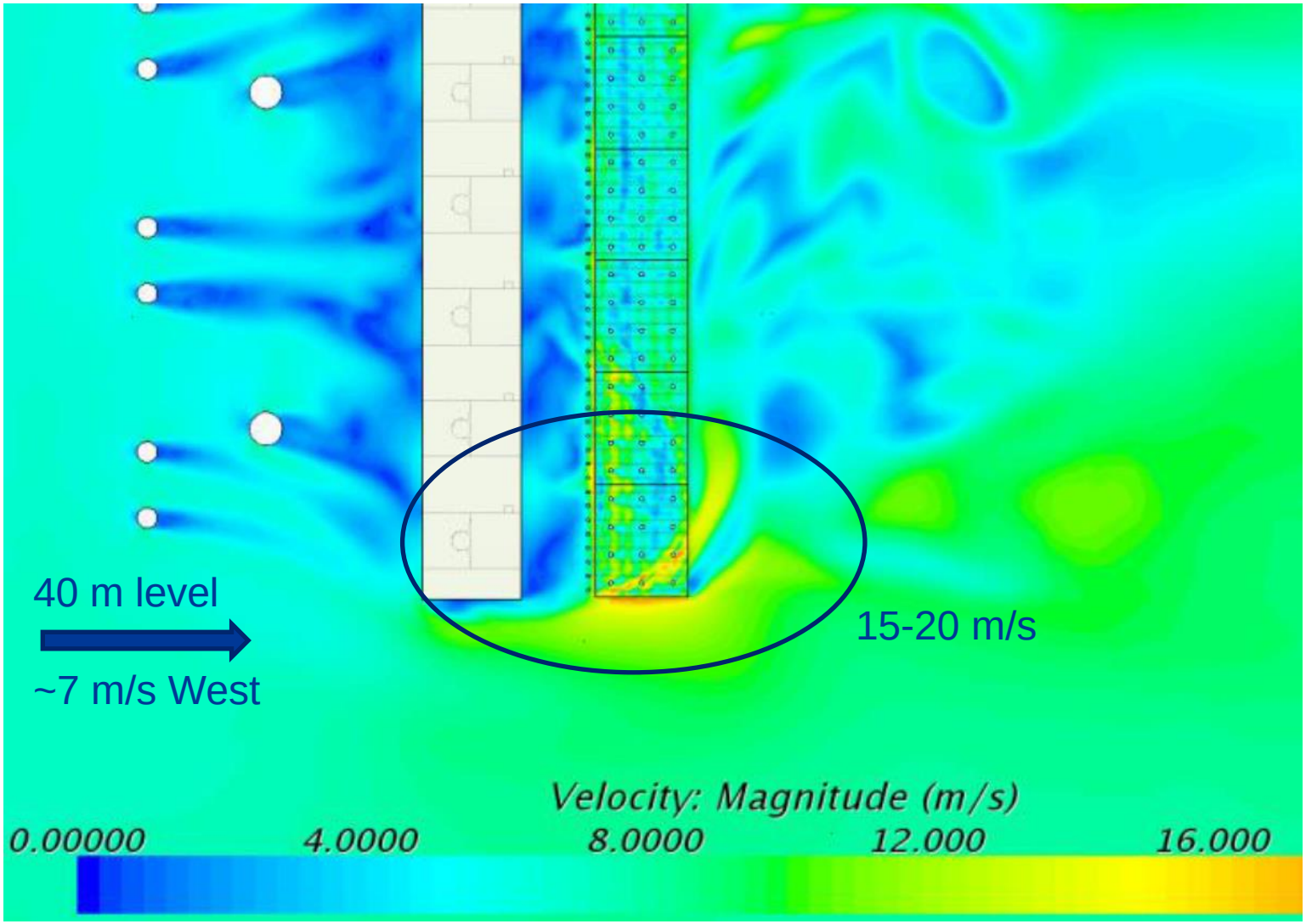
Date	Time	MW Load loss
September	16:00-17:00	1003
October	15:00-16:00	1025
October	14:00-17:00	1121
October	15:00-16:00	1041
October	14:00-15:00	1082
October	13:00-16:00	1135
December	14:00-15:00	1077

About the ACC

The “problem” with solving the problem

- Typical average production ~ 24 000 GWh
- MWh loss due to vacuum related problems in 2016 ~ 350 GWh
- Loss percentage of total average production < 1.5%
- Economics makes it difficult to find a solution that justifies the capital expenditure without the guarantee of total (or large) load loss reduction.
- >> Not feasible to reduce load losses entirely and very expensive to reduce given uncertainty.

Modifications



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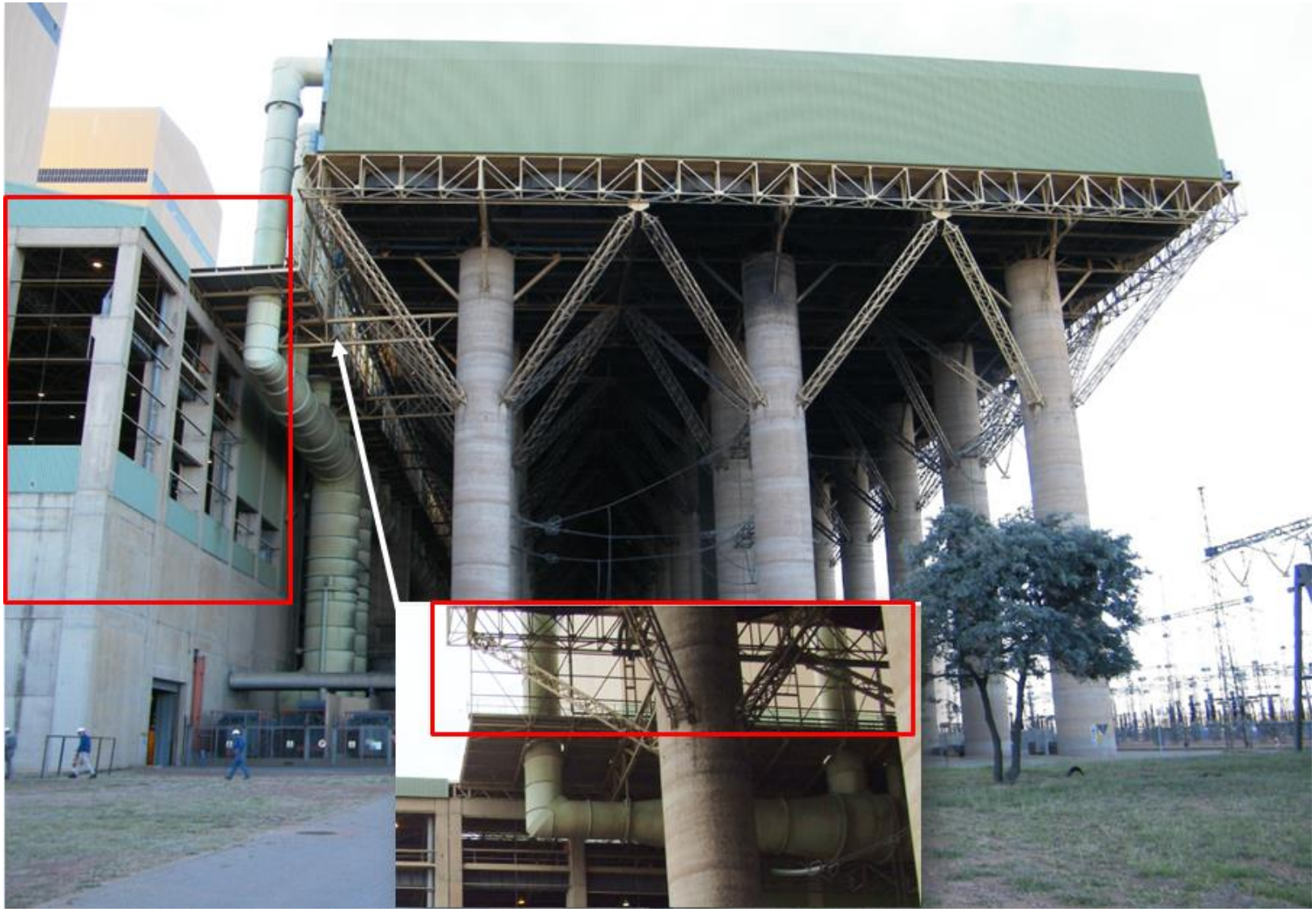
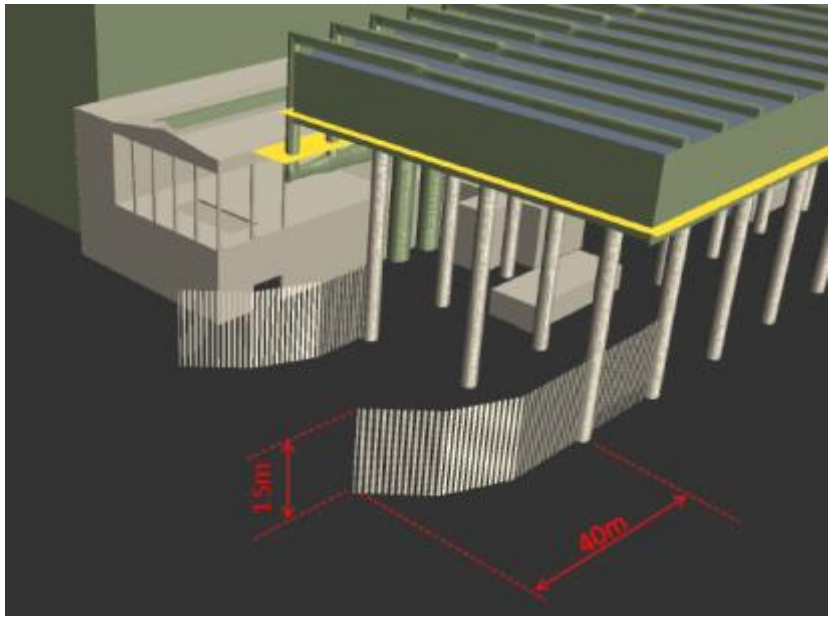
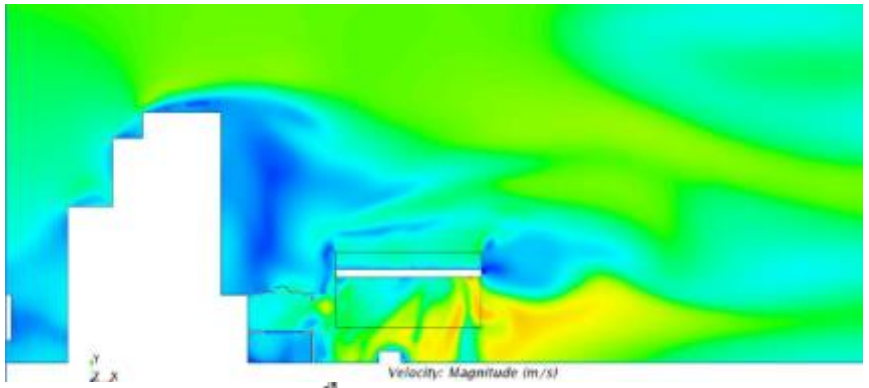
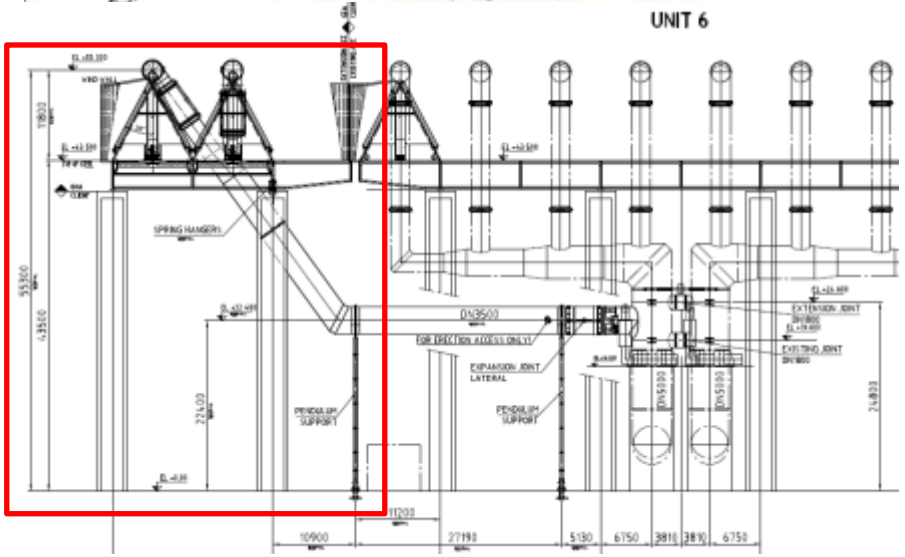


Previous studies

- CFD studies
- Unit 1 & 6 project
- Ash dam-condenser project







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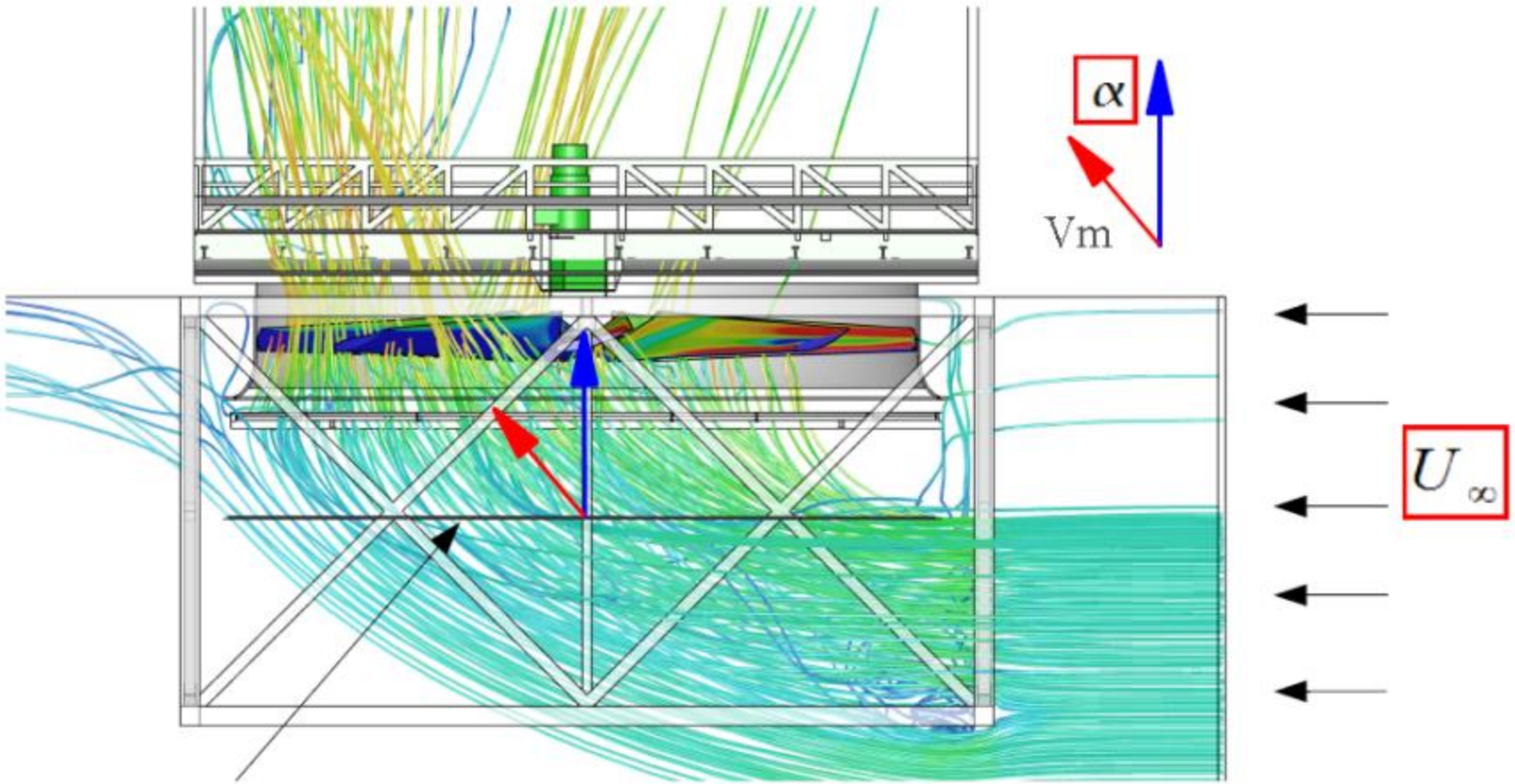
Basics of fan performance



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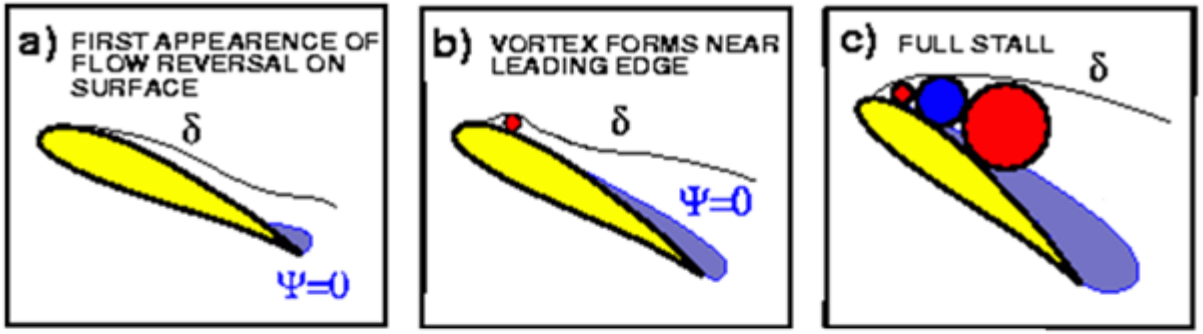

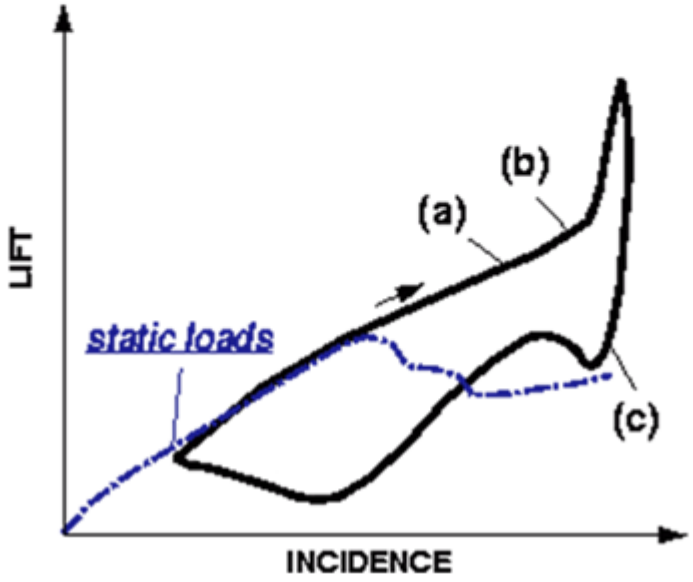

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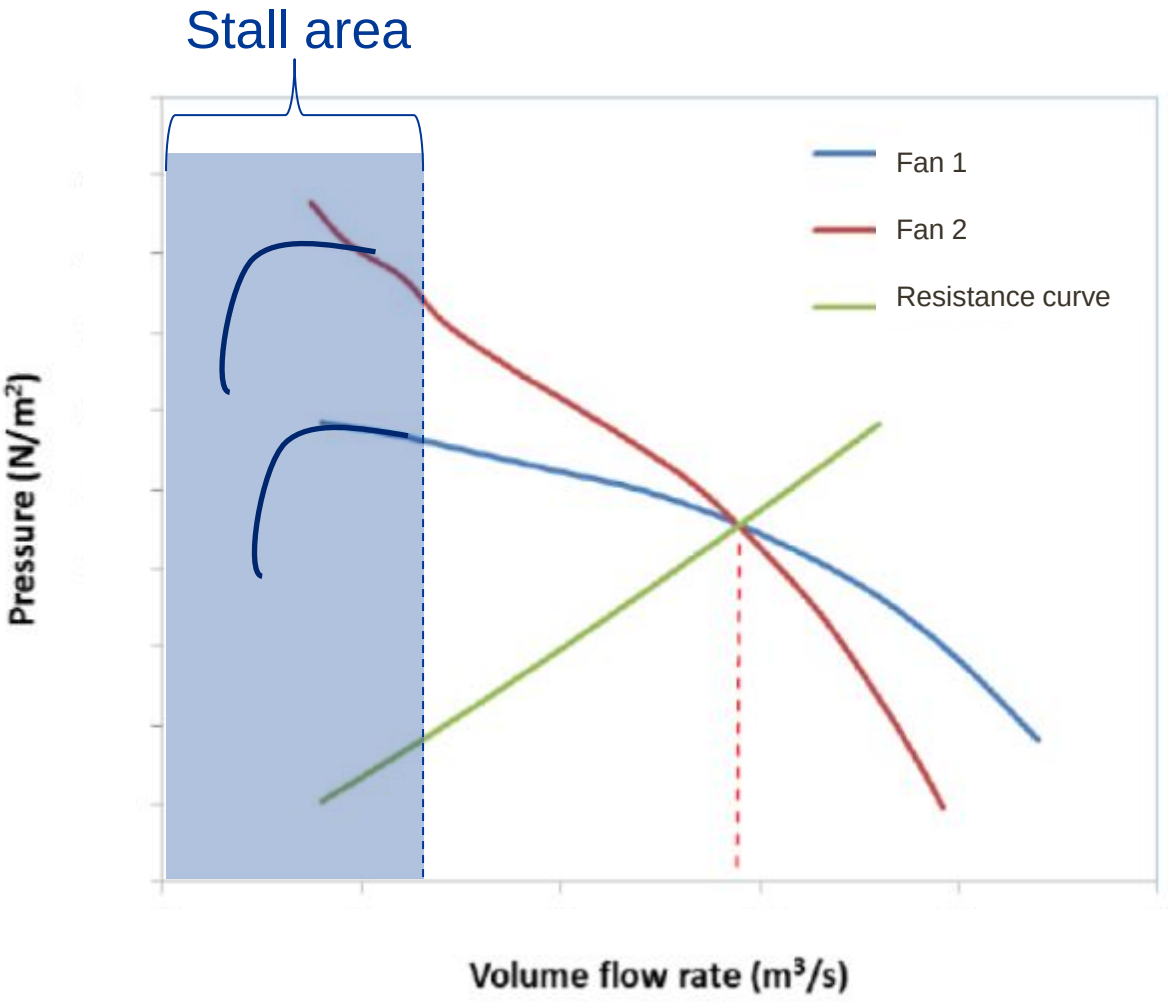

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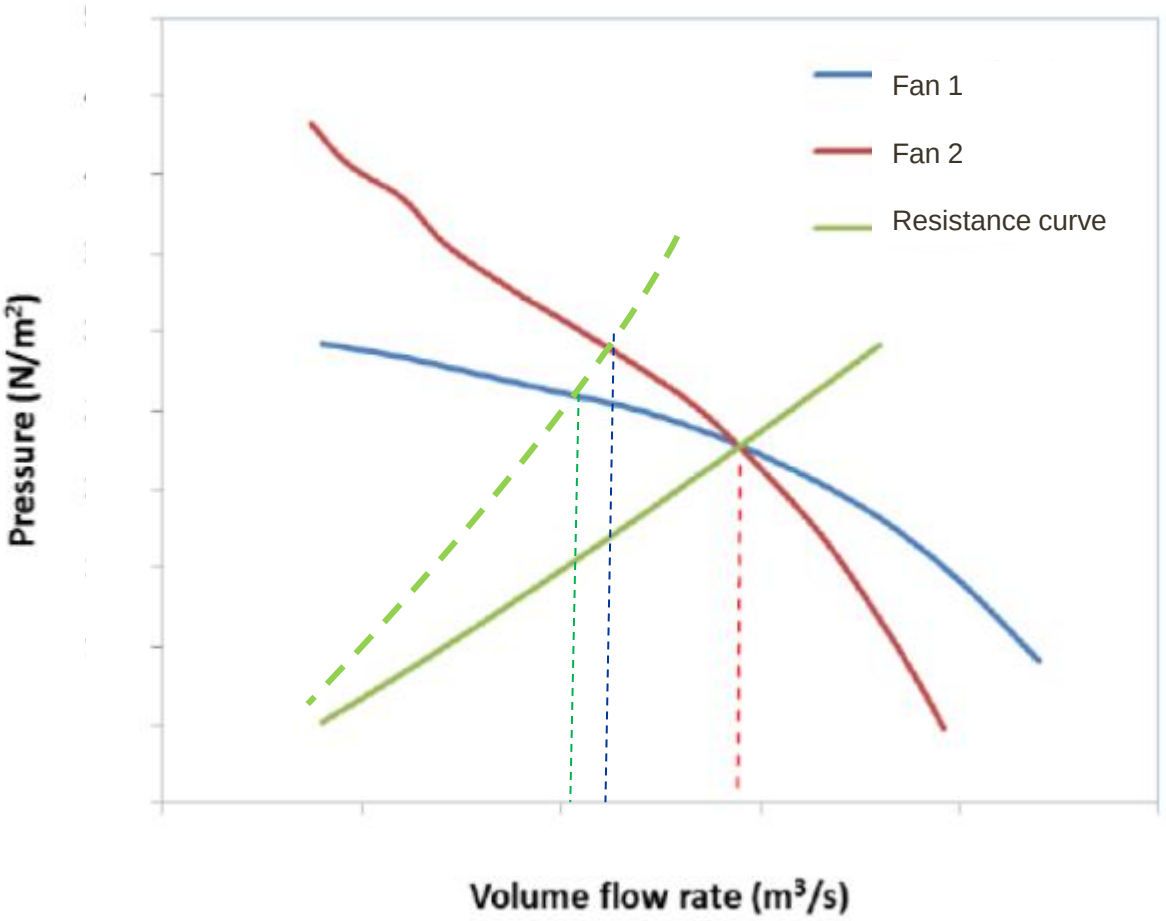


A different approach

- Horizon 2020: MinWaterCSP; EU funding program.
- Reduction of water consumption in CSP applications.
- Consortium: Kelvion & Enexio, ECILIMP Thermosolar, Soltigua, IRESEN, WATERLEAU Group, Notus Fan Engineering.
- Design, manufacture, install and commission a 30ft. diameter ACC fan.

MinWaterCSP

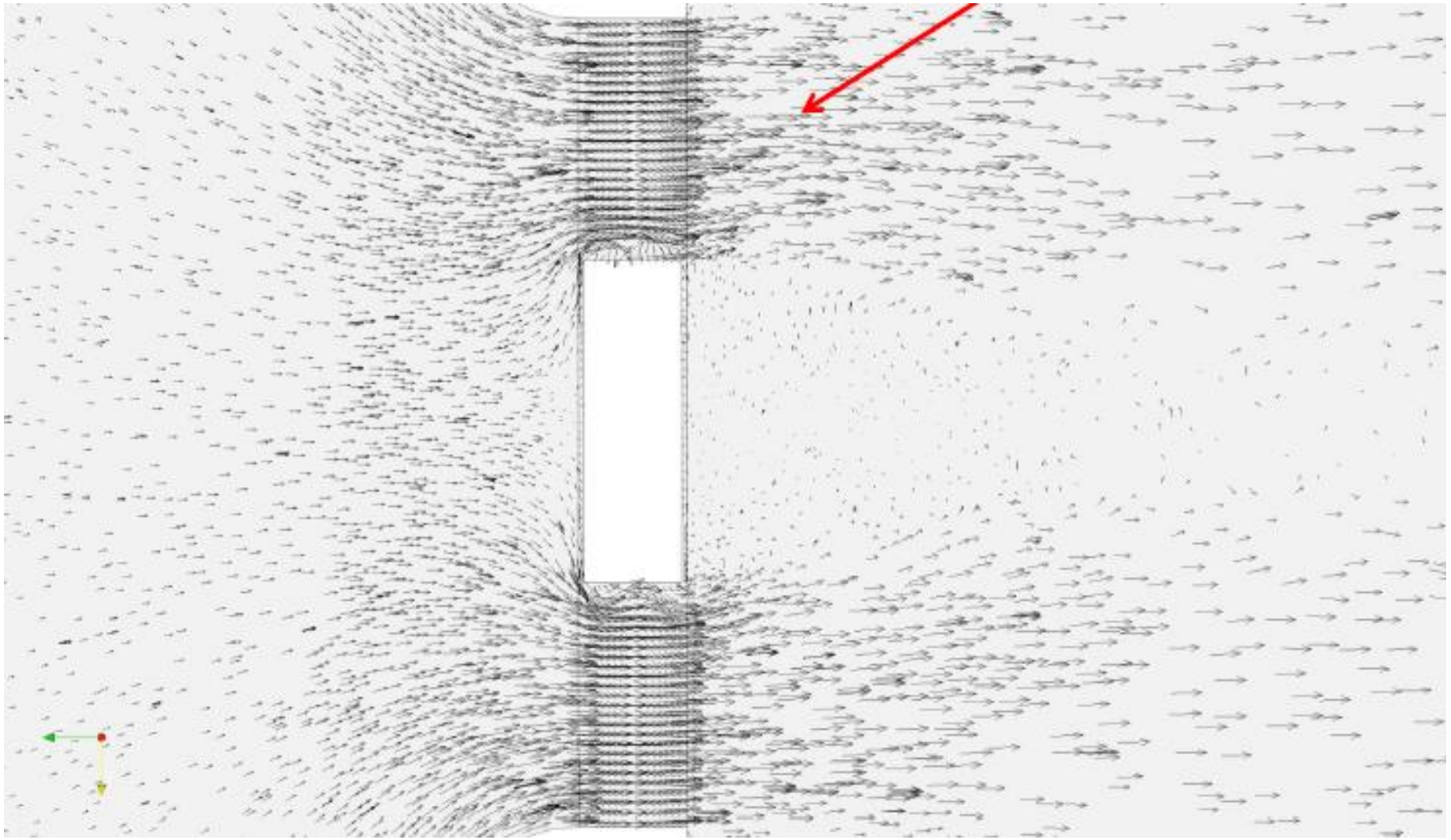
A different approach – fan design

Aerodynamic design

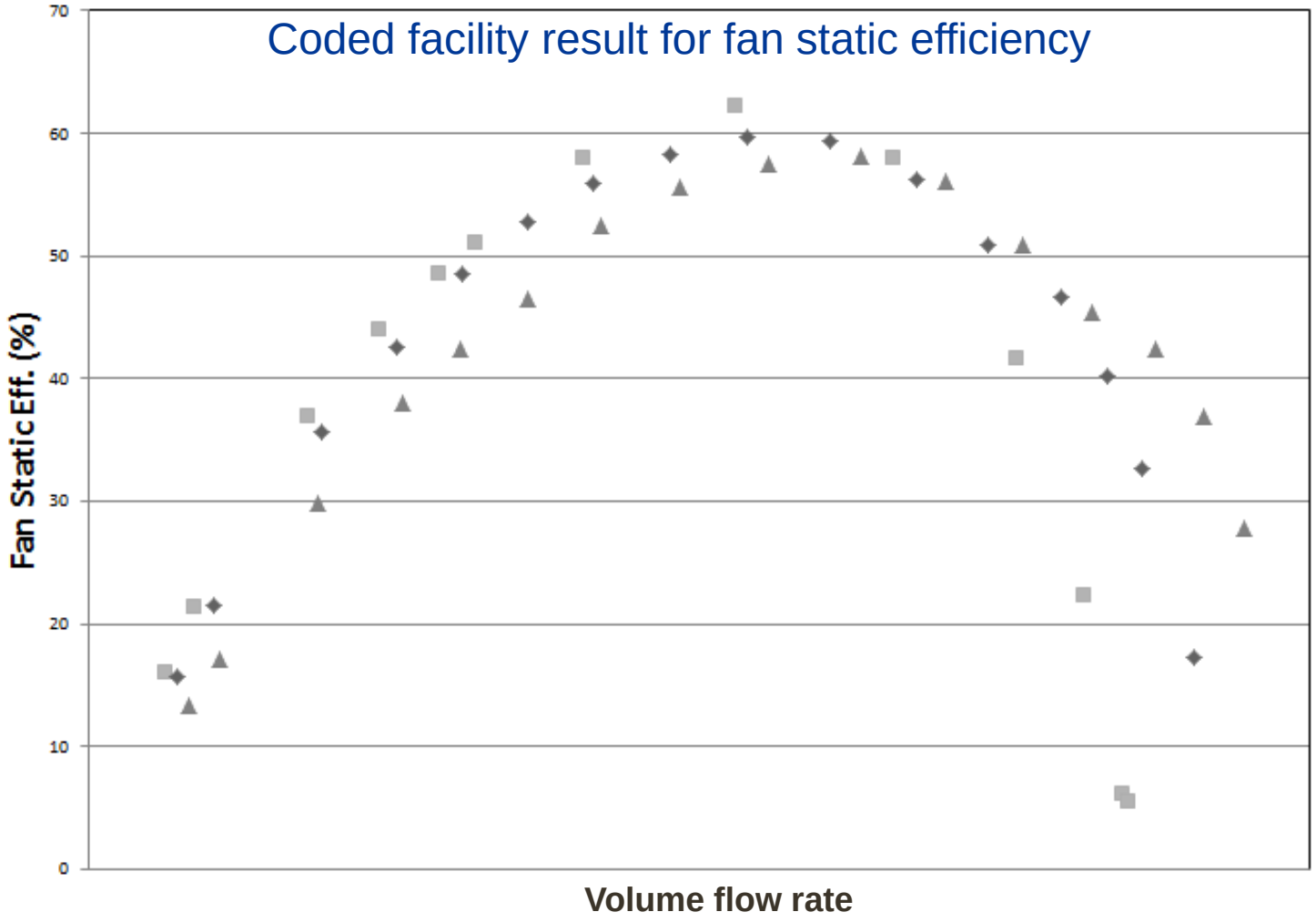
- Computational Fluid Dynamics (CFD)
- Duty point – same as current fan installed at Power station
- High fan static efficiency (~ 60%)
- Protection against wind (“steep” curve)

A different approach – fan design

Uniform flow distribution through the fan

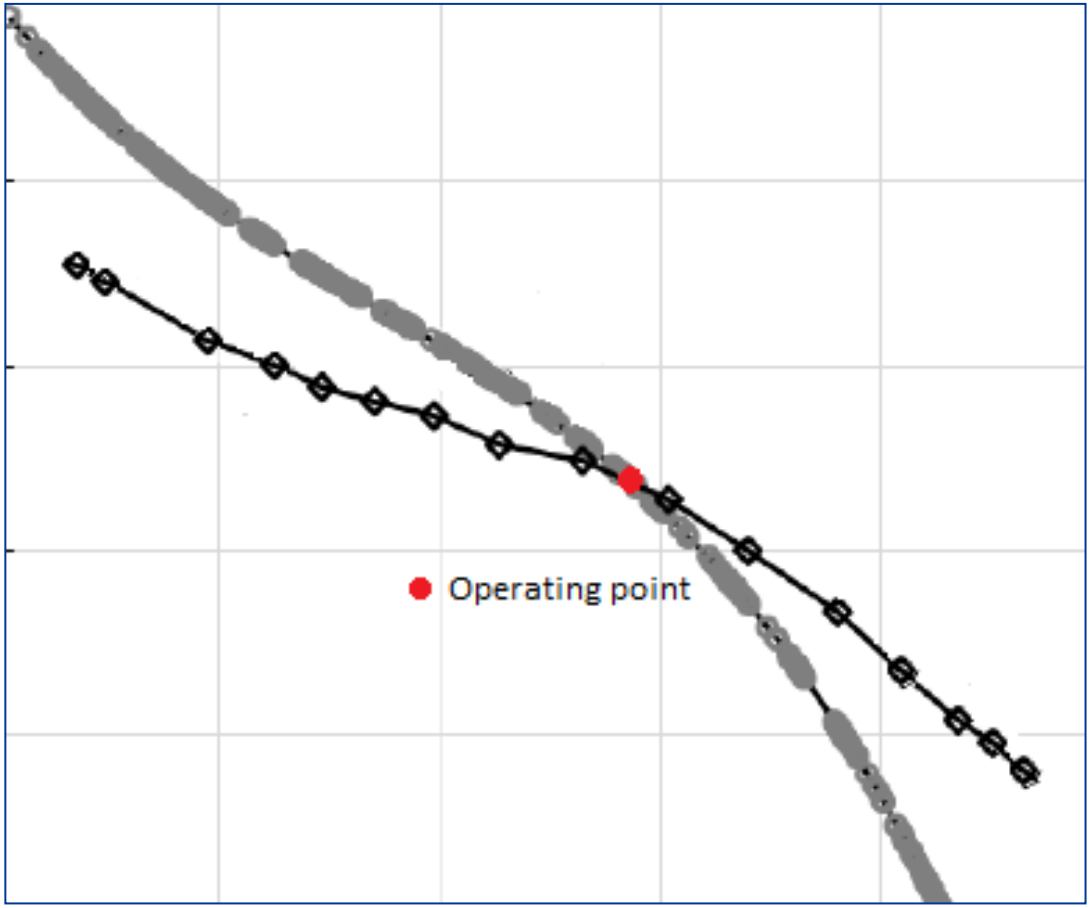


A different approach – fan design



A different approach – fan design

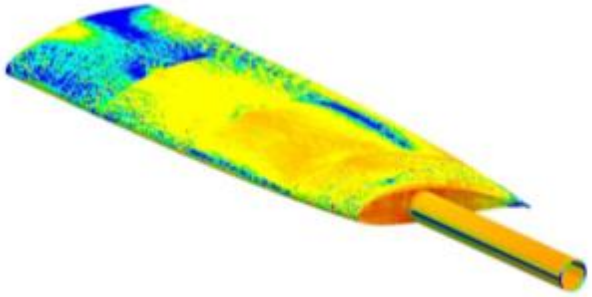
Steeper fan curve for the operating duty point

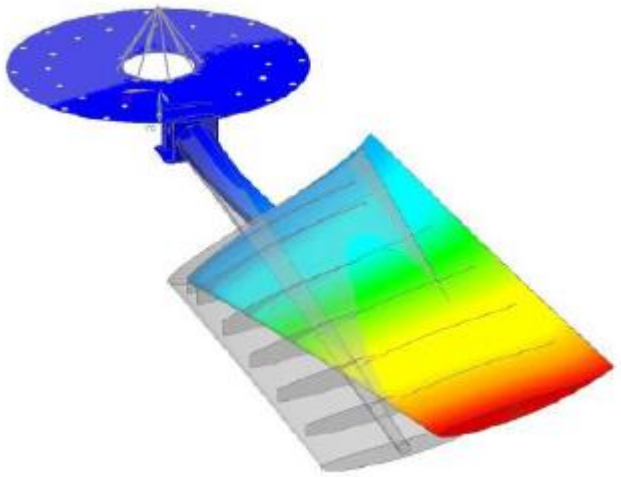


A different approach – fan design

Structural & dynamic design

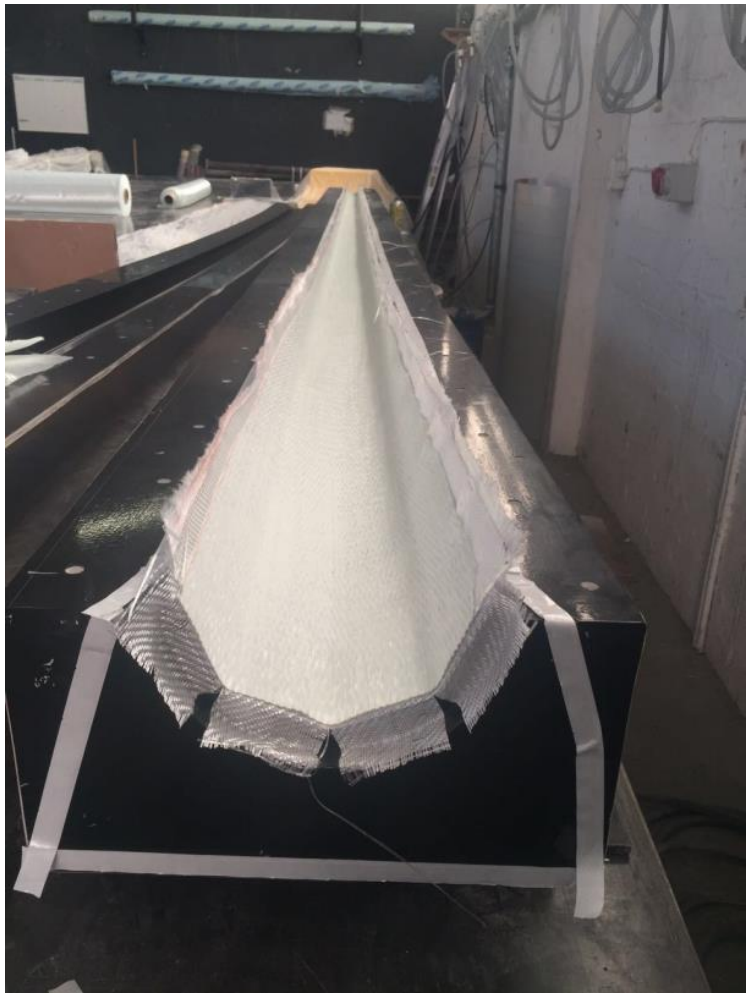
- Finite Element Analysis (FEA)
- Modal analysis (vibration)
- Experimental data from PS (MSc)





A different approach - manufacturing

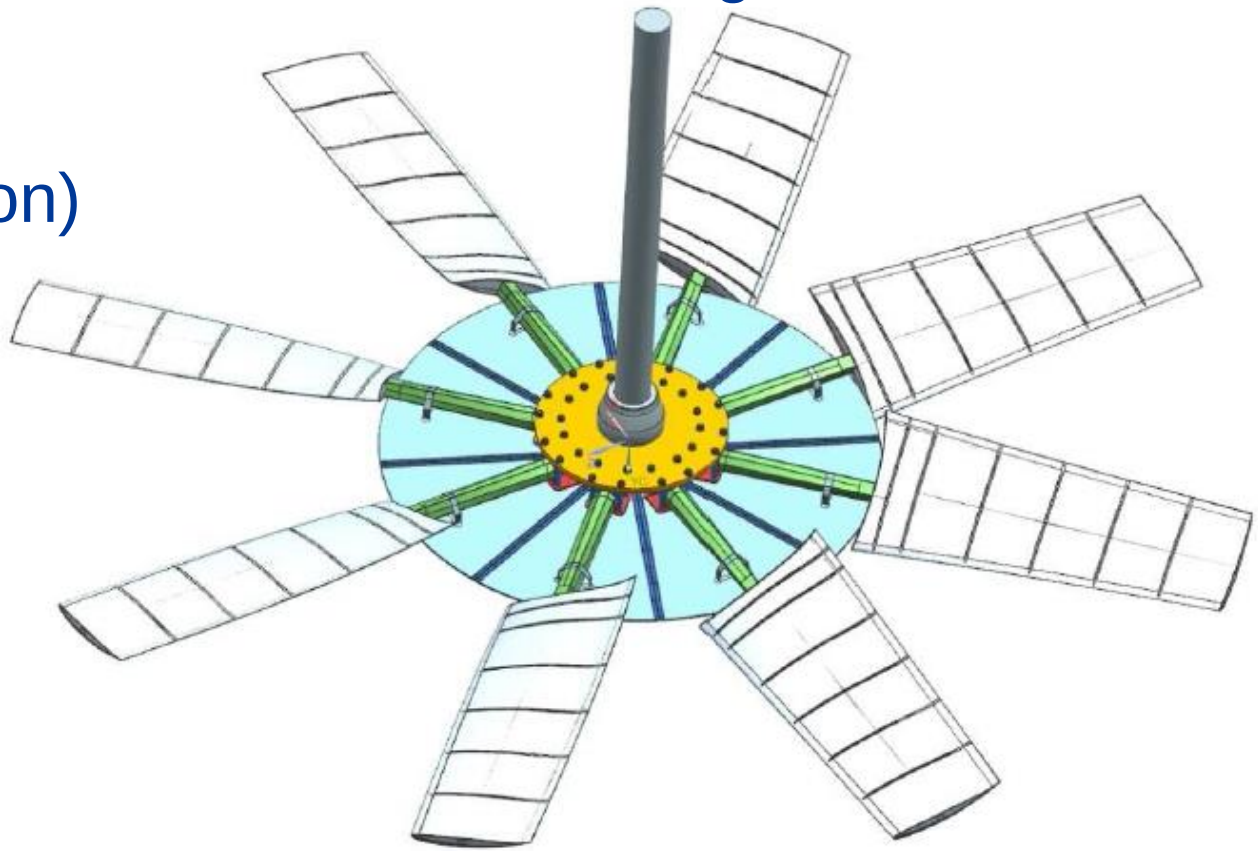
- Large scale ↔ model scale
- Blade setting angle - vibration
- Consistent weight
- Consistent weight distribution
- Repeatable infusion process



A different approach – static tests

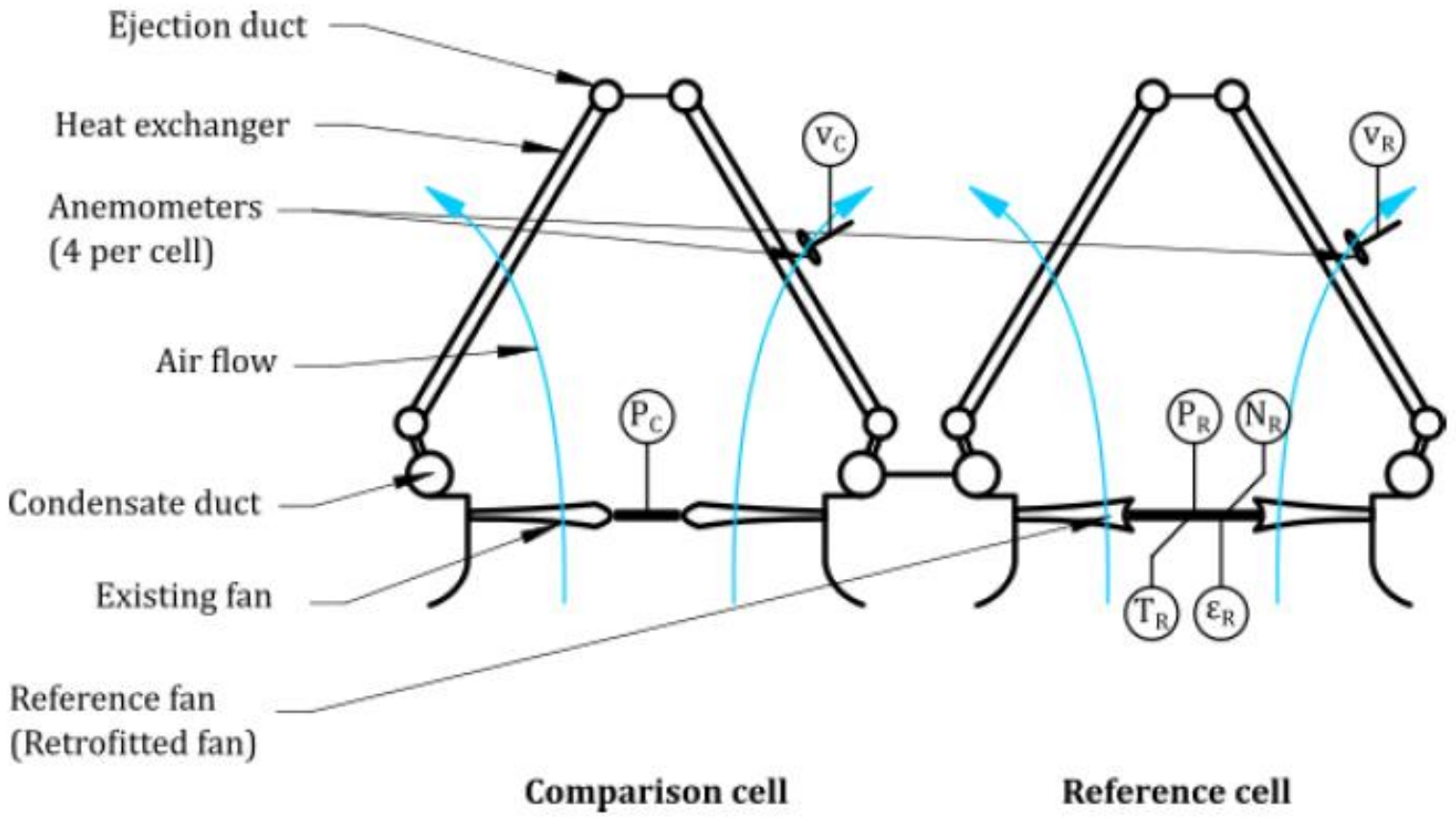
A different approach – pilot testing

- Retrofit
- No modifications to current fan arrangement
- Lightweight (50% reduction)



A different approach – pilot testing

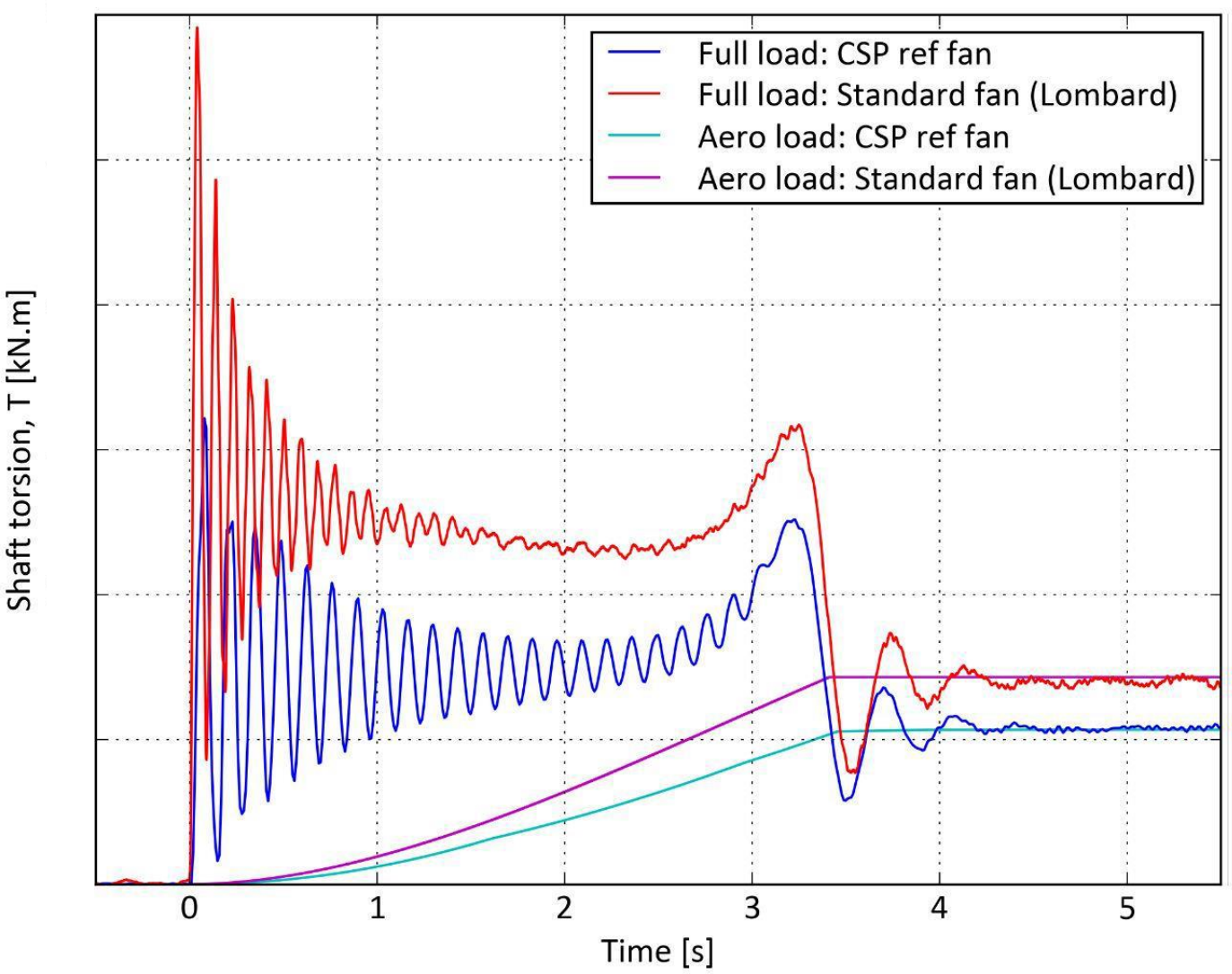
A different approach – results



A different approach – results

Motor current [A]	
	Difference, %
Test 1	-21.5
Test 2	-18.8
Test 3	-16.3
Test 4	-20.1
Bundle outlet velocity [m/s]	
	Difference, %
Test 1	-0.43
Test 2	-2.68
Test 3	0.78
Test 4	-3.77

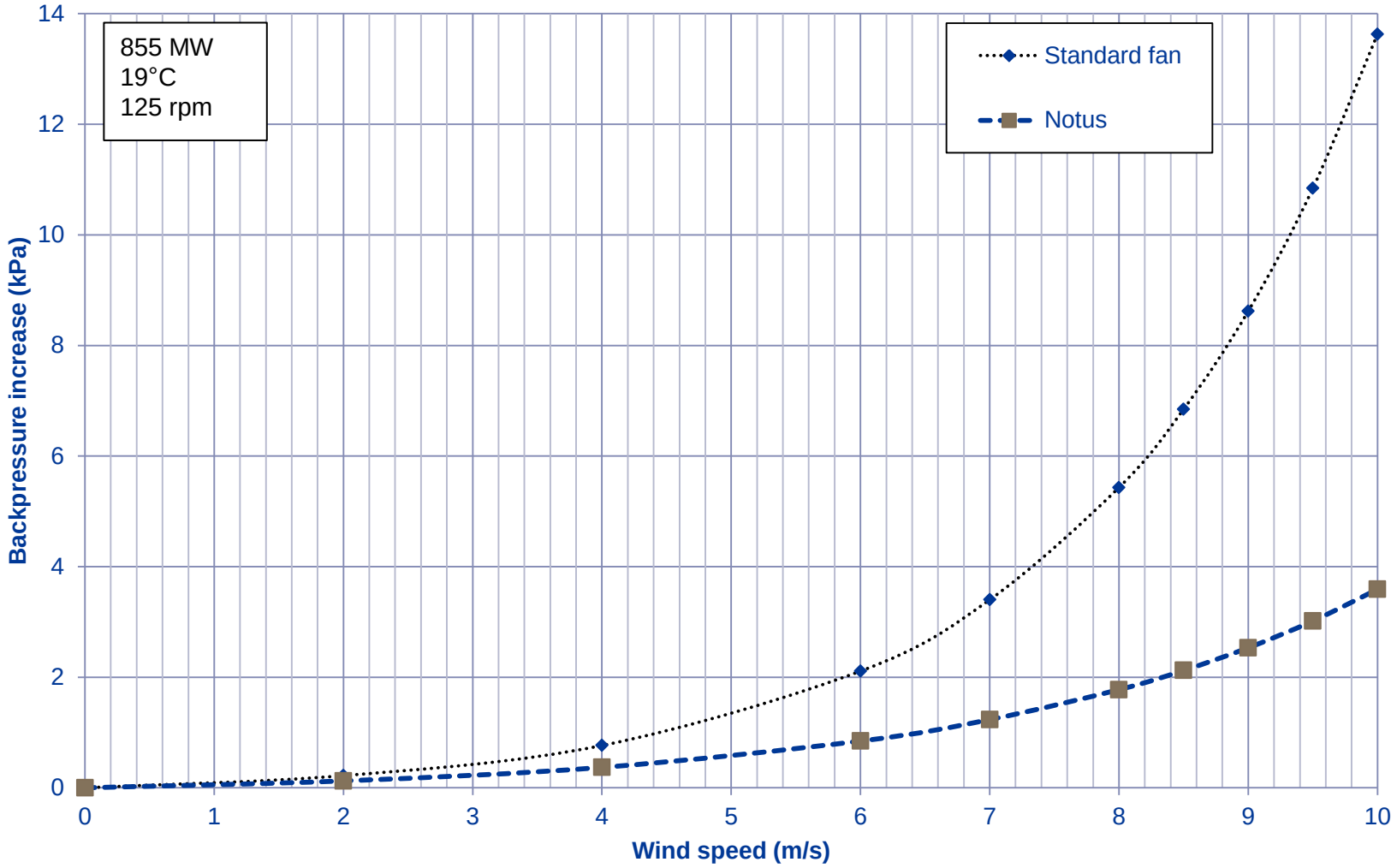
A different approach – results



A different approach – results

Increase in blade setting angle (°)	Fan volume flow rate increase (%)	Fan power consumption increase (%)
Reference	-	-
+4	11	44
+6	16.6	70.5
+8	22.5	100

So what is the effect on backpressure?



Conclusion

Aerodynamic improvement:

- New fan consumes 15-20% less power than current fan for similar flow displacement.
- Alternatively volume flow rates can be increased by more than 10%.
- Greater protection against detrimental effects of wind.

Structural improvements:

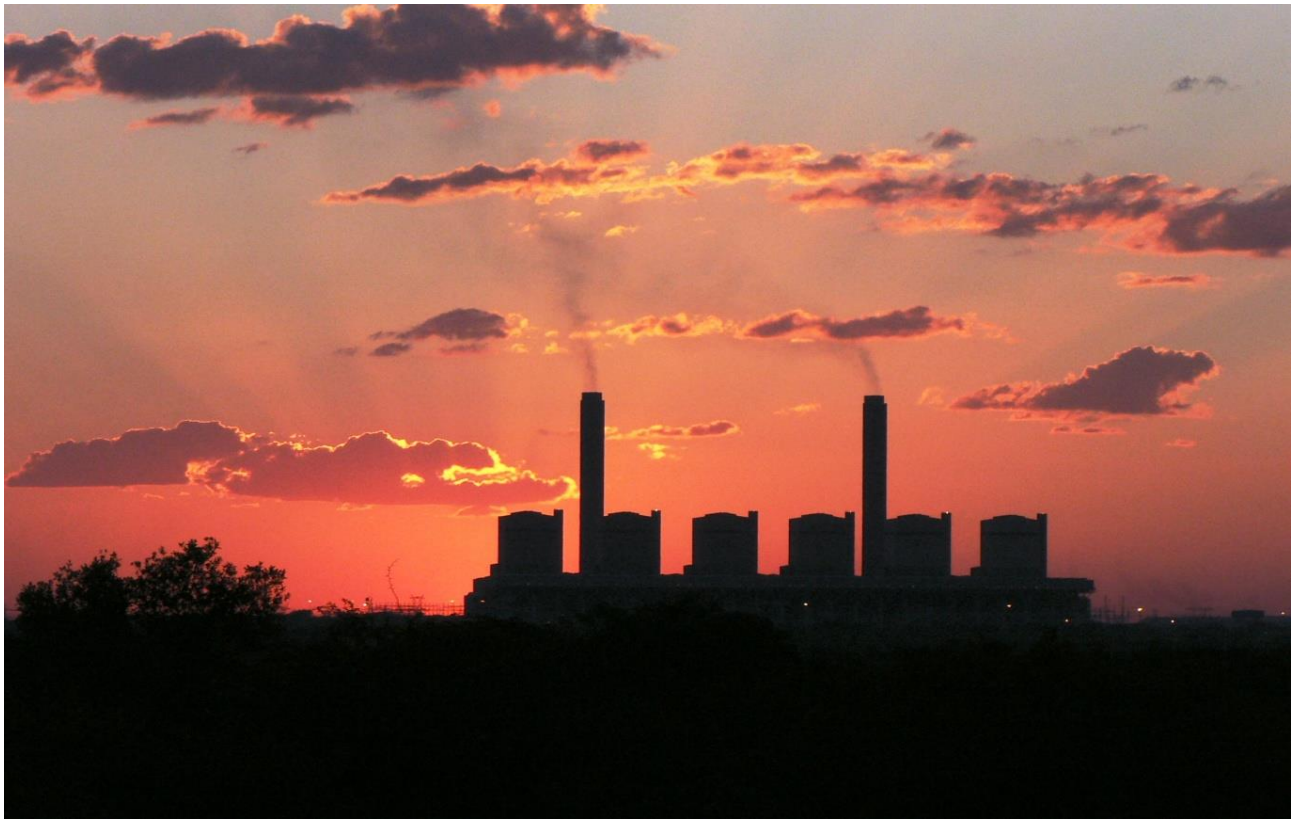
- Blades are not resonating (vibrational loads on gearbox greatly reduced).
- Fan blade weight is reduced by 50%.
- Blade shape and structure is consistent (interchangeable blades).

Acknowledgements

Team effort by many stakeholders

- EU providing funding through HOR2020
- Matimba Power Station personnel
- Notus Fan Engineering
- Kelvion
- Stellenbosch University

Questions?



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443