Medical Imaging Equipment Energy Efficiency

Background

The energy use of medical imaging equipment (MIE) in healthcare facilities is estimated to be about 5% of total site energy use. MIE energy use is only expected to increase as technology advances and more patients seek services from MIE, enabling more facilities to install additional MIE. Healthcare organizations need reliable information regarding comprehensive energy use or lifetime energy costs with which to make energy-efficient MIE procurement decisions, and there are currently no MIE energy or efficiency standards in the United States (U.S.) [1].

Types of MIE

Major MIE in healthcare facilities include:

- **Nuclear Magnetic Resonance Imaging (MRI)**
  Imaging method: Magnetic resonance
- **Nuclear imaging – Positron Emission Tomography (PET)**
  Imaging method: Radiotracers
- **Computed Tomography (CT)**
  Imaging method: Ionizing radiation
- **Ultrasound imaging/sonography**
  Imaging method: Sound waves
- **X-ray radiography**
  Imaging method: Ionizing radiation

Typical MIE Operating Modes

- Scan Mode: The system is actively scanning the patient to generate images.
- Ready-to-scan/Standby Mode: This mode represents the state of the system between individual scans, where no scan has been prescribed.
- Low-power Mode: In this mode, the system functions at its lowest energy consuming state that the user can select according to the user manual.
- OFF Mode: The system is shut down with AC mains off, according to the user manual, and consumes NO energy.

MIE Energy Consumption

MIE are typically in ready-to-scan/standby mode to allow for quick startup for emergency use.

Typical energy consuming systems associated with MIE are:

- **Imaging Systems.** Systems that are directly responsible for image production, such as magnets, primary cooling systems and display monitors, and detector arrays.
- **Auxiliary Systems.** Systems that are required by the MIE to operate but are not responsible for the imaging, such as lighting, additional display monitors, and MIE electrical and cooling backup systems.
- **Indirect Systems.** Systems that are essential for maintaining patient, technician and diagnosis room conditions but are not directly tied to MIE operation, such as space heating, ventilation, and air-conditioning (HVAC), and electrical distribution system loss.

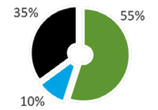
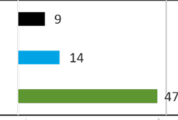
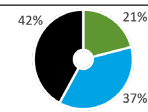
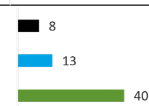
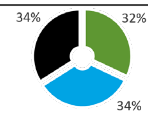
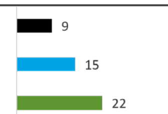
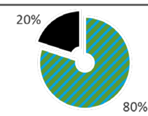
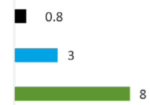
Energy Consumption of MRI Machines

Table 1 shows that MRIs consume more than 2x and 10x the energy of CT scanners and X-rays, respectively, and represent an opportunity for significant energy savings. Table 2 shows that 21% to 55% of the total energy is consumed during active scanning, and 25% to 40% is consumed when it is not operational during nights and weekends. The remaining energy is consumed between active scans and when the patient is preparing to be scanned. The majority of the energy is consumed by the MRI magnet, followed by cryocoolers for superconducting magnet-based MRIs, which are required to run constantly to cool the cryogen.

Table 1. MIE Typical Energy Use[1]

	MRI	X-ray	CT
Average Annual Energy Consumption (kWh/unit/yr)	111,000	9,500	41,000
Average Annual Energy Operating Cost ($/unit/yr)	20,000–30,000	100–400	3,000–6,000
Rated Power Range (kVA)	50–100	0.5–1.5	50–100

Table 2. Energy Consumption of MRI Machines

Reference Name	Year	Region	Energy Use in Each Mode	Avg. Power (kW) Reading in Each Mode	Test Period
The Energy Consumption of Radiology: Energy- and Cost-saving Opportunities for CT and MRI Operation[2]	2020	Switzerland (Europe)			12 months
MRI Transparency Document[3,4]	2012	USA			4 days
COCIR* MRI Guidelines for Users on Saving Energy[5]	2015	Europe			Daily avg.
Energy usage of a newly operational GE Healthcare Signa Premier 3T MRI**[6]	2019	USA			Daily avg.

■ Active scan ■ Standby / Ready-to-scan ■ Low-power

* COCIR is the European Trade Association representing the medical imaging, radiotherapy, health ICT and electromedical industries.

** This study consolidates active mode and standby/ready-to-scan mode for energy use analysis.

Opportunities for Energy and Cost Savings

Energy savings can be achieved by transitioning MIE that are in ready-to-scan/standby mode to low-power mode if the ready-to-scan/standby functionality is not needed. Implementing low-power mode can achieve 21.8% energy savings[7]. To operate MIE to transition into and out of low-power mode, the radiologist department should define a process that is seamless, easy to follow, and incorporated into documentation and daily use of the machine.

Indirect savings opportunities include reduced HVAC load through strategies such as thermostat setbacks. During unoccupied hours, the room does not need to be conditioned for human comfort but note that it may still need to be maintained at specific conditions for the MIE. There is also an opportunity to use occupancy sensing and scheduling to turn off non-critical MIE auxiliary system loads like screens and lights during unoccupied hours. For cost optimization, healthcare procurement teams should define a procurement framework for total ownership cost or lifecycle cost, which includes initial, remodel construction, direct operational energy, auxiliary, and indirect costs.

Summary

MIE, especially MRIs, can consume substantial energy even when not actively scanning patients. MRIs consume about 9 kW in system low-power mode, and they are often left in standby/ready-to-scan mode, consuming 14 kW+ depending on equipment design and configuration. According to ENERGY STAR Portfolio Manager, adding an MRI to a healthcare facility can result in a statistically significant increase in energy consumption. Implementing MIE energy reduction strategies can reduce the overall energy consumption of healthcare facilities.

References

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