University of Zurich[UZH] | Sustainability Team

Final report: Making UZH a real-world laboratory for climate change mitigation

Project: *Assessing environmental sustainability in Dual-Energy CT: Exploring energy consumption and ecological-economic impact in low utilization times*

General information

Project title	***Assessing environmental sustainability in Dual-Energy CT: Exploring energy consumption and ecological-economic impact in low utilization times***
Short title or acronym	*Sustainability Project*
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Project description

Within global sustainable resource management efforts, reducing healthcare energy consumption is of public concern. This study aims to analyze the energy consumption of three Dual-Energy computed tomography (DECT) scanners and to predict the power consumption based on scan acquisition parameters.

This study consisted of two parts assessing three DECT scanners: one Dual-Source and two Single-Source DECT. In Part A, the energy consumption for various single- and dual-energy CT scans with different acquisition parameters using a chest phantom was measured. The measurements were compared with the calculated power consumption. In Part B, the energy consumption baselines during non-utilization states of the DECT devices: idle (ready to scan), low-power (incomplete shutdown), and system-off mode (complete shutdown) was measured. Descriptive statistics were used.

The phantom study revealed a positive correlation between measured and calculated energy consumption (r2=0.82), except for single-source split-filter DECT acquisitions, indicating a relationship between scan parameters and energy consumption. The baseline study results showed a mean energy consumption of 2.6 kWh/hour ± 1.34 kWh in idle, 0.89 kWh/hour ± 0.42 kWh in low-power, and <0.01 kWh/hour ± 0.003 kWh in the system-off state. The potential total annual CO2 savings for the assessed DECT-scanners amounted to 3,767 kgCO2 (low power) and 5,868 kgCO2 (system off) compared with the idle state. Time-related calculations indicated energy savings starting after 5 minutes in low-power- and after 2 minutes in the system-off state. Therefore, switching off the scanner, even during shorter periods of non-utilization, can be efficient.

Our results emphasize a positive correlation between scan parameters and energy consumption in DECT. Complete shutdown of DECT devices can have a significant ecological-economic impact.

Achieved impact in terms of GHG emissions (in t CO_2e) and co-benefits

Three different Dual-Energy CT scanner models from one vendor (Siemens Healthineers AG) were included in our analysis: One Dual Source DECT (SOMATOM Drive); One Single Source DECT with split-filter dual-energy (SOMATOM X.ceed); One Single Source DECT with dual-spiral dual-energy (SOMATOM Definition AS).

In our institution the combination of scanners evaluated in this analysis is used as follows: The SOMATOM Drive is in use 24 hours daily; The SOMATOM X.ceed is mainly used for interventions and is the backup for the SOMATOM Drive; The SOMATOM Definition AS is located at an external site for elective patients in a private practice setting and is operated only during day shifts from 7:00 AM to 6:00 PM, otherwise it is turned off.

Our calculations for CO2 emissions were based on official data from our local Federal Office for Environment, which provided an mixed emission factor for consumers of 128 gCO2/kWh in 2018. Switching the SOMATOM Definition AS located at our external site to low power mode during nights and weekends, as is currently practiced, saves 3,808 kWh of electricity, and reduces annually CO2 emissions by 487 kg.

Upscaling activities inside and outside UZH

During the project phase, our working horse the SOMATOM Drive and our backup CT The SOMATOM X.ceed where available 24/7. Furthermore, the SOMATOM Definition AS was only switched to low power mode, which has been proven to have significant residual consumption. In the future, the greatest savings potential lies in transitioning the SOMATOM Definition AS and the SOMATOM x.ceed to system-off mode during non-usage times. This scenario yields in annually CO2 emission savings of 2,757 kg CO2.

Transdisciplinarity

The scientific team, primarily based in the KSB, closely collaborated with the technical team from the UZH comprising staff from the Department of Occupational and Environmental Medicine at the Institute of Epidemiology, Biostatistics, and Prevention, as well as the Engineering and Equipment team.

Lessons learned

Our project aimed to examine the energy consumption of DECT devices. Environmental sustainability is increasingly crucial for healthcare institutions. Our assessment highlighted three key points for greener radiology.

First, optimizing scanning processes and protocols is essential for enhancing energy efficiency in medical imaging. Our project has investigated the correlation between scan parameters and energy consumption, revealing a notable relationship for some of them. But predicting power usage in complex scan modes, such as single-source split-filter dual-energy scans, remains a challenging task. It might be due to the application of filters during single-source split-filter dual-energy scans, requiring somewhat unpredictable energy inputs beforehand. Nevertheless, revising scanning protocols can impact energy consumption.

Second, optimized shutdown management is mandatory. Our measurements showed differences in the shutdown process. Significant residual energy consumption was evident, especially for the SOMATOM Definition AS (only 32% reduction) and the SOMATOM x.ceed (only 52 % reduction), despite the low power mode. The SOMATOM Drive had the most significant energy-saving impact at 85% when switching to low power mode, primarily because of its elevated baseline power consumption during idle periods. Nevertheless, it is crucial to proceed to a comprehensive shutdown, which includes deactivating wall switches, to achieve optimal energy savings of over 99%.

Indeed, the focus of shutdown management should not be limited solely to night or weekend shifts. It's the first time that comprehensive analysis conducted a time range within which shutdown proves sufficient. Our calculations have revealed that a shutdown into the low power state proves advantageous after 5 to 26 minutes, varying depending on the CT device. With wall-switch activation (system off), the benefit is realized after an off-time between 2 and 6 minutes. This suggests that even short nonutilization periods of less than 1 hour may be suitable for CT shutdown. This leads to the optimization of energy consumption not only during night and weekend shifts but also during shorter periods of nonutilization during the day. Certainly, it's essential to consider the times for shutdown and bootup, which collectively take between 6 and 12 minutes for the CT devices in our study. However, the longer boot-up time of the workstation primarily dictates the boot-up time for all three devices. Thus, introducing a system off mode solely for the CT devices, while keeping the workstations operational, could result in faster boot-up times.

Third, the implementation of standby modes is imperative for enhanced energy efficiency. Manufacturers should integrate easily deployable standby modes to optimize energy consumption during brief nonutilization times, particularly when a full shutdown is unfeasible. Although transitioning to low power mode may be advisable after 5 to 26 minutes of inactivity, a complete shutdown is not always feasible for logistical reasons. For example, the SOMATOM Drive must always remain available for emergencies, resulting in an annual energy consumption of 24,303 kWh in its idle state, which is comparable to more than six households of two to three people. In these cases, manually activated standby modes would prove to be beneficial. They should feature fast boot-up times in ready-to-scan mode, serving as a compromise between the idle state and shutting down the CT device. Additionally, it's conceivable that in the future, AI-supported automatic standby modes, comparable to the start-stop mode commonly used in today's automobile industry, may become commonplace, further enhancing efficiency and user convenience.

Open science

The paper has been accepted by the Academic Radiology Journal, but publication is pending.

Further remarks

N/A