Reducing costs in Data Centres using active front end drives

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ABB

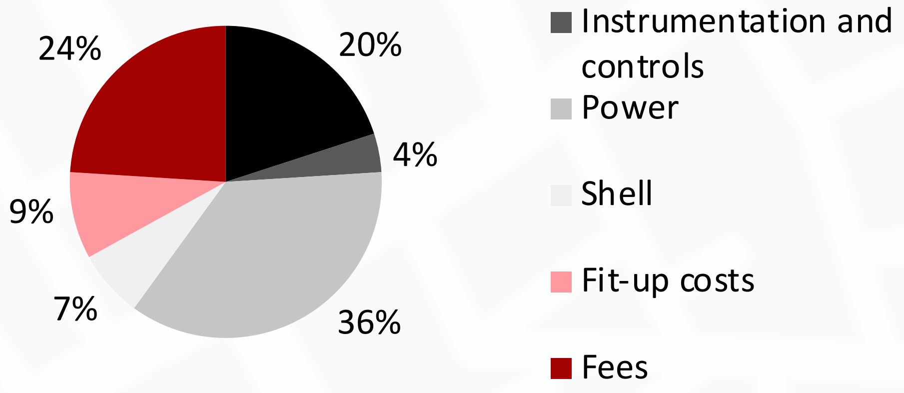
Agenda

- Data centre cost structure
- Energy use in data centres
- PUE improvement with variable speed solutions for cooling
- Specifying variable speed solutions for data centres
- Capital and operating cost savings with active front end drives
- Summary

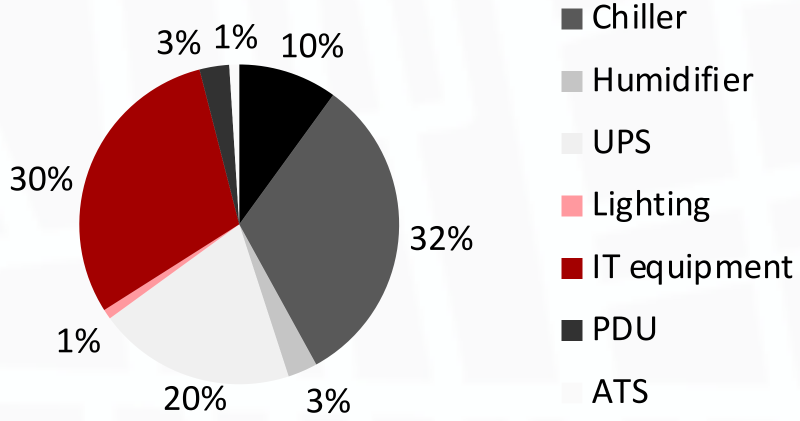
Data centre cost structure

- 20% capital costs from mechanical and 36% capital costs from power systems
- About 40% operating costs from cooling

Capital costs



Operating costs

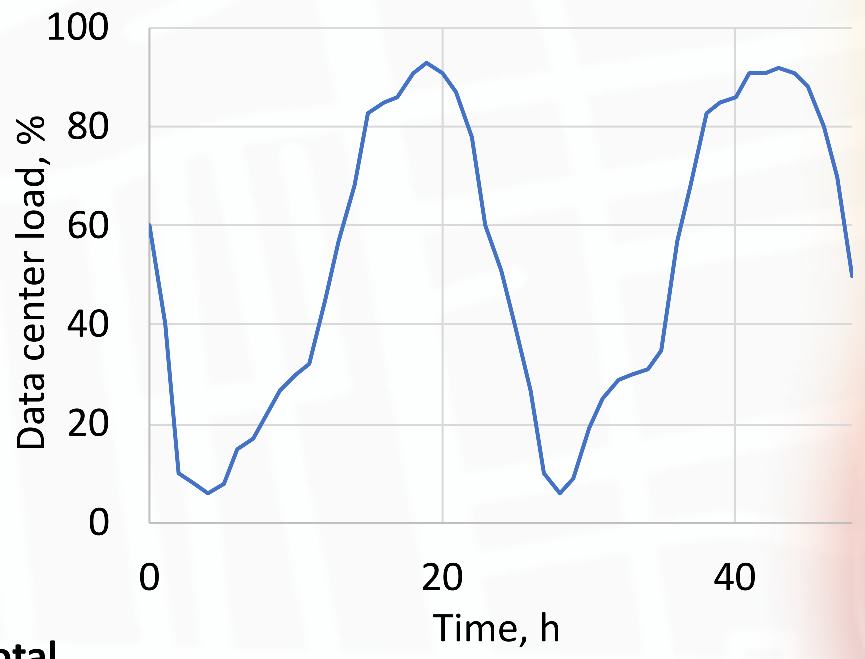


Energy use in data centres

- Data centres are sized for peak loads, but do not operate at peak loads most of the time.
- The challenge is to make data centres efficient at part loads.
- Cooling system should adjust to a data centre's load profile as well as to environmental conditions and be able maintain high system efficiency even at part loads.
- Power Usage Effectiveness is one of the performance indicators for data centers, where P_{Total} is the total power consumed by a data center, $P_{IT\ load}$ is the power consumed by IT equipment.

$$PUE = \frac{P_{Total}}{P_{IT\ load}}$$

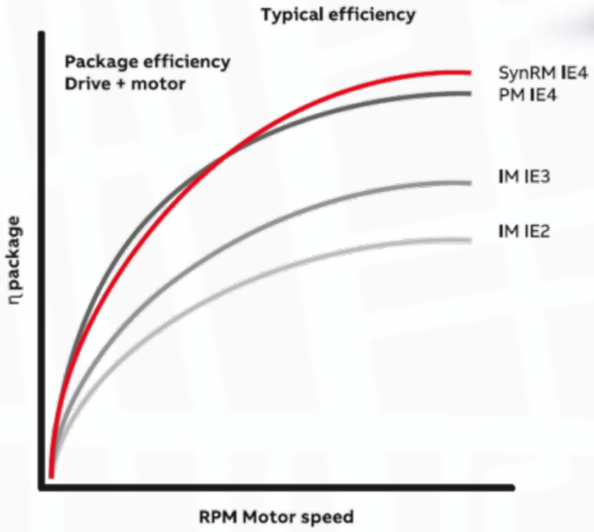
Normalised 2 day data centre load*



*Source: Google transparency reports

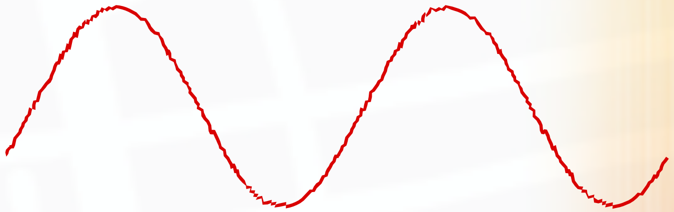
PUE improvement with variable speed solutions for cooling

- There are many motor types and motor control solutions for fans, pumps and compressors aiming to increase data centre cooling efficiency.
- IE4 and IE5 motors bring significant energy savings.
- Motor variable speed control adjusts motor speed in accordance to a current need typically allowing to decrease energy consumption by 20-60%.
- Drives’ ability to optimise motor magnetic flux in accordance to load type (centrifugal for HVAC) brings additional 1…20%.
- Cooling process optimisation through loading less energy consuming elements, running equipment at the points of higher efficiency (cascade control vs parallel control) can bring up to about 30% energy savings.



Specifying variable speed solutions for data centres

- The majority of data centres utilise variable speed motor control solutions. They allow to save a considerable amount of energy adjusting motor speed in accordance to actual load.
- However, variable speed controls like other non-linear loads cause current and voltage wave form distortion resulting in harmonics in the network.
- Excessive harmonics decrease system reliability and energy efficiency:
  - they generate power losses on motors, transformers and cables
  - risk of equipment malfunction or failure
  - capital and operating costs rise due to reduced equipment lifetime, compensating measures, maintenance of malfunctioning devices
  - electrical utilities might charge for high harmonics content in the network



Ideal current wave form

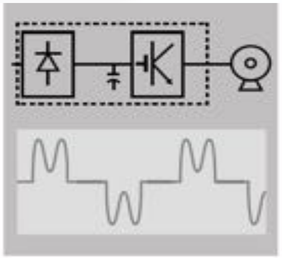
Current distortion caused by non-linear loads in the network

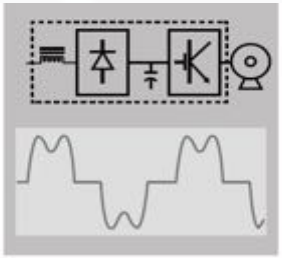
Specifying variable speed solutions for data centres

- Nobody wants a data centre to run into problems with a power supply network and its components due to excessive presence of harmonics.
- Variable speed solution and harmonic mitigation technologies matter.
- It is not only about decreasing harmonic content in the system, but also decreasing it in the right part of the system using right technologies to get the most benefits out of it.
- Besides network and connected equipment stability, it might result in significant operating and capital savings for the data centre.

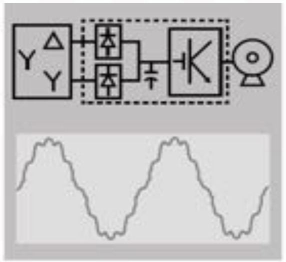
Specifying variable speed solutions for data centres

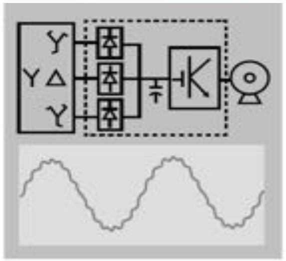
- There are different technologies of harmonics mitigation with a different complexity level and effect on the power quality:
  - DC and AC reactors
  - Multi-pulse drives
  - Passive and active filters
  - Active front end (AFE) drives
- An optimal harmonic mitigation solution is defined by the project type (brownfield/greenfield), grid and load character.
- Active front end drives is the variable speed solution with a positive effect on the grid as well as on capex and opex.
- One of the project requirements should be solution analysis on a cost/performance basis from the solution manufacturer.

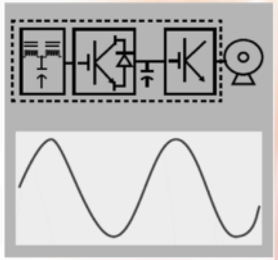

6-pulse drive, no harmonic reduction THDi = 40 - 120%


6-pulse drive, input reactor THDi = 32 to 48%


6-pulse drive, input passive filter THDi = 6 to 12%


12-pulse drive THDi = 8 to 12%


18-pulse rectifier THDi = 5 to 8%


Active front end drive THDi ≤ 3%

Capital and operating cost savings with active front end drives

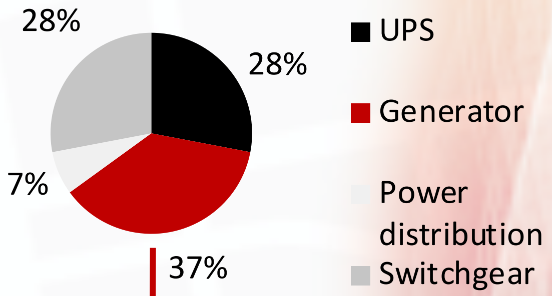
- Standard 6-pulse drives require transformer selection using a factor of 1.35 x motor kVA to consider power factor and harmonic distortion.
- With AFE drives, the factor is 1.1 x motor kVA.

- Cable oversizing depends on the harmonics content in the grid.

TDD	Oversize
10%	1.00
20%	1.02
30%	1.04
40%	1.08
50%	1.12
70%	1.22

- Generator may need oversizing due to a poor power factor since its AVR (automatic voltage regulator) might not operate properly.
- Generator supplying 6-pulse inverters to be de-rated by 50%, which can be avoided if using AFE drives.

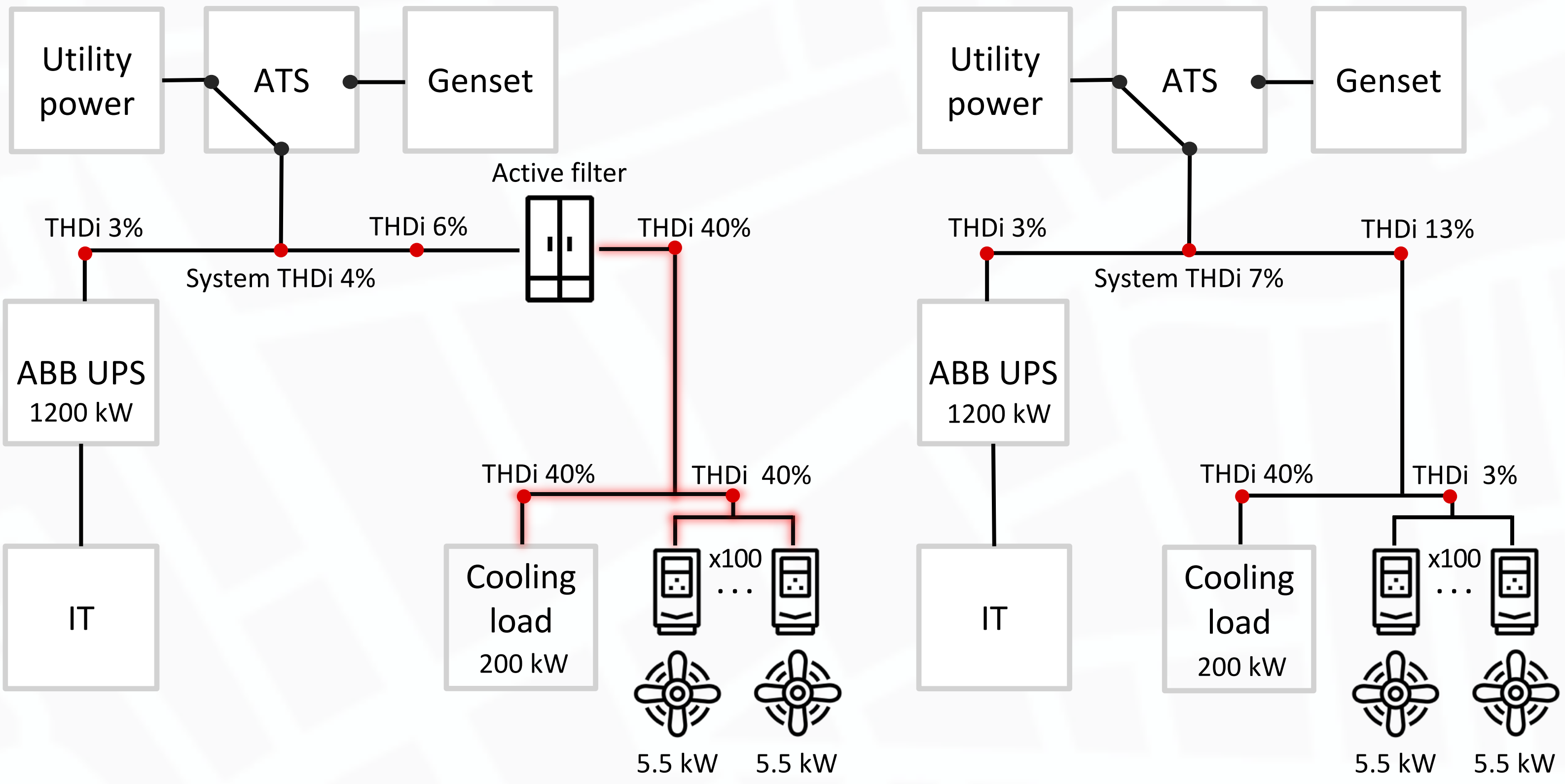
Capital costs breakdown - Power



10% costs down with AFE

50% costs down with AFE

Capital and operating cost savings with active front end drives



- Active front end drives are decentralised harmonics mitigation solutions solving the root cause issue
- Benefits of the decentralised harmonics management:
  - no overdimensioned cables and network components
  - no disruption in power network operation due to harmonics
  - no energy losses over the power network length including cables and network equipment

Overdimensioned cables and power network components

Capital and operating cost savings with active front end drives

Supply voltage **400 V**

Network efficiency **~ 98%**

Passive filter efficiency **98.5%**

6-pulse drive efficiency **98%**

Actual motor efficiency due to drive waveform and lower motor voltage **92%***

Motor voltage after system losses **~ 370 V**

Network eff x PF eff x Drive eff x Motor eff = 0.98 x 0.985 x 0.98 x 0.92 = **87%**

Supply voltage **400 V**

Network efficiency **~ 98%**

ABB AFE drive efficiency **96.5%**

Actual motor efficiency at nominal motor voltage **92.5%***

Motor voltage after system losses **400 V**

Network eff x Drive eff x Motor eff = 0.98 x 0.965 x 0.925 = **87.5%**

Note: Standard drive can have higher efficiency than AFE, but it is critical to consider a whole system efficiency: the efficiency drop in the passive or active filter and the lower motor voltage make the system efficiency lower meaning higher operating costs.

* Standard IEC motor rated efficiency 93%

Capital and operating cost savings with active front end drives

Data centre downtime avoidance

- The average cost of data centre downtime is 5000 USD / min.
- Leading power factor may cause instability in generator run, so it's critical to maintain its unity.
- Negative harmonic effects on transformer often are not noticed until an actual failure.
- AFE drives help solve both power factor and harmonics caused issues.

Eliminating reactive power compensating measures and penalties

- Utilities may charge for a power factor below 1 – the lower the power factor, the higher the overpayment.
- Increasingly utilities include also harmonics in power factor.
- Compensating measures may lead to a significant project cost increase.
- Utilizing AFE solutions provides the most optimum true power factor management.

Eliminating harmonics related losses

- Harmonic currents present in the network generate excessive heat which is energy loss.
- Harmonics affect system efficiency if THDi is too high and no compensation measures are taken.
- PUE doesn't reflect the losses, generated by poor power quality in a data centre network!

Summary

- Mechanical and power systems are accountable for most of the data centre capital costs – on average, 20 and 35% respectively.
- Data centres are sized for peak loads, but do not operate at peak loads most of the time, so it's critical to make them efficient at part loads.
- There are many variable speed technologies for cooling applications to improve data centre efficiency, but they should be specified carefully to avoid power quality issues and data centre operation instability as well as excessive capex and opex.
- Harmonics and reactive power are the aspect to consider – managing both with active front end drives brings significant capital and operating cost savings and ensures data centre power network reliability and resilience.

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