ADVANCED TECHNICAL CONCEPTS

The RenewIT tool allows introducing a number of advanced technical concepts for the supply of power and cooling energy into Data Centres with enhanced utilisation of renewable energy sources in order to achieve Net Zero Energy Data Centres. Because of the high energy density nature of these infrastructures, it is essential to implement energy efficiency measures and reduce consumption before introducing any renewable energy source. In particular, the tool incorporates:

Advanced technical concepts for **efficient IT management**. Here, the RenewIT tool supports:

- **Consolidation strategy**. The objective of this strategy is to allocate the virtual machines, necessaries to satisfy the IT workload demand, in the minimum number of servers. Therefore some servers are working at full load and the rest are kept in an idle state.
- **Turn-off idle servers**. Is a complementary strategy to the consolidation method, where the servers that are not being used are turned off, instead of being in an idle state.

Advanced technical concepts for efficient electric power distribution. Here the RenewIT tool supports:

- **Modular UPS**. This strategy proposes to use a modular UPS so that the number of modules connected can vary depending on the workload conditions. Each module can be activated or deactivated separately depending on workload to maximise the efficiency.
- **Bypassed UPS in normal operating conditions**. Depending on the power grid quality and UPS characteristics, the UPS will be working in normal conditions or partially bypassed. In the framework of the project, it is assumed that the converter downstream of the UPS will be always energized when the UPS is working in the partially bypassed mode.

Advanced technical concepts for efficient thermal power distribution. Here the RenewIT tool supports:

- **Free cooling**. Indirect airside free cooling operating through air-to-air heat exchangers. Adiabatic system is not considered in the RenewIT tool. The control of the free cooling is regulated with the temperature difference between exterior temperature and supply air temperature. If the difference is lower than 3 ºC, the indirect air free cooling is stopped. Moreover, there is a concept (wet cooling tower) that uses direct air free cooling.

- **Cold aisle containment**. The objective is to prevent air mixing and therefore enhance air management efficiency.
- **Increasing the deltaT through the whitespace**. Increasing the air temperature difference between rack outlet and rack inlet reducing the air flow rate through the whitespace.
- **Variable air flow**. A variable airflow system is based on the actually required cooling, not on the maximum required cooling. Reducing the airflow implies reduced pressure drop inside the ventilation units. Consequently, running in partial operation gives a significant reduction in the energy usage.
- **High energy efficiency components**. In this concept, high energy efficiency components, in particular vapour compression chillers are implemented. This obviously increases the coefficient of performance of the unit and the CAPEX.

Finally, the tool allows implementing different advanced technical concepts for power and cooling supply systems. These are the followings:

- **Conventional data centre**. A standard vapour-compression chiller with CRAH units.

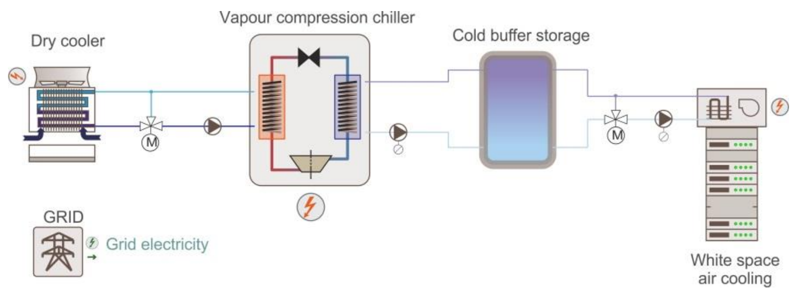

Figure 1 Thermal scheme of a conventional data centre

- **District cooling** and **heat reuse** system. This system was though for liquid cooled data centres. During summer, chilled water from the district cooling system is used to cool the air flowing into the Data Centre and during winter, indirect free air-cooling is conducted. The water for direct liquid cooling is cooled by a heat pump, which provides heat for space heating and domestic hot water. A dry cooler could be used if there is no heat demand.

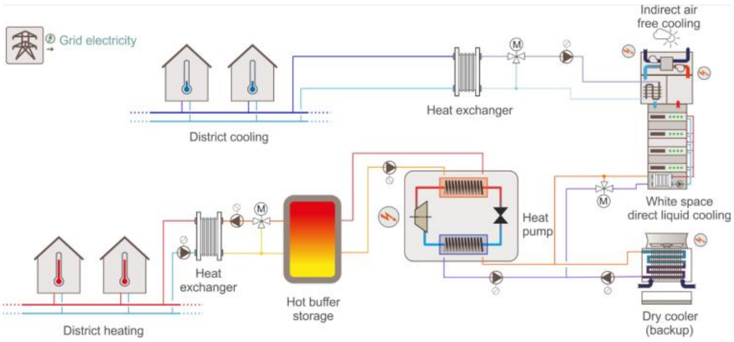

Figure 2 Thermal scheme of a data centre connected to a district cooling and heating network and with direct liquid cooling system

The user can select between two different types of liquid cooling technologies, on-chip liquid cooling and immersed racks:

- On-chip liquid cooling: As is shown in Figure 3, a loop of tubes is installed over the motherboard. Later on chilled water is pumped thought these loops to exchange heat with the server components such as CPU, memory etc. Almost a 75% of the heat will be removed by the direct liquid system, while the remaining one will be exhausted by the air cooling system.

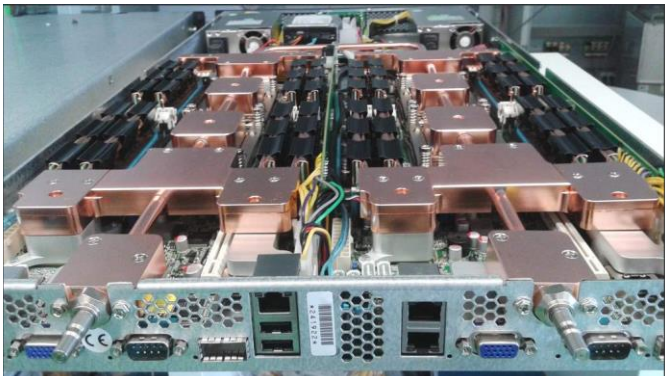

Figure 3 Server with on-chip liquid cooling system

- Immersed racks: The racks are immersed in an inert Novec coolant, as is shown in Figure 4. A low-energy pump drives a secondary coolant circuit in which water removes the heat from these racks. The coolant is reusable and fire-resistant and since it does not conduct electricity, it can come in direct contact with electronics.

Figure 4 Immersed racks on a nonconductive fluid. Source: technologyreview[1]

- **Grid-fed wet cooling tower without chiller**. The main idea is to use wet cooling towers (without chillers) to produce cooling energy. When this evaporative free cooling is not possible, backup vapour-compression chillers along with cooling towers are used. The electrical power required to drive the cooling towers and the backup chillers can be purchased from the national grid. In winter, direct air free cooling is performed for efficient cooling supply to the Data Centre.

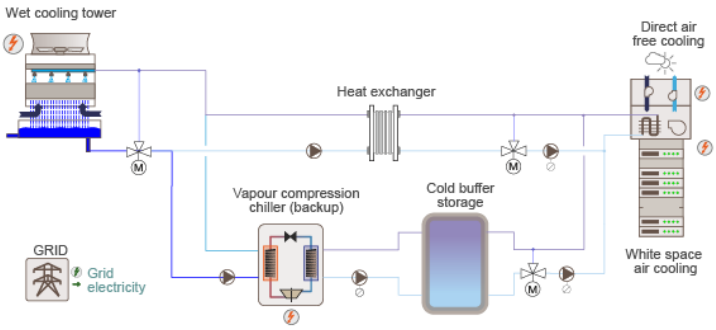

Figure 5 Thermal scheme of a data centre with wet cooling towers

- **Grid-fed vapour-compression chiller with chilled water storage and electric batteries**. During winter, indirect air free cooling is performed for efficient cooling supply to the Data Centre. In this concept, vapour-compression chillers along with wet cooling towers are used to produce cooling energy during summer. The electrical

[1] MIT Technology review, September 2012, "Intel Servers Take a Deep Dive to Cool Off". Available at: https://www.technologyreview.com/s/429179/intel-servers-take-a-deep-dive-to-cool-off/

power required to drive the chiller can be purchased from the national grid. A combination of thermal and electrical energy storage is possible. For thermal storage, a large chilled water storage tank is used for decoupling cooling generation from cooling demand. Thus, chilled water can be generated when cheap electricity or a high share of renewable power is available from the grid. Additionally, charging the storage during the colder night might be advantageous especially in warmer regions because cooling tower operation requires less energy when the ambient temperature is lower. For electrical storage, Li-Ion batteries are used for decoupling power generation from power consumption and cooling demand. Thus, batteries are charged for example when the cost of electricity is low or when the share of renewables is high. This strategy allows adopting the Data Centre's total energy consumption from the grid to the fluctuating parameters (e.g. cost and share of renewables) in order to optimise the Data Centre energy supply.

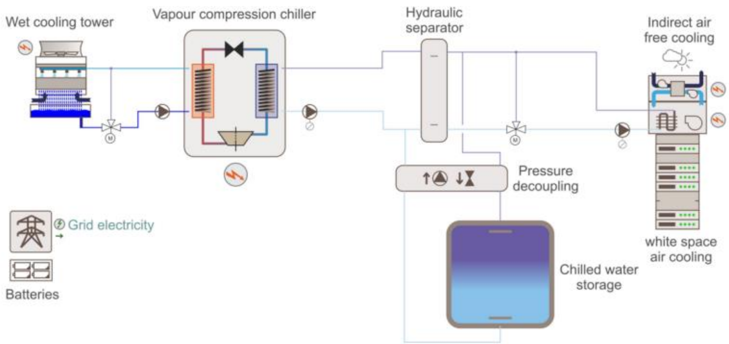

Figure 6 Thermal scheme of a data centre with thermal and electrical energy storages

- **Biogas fuel cell with absorption chiller**. Here, a biogas-fed fuel cell is applied for generating both power and heat, which is used for driving an absorption chiller during summer. In winter, indirect air free cooling avoids the operation of the chillers. Then, the waste heat from the fuel cell can be recovered for space heating or might also be dissipated by a wet cooling tower. Because of the high temperature and pressure of the hot water, shell and tube heat exchanger is used for transferring the heat between the cooling tower and the fuel cell hot water circuit.

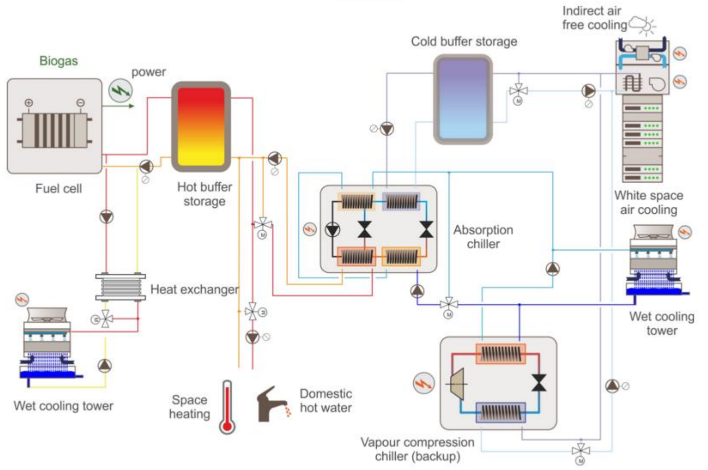

Figure 7 Thermal scheme of a data centre with a biogas fuel cell and absorption chiller.

- **Reciprocating engine CHP with absorption chiller**. This concept is based on biogas-fed tri-generation by means of a reciprocating engine CHP plant. The heat from this plant is used for driving a single-effect absorption chiller during summer and supplying space heating for offices or buildings close to the Data Centre during winter. Additionally, indirect air free cooling is implemented for efficient cooling supply to the Data Centre especially during winter. Then, the heat from the CHP plant should be used for space heating and producing domestic hot water if required.

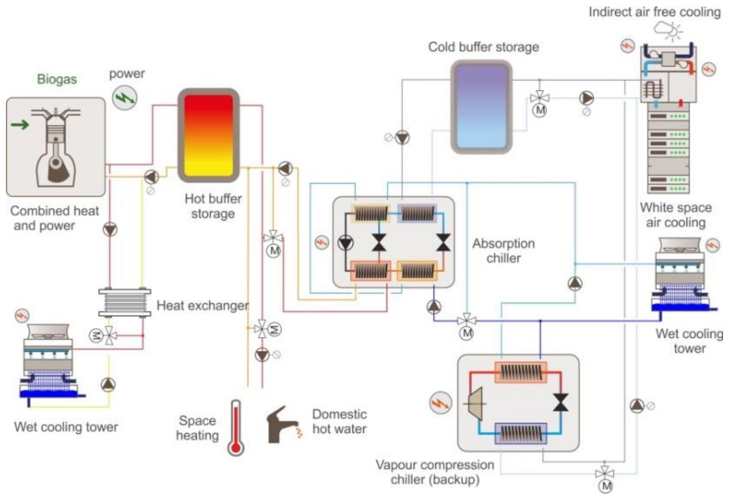

Figure 8 Thermal scheme of a data centre with a reciprocating engine CHP and absorption chiller.

For more information about the energy efficiency strategies as well as for the advanced concepts for power and cooling supply, download the Deliverable D4.5 Catalogue of advanced technical concepts for Net Zero Energy Data Centres.