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REDISCOVERING RADIATION MEDICINE AND EXPLORING NEW INDICATIONS

Quantifying Energy Consumption in Radiation Oncology: A Multi-Modality Assessment for Sustainability and Efficiency

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INTRODUCTION

- The **U.S. healthcare sector** contributes significantly to the country's greenhouse gas (GHG) emissions – which perpetuate the human health risks of climate change – in part due to its energy consumption[1]
- **Radiation oncology** utilizes energy-intensive imaging & radiotherapy equipment, and has therefore taken a lead in advocating for improved environmental sustainability in healthcare[2]
- Prior studies have highlighted opportunities for significant energy savings from **optimizing the standby mode settings of medical imaging machines**
  - Woolen et al found that power-save mode overnight in all outpatient MRI units in the U.S. could save 58,863–76,288 MW-hours[3]
- **Direct energy metering** represents the gold standard for understanding equipment energy consumption trends over time, which may **highlight areas for high-yield intervention** across radiation oncology imaging and treatment modalities

AIMS

To **quantify energy consumption** across multiple imaging and treatment modalities in radiation oncology

To identify **opportunities for efficiency improvements** by analyzing operational power states and usage patterns

METHODS

- We conducted direct energy metering to collect energy usage data from six radiation oncology imaging & treatment modalities over 2-week periods:
  - Varian TrueBeam LINAC, CyberKnife S7 Radiosurgery System, GE LightSpeed VCT CT Scanner, Siemens Biograph Vision PET/CT Scanner, GE Discovery MR750 MRI Scanner, and GE Ultrasound LOGIQ E10
- Direct metering recorded power draw from each machine across time spent in various operational states, including Low Power, Ready to Scan, and Scan modes, as well as during Peak Power
  - We generated load duration curves to assess energy distribution
- We compared manufacturer-reported specifications to real-world power consumption to identify inefficiencies

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RESULTS

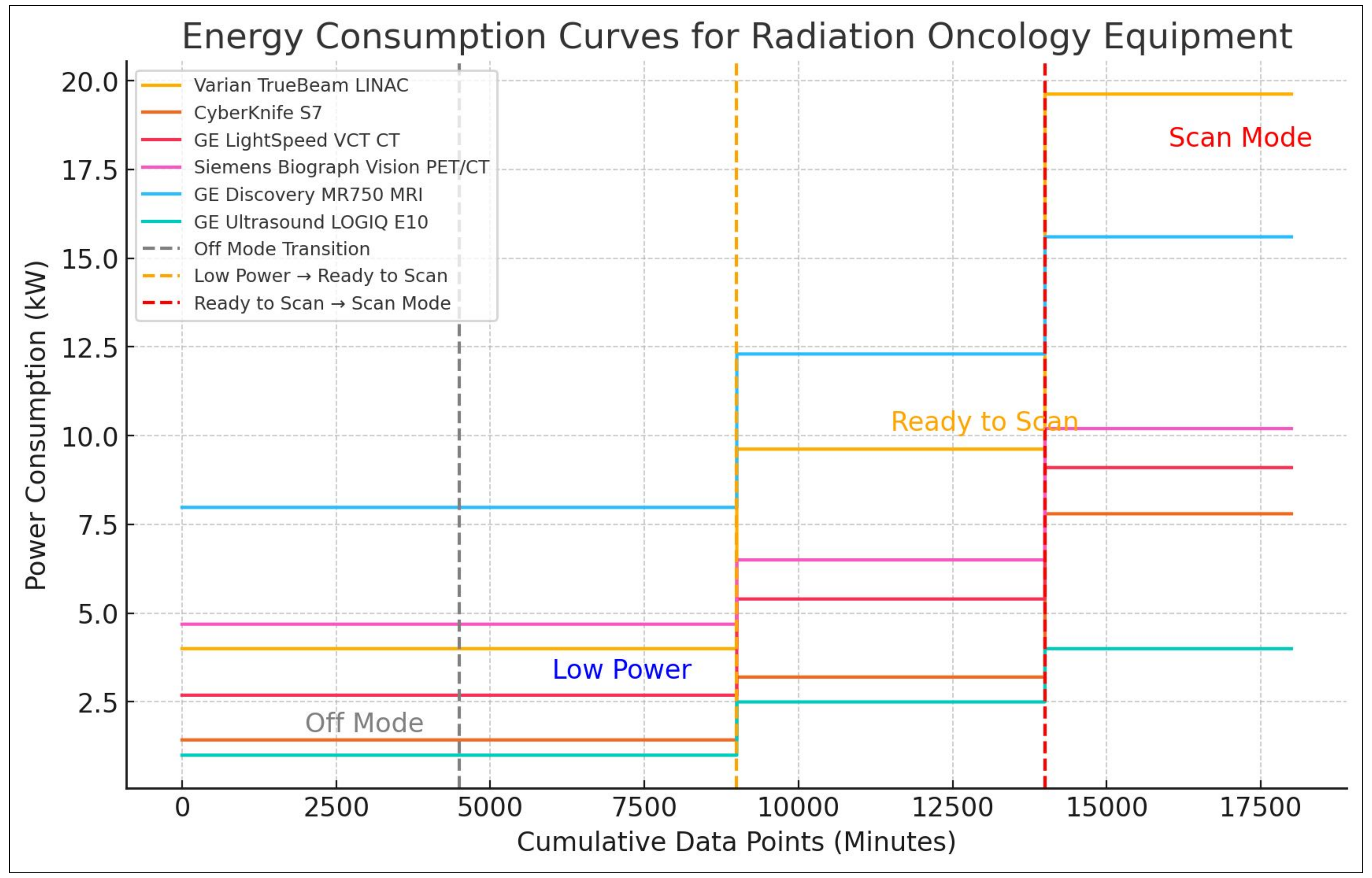
- Time spent in **Low Power mode** accounted for significant energy consumption across machines *(Table 1)*
  - **GE CT scanner** spent the **most time** in **Low Power** mode **(83.7%)**, accounting for **2.69 kW** over the 2-weeks
- The **GE ultrasound** machine had the **lowest overall** power consumption (13.5 kW), drawing the least amount of energy in all modes
- The **TrueBeam LINAC** had the **highest overall** power consumption (67.44 kW), largely due to its energy draw during Scan Mode *(Table 1)*
- While in **Ready to Scan & Scan** modes, the **TrueBeam LINAC** & **GE MRI** machines were the most energy-intensive (*Fig 1*)
- While in **Low Power** mode, the **GE MRI** was the most energy-intensive *(Fig 1)*

Table 1. Energy Consumption by Operational State Across Radiation Oncology Imaging & Treatment Modalities

Radiation Oncology Modalities	Low Power Mode Energy consumption; Time (% of total)	Ready to Scan Mode Energy consumption; Time (% of total)	Scan Mode Energy consumption; Time (% of total)	Peak Power Mode Energy consumption	Total Energy Consumption
Varian TrueBeam LINAC	4.00 kW; 58%	9.62 kW; 29%	19.62 kW; 13%	34.20 kW	67.44 kW
CyberKnife S7	1.43 kW; 72.9%	3.2 kW; 20%	7.8 kW; 7%	12.0 kW	24.43 kW
GE LightSpeed VCT CT	2.69 kW; 83.7%	5.4 kW; 12%	9.1 kW; 4%	14.5 kW	31.69 kW
Siemens Biograph Vision PET/CT	4.69 kW; 65.4%	6.5 kW; 18%	10.2 kW; 10%	16.0 kW	37.39 kW
GE Discovery MR750 MRI	7.98 kW; 65.9%	12.3 kW; 22%	15.6 kW; 12%	20.0 kW	55.88 kW
GE Ultrasound LOGIQ E10	1.0 kW; 49.3%	2.5 kW; 15%	4.0 kW; 5%	6.0 kW	13.5 kW

Total energy consumption (kilowatts, kW) while in each of the four machine modes for each piece of radiation oncology equipment, along with percent of time over metering period spent in each mode over the 2-week metering periods. LINAC: linear accelerator, CT: computed tomography, PET: positron emission tomography, MRI: magnetic resonance imaging.

Figure 1. Energy Consumption Curves for Six Radiation Oncology Imaging & Treatment Modalities



Power consumption trends across radiation oncology imaging & treatment modalities: linear accelerator (LINAC), CyberKnife (includes LINAC), computed tomography (CT), positron emission tomography/CT (PET/CT), magnetic resonance imaging (MRI), and ultrasound. Vertical dashed lines indicate transitions between Off, Low Power, Ready to Scan, and Scan Mode states for each machine.

CONCLUSIONS

- We provide a **data-driven framework for formulating energy reduction strategies** in radiation oncology
  - Enhanced auto-sleep functions, optimized power scheduling & cooling cycles, and adoption of Energy Star-aligned efficiency features could **reduce energy waste while maintaining high-quality patient care**
- **Policies** incorporating energy efficiency into equipment standards & hospital infrastructure planning would support **leadership in environmental sustainability within oncology**
- Future efforts should focus on long-term cost benefits, integrating energy-monitoring technologies into clinical infrastructure, & strengthening **clinician advocacy around energy conservation**

REFERENCES

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CONTACT INFORMATION

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