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U.S. DEPARTMENT OF ENERGY

Fact Sheet

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.[1]

Types of MIE

Major MIE and its imaging method in healthcare facilities include:

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

Typical MIE Operating Modes

- Scan: The system is actively scanning the patient to generate images.
- Ready-to-Scan/Standby: This mode represents the state of the system between individual scans, where no scan has been prescribed.
- Low Power: In this mode, the system functions at its lowest energy-consuming state that the user can select according to the user manual.
- Power-Save Mode: Vendor-specific mode that engages automatic power management for energy saving.
- Off: The system is shut down with mains off, according to the user manual, and consumes NO energy (not possible for superconducting magnets).

MIE Energy Consumption

MIE energy use is commonly categorized as "productive" (scan mode) and "nonproductive." However, more specific operating mode categorization can be helpful to gain insights. These more specific definitions are described in the blue callout box.

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.

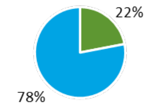
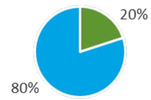
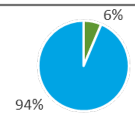
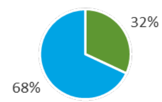
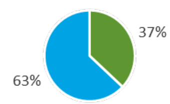
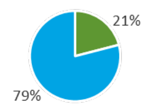
Table 1. MIE Typical Energy Use[1]

	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

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 6% to 37% of the total energy is consumed during active scanning, and 63% to 94% is consumed in nonproductive modes. Most of the energy is consumed by the MRI magnet,

Table 2. Energy Consumption of MRI Machines

Reference Name	Year	Region	Duration in Each Mode	Avg. Power Reading (kW)		Test Period
				Productive	Nonproductive	
A semi-automatic analytical methodology for characterizing the energy consumption of MRI systems using load duration curves[2]	2024	USA		30-37	11-19	1 month
Energy consumption in MRI: Determinants and management options[3]	2024	Europe		30	12	1 week
Ecodesign and Operational Strategies to Reduce the Carbon Footprint of MRI for Energy Cost Savings[4]	2023	USA		20-60	5-26	39 days
State of Medical Sustainability Research Medical Imaging Equipment[5]	2022	Europe		22	9-15	Daily avg.
The Energy Consumption of Radiology: Energy- and Cost-saving Opportunities for CT and MRI Operation[6]	2020	Switzerland (Europe)		17-29	8-11	12 months
Environmental impact reduction as a new dimension for quality measurement of healthcare services[7,8]	2012	USA		40	9-13	4 days

■ Productive ■ Nonproductive

followed by cryocoolers for superconducting magnet-based MRIs, which are required to run constantly to cool the cryogen.

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 22% energy savings.[9] To operate MIE to transition into and out of low-power mode, the radiology 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 life cycle cost, which includes initial, remodel construction, direct operational energy, auxiliary, and indirect costs.

Additional savings opportunities can be uncovered through MIE metering.

Metering MIE

Implementing a metering strategy for MIE can uncover opportunities for energy savings, improve operational efficiency, and support compliance and sustainability goals. The following sections provide guidance on why and how to meter MIE, helping stakeholders make informed decisions to enhance their facility's performance.

Why Meter?

Metering your MIE provides data that can support various operational and strategic objectives. Understanding the benefits can help justify the investment in metering technology.

- **Identify Savings Opportunities.** Metering MIE in your facility can lead to energy savings through operational strategies, like optimizing schedules and updating operating procedures.

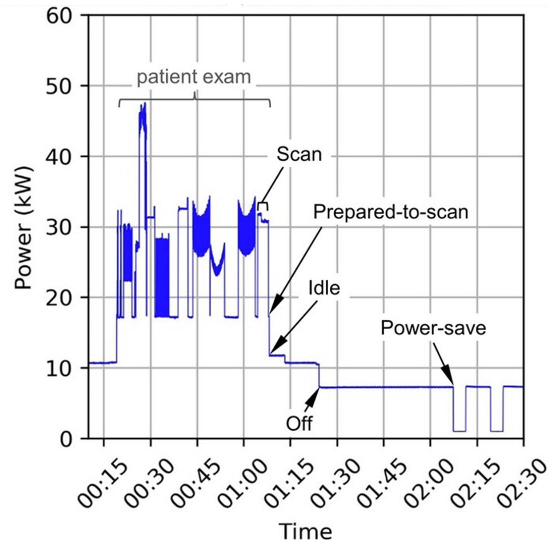


Figure 1. Example load profile of an MRI scanner during system shutdown[2]

- **Compliance and Reporting.** Metering can ensure adherence to regulatory requirements and enhance transparency through detailed energy usage reports.
- **Sustainability Goals.** Support your facility's sustainability initiatives by tracking and reducing MIE energy consumption.
- **Benchmarking.** Compare your facility's performance against industry standards and identify areas for improvement.
- **Maintenance.** Monitor equipment performance to anticipate and prevent potential issues, ensuring consistent operation.
- **Inform Planning for Future MIE Installations.** Use metered data to make informed decisions for future installations, optimizing both cost and performance.

Planning Meter Installation

Effective planning is essential for a successful metering project. By carefully considering the type and purpose of the study, the machines to be metered, and the necessary personnel, you can ensure accurate and useful data collection.

- **Determine Goals.** It is important to first consider *why* you are choosing to meter.
- This will inform future steps in the metering process. Refer to the previous section for a list of common reasons for MIE metering. This will then help you identify whether your study will involve short-term (spot measurements) or long-term monitoring.
- **Identify Machines.** Consider the setting (emergency vs. outpatient) and the purpose of the study to determine which machines to meter. For example, in an emergency setting, you may focus on long-term monitoring of critical equipment that runs continuously, while in an outpatient setting, you might prioritize machines with variable usage patterns to identify savings opportunities.
- **Assemble Personnel.** Metering MIE will involve collaboration between facilities and clinical personnel. See Table 3 for recommended personnel for metering.

Table 3. Recommended Personnel for Metering

Facilities Personnel	Clinical Personnel
▶Electricians ▶IT support ▶Facilities personnel or energy manager	▶Technologist ▶Radiologist, medical physicist, or clinical engineering staff

- **Upfront vs. Retrofit.** Decide if the metering will be part of new installations (upfront) or added to existing setups (retrofit). Upfront installations often allow for seamless integration with minimal disruption, ensuring that the metering system is built into the design from the start. Retrofit installations, while potentially more disruptive, can provide valuable insights into existing systems, helping to identify immediate efficiency improvements and cost savings opportunities.

Selecting a Meter

Choosing the right meter is important for accurate and effective monitoring of your MIE's energy consumption. Consider the specific requirements of your facility and the type of data you need to collect.

- **Electrical Measurements.** Power metering equipment measures power levels over time to calculate system energy use. Metering systems need voltage and current sensing for accurate power measurement. Voltage measurement requires a physical wire connection while current can be measured through non-contact transducers like current transformers, Rogowski coils, zero flux, and Hall effect sensors. MIE components may be powered through multiple connections, and multi-circuit meters are useful for monitoring multiple circuits on the same electrical panel.

Example permanent circuit-level power meter
Photo from iStock 153688187

Temporary non-contact circuit-level current transducer
Photo from iStock 111905131

- **Thermal Measurements.** Thermal measurements for chilled water can be achieved using temperature sensors as well as flow meters connected to BTU meters.
- **Temporary vs. Permanent Meters.** The choice between temporary and permanent meters depends on the study's goals; temporary meters are ideal for short-term or spot measurements to estimate power, energy, or other parameters, whereas permanent meters are suited for long-term monitoring, though they may require permits and a longer installation timeframe.

Accessing the Data

Making data accessible and actionable is crucial for effective energy management. Choose systems that allow for easy data retrieval and integration with existing monitoring infrastructure.

Integrating metered data into a central monitoring system enhances its usability and provides valuable insights for managing your facility's energy consumption. Ensure your chosen metering product is compatible with existing systems.

Summary

MIE, especially MRIs, can consume substantial energy even when not actively scanning patients. MRIs spend most of their time in nonproductive modes, consuming 5–26 kW, and they are frequently kept in ready-to-scan/standby mode, consuming 14 kW or more, 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 a comprehensive metering strategy for your facility's MIE can lead to operational savings, enhanced compliance, and improved sustainability. Plan carefully, select the right equipment, and involve the necessary personnel to ensure a successful implementation.

References

1. J. Knott, L. Varangu, K. Waddington, T. Easty, and S. Shi, "Assessing Opportunities to Reduce Energy Consumption in the Health Care Sector," 2017.
2. A. M. Hernandez, R. Alizadeh, O. Ghatpande, A. Van Sant, and Y. Jung, "A semi-automatic analytical methodology for characterizing the energy consumption of MRI systems using load duration curves," Medical Physics, pp. 1–13, 2024, doi: 10.1002/mp.17327.
3. M. Chodorowski, J. Ognard, À. Rovira, J.-C. Gentric, D. Bourhis, and D. Ben Salem, "Energy consumption in MRI: Determinants and management options," Journal of Neuroradiology, vol. 51, no. 2, pp. 182–189, Mar. 2024, doi: 10.1016/j.neurad.2023.12.001.
4. S. A. Woolen et al., "Ecodesign and Operational Strategies to Reduce the Carbon Footprint of MRI for Energy Cost Savings," Radiology, vol. 307, no. 4, p. e230441, May 2023, doi: 10.1148/radiol.230441.
5. Global Electronics Council, "State of Sustainability Research Medical Imaging Equipment," Jun. 2022. [Online]. https://globalelectronicscouncil.org/wp-content/uploads/medical-imaging-equipment-state-of-sustainability-research.pdf.
6. T. Heye et al., "The energy consumption of Radiology: Energy- and cost-saving opportunities for CT and MRI operation," Radiology, vol. 295, no. 3, pp. 593–605, 2020, doi: 10.1148/radiol.2020192084.
7. A. Esmaeili, C. McGuire, M. Overcash, K. Ali, S. Soltani, and J. Twomey, "Environmental impact reduction as a new dimension for quality measurement of healthcare services." Int J Health Care Qual Assur. 2018 Oct 8; 31(8): 910-922. doi:10.1108/IJHCQA-10-2016-0153. PMID: 30415627.
8. A. Esmaeili, J. M. Twomey, M. R. Overcash, and S. A. Soltani, "MRI Transparency Document," 2017. [Online]. https://floridapoly.edu/wp-content/uploads/MRI-Transparency-Document.pdf.
9. "COCIR Self-Regulatory Initiative for the Ecodesign of Medical Imaging Equipment Status Report 2018," 2018. [Online] https://www.cocir.org/fileadmin/6_Initiatives_SRI/SRI_Status_Report/COCIR_SRI_Status_Report_2018_-_June_2019.pdf.

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