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Hybrid (dry/wet) dephlegmator for incorporation into ACCs

Hanno Reuter & Detlev Kröger

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Outline

1. Background
2. Description of hybrid (dry/wet) dephlegmator
3. Performance impact
4. Economics of a retrofit

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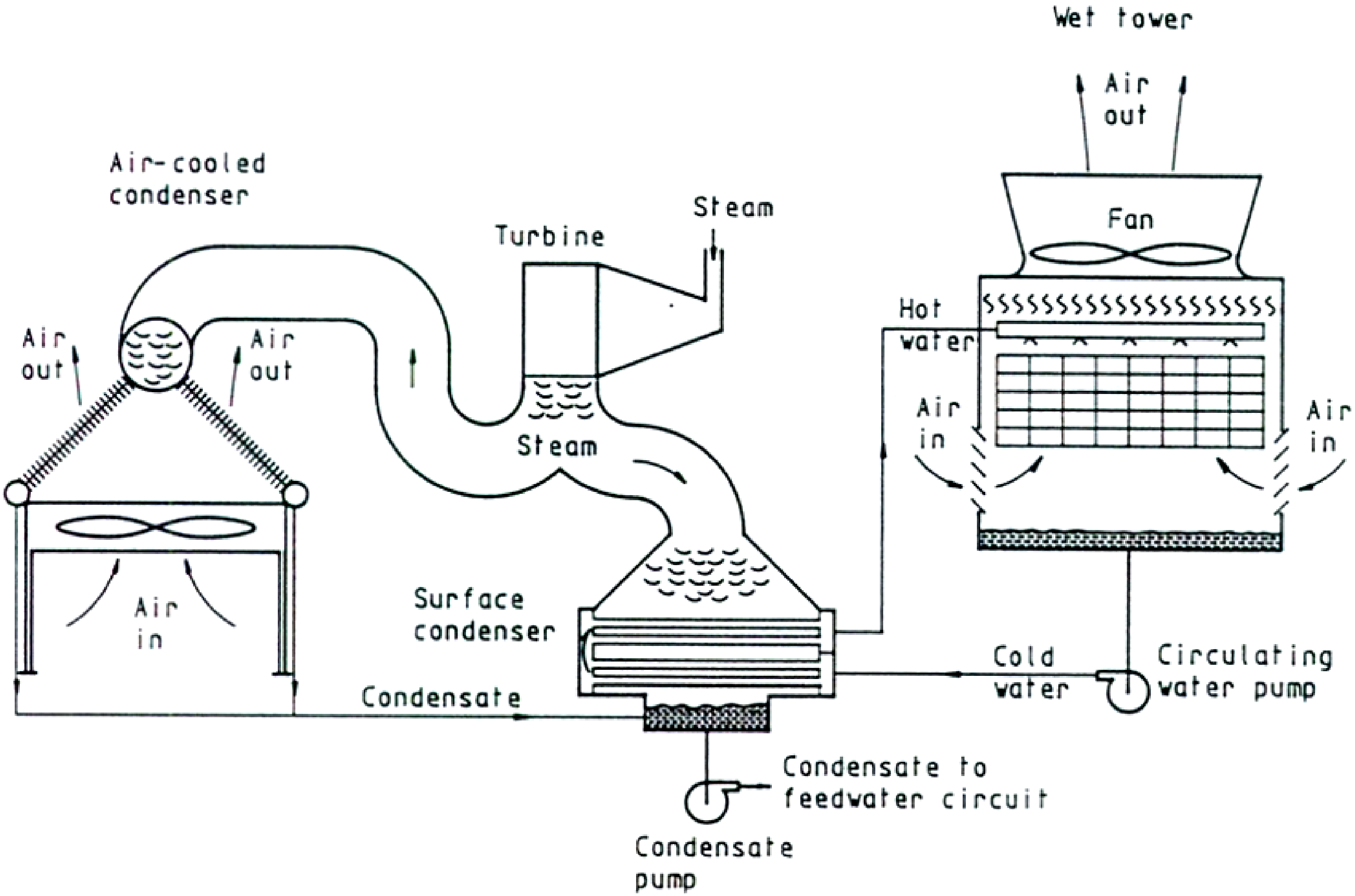
Why dry/wet-cooling?

- ❑ **Has a lower water consumption than wet-cooling systems which saves water in arid regions**

- ❑ **Enhances power plant performance with quick response when:**

  ⇒ Ambient temperatures are high
  ⇒ Wind speeds are high
  ⇒ Both ambient temperatures and wind speeds are high
  ⇒ Peak demand is high

Dry/wet cooling (parallel system)



Dry/wet cooling (parallel system)

De Backer and Wurtz (2003)

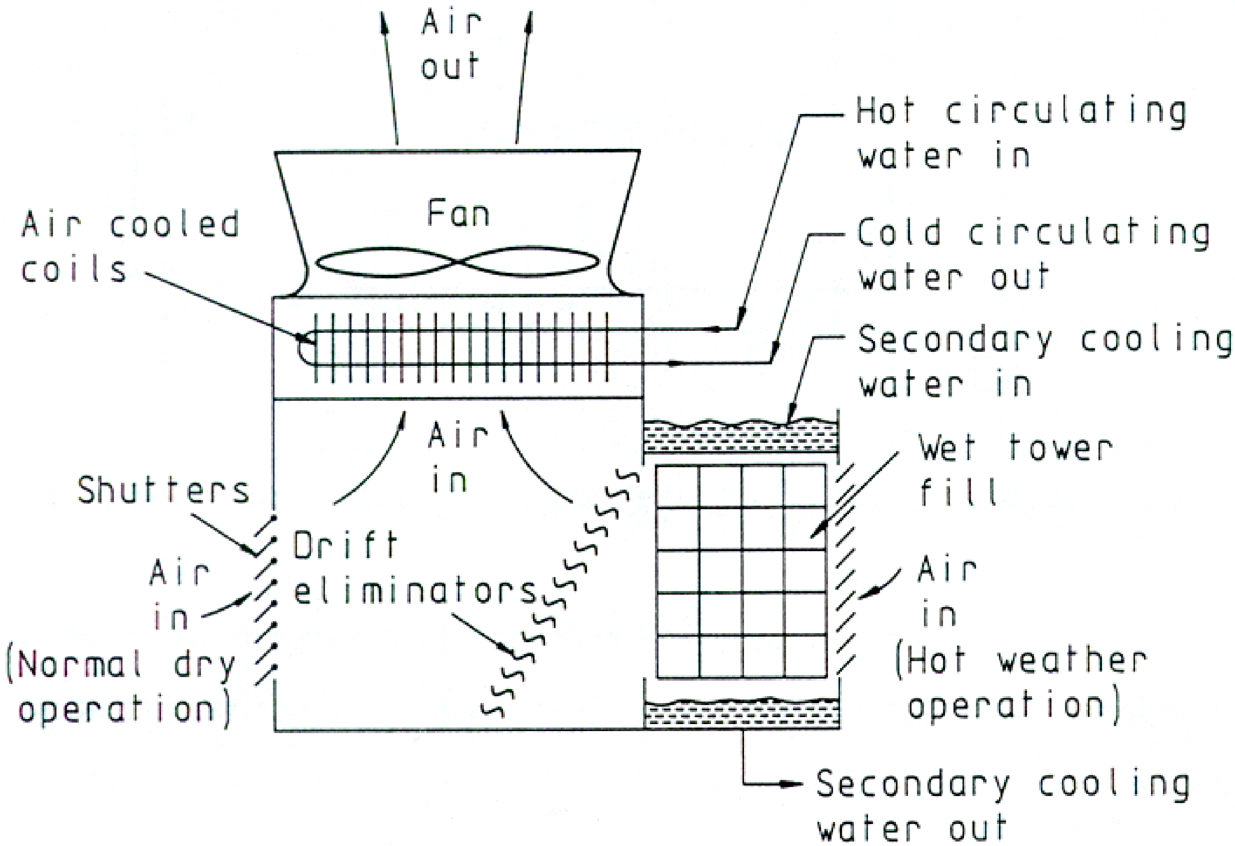
- For a particular parallel dry/wet cooling system, during the warmest periods, the turbo generator can operate at a 20 % lower steam back-pressure than when an all-dry cooling system is employed.
- The overall amount of water consumed by the particular dry/wet cooling system is only 4 % of the water of an all-wet cooling system.

Dry/wet cooling (parallel system)

Boulay et al. (2005)

- Conducted a study for two sites: north-eastern USA (Harrisburg, PA) and a hotter and drier south-western location (Phoenix, AZ)
- Oversize air-cooled systems or use alternative dry/wet systems to achieve lower back-pressures during summer time and generate additional revenue when energy prices peak.
- The dry/wet systems offered better paybacks but, due to their high capital cost, only had a marginal return at the north-eastern site and proved not to be economical for the south-western site.

Dry/wet cooling
(adiabatic cooling of inlet air)



Dry/wet cooling
(adiabatic cooling of inlet air)

Maulbetsch and DiFilippo (2003)

- Conducted tests on various low-pressure nozzles and nozzle arrangements with and without drift eliminator.
- Tests showed that during periods of high ambient temperatures it is possible to achieve between 60% and 100% of the prevailing wetbulb depression and 75% of the output losses can be recovered through the use of spray enhancement during the 1000 hottest hours of the year.
- Under these conditions the installation payback period will be between a year and two and a half years.

Dry/wet cooling (adiabatic cooling of inlet air)

Maulbetsch and DiFilippo (2003)

- For the nozzles tested only 60% to 70% of the spray water is evaporated and even the introduction of the drift eliminator cannot ensure that the finned surfaces remain dry.
- Unevaporated water droplets accumulating on the structure lead to corrosion of the structure surfaces as well as undesirable rainback that causes surface and ground water contamination.
- Finer sprays may be achieved with smaller high pressure nozzles. Due to practical and cost considerations, however, spray cooling of inlet air is not likely to find application in large air-cooled condensers.

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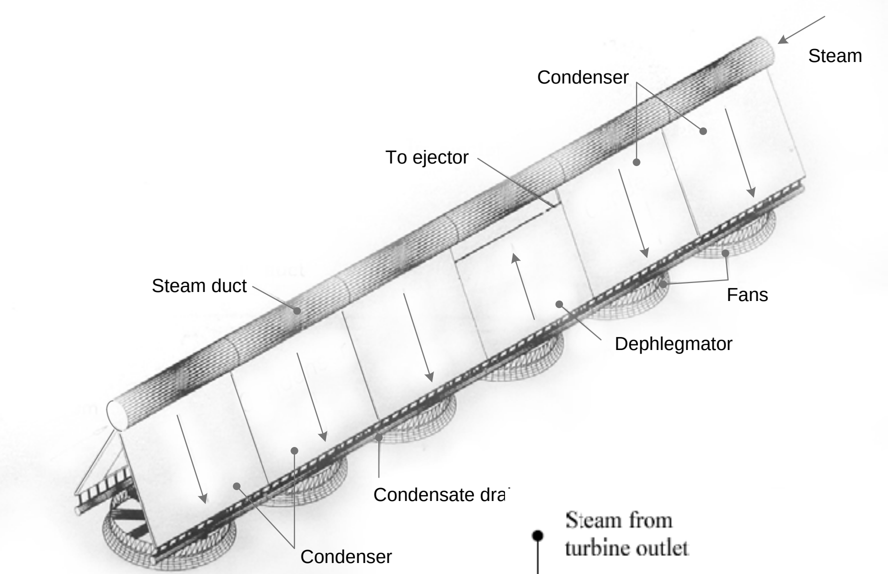
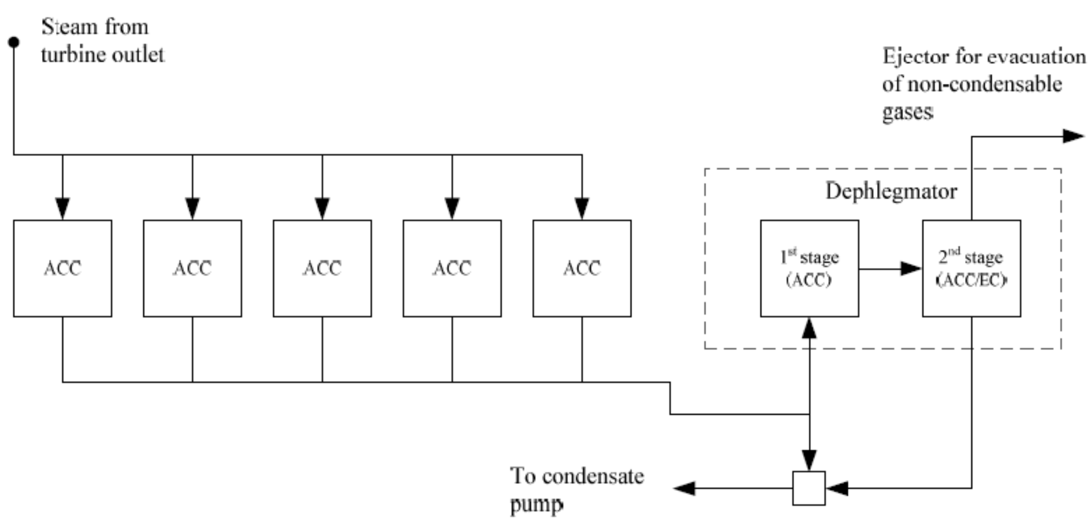
Hybrid (dry/wet) dephlegmator (Heyns & Kröger)





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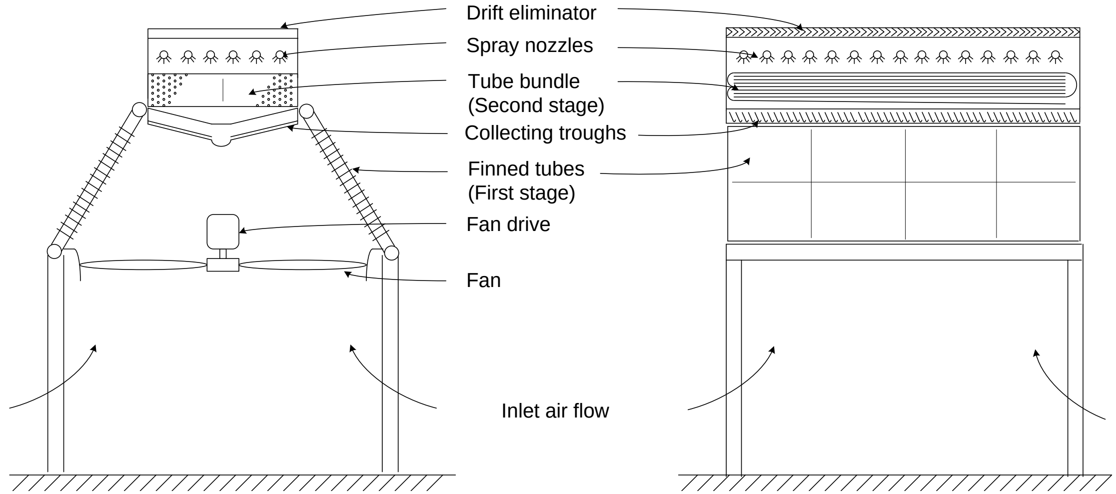
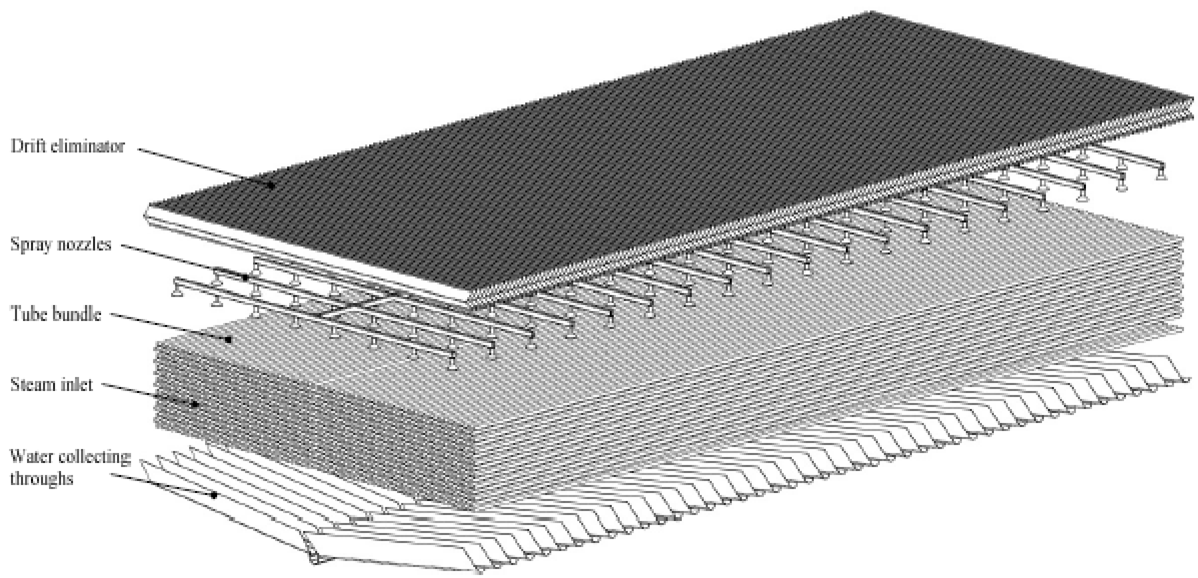
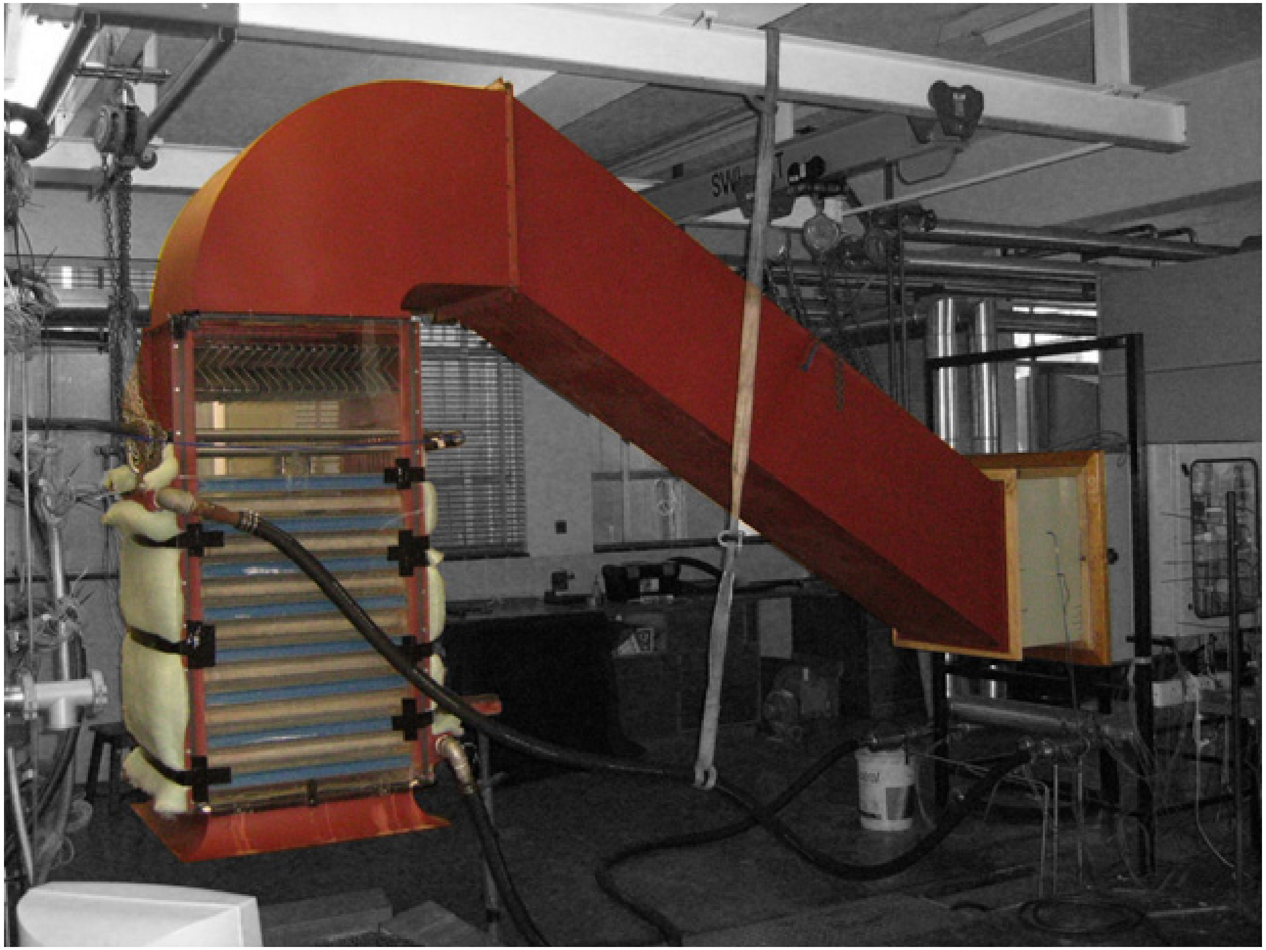
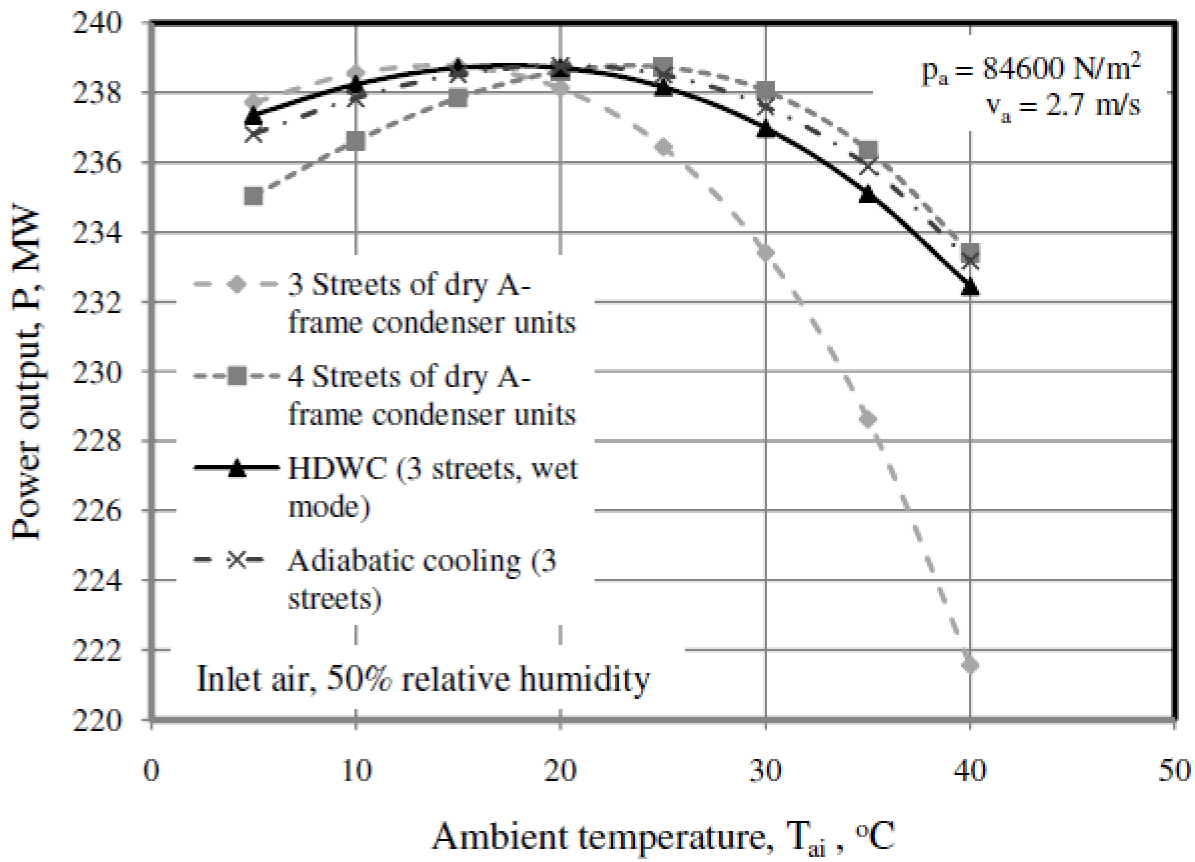




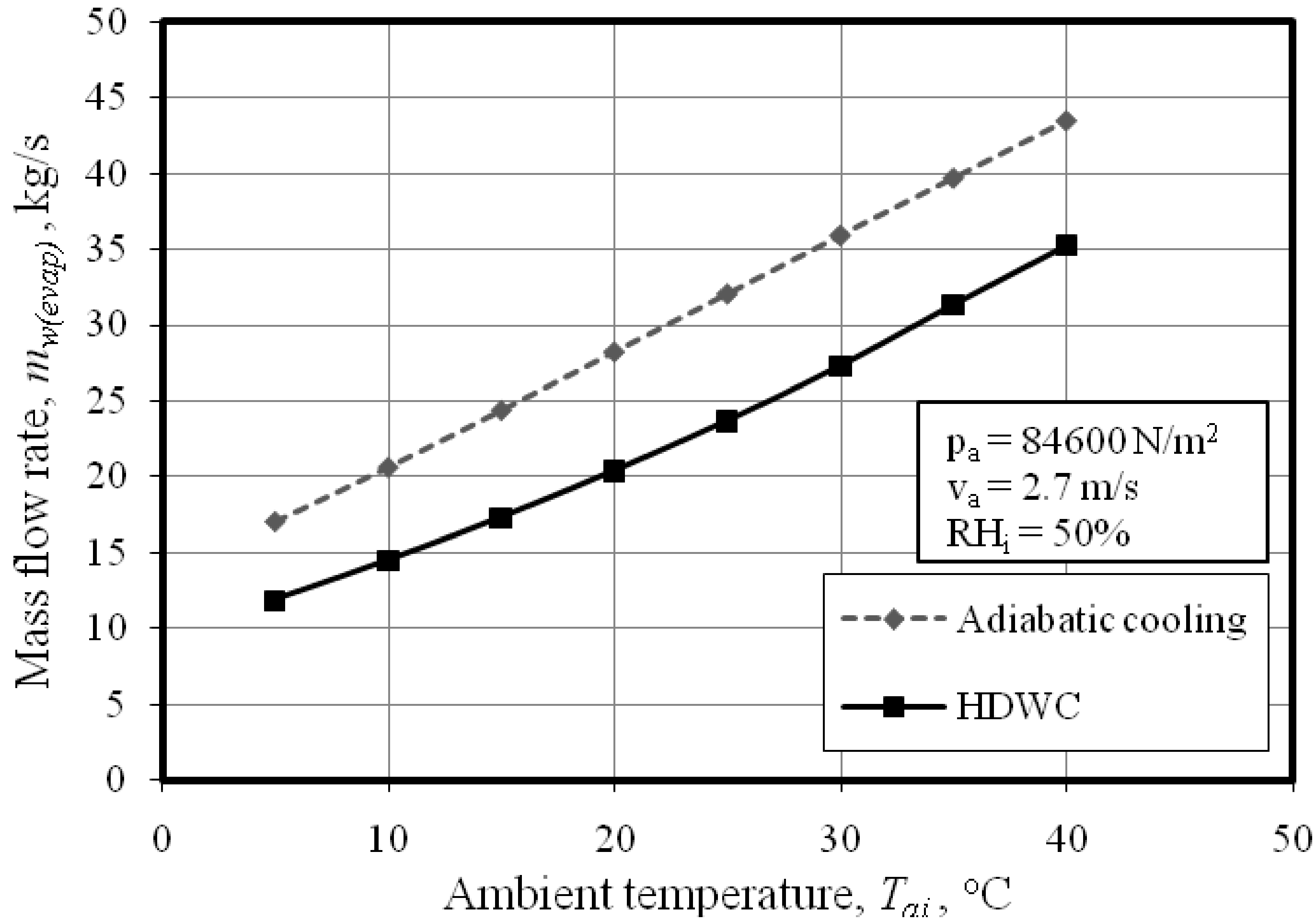
Hybrid (dry/wet) dephlegmator (Heyns & Kröger)



Effect of HDWD on turbine output



Deluge water evaporation rate



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Advantages of the HDWD

- Potential to measurably enhance the thermal performance of an ACC during periods of high ambient temperatures.
- It is estimated that the capital cost will be only slightly more than that of a standard dephlegmator and it therefore offers a measurable economic advantage over existing dry/wet systems.
- Same enhancement in thermal performance as a spray cooled system while consuming significantly less water.
- Finned tubes of the unit remain dry, reducing the risk of corrosion and scaling, while the galvanized wetted plain tube surfaces will be rinsed with clean water on a regular basis to minimize fouling.
- Plume abatement

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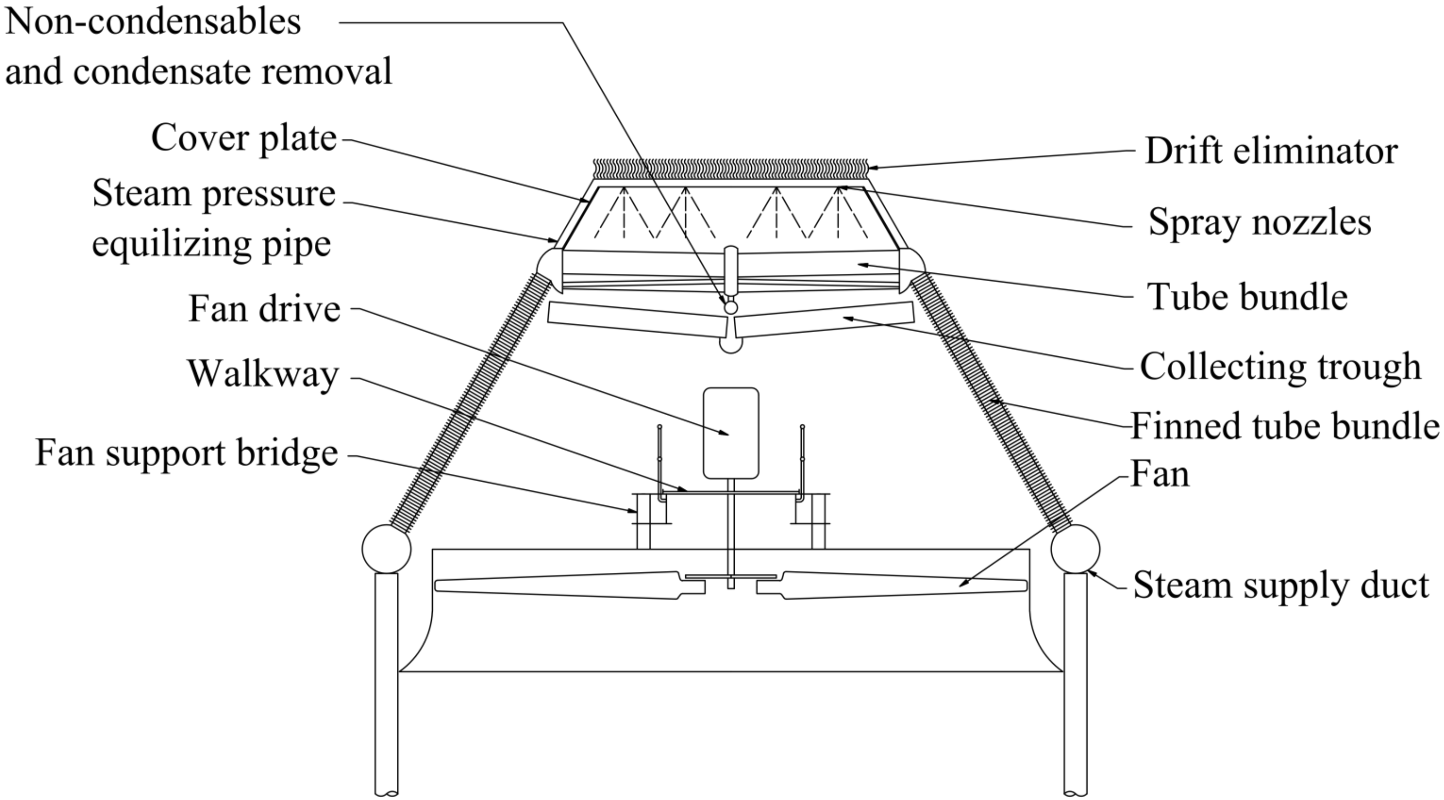
Key technical issues (EPRI research)

- Increased steam-side pressure drop during wet operation.
- Uncertainty in existing heat transfer coefficient data.
- Uncertainty in existing pressure drop data.
- Ineffective collecting trough performance.
- Ineffective spray nozzle performance.
- The handling of non-condensables and increased risk of leakage.

Forced draft hybrid (dry/wet) dephlegmator (Reuter & Kröger)



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Delugeable test bundle

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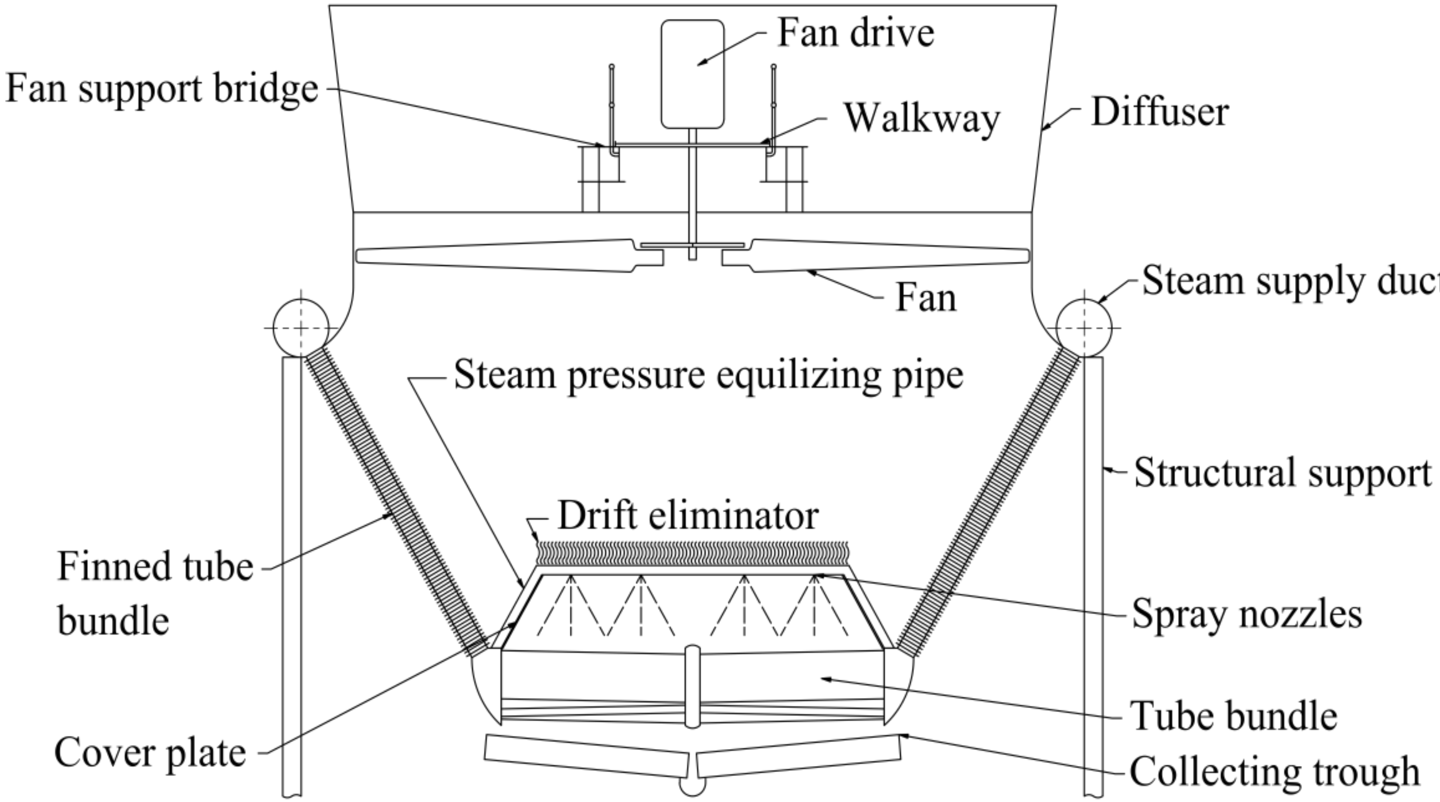
Induced draft hybrid (dry/wet) dephlegmator (Reuter & Kröger)



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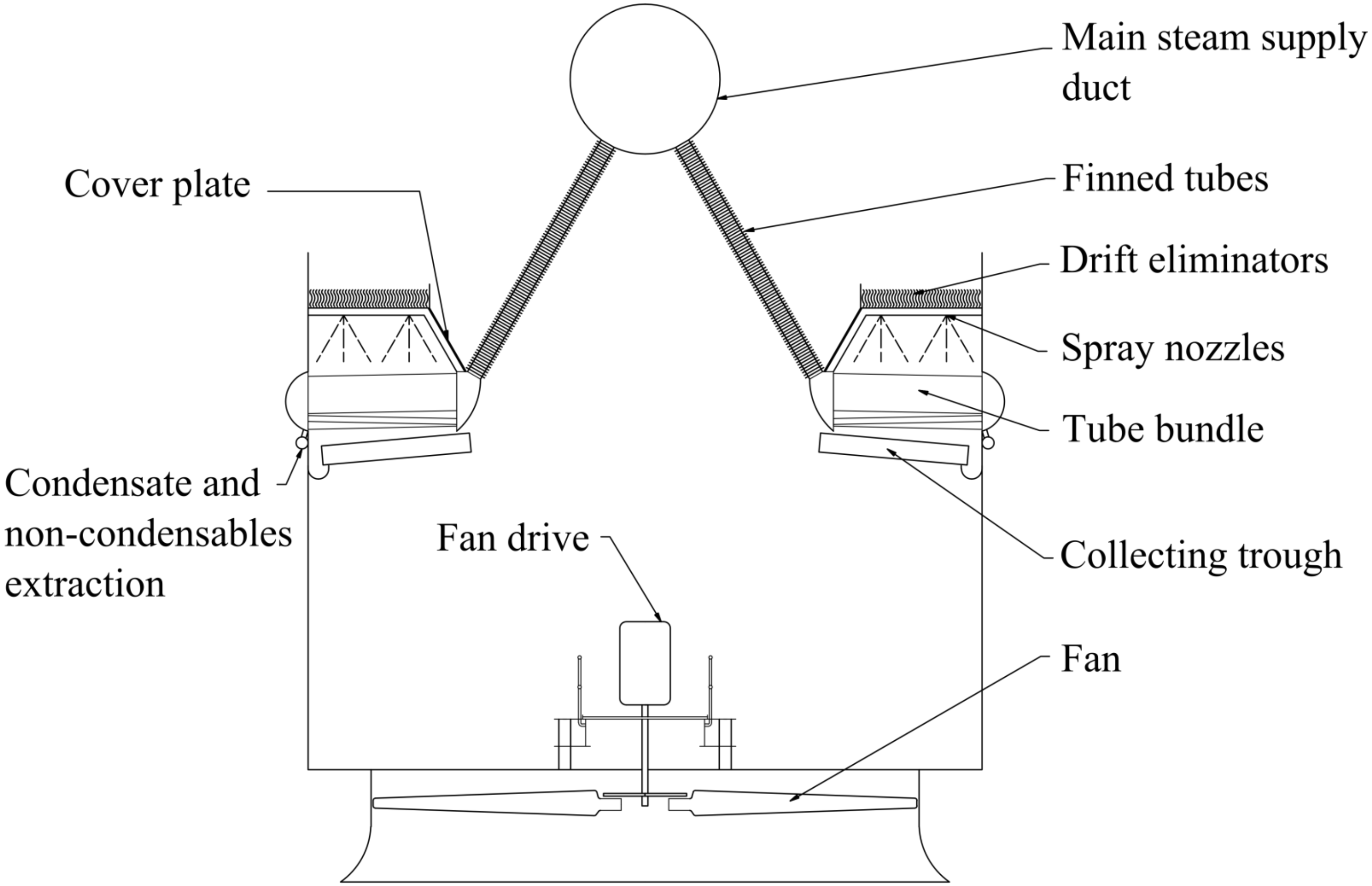

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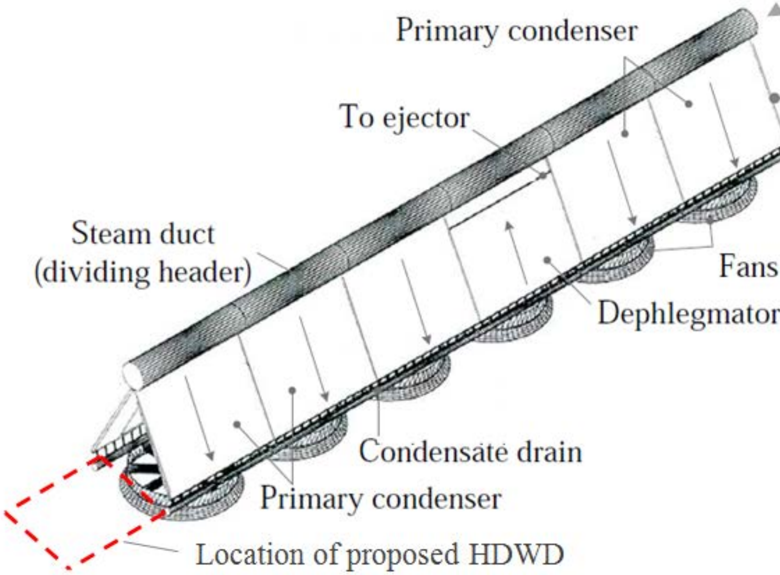
Matimba

6 x 620 MW
6 x 48 fan units



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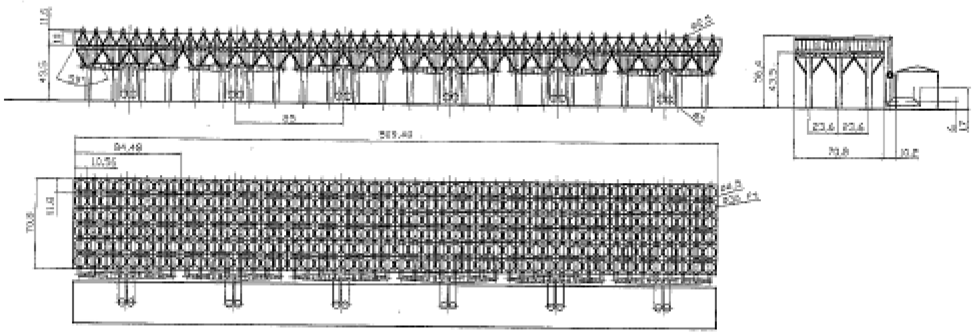
Direct dry-cooling – Matimba vs Medupi

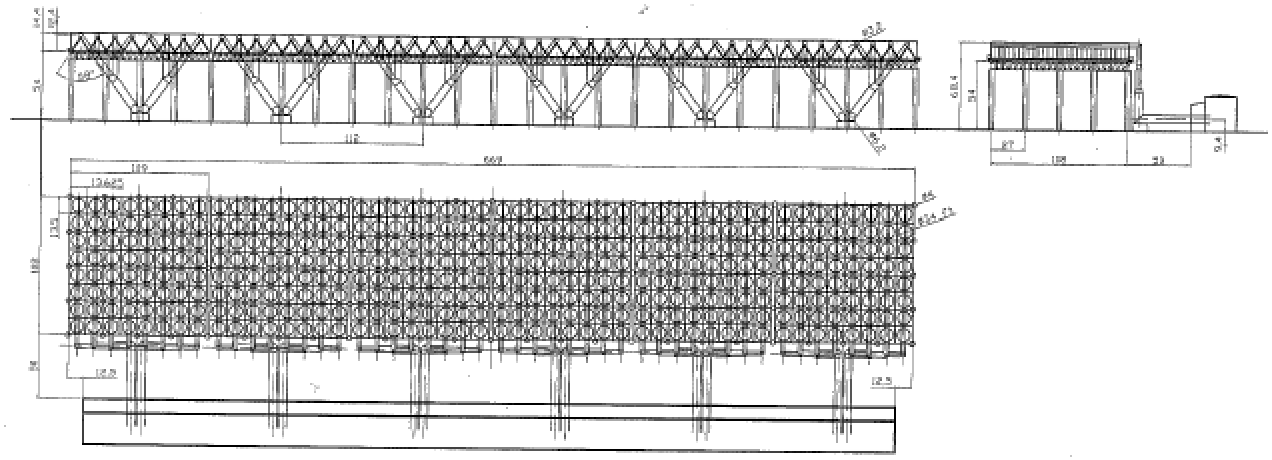
Matimba ACC

70.8 x 509.48 = 36,071 m²
48 x 6 = 288 fans



Medupi ACC

108 x 669 = 72,252 m²
64 x 6 = 384 fans



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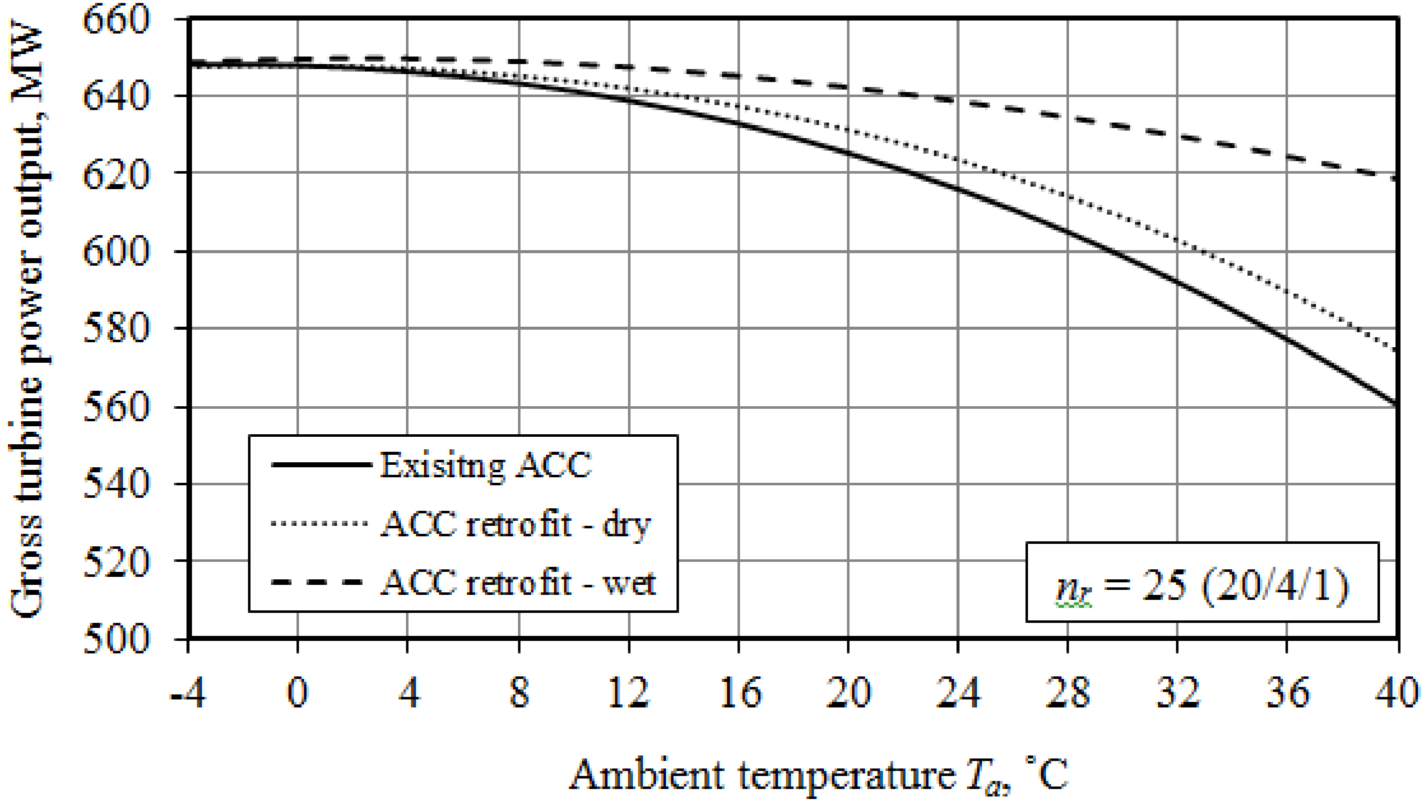

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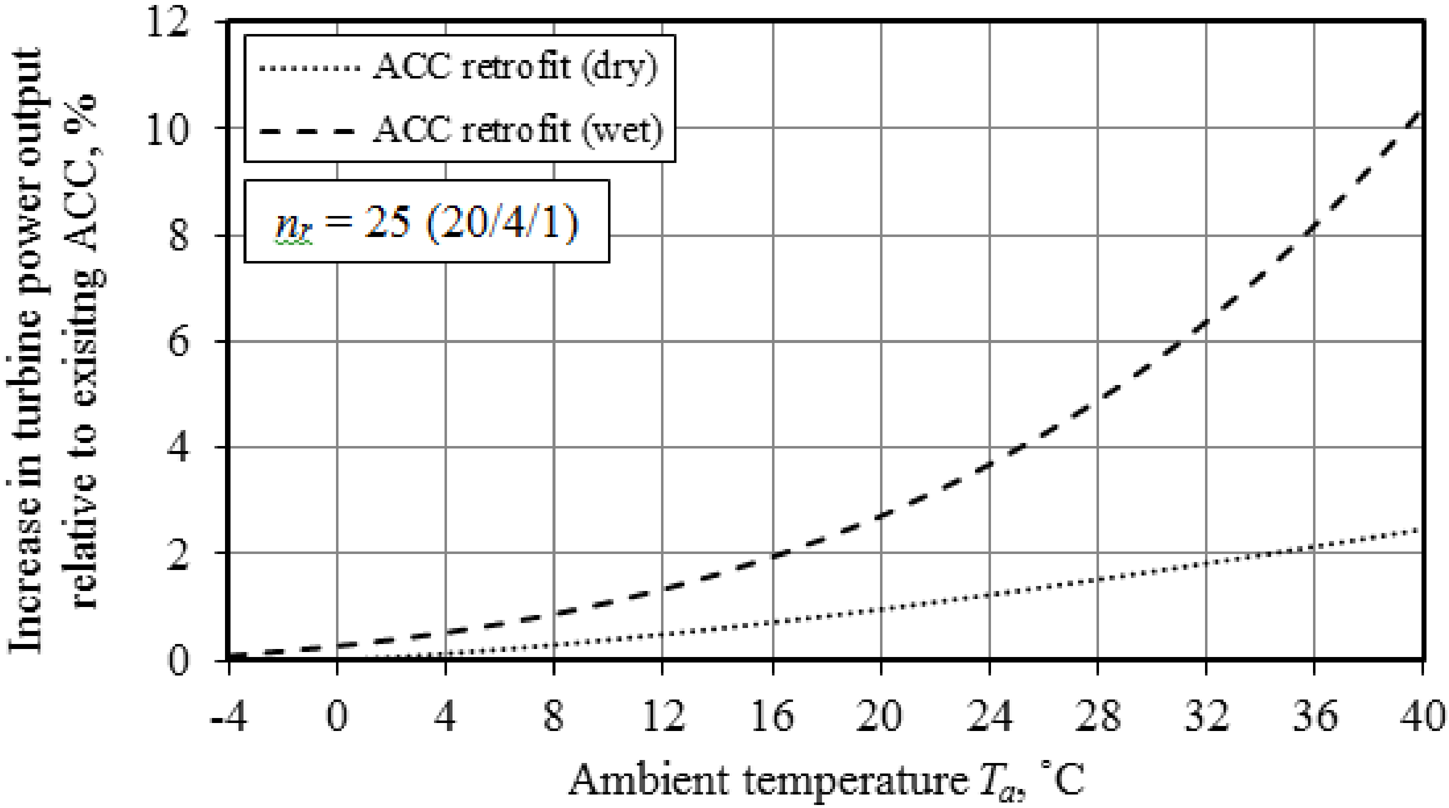
Enhancement of turbine output



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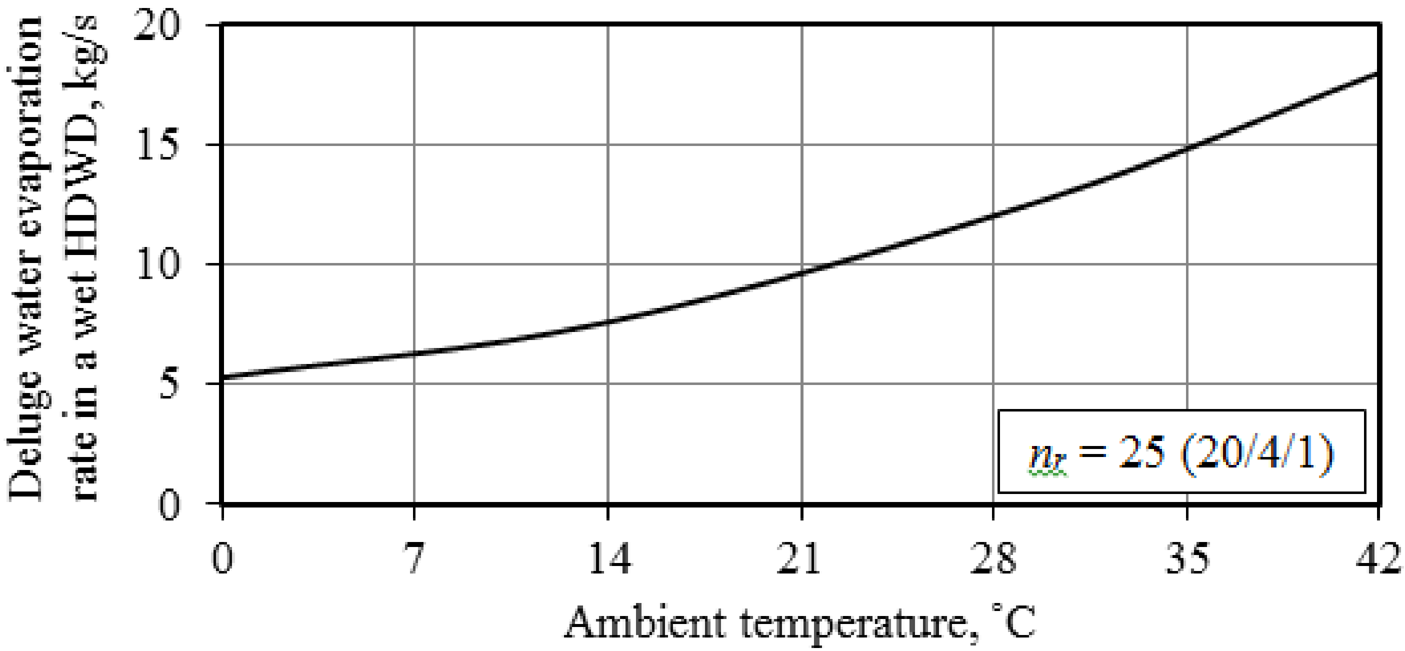

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Economics

- Cost: R 150 million ($15 million) for 1 turbine unit (8 x HDWDs)
- Additional output per turbine unit:
  - ⇒ Dry: 51 x 10^6 kWh per annum
  - ⇒ (Wet: 152 x 10^6 kWh per annum)
- Payback period (R0.61 income per kWh)
  - ⇒ Dry: 5 years
  - ⇒ (Wet: 1.6 years)
  - ⇒ Dry/wet: 3 years
- Average increase in power output:
  - ⇒ 104 MW for 6 units
  - ⇒ R0.20/ kWh

Best technology?

Appropriate technology:

- Availability of fuel and water
- Climate
- Flora, fauna, pollution, acid, dust, etc
- Economics (life-cycle costs)
- Aesthetics
- Sociology
- Policy legislation