

Climate Change and Imaging: A Toolkit for Action

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At the end of this presentation, participants will be able to:

- Describe the human health effects of climate change
- Discuss the environmental impact of imaging
- Implement actions to decrease greenhouse gas emissions

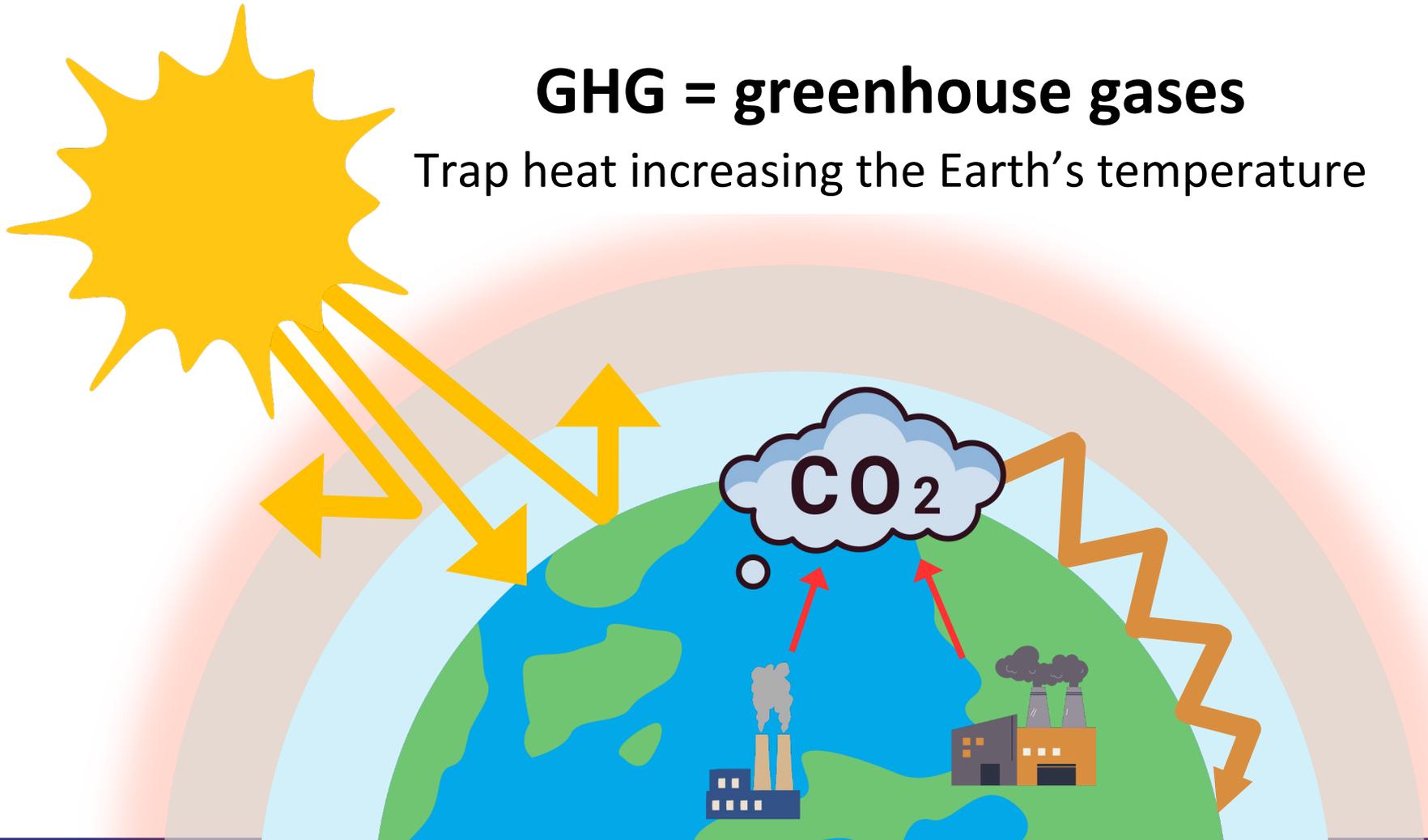
Climate Change

Long-term shifts in
temperature and
weather



GHG = greenhouse gases

Trap heat increasing the Earth's temperature



Global Warming Stripes

Annual mean global temperatures (1850-2018)

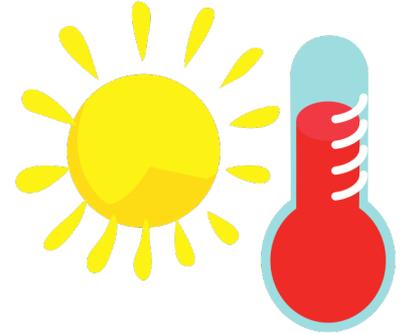
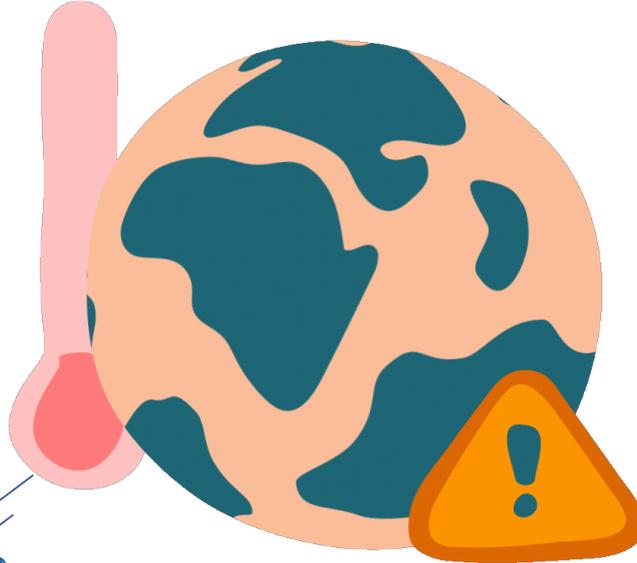
Effects of Climate Change



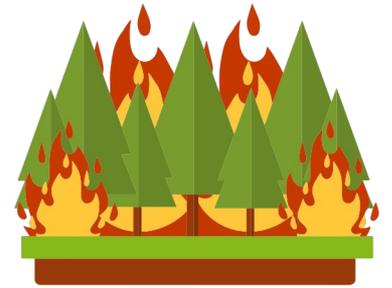
Flooding



Storms



Extreme Heat



Fires

Brain

Mental and psychosocial health, anxiety, stroke

Multi-system

Vector-borne disease, heat-related illness, heat-drug interaction, interpersonal violence, exacerbation of social and health inequities

Lungs

Respiratory illnesses, COPD, asthma

Heart

Heart failure, ischemic heart disease, exacerbation of existing cardiovascular disease

Genitourinary

Exacerbation of existing renal disease, adverse pregnancy outcomes

Gastrointestinal

Malnutrition, water-borne disease, food-borne disease, food scarcity, decreased food quality

Musculoskeletal

Injury due to weather related events

Exacerbation of asthma and COPD

Increased risk MI and death



Climate change

Vulnerability

Exposure pathways

Climate change
is the greatest
threat to human
health

Vulnerability factors

- Demographic factors
- Geographic factors
- Biological factors & health status
- Sociopolitical conditions
- Socioeconomic factors

Health system resilience

governance
systems
& technologies



Injury and mortality from extreme weather events



Heat-related illness



Respiratory illness



Water-borne diseases and other water-related health impacts



Zoonoses



Vector-borne diseases



Malnutrition and food-borne diseases



Noncommunicable diseases (NCDs)



Mental and psychosocial health



Impacts on healthcare facilities



Effects on health systems

TAKE HOME POINT 1

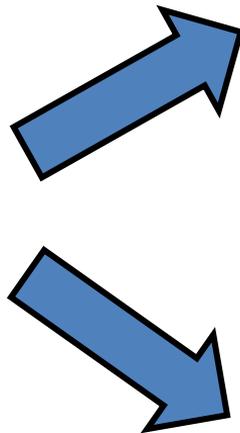
Climate change affects us all but not everyone is affected equally

Le changement climatique nous affecte tous, mais tout le monde n'est pas touché de la même manière

Climate Change and Imaging



Health care → 4-10% of
global GHG emissions



Energy

~1% of global GHG
emissions

Scanner production
and use phases

Waste

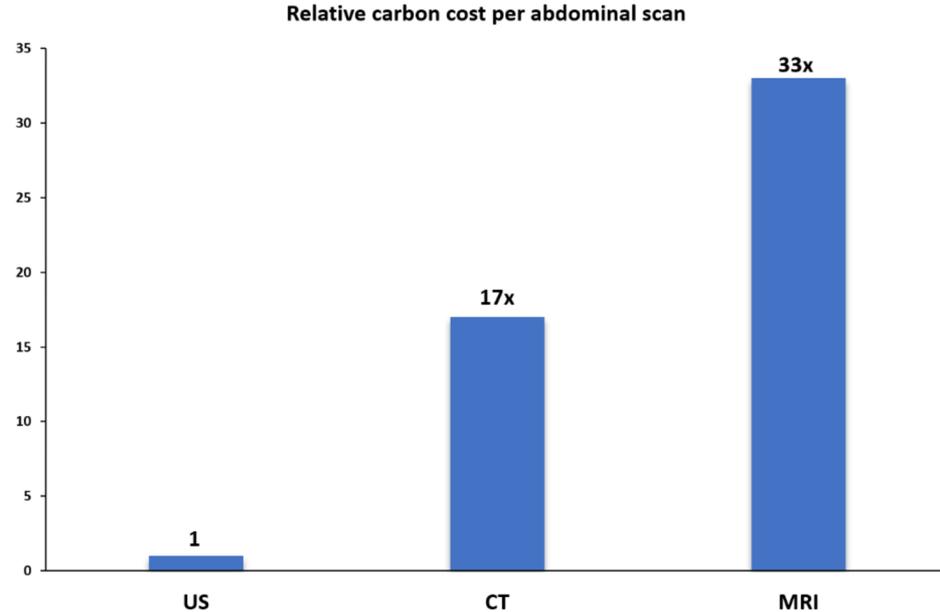
Single-use supplies

Contrast

Emissions from Medical Imaging

Varies by modality

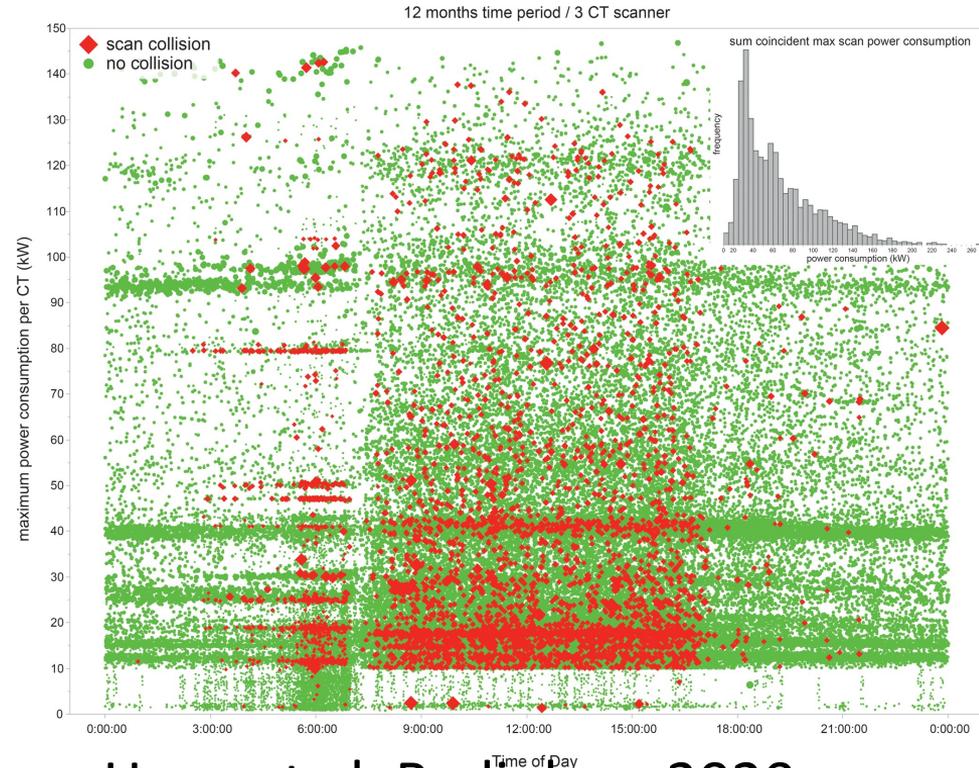
MRI > CT > US



From the original data of
McAlister, S. et al., Lancet Reg Health West Pac, 2022

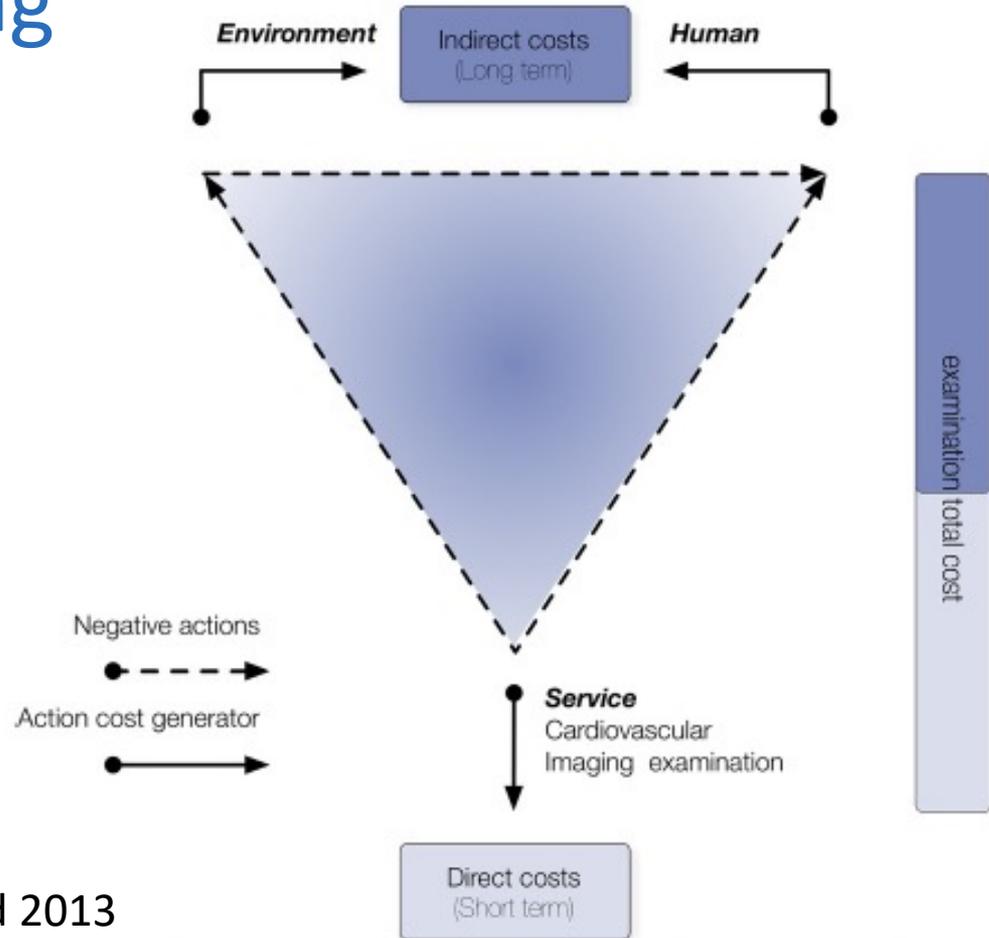
Emissions from Medical Imaging

- Substantial wasted energy and cost in non-productive time



True cost of imaging

- Direct cost (\$)
- Health (radiation)
- Waste
- Environmental



MRI Emissions

Annual energy for one MRI scanner 83-171
MWHr →

Energy produced by



7.4



passenger
vehicles

or

10,286



litres of gasoline
consumed

or

8.7



homes' electricity
use for one year

Gadolinium Contamination

GBCAs injected during MRI

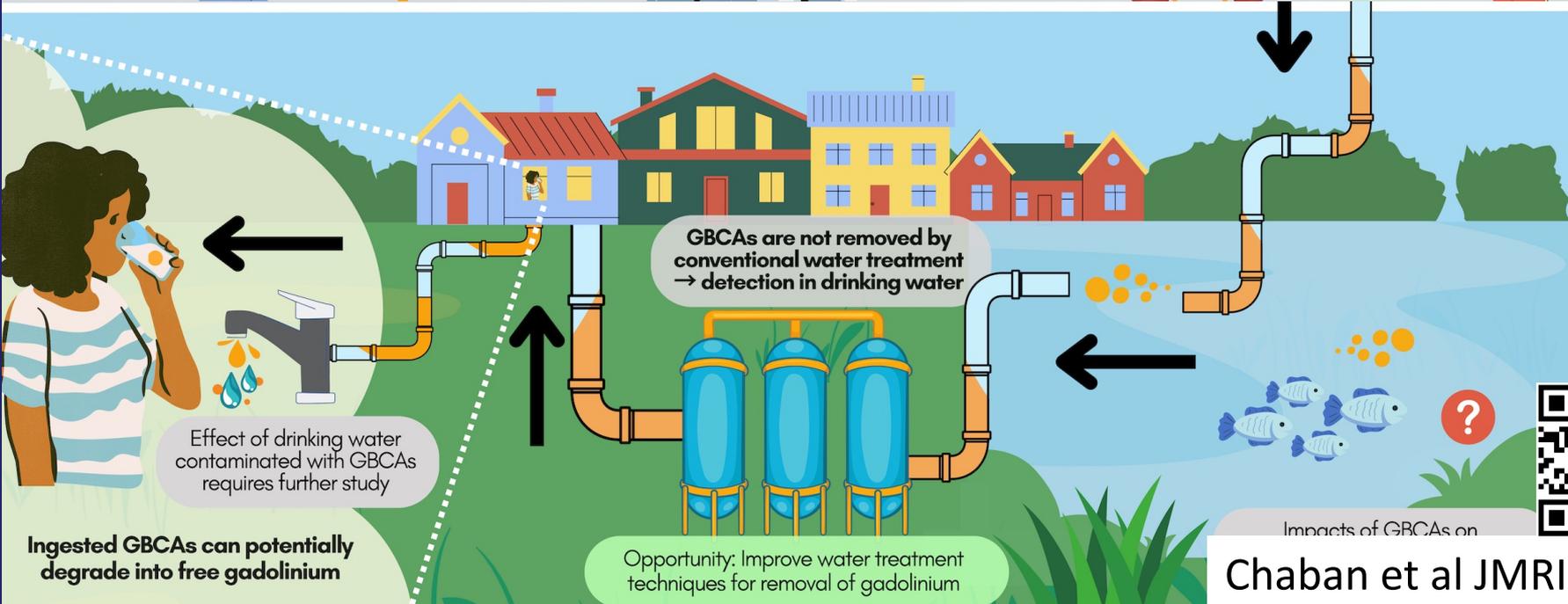


Opportunity: Reduce GBCA dose

GBCAs excreted unmetabolized in urine



Opportunity: 24-hour urine collection after GBCA administration



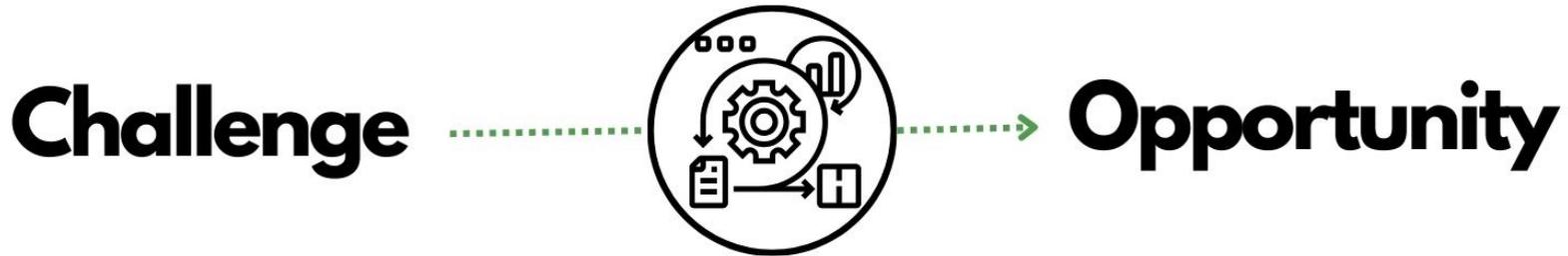
TAKE HOME POINT 2

Medical imaging has a large impact on global GHG emissions and environmental sustainability

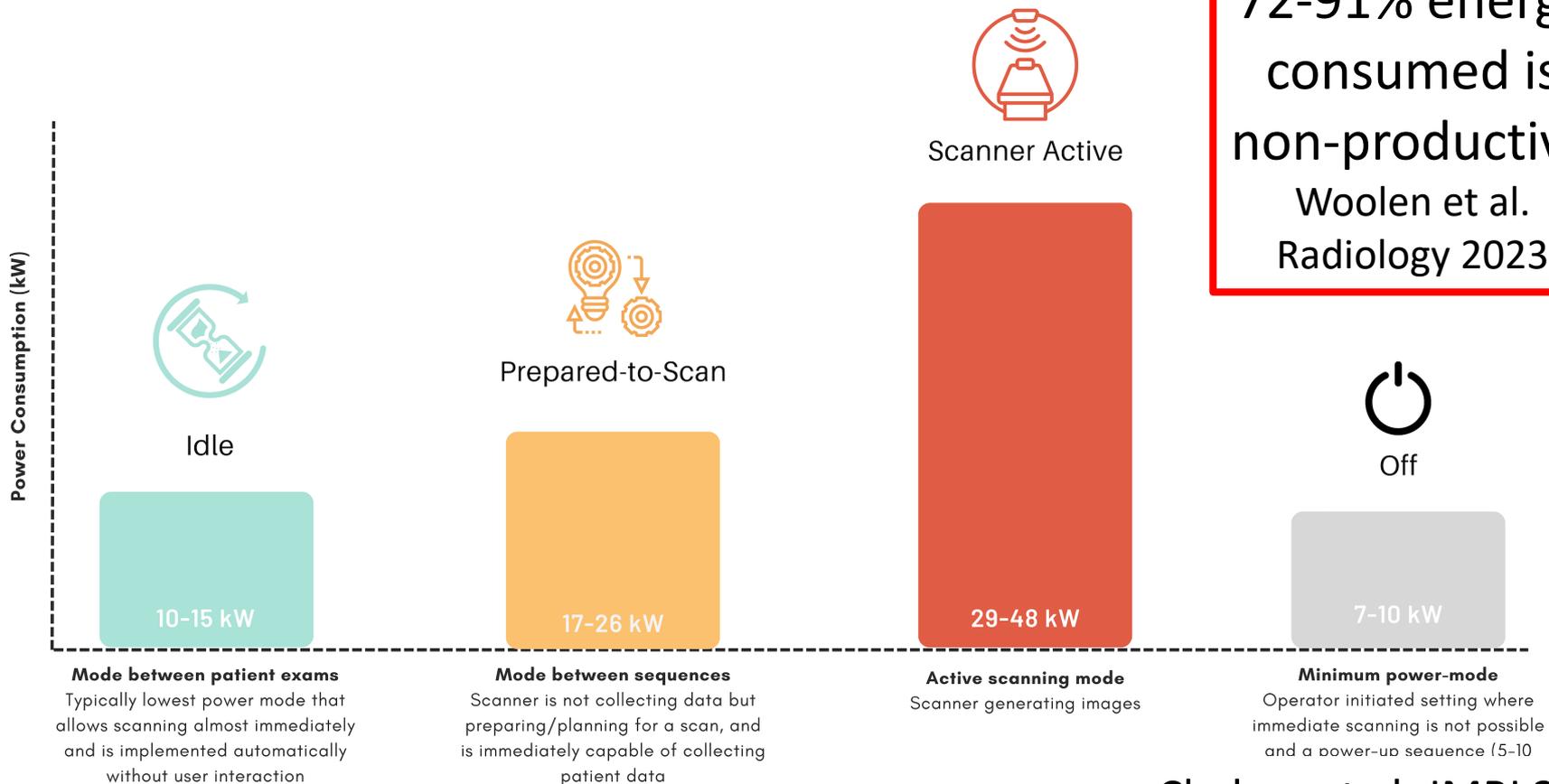
L'imagerie médicale a un impact important sur les émissions mondiales de gaz à effet de serre

Actions to Improve Sustainability

Medical imaging is energy intensive → many actions can be taken to improve environmental sustainability

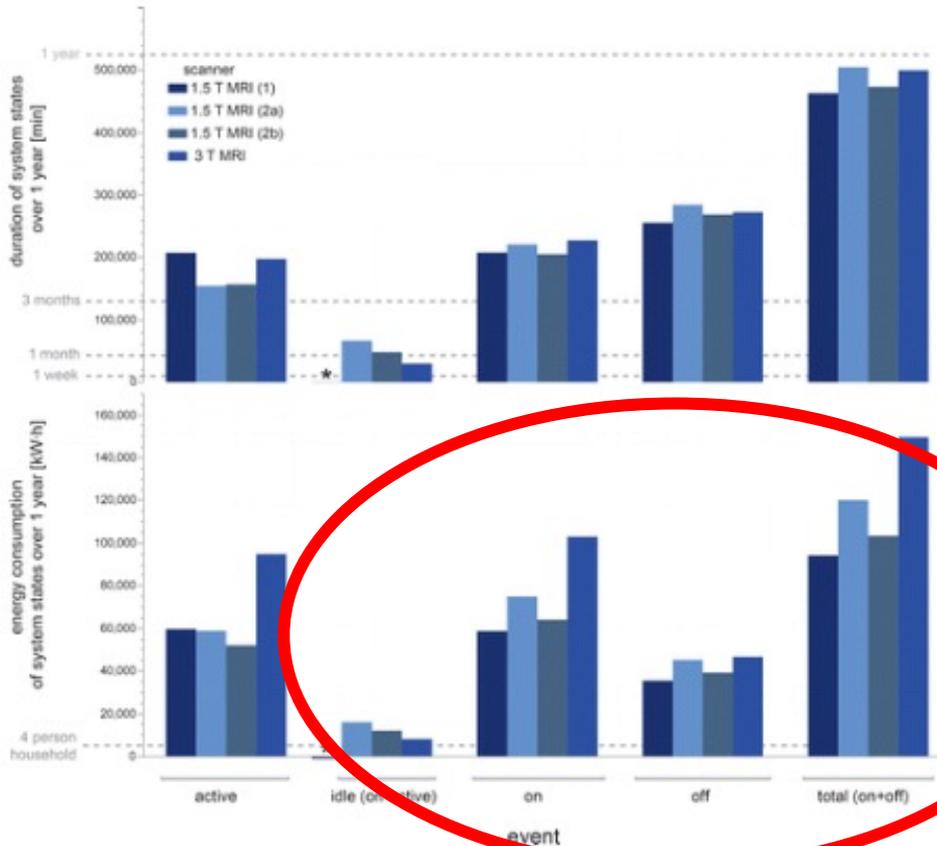


Energy Saving Opportunities



72-91% energy consumed is non-productive
Woolen et al. Radiology 2023

Reduce Non-Productive Energy



Turn scanners off
or use low-power
modes



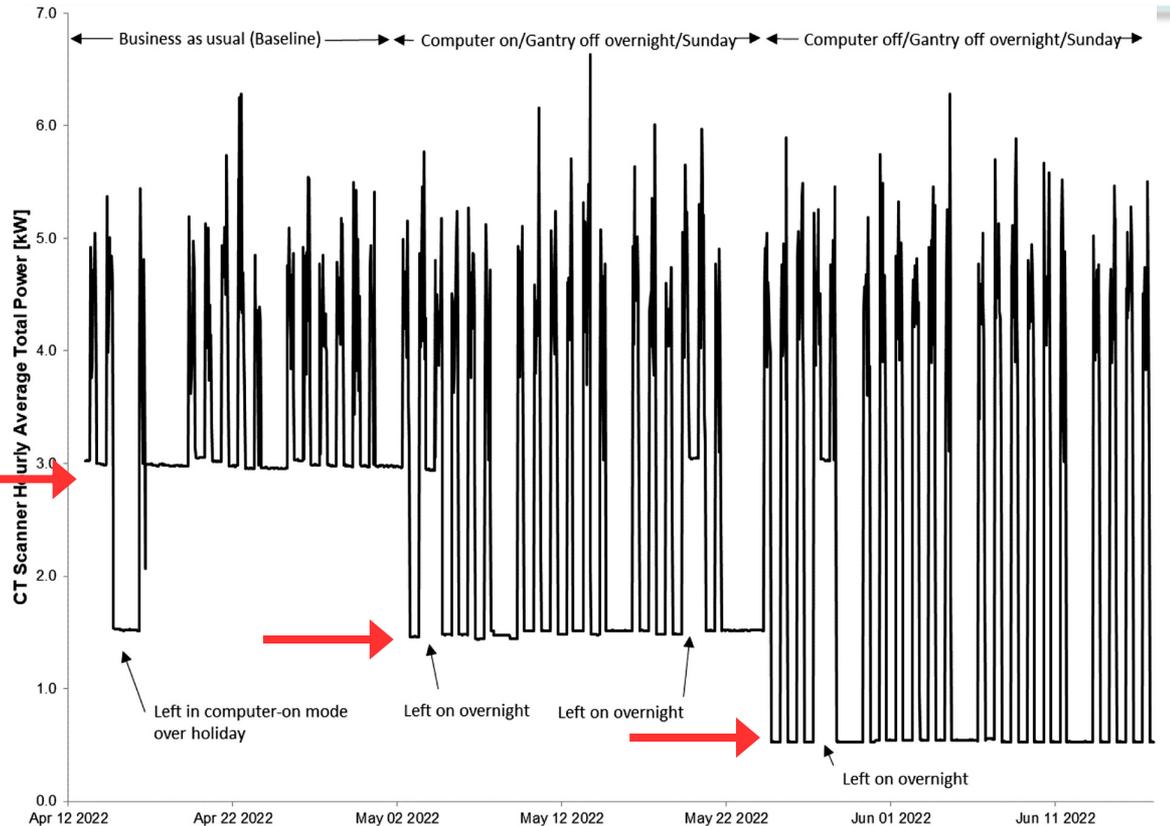
Reduce energy
waste in non-
productive states

	Total time spent - hrs	Total scans	Average scans per week	Average time (min) per scan (95% CI)	Total power kWh	Average power Wh/min	ALCA power Wh/min	CLCA power Wh/min
CT Active	28.2	399	200	8.4±0.2	278	164	939	64
CT Active standby	145.6				927.5	106		
CT Passive standby	162				280.7	29		
MRI Active	110.5	245	122	26.7±2.5	1749.3	265	605	91
MRI Active standby	63.4				660.1	174		
MRI passive standby	163.1				1473.6	151		
US Active	48.4	146	69	19.9±2.1	25.5	9	23	0.85
US Active standby	69.2				33.4	8		
US passive standby	237.6				5.2	0.4		
	Total time spent - hrs	Total scans		Average time (min) per CXR (95% CI)	Total power - kWh	Average power Wh/CXR	ALCA power Wh/CXR	CLCA power Wh/CXR
CXR Active	1.2	47	24	1.5±0.3	0.7	10	171	5
Total X-ray Standby	321.3				114	6		

Table 1: Electrical power consumed,

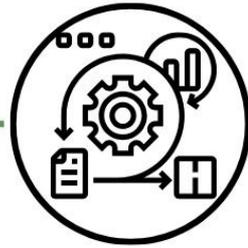
McAlister et al. Lancet Regional Health – Western Pacific 202

Reduce Non-Productive Energy



Overnight and Sunday CT system shutdown saved approximately 14 000 kWh over one year

Challenge



Opportunity

01

Substantial wasted energy for CT and MRI scanners during non-productive times

Turn scanners off

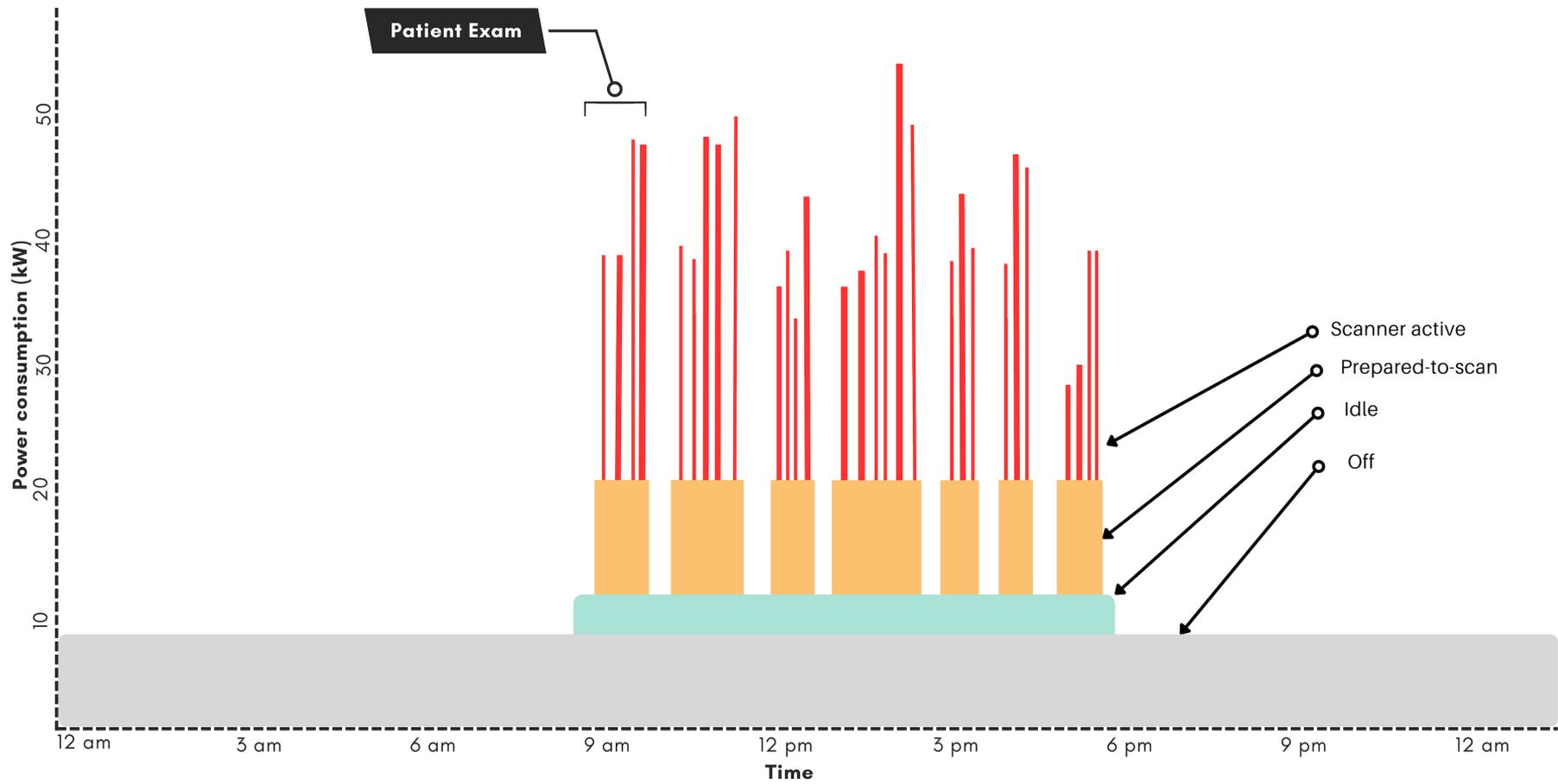


Turn scanners off or switch to low-power mode overnight and when not in use

30-80% energy savings by powering down scanners overnight

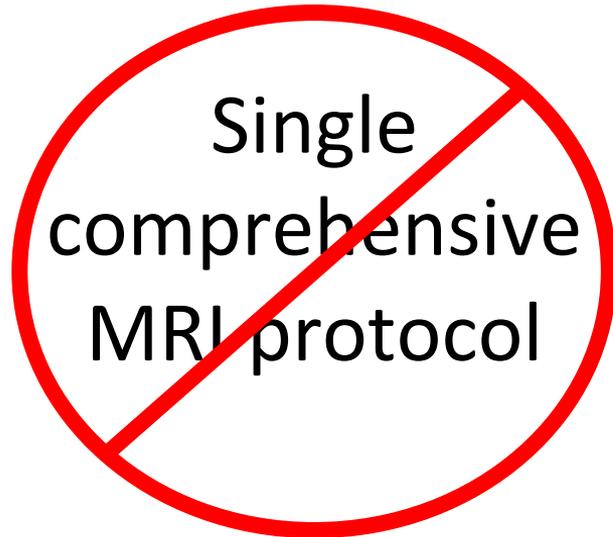
Lower cost

Use Phase Emissions



Abbreviated MRI protocols

- Shorter scan time → Lower energy, emissions, and cost
- Remove unnecessary sequences



Tailored (shorter)
protocols to
answer a specific
clinical question

Abbreviated MRI protocols

- Shorter scan time → Lower energy, emissions, and cost
- Remove unnecessary sequences
- Accelerated sequences → AI guided de-noising

02

Use-phase MRI energy consumption is proportional to the total scan length

Shorten protocols



Abbreviate cardiac MRI protocols and remove unnecessary sequences

Energy During Scanning

Table 2. Mean energy consumption per body region, pulse sequence, and field strength.

Body Region	Sequence	Energy Consumption (kWh)		
		0.55T	1.5T	3T
Ankle	PD fs coronal	1.2±0.1	2.2±0.1	3.1±0.1
	PD fs sagittal	1.3±0.1	1.6±0.1	2.8±0.1
	T1 coronal	0.9±0.1	1.5±0.1	2.9±0.2
	T2 axial	1.3±0.1	1.4±0.1	3.6±0.2



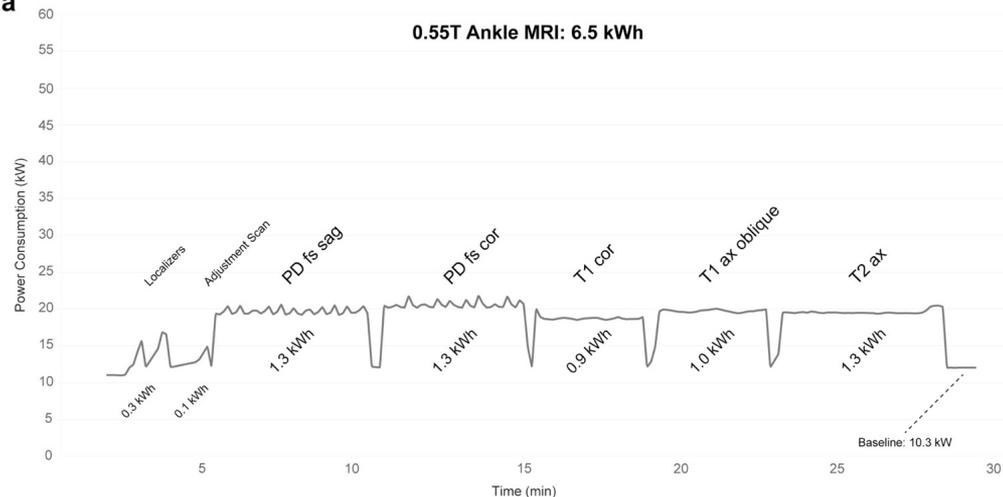
Energy During Scanning

- Varies between scanners, pulse sequences, and field strength
- Energy consumption is directly proportional to the total scan length
- Abbreviated protocols can reduce scan length, reducing overall energy use and GHG emissions

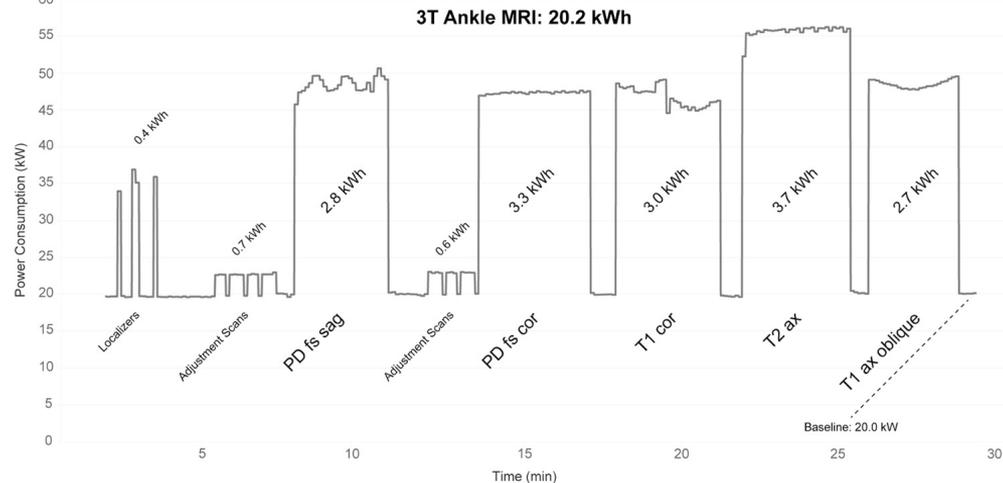
Low-Field MRI

- Lower cost
- Lower energy

a



c



Low-Field MRI



Low-value imaging

- Contributes unnecessary GHG emissions
- Cost and incidental findings
- Does not improve patient outcomes
- Appropriate use criteria and decision support tools

03

Unnecessary imaging contributes GHG emissions but does not improve outcomes

Low-value imaging



Reduce low-value imaging with appropriate use criteria and clinical decision support tools

Energy from Workstations and Electronics

04

Workstations and other electronics consume energy when not in use if left on

Turn equipment off



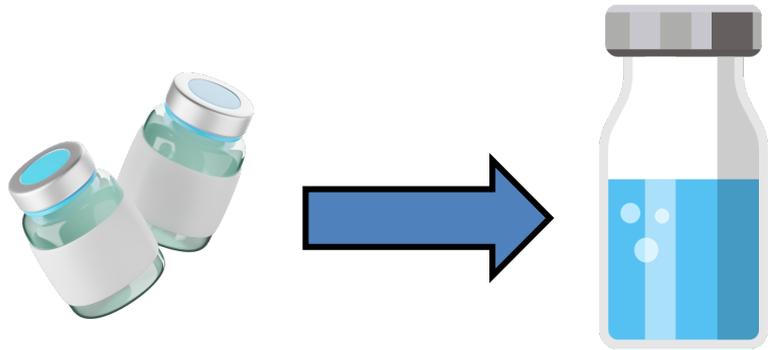
Turn off equipment and workstations off overnight and when not in use

- Per year energy savings → 72,337 kWh = \$19,531 energy cost = 9.3 tons CO2 emissions



Environmental Impact of Contrast

- Iodine and gadolinium are finite resources
- Potential for environmental contamination
- Packaging contributes to medical waste



Switch from single-dose to multi-dose contrast delivery

73% ↓ in contrast material waste and
93% ↓ in plastic waste

Environmental Impact of Contrast

- Switch from single-dose to multi-dose contrast
- Iodine recycling
- Reduce contrast use or dose when feasible

05

CT and MRI contrast
contaminates water bodies
and contributes waste

Reduce contrast waste



Switch to multi-dose delivery
and reduce contrast volume
when feasible

Environmental Sustainability and MRI

Climate change is the greatest global threat to human health

Challenge



Need for Action



MRI is energy intensive with high greenhouse gas emissions

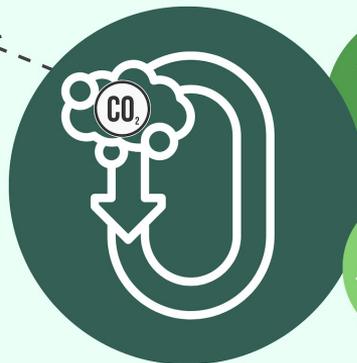


Opportunities

There are many actions that can be taken now to improve the environmental sustainability of MRI and prepare for the effects of climate change

Strategies to reduce GHG emissions

- Power management strategies 
- Scanner, sequence and protocol length
- AI applications 
- Low-field MRI
- Appropriate use and decision support tools 
- Power and energy-savings for other equipment
- Production and refurbishment of MRI equipment
- Reducing waste 
- Travel related emissions



Other strategies to address sustainability in MRI

- Gadolinium waste and contamination 
- Sustainable management of helium 

Adaptation strategies

- Adaptation plans to prepare for the effects of climate change



TAKE HOME POINT 3

It's not too late – but we need to act now
Individual and collective action is needed

Il n'est pas trop tard, mais nous devons agir
maintenant

Une action individuelle et collective est nécessaire

01

Substantial wasted energy for CT and MRI scanners during non-productive times

Turn scanners off



Turn scanners off or switch to low-power mode overnight and when not in use

Éteignez les scanners CT et MRI lorsqu'ils ne sont pas utilisés

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02

Use-phase MRI energy consumption is proportional to the total scan length



Shorten protocols

Abbreviate MRI protocols and remove unnecessary sequences

Abréger les protocoles MRI et supprimer les séquences inutiles

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Low-value imaging

Reduce low-value imaging with appropriate use criteria and clinical decision support tools

Réduire l'imagerie médicale de faible Valeur

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05

CT and MRI contrast contaminates water bodies and contributes waste

Reduce contrast waste

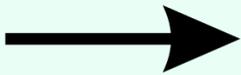


Switch to multi-dose delivery and reduce contrast volume when feasible

Réduisez le volume de contraste et passez à l'administration multidose

Actions and Impact

	Action		Impact
Personal and Home	① Increase plant-forward meals and reduce waste		20-30% reduction of GHG emissions by halving meat consumption
	② Use alternative modes of transportation		67% decrease in GHG emissions from transport by shifting one car trip to one bike trip per day
	③ Shift toward building electrification		38-53% reduction in CO2 emissions for a residential heat pump over a gas furnace
Industry and Vendors	⑧ Implement sustainable procurement policies		50-80% potential energy savings
	⑨ Improve energy consumption in idle and system-off states		30-67% energy consumption for CT and MRI in non-productive modes
	⑩ Decrease packaging of medical supplies		Less waste and lower energy and cost from transportation



Mitigation

VS

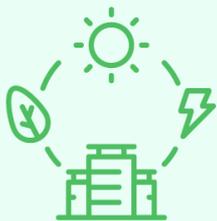
Adaptation

Reducing the impacts of radiology on climate change

Building resiliency to the risks of climate change



24 hr operating system to reduce carbon emissions



Transition to renewable energy



Limiting patient travel



Sustainable waste management programs



Infrastructure upgrades to support systems during extreme weather events



Develop disaster management protocols



Building protection (floods, heat, cold, natural disasters)



Integrate green energy systems for power loss

Hayley McKee

Adaption in Radiology

- Prepare for current and future effects of climate change
- Design scanner rooms to be watertight and stabilized
- Develop and maintain a disaster management plan
- Stay updated on changing disease patterns

TAKE HOME POINT 4

Collaboration between imagers, technologists, scientists and vendor partners is needed to reduce the environmental impact of imaging

La collaboration entre les radiologues, les technologues, les scientifiques et les fournisseurs partenaires est nécessaire pour réduire l'impact environnemental de l'imagerie

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