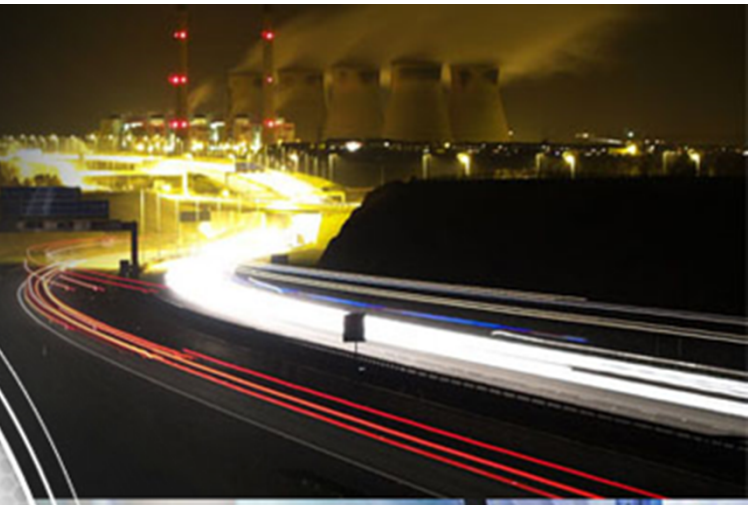

OPERATIONAL ADVANTAGES OF MOBILE REFRIGERATION USING A CLOSED LOOP HEAT REJECTION CONFIGURATION

MVSSA ANNUAL CONGRESS

2017

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Leading Energy Solutions

INTRODUCTION : AUTHORS

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- Prof. M van Eldik
  - Professor at the School of Mechanical Engineering of the North-West University

INTRODUCTION INTO SPOT-COOLING

- Large heat loads on air due:
  - Auto-compression
  - Heat pickup from rocks
  - Mining activity
  - Etc.
- Move cooling close to workings
- Re-cool air
- Easily change cooling layout

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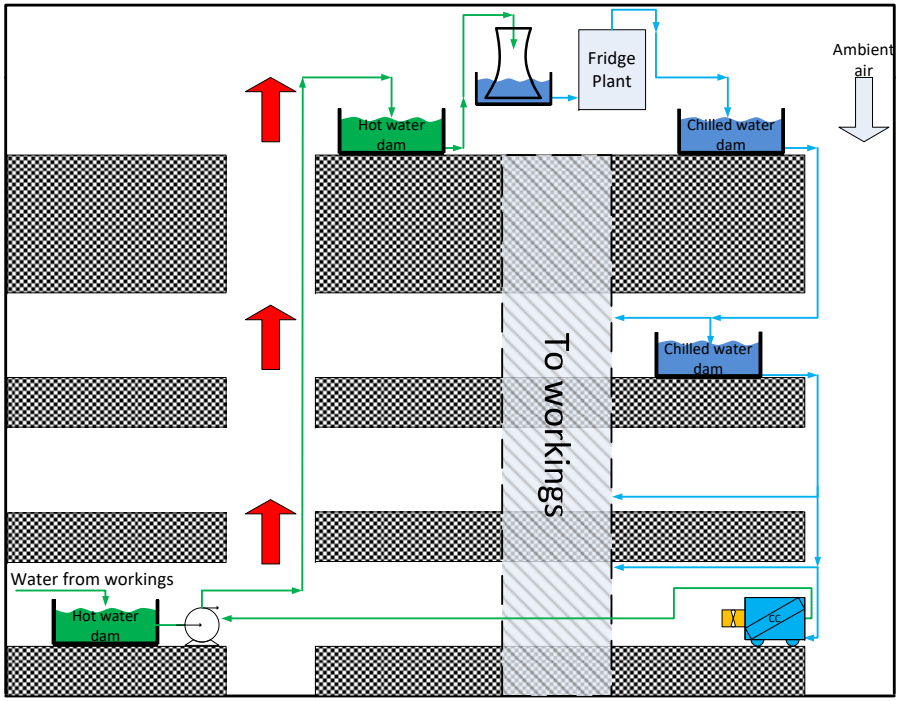
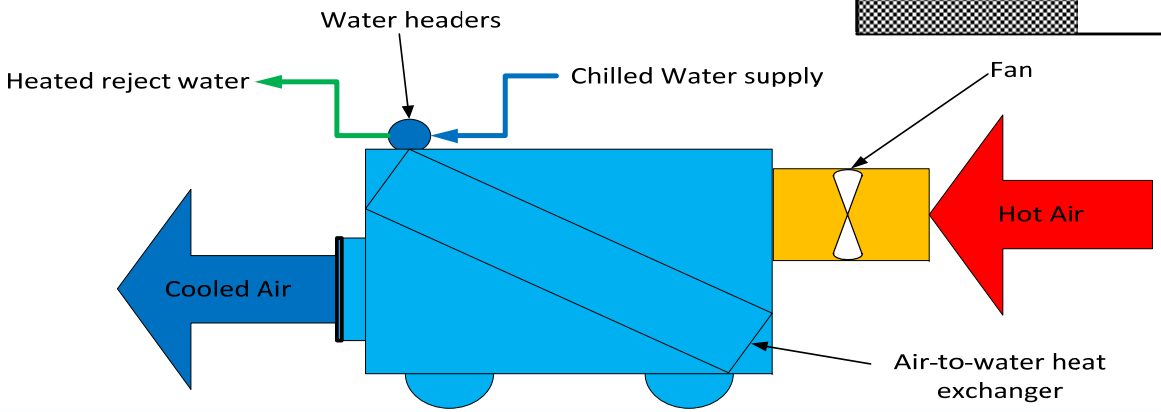
CONVENTIONAL COOLING

- Conventional cooling setup with cooling car
  - Fridge plants on surface or underground
  - Chilled water in water-to-air heat exchanger
  - Water pumped to surface (or underground fridge plants) for re-cooling





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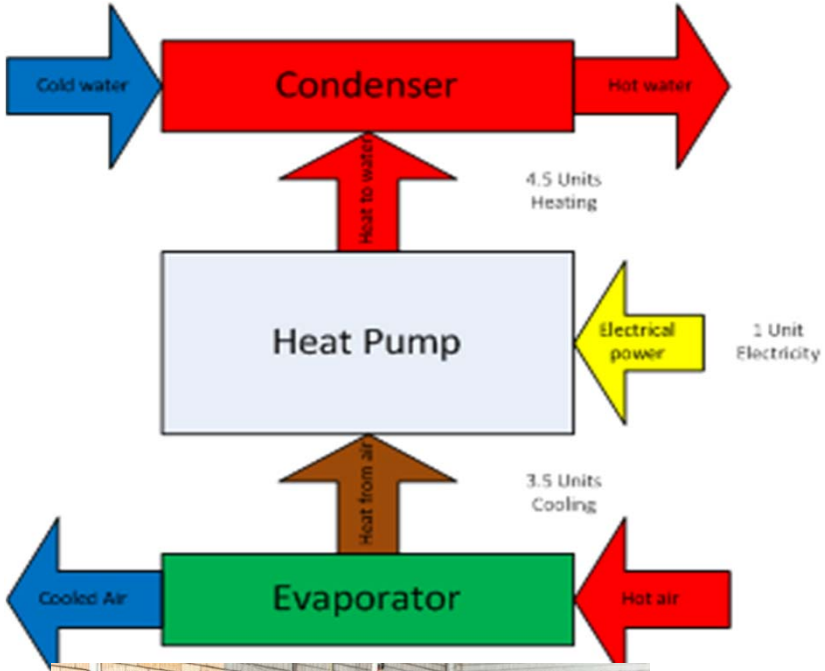
THE ACU

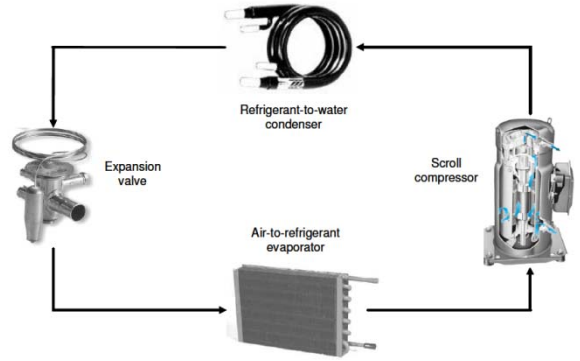
- Move cooling **source** near working areas
- Small size fridge plant.
- Mobile.

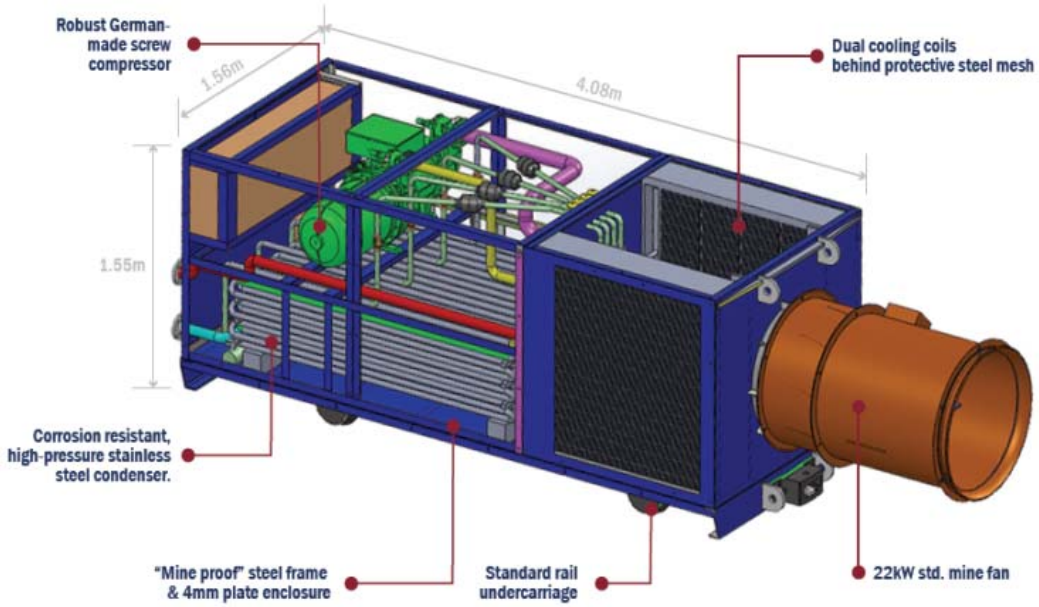
- Robustness and reliability.
- Ease of maintenance.

- High positional efficiency.
- Sufficient heat rejection capabilities via current installed water reticulation.

THE ACU







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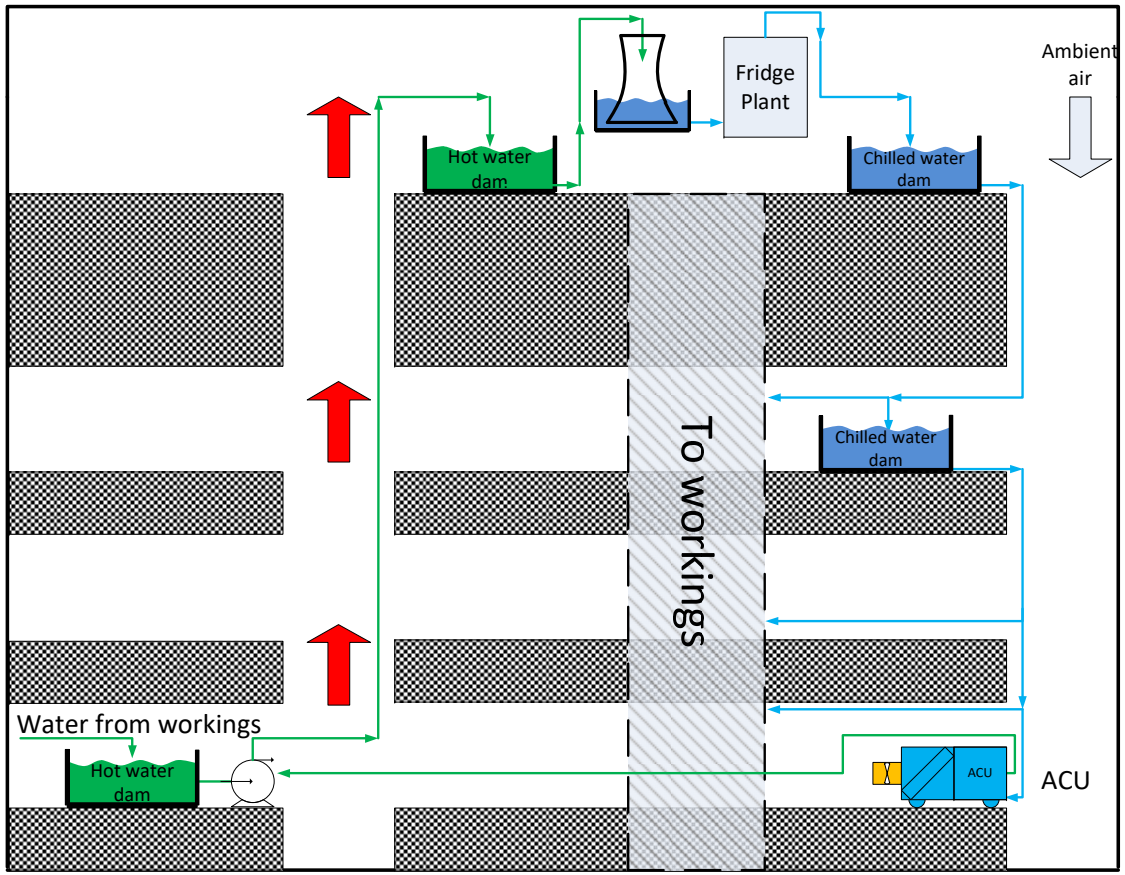
ACU IN CONVENTIONAL COOLING INSTALLATION

- Conventional cooling setup with ACU



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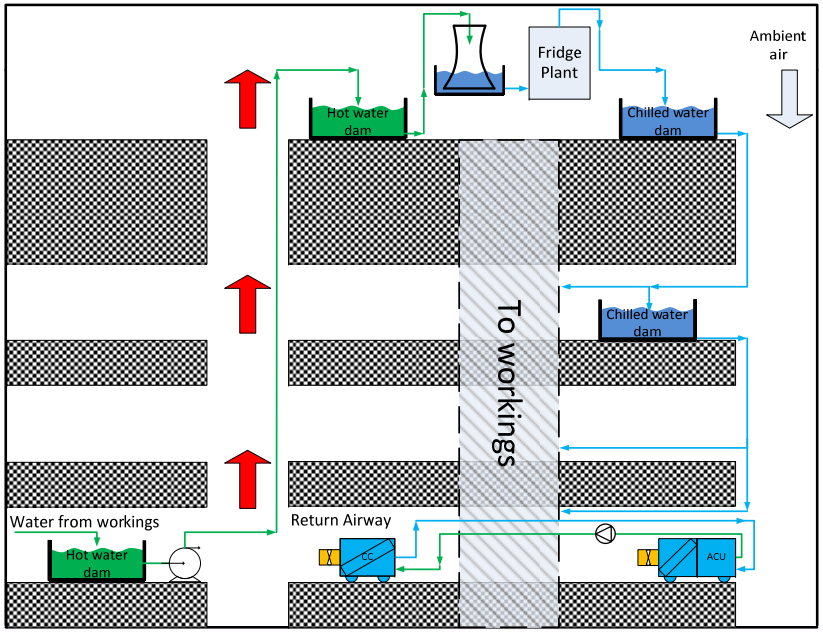
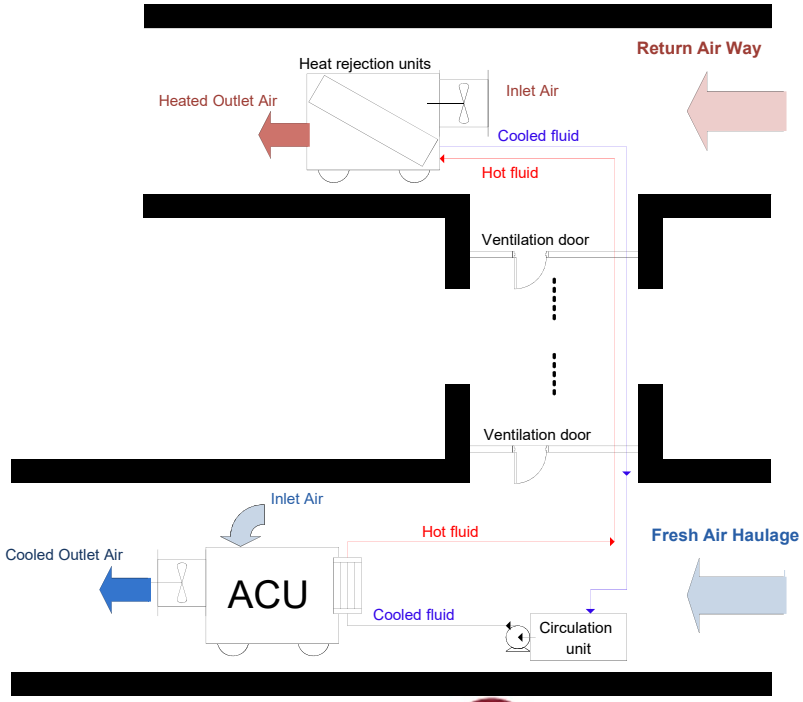
ACU IN CLOSED LOOP HEAT REJECTION CONFIGURATION

- ACU in CL heat rejection configuration
  - Cooling with ACU
  - Heat rejected in closed loop water circuit
  - Heat rejected to RAW via heat exchangers
  - No other water reticulation required





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ENERGY EFFICIENCY COMPARISON

- Model mine created using Flownex®
  - Simulate air and water temperatures at different depths
- Spot cooling models created to simulate different cooling applications:
  - CCs in conventional water reticulation system
  - ACU in conventional water reticulation system
  - ACU in closed loop heat rejection configuration
- Different cooling methods evaluated based on electrical power usage per kW cooling:
  - Fans for: Cooling car, ACU and ACU CL
  - Dewatering pumps, circulation pumps
  - Fridge plant power
  - ACU compressor power

ENERGY EFFICIENCY COMPARISON

- Simulation results:
  - At depth 2472 below surface:
    - » CC 2.34 kW_e/kW_c
    - » ACU 0.71 kW_e/kW_c - 69.6% reduction
    - » ACU CL 0.68 kW_e/kW_c - 71% reduction
  - At depth 4000 below surface:
    - » CC 2.69 kW_e/kW_c
    - » ACU 1.02 kW_e/kW_c - 62.14% reduction
    - » ACU CL 0.73 kW_e/kW_c - 72.8% reduction

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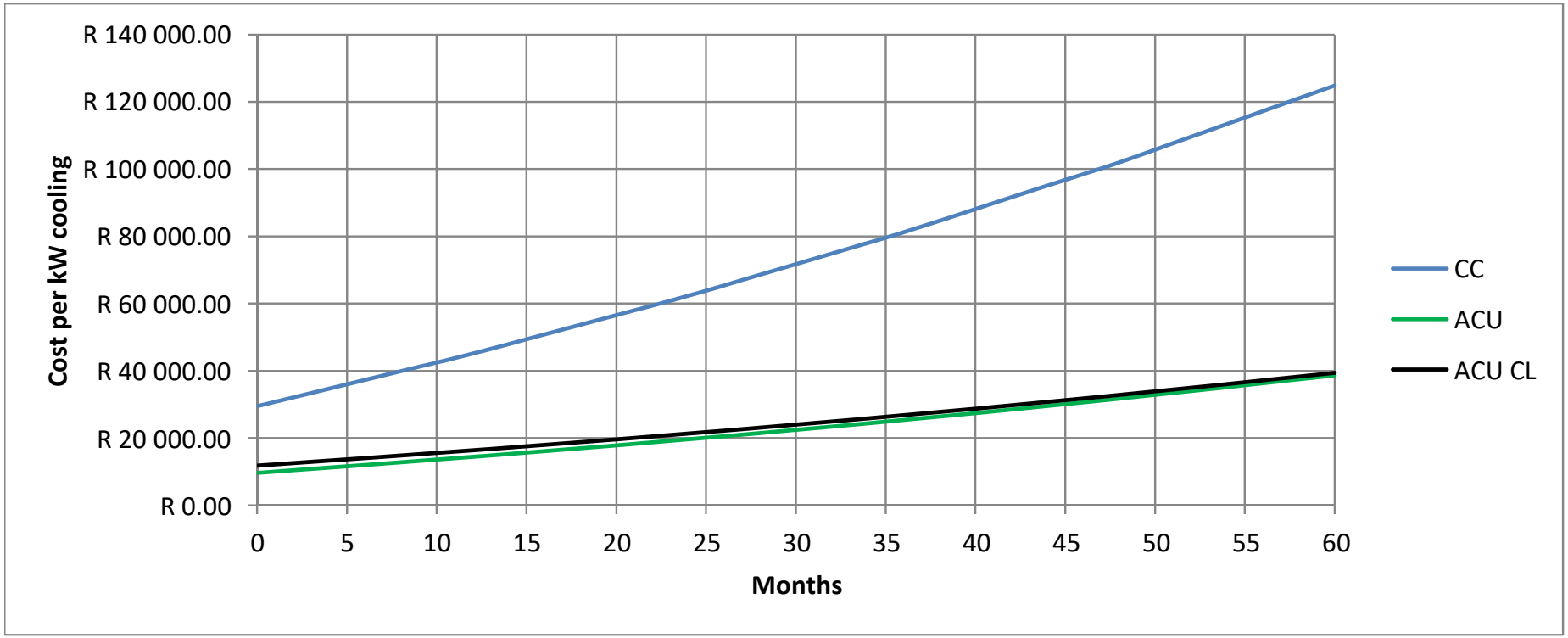
ECONOMIC COMPARISON

- Based on simulation results
- Capital costs calculated per installed kW cooling
  - Real component costs used for cooling units
  - Fridge plant capital costs per installed kW cooling based on literature and adapted for changed R/$ exchange rate for 2016
- Active energy charge based on 2016 Megaflex tariffs
- 5 year cost analysis done to compare costs

ECONOMIC COMPARISON - RESULTS

- 5 Year cost prediction per kW cooling at 2472m depth below surface



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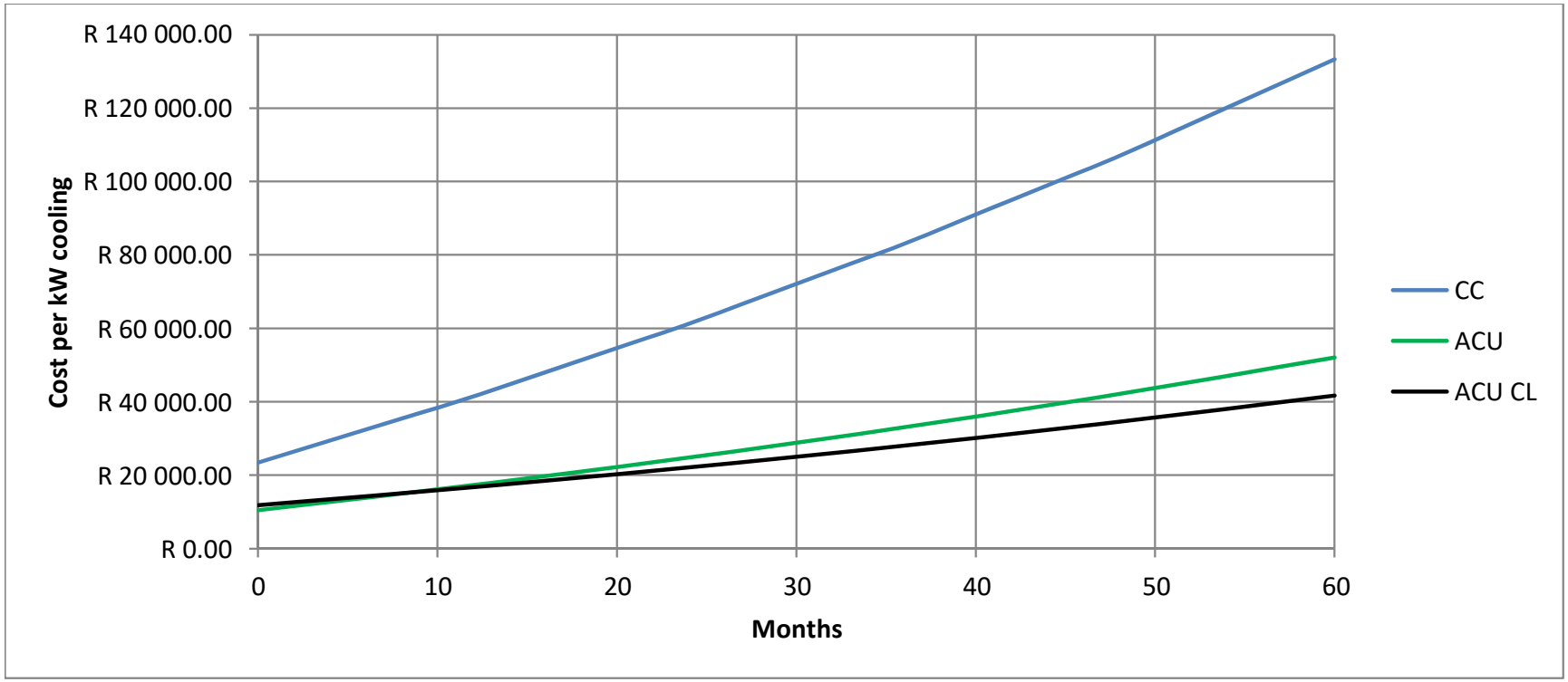
ECONOMIC COMPARISON - RESULTS

- 5 Year cost prediction per kW cooling at 4000 m depth below surface



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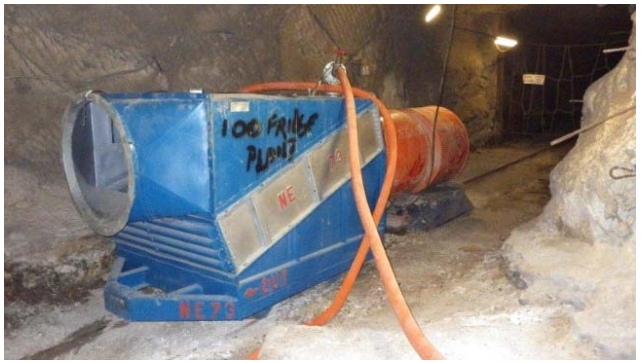
OPERATIONAL CONSIDERATIONS

- Small installation size
- Quicker implementation time
- Modular
- Ease of maintenance
- Reduced corrosion probability
- Possible corrosion/erosion on RAW heat rejection coils
- RAW rejection capacity to be evaluated



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THANK YOU