GreenHealth Lab

Energy-Saving Interventions for MRI: Reducing Costs and Environmental Health Impacts

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INTRODUCTION

- The field of radiology has been a leader in the sustainability space by advocating for reducing healthcare's environmental emissions and highlighting **energy conservation as an opportunity** for **innovation in radiology**.[1-3]
- The energy consumption by **MRI represents a high-yield target** for energy conservation and healthcare's environmental footprint through **optimizing machine settings and management**.
  - Recent study quantified the energy and cost savings from low-energy MRI interventions (e.g. activating **power-save mode)** – projected to save up to $10.7 million annually across the US.[1]
- To characterize the holistic healthcare value from such interventions, **we present a cost-effectiveness analytic approach** estimating the potential savings in both (1) health system costs & (2) patient health outcomes associated with MRI energy consumption & associated environmental pollutants.

METHODS

Data Sources
- Data on MRI energy-savings regimens and costs per regimen from Woolen et al[1]
- UCSF electricity utility rates from medical center billing department
- Constants for converting units of energy utilization into environmental impact factors and disability-adjusted life-years (DALYs) from previously-published life cycle assessment of radiotherapy (conversion factors listed in Tables 1-2)[4]

Health System Costs
- Costs of energy consumption calculated by translating MRI regimen costs reported in Woolen et al into costs at UCSF for the equivalent energy amount using UCSF utility rate ($0.19/kwh/hr)

Pollution-Associated Health Impacts
- Environmental impacts/energy use (kWh) estimated via TRACI conversion factors (Table 1)
- DALY impacts calculated using conversion factors for environmental pollutants' impacts on health (Table 2)

Analytic Approach
- Compared absolute annual cost and DALY savings across MRI energy-saving regimens, and extrapolated to US-wide savings
  - Off vs. simulated power save mode
  - Idle vs. off
  - Idle vs. simulated power save mode
- Incremental cost-effectiveness ratio (ICERs) were calculated as ΔCost/ΔDALY

Table 1. Energy Environmental Impact Conversion Factors

Impact category	Electricity (1 kWh)
Global warming potential (kg CO_2 eq)	2.83^{E-01}
Respiratory effects (kg PM2.5 eq)	2.28^{E-04}
Carcinogenic pollution (CTUh)	1.03^{E-07}
Non-carcinogenic pollution (CTUh)	1.08^{E-07}
Acidification (kg SO_2 eq)	1.13^{E-03}
Ozone depletion (kg CFC-11 eq)	2.72^{E-08}

Environmental impact conversion factors associated with electricity usage, based on TRACI 2.1 V1.07 / US 2008. Electricity factors reflect the US energy grid.

Table 2. Environmental Impact to DALY Conversion Factors

Impact category	DALY Conversion Factor
Global warming potential	3.17^{E-07} (DALY/kg CO2-e)[5]
Respiratory effects	4.50^{E-04} (DALY/kg PM2.5)[6]
Carcinogenic pollution	3.36^{E-07} (DALY/CTUh)[5]
Non-carcinogenic pollution	3.67^{E-08} (DALY/CTUh)[5]
Acidification	5.30^{E-05} (DALY/kg SO2)[6]
Ozone Depletion	1.05^{E-03} (DALY/kg CFC-11 eq)[5]

Conversion factors from the literature used to translate TRACI environmental impacts from life cycle assessment of EBRT into human health impacts (disability-adjusted life years (DALYs)).

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References

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RESULTS

- Switching a standard MRI model from **idle to simulated power save mode on weeknights and on weekends** led to the **greatest estimated annual savings** in costs ($7,578), DALYs (0.010), and greenhouse gas (GHG) emissions (~11,473 kg CO_2e)
  - Translates to **maximum savings** of **over ~$95M** and **~130 DALYs across US outpatient MRI units** per year, based on an estimated 12,920 MRIs in the US in 2023-24[7,8]
  - Across four* MRI models, annual cost savings range $7,578–$5,052 & DALY savings range 0.010-0.007 per MRI
- Switching this MRI from **idle to off on weeknights and weekends** had the **second-highest impact** on estimated annual cost ($4,841) and DALY (0.007) savings, with GHG savings of ~7,337 kg CO_2e / year
  - Translates to **maximum savings** of **over ~$60M** and **~90 DALYs across US outpatient MRI units** per year
  - Across four MRI models, annual cost savings range $4,841–$2,945 & DALY savings range 0.007-0.004 per MRI
- Reducing electricity consumption overall may lead to maximum approx **savings of $741,954 per every DALY saved**

*Magnetom Vida (Siemens Healthineers), Ingenia (Philips), Signa Premier XT (GE Healthcare), Magnetom Skyra (Siemens Healthineers)

Table 3. Annual Energy-Associated Cost and DALY Savings per MRI Intervention

	Cost Savings	Energy Savings (MWh)	ΔGHG (kg CO_2e)	ΔR (PM 2.5)	ΔC (CTUh)	ΔNC (CTUh)	ΔA (kg SO2eq)	ΔO (kg CFC-11eq)	DALY Savings
Weeknights									
MRI off to simulated PS	$2,129	11.40	3,229	2.595	0.001	0.001	12.86	0.0003	0.003
MRI idle to off	$3,768	20.10	5,694	4.575	0.002	0.002	22.67	0.0005	0.005
MRI idle to simulated PS	**$5,897**	**31.50**	**8,923**	**7.170**	**0.003**	**0.003**	**35.53**	**0.0009**	**0.008**
Weeknights & weekends*									
MRI off to simulated PS	$2,737	14.60	4,136	3.323	0.002	0.002	16.47	0.0004	0.004
MRI idle to off	$4,841	25.90	7,337	5.895	0.003	0.003	29.22	0.0007	0.007
MRI idle to simulated PS	**$7,578**	**40.50**	**11,473**	**9.218**	**0.004**	**0.004**	**45.69**	**0.0011**	**0.010**

MRI: representative magnetic resonance imaging machine with maximum energy impact potential. PS: power-save mode. DALY: disability-adjusted life-year. DALYs account for the: GHG (greenhouse gas emissions [kg CO2eq]; R (respiratory effects [kg PM2.5eq]); C (carcinogenic pollution [CTUh]); NC (non-carcinogenic pollution [CTUh]); A (acidification [kg SO2eq]); and O (ozone depletion [kg CFC-11eq]) associated with energy use. *Refers to weekday nights and all day/night on the two weekend days.

CONCLUSIONS

- Opportunities exist for radiology departments to **improve holistic quality of care** by **reducing excess healthcare expenditures** and harmful energy-associated downstream **environmental pollutants** – supporting **radiology's role in helping to lead the healthcare sustainability movement**
- Energy-saving interventions for MRI machines have the potential to yield savings via automated power setting changes that do not impact the delivery of quality patient care or disrupt clinical workflow
- This highlights further opportunities to investigate **power-save and other energy-conserving modes** for MRI
  - **Other imaging modalities** may also be **monitored & automated** to leverage emerging tech and yield savings

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