CARBOMICA WEBINAR

A Carbon Mitigation Tool in Healthcare Facilities

Funded by the European Union

UKRI Innovate UK

HIGH HORIZONS

18 September 2023

Jetina Tsvaki
Data Scientist

Craig Parker
Data Scientist

Farah Houdroge
Mathematical Modeller

aiding distribution of climate mitigation resources in healthcare

SPECIFIC OBJECTIVES

1. **Identify and select suitable indicators** for quantifying and monitoring the global, EU and national-level health impacts of extreme heat among pregnant and postpartum women, newborns and infants in Europe and sub-Saharan Africa;

2. **Develop and test an Early Warning System** using a smartphone app to provide individualized heat stress warnings, and locally adapted messaging for protecting pregnant and postpartum women, infants and health workers;

3. **Identify cost-effective, integrated adaptation-mitigation interventions** to alleviate heat impacts on health workers, and to reduce carbon emissions associated with health care;

4. **Support global and EU climate policies and activities** on the monitoring of direct and indirect impacts of climate change on health, and the strengthening of Early Warning Systems through guidance documents, and risk assessment and cost-benefit analysis tools.

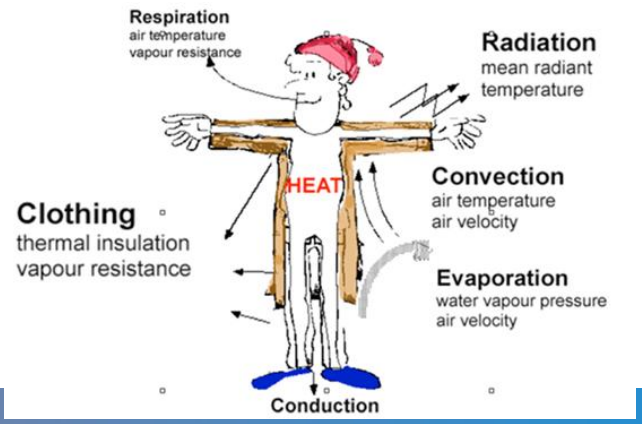
ADAPTATION & MITIGATION

Objective 3a and 3b:

Identify cost-effective, integrated adaptation-mitigation interventions to alleviate heat impacts on health workers, and to reduce carbon emissions associated with health care

Approach:

- Implementation and evaluation of integrated adaptation-mitigation actions in health facilities in Kenya, South Africa and Zimbabwe
- Pre- and post-intervention comparison



MITIGATION

AKDN

Aga Khan Development Network

HIGH HORIZONS

- AKDN's Carbon Measurement Tool in Kenya, South Africa and Zimbabwe
- Pre- and post-intervention comparison of health facility emissions

Calculate

carbon footprint of your organization or operations

Identify

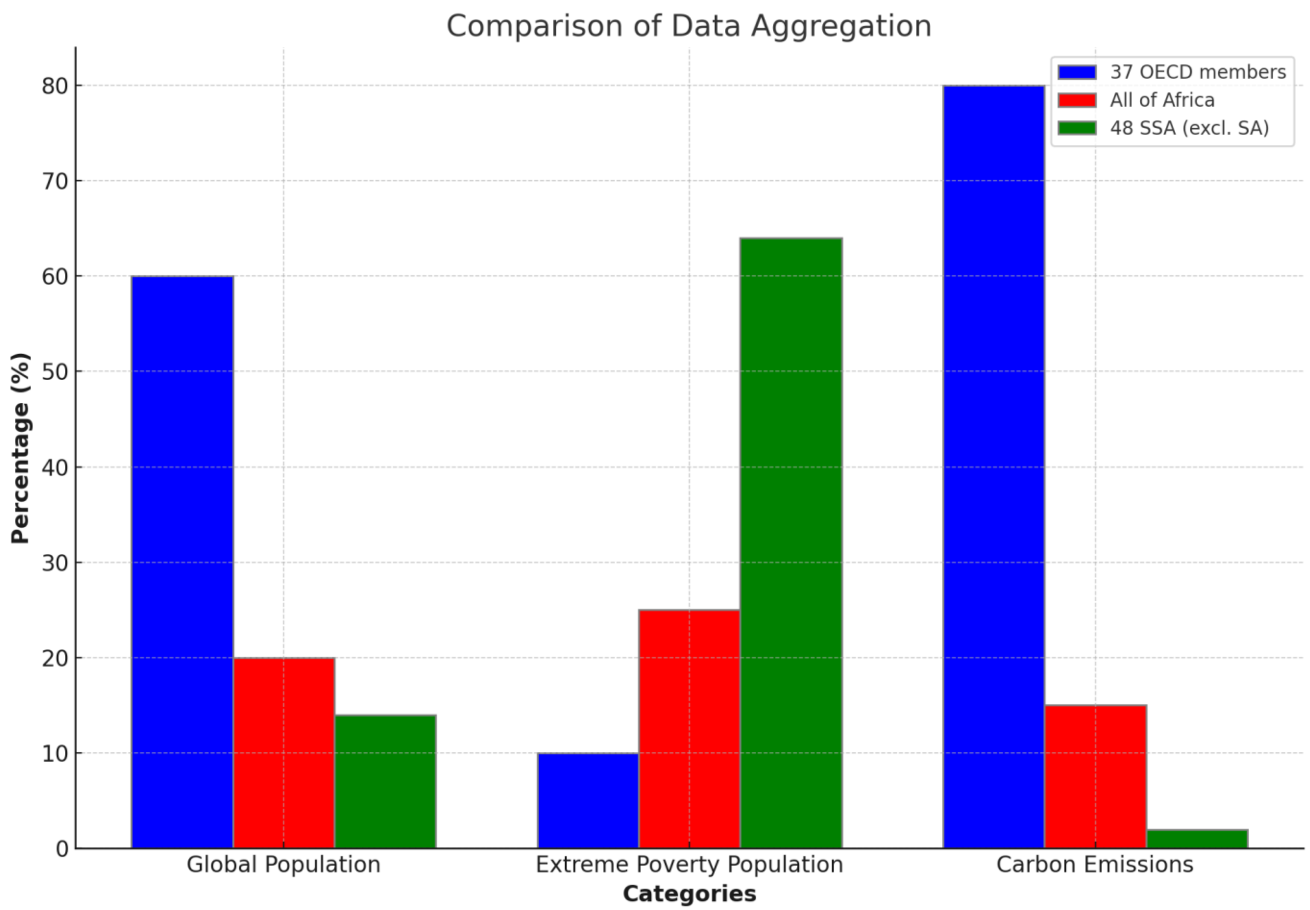
carbon emissions hotspots areas that represent most of carbon emissions

Develop

interventions and track progress with decarbonizing operations

Climate Vital Signs

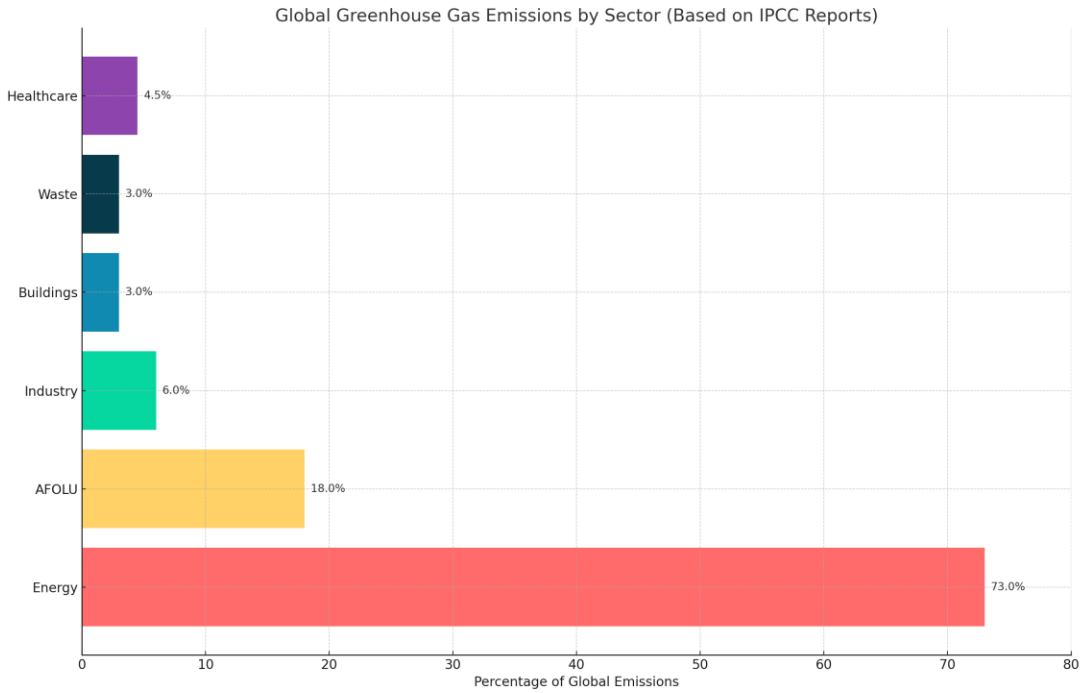
Disparities in Global Data: Population, Poverty, and Carbon Emissions



Source: Our World in Data

Background

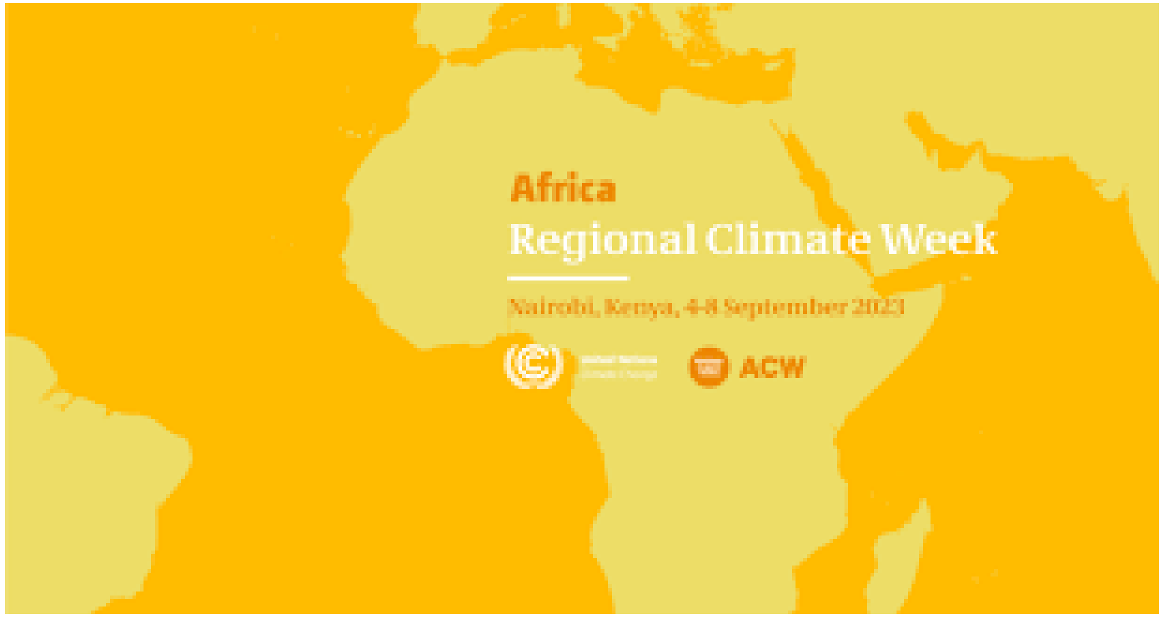
- The escalating climate crisis poses profound threats to global public health, marked by exacerbated weather extremities and declining air quality, both detrimental to human health (IPCC, 2022; Kurane, 2010).



Source: IPCC Report 2022

Need for CARBOMICA

- Africa Climate Week in Nairobi focused on climate finance, loss, damage, and justice.
- Cleaner energy and transport can boost health, but lack of healthcare funds limits climate change efforts (Watts et al., 2015).



Need for CARBOMICA

Disadvantaged communities face greater environmental health risks and ***lack funds*** for mitigation (Brulle & Pellow, 2006).

Policy interventions and ***increased funding*** are needed to address health and climate change together (Friel et al., 2008).

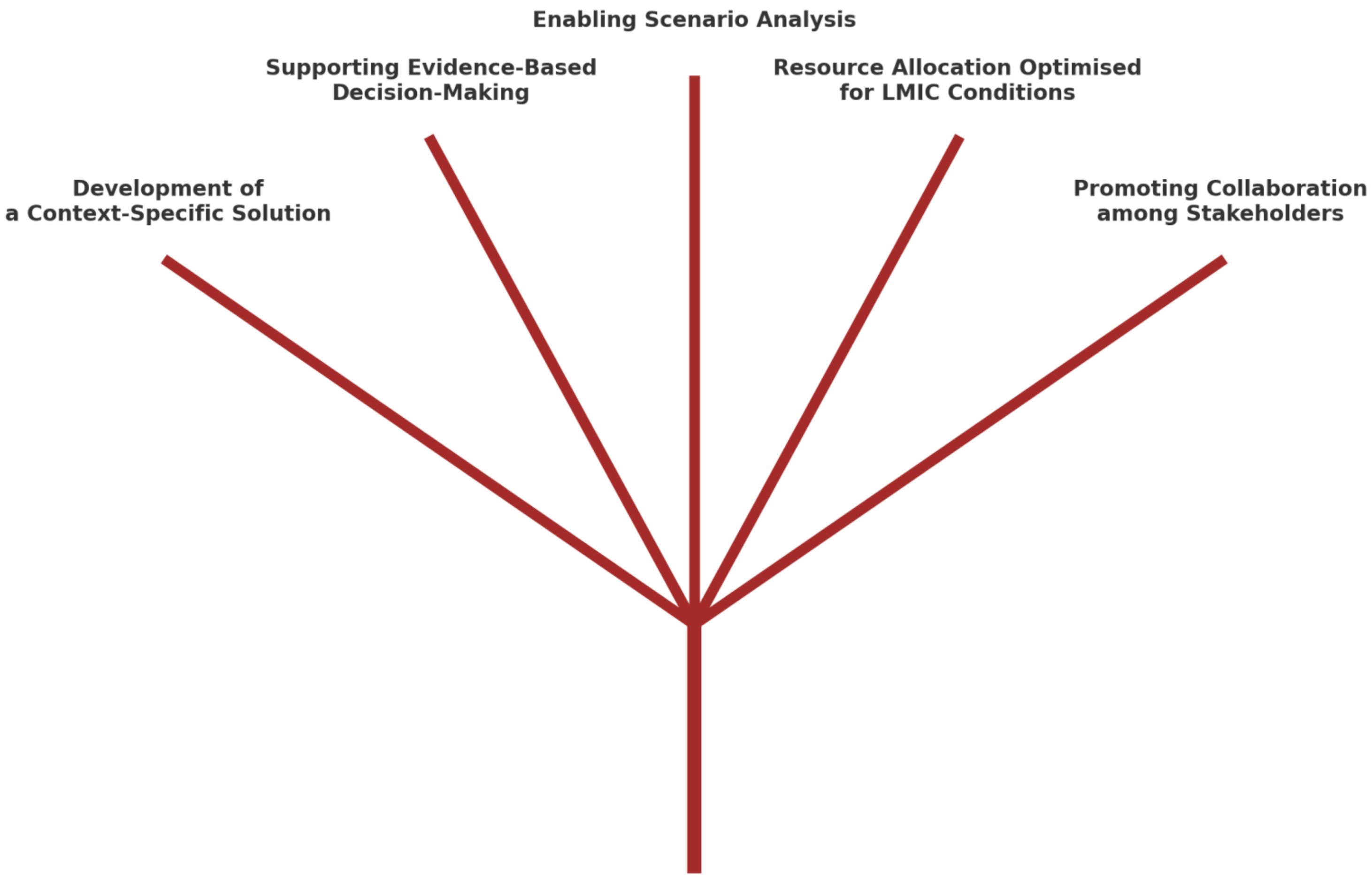
What is CARBOMICA

CARBOMICA is a tool from the HIGH Horizons initiative for carbon mitigation in healthcare.

It guides decision-makers on resource allocation for climate action in healthcare.

Designed as a data science tool, it optimizes resource use to reduce carbon emissions in healthcare facilities, especially in LMICs

Objectives

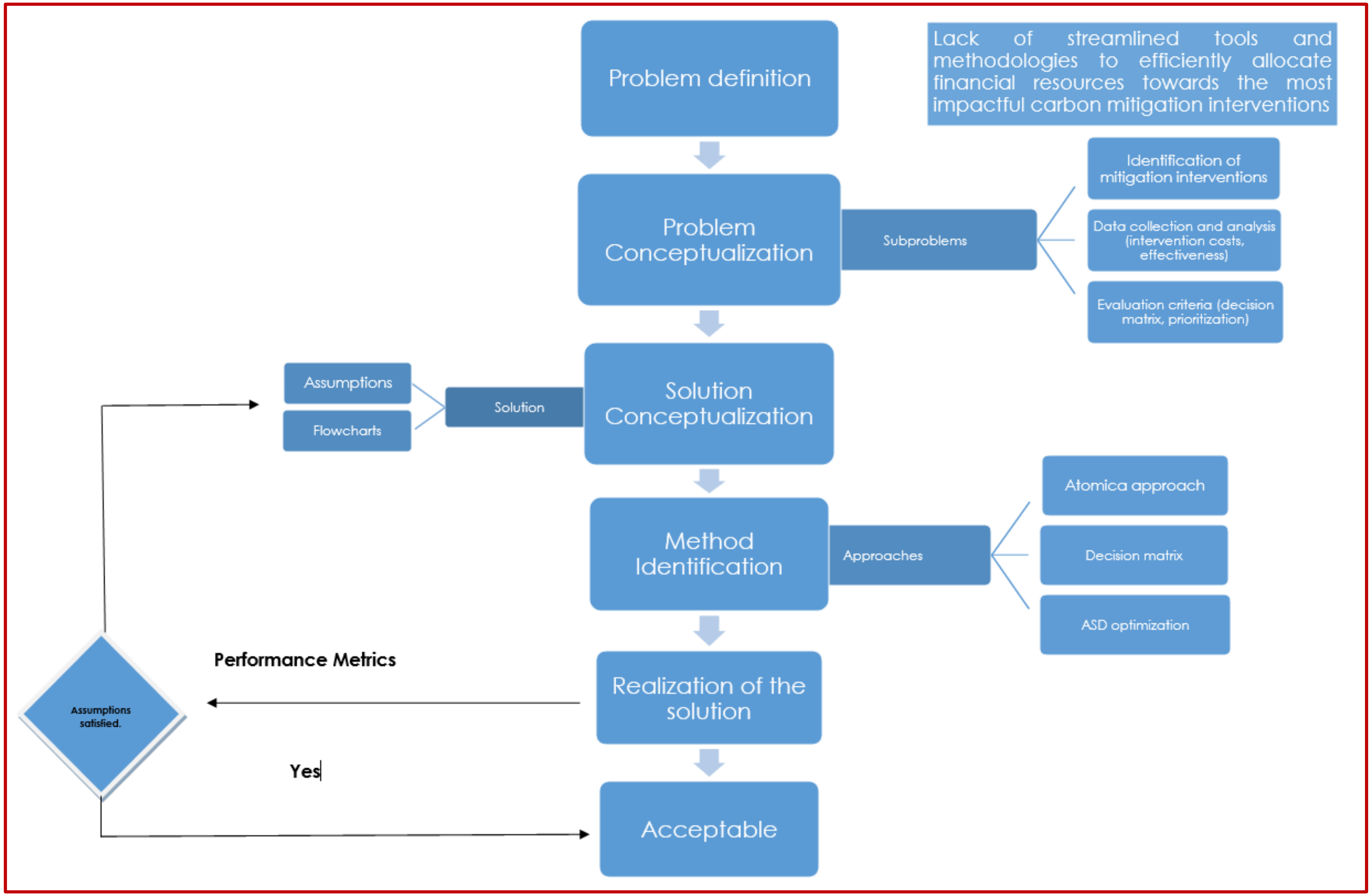


Enabling Scenario Analysis
Supporting Evidence-Based Decision-Making
Resource Allocation Optimised for LMIC Conditions
Development of a Context-Specific Solution
Promoting Collaboration among Stakeholders

Scope of CARBOMICA

1. Healthcare sector focus:	• CARBOMICA is designed specifically for the healthcare industry, considering the unique requirements, operations, and challenges faced by healthcare organizations in mitigating their carbon emissions.
2. Carbon mitigation strategies:	• The tool focuses on evaluating and prioritizing a range of interventions and strategies that aim to reduce carbon emissions within the healthcare sector. This includes areas such as energy efficiency, waste management, transportation optimization, and other operational practices.
3. Data-driven analysis:	• CARBOMICA utilizes data inputs related to healthcare operations, energy consumption, waste management, and transportation, among others, to perform quantitative analysis and modeling of emissions and intervention impacts.
4. Decision support and reporting:	• CARBOMICA provides decision support by offering a decision matrix that quantifies and weighs the impact, feasibility, and scalability of interventions. It generates reports and visualizations to communicate the results of scenario analysis and aid in decision-making.
5. Stakeholder engagement:	• CARBOMICA emphasizes stakeholder engagement, incorporating the input and expertise of healthcare professionals, industry experts, and policymakers throughout its development and implementation process.

Conceptual Framework



Approach

Stakeholder engagement

- Meetings, Calls, Emails

Data science approach

- Data collection and management
- Atomica framework integration
- Decision matrix

Stakeholder Engagement

- Engaging with stakeholders within the HIGH Horizons Consortium, the Burnet Institute and healthcare professionals to understand challenges and requirements specific to carbon mitigation in the healthcare sector.

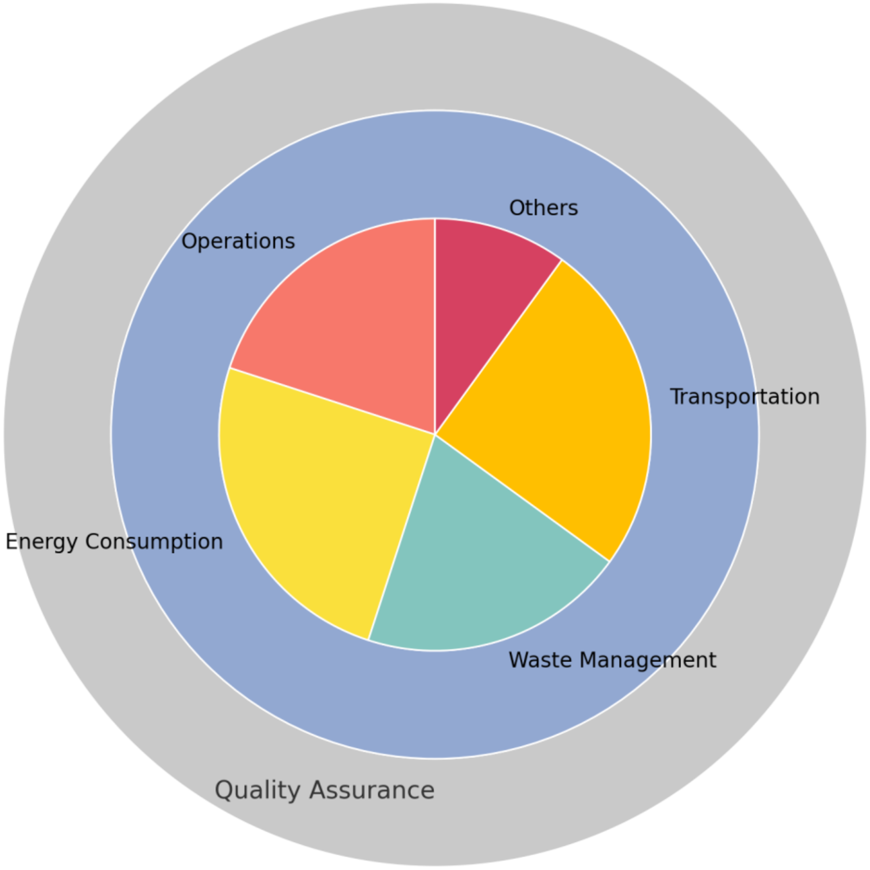
Burnet Institute Medical Research. Practical Action.

WITS RHI

CeSHHAR Zimbabwe

Aga Khan Health Services

Data Collection & Processing



- Comprehensive collection of:
  - Carbon mitigations interventions
  - Carbon emissions
- Quality assurance for:
  - Carbon data accuracy and reliability
- Organization of data covering:
  - Operations
  - Energy consumption
  - Waste management
  - Transportation
  - Other factors

Carbon Emissions Data Collection

Use AKDN tool to gather monthly data on emissions, energy use, waste, transportation, etc.

Intervention List

Source strategies based on best practices, guidelines, and expert opinions targeting energy efficiency, waste reduction, etc.

Intervention Evaluation

Review details from articles for prioritizing interventions using a decision matrix.

Intervention Costs

Obtain cost data from local sources for financial feasibility.

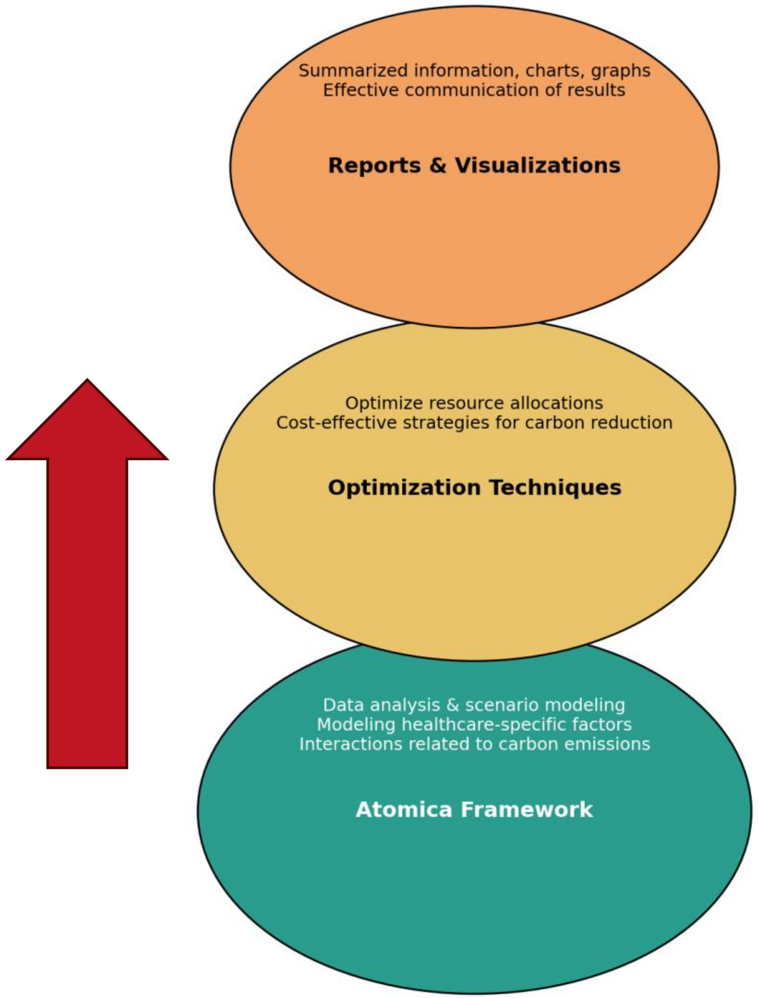
Adapting the Atomica Framework: From HIV/TB to Carbon Emissions Modeling

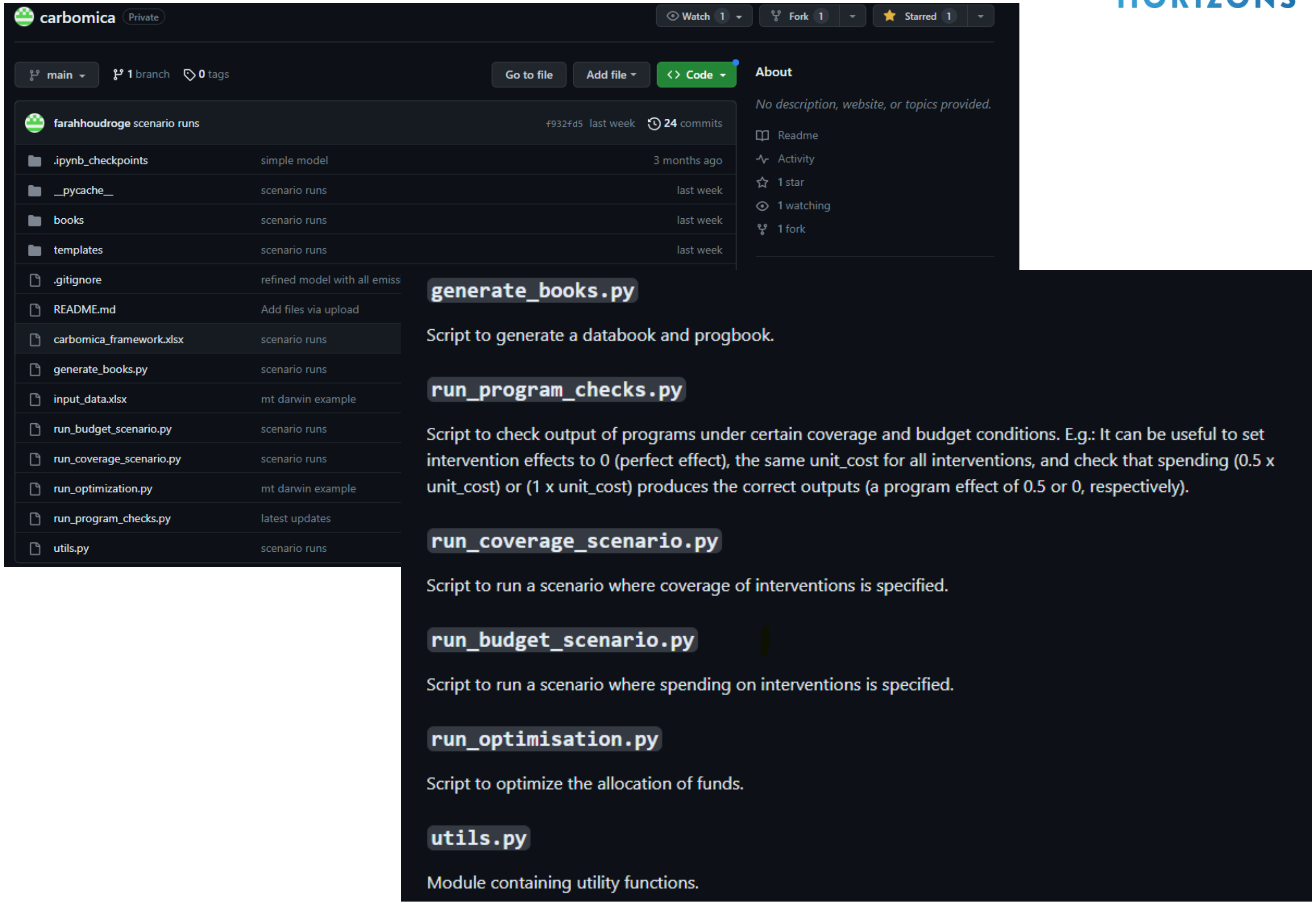
- **Before**: Optimized resources for HIV/TB treatment.
- **Now**: Models carbon emissions in health facilities.
- **How We Adapted**:

1. Used environmental data instead of health data.
2. Created new scenarios for carbon sources like energy and waste.
3. Goal changed to reducing carbon emissions.

- **Result**: A tool that helps make healthcare more eco-friendly.

CARBOMICA Framework





Atomica Framework

Generate an excel input

- Create an input excel file that contains respective information

Generate books

- Using the atomica engine to generate framework, databook and progbook based on the input data

Run the optimization

- Run the optimization script to find best

Run coverage scenario

- Run coverage scenario script to find how different coverage scenarios will impact carbon reduction

Run budget scenarios

- Run coverage scenario script to find how different budget scenarios will impact carbon reduction

Decision Matrix

Intervention	Impact	Feasibility	Scalability	Prioritization Score
Intervention 1	High	Medium	High	
Intervention 2	Medium	High	Low	
Intervention 3	Low	High	High	
Intervention 4	High	High	Medium	
Intervention 5	Medium	Low	Medium	

How does CARBOMICA works

Install Jupyter notebook integrated with Python → Import atomica framework and relevant packages → Populate the input file using the template file requires → Generate framework, databooks and progbooks by running the generate script provided → Run the optimization scripts → Run the scenario scripts

Results: Case Study Mt Darwin Hosp

- **General information**

- Mount Darwin District, located in Mashonaland Central Province, Zimbabwe

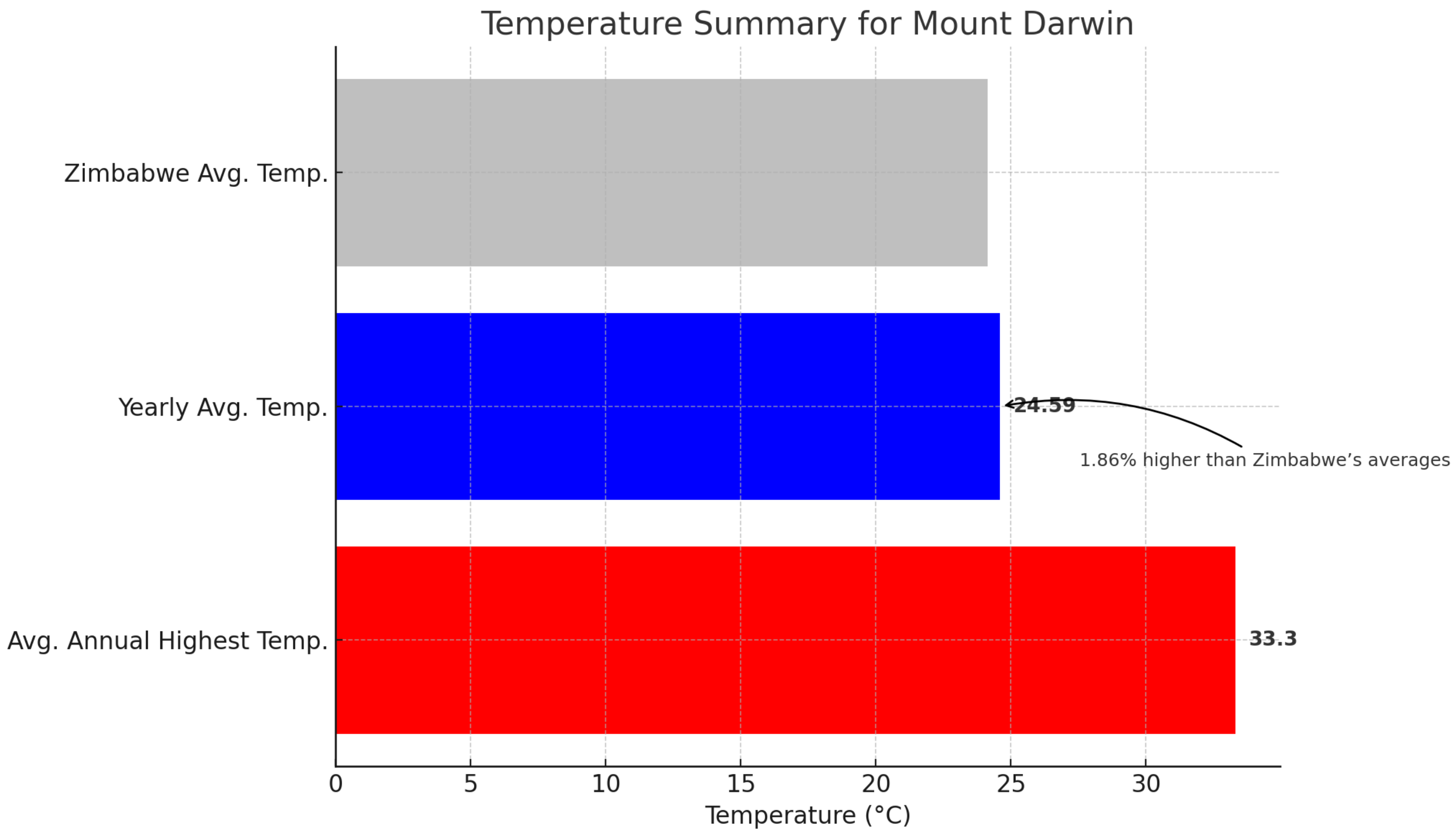
- Rural setting characterized by a humid subtropical climate with dry winters and hot summers.

Results: Case Study Mt Darwin Hosp

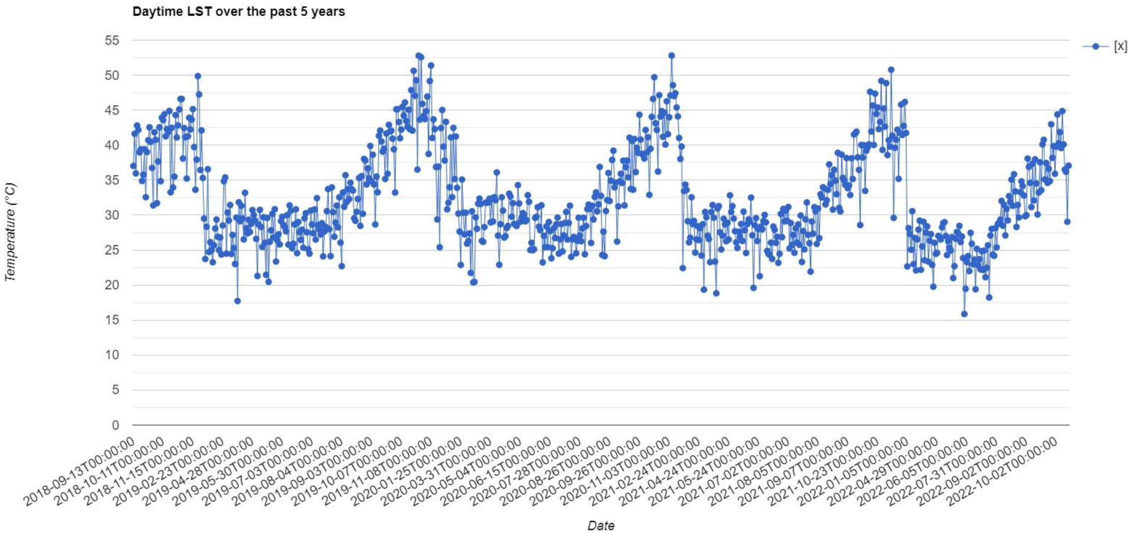
Elevation Data:
"SRTM Digital Elevation Data. (2023). Elevation over Mount Darwin. NASA's Shuttle Radar Topography Mission. Retrieved from Google Earth Engine."

NDVI Data (derived from MODIS):
"MODIS Terra. (2023). Normalized Difference Vegetation Index (NDVI) over Mount Darwin. NASA EOSDIS Land Processes Distributed Active Archive Center (LP DAAC). Retrieved from Google Earth Engine."

Case Study Mt Darwin Hosp

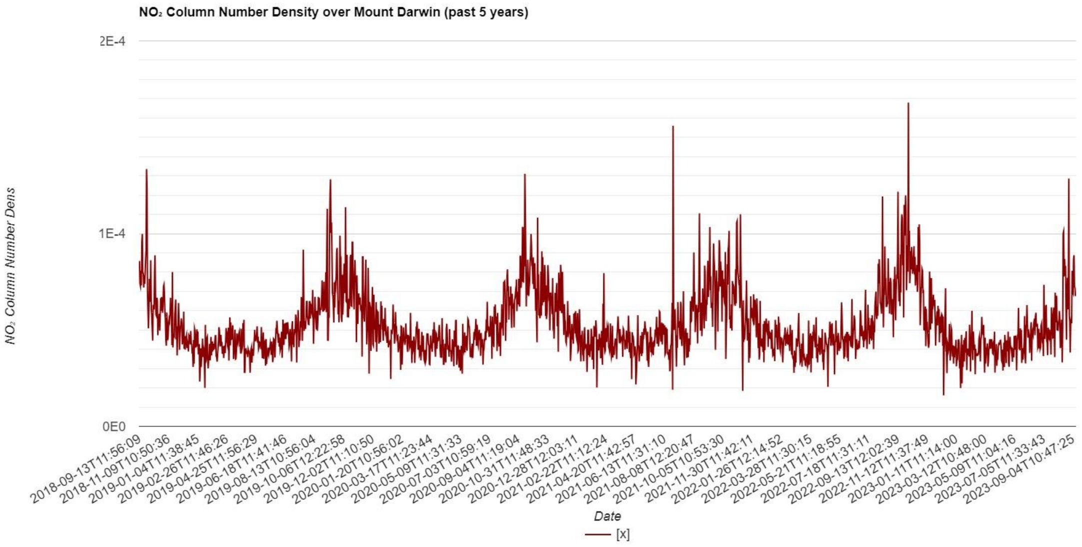


NO2 and Heat in Mount Darwin over last 5 years



NO_2 Data:

"Sentinel-5P TROPOMI. (2023). Nitrogen Dioxide (NO_2) Level over Mount Darwin. European Space Agency. Retrieved from Copernicus Open Access Hub."



Land Surface Temperature (LST):

"MODIS Terra. (2023). Land Surface Temperature over Mount Darwin. NASA EOSDIS Land Processes Distributed Active Archive Center (LP DAAC). Retrieved from USGS Earth Explorer."

Results: Case Study Mt Darwin Hosp

- Established in 1992.
- Expansive medical complex.
- Spans an area of 34,925 square meters.
- Comprises a network of 20 buildings.
- Dedicated to providing comprehensive healthcare services.
- Serves the community.

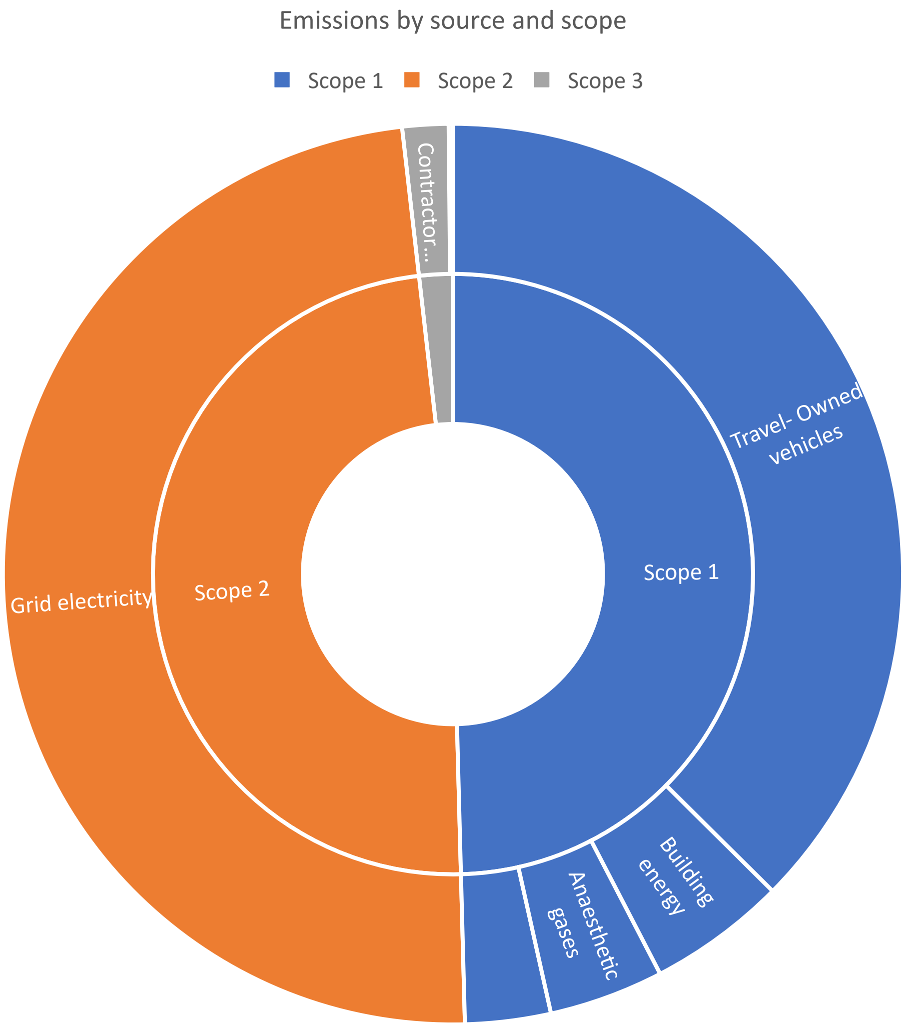
Mt Darwin Hosp Carbon Emissions

Scope	Emission area	January	February	March	April	May	June	Total
Scope 1	SC1 Building energy	0.31	0.28	0.37	0.31	1.20	1.21	3.68
	SC1 Travel	6.13	3.73	1.66	3.01	6.13	7.10	27.75
	SC1 Refrigerants	-	-	-	-	-	-	-
	SC1 On-site incineration	0.36	0.38	0.48	0.30	0.36	0.40	2.28
	SC1 Anaesthetic gases	0.51	0.51	0.51	0.51	0.51	0.51	3.05
Scope 2	SC2 Purchased and consumed grid electricity	11.36	4.42	7.58	-	11.36	1.32	36.05
	SC2 Heat networks	-	-	-	-	-	-	
Total Scope 1 & Scope 2		**18.68**	**9.31**	**10.60**	**4.14**	**19.56**	**10.54**	**72.81**
Scope 3	SC3 Building energy (building not owned)	-	-	-	-	-	-	-
	SC3 Refrigerants (building not owned)	-	-	-	-	-	-	-
	SC3 Travel (vehicles not owned)	0	0	0	0	0	0	-
	SC3 Employee business travel-road, rail, air	0.02	0.02	0.02	0.01	0.02	0.04	0.11
	SC3 Water	-	-	-	-	-	-	-
	SC3 Waste	-	-	-	-	-	-	-
	SC3 Contractor logistics	0.25	0.25	0.25	0.25	0.25	-	1.23
	SC3 Construction materials	-	-	-	-	-	-	-
	SC3 Inhalers	0.39	0.38	0.39	0.46	0.39	0.34	2.34
	SC3 supply chain	0.78	0.02	0.28	0.97	0.38	1.40	3.83
Total Scope 3		**1.43**	**0.66**	**0.93**	**1.69**	**1.03**	**1.78**	**7.51**
Total All Scopes		**20.10**	**9.97**	**11.52**	**5.83**	**20.58**	**12.31**	**80.32**

Table 1: Monthly Carbon Emissions Breakdown by Scope and Emission Area (January to June)

- Monthly CO2-e emissions analysis for Mt Darwin District Hospital.
- Data presented in metric tonnes.
- Emissions categorised under three distinct scopes

Mt Darwin Hosp Carbon Emissions



- Total half yearly breakdown:
- CO_2-e emissions (in metric tonnes) for Mt Darwin District Hospital.
- Emissions categorized under three scopes

Mt Darwin Hosp Carbon Emissions

Scope 1 includes direct emissions from the hospital's operations, such as building energy consumption, travel, on-site incineration, and anaesthetic gases.

For the first half of the year, the most significant contributor under this scope is travel, with a total of **27.75** metric tonnes.

Mt Darwin Hosp Carbon Emissions

Scope 2 captures indirect emissions from purchased electricity and heat networks.

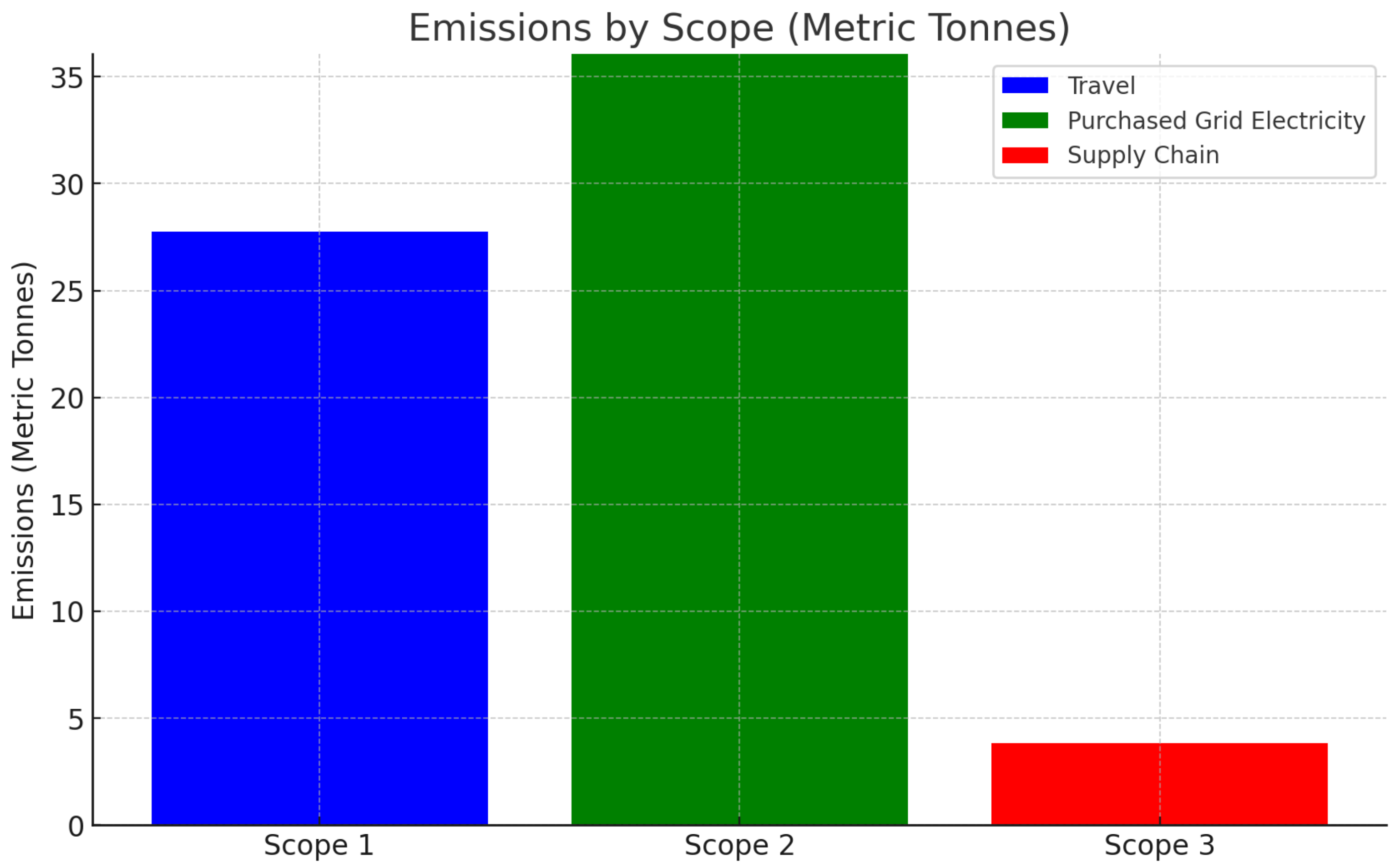
The most dominant emission source here is the purchased and consumed grid electricity, totaling **36.05** metric tonnes over six months.

Mt Darwin Hosp Carbon Emissions

Scope 3 represents other indirect emissions, such as those from buildings not owned by the hospital, travel in vehicles not owned by the hospital, business travel, contractor logistics, inhalers, and supply chain processes.

The supply chain has the highest cumulative emission in this category at **3.83** metric tonnes.

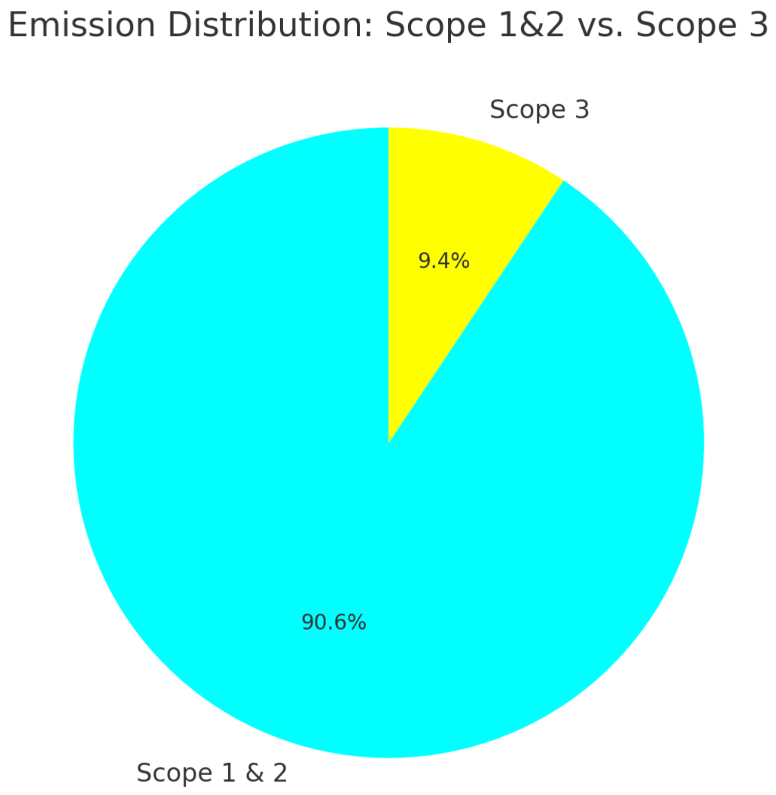
Highest Scope-wise Emission Categories for the First Half of the Year

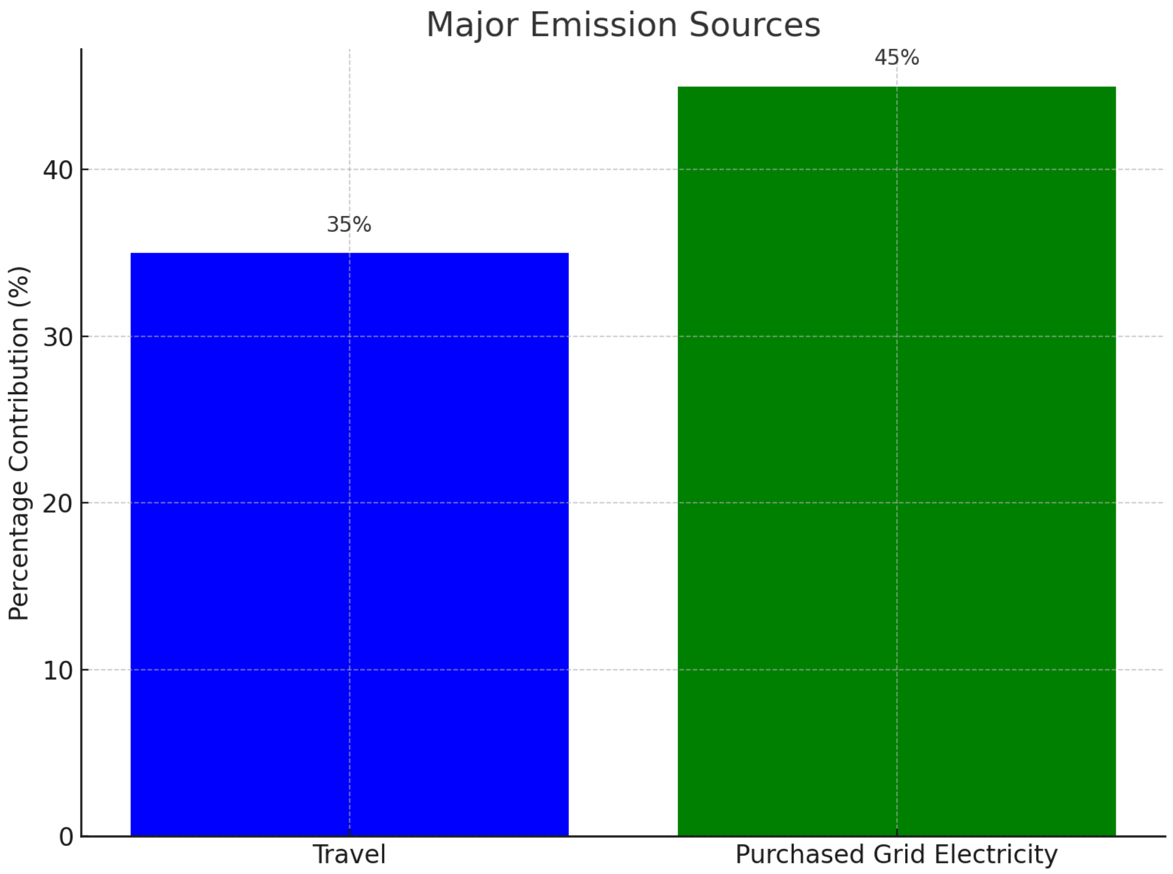


Mt Darwin Hosp Carbon Emissions

- When aggregating the data, the total emissions for Scope 1 & Scope 2 combined come to **72.81** metric tonnes, while Scope 3 totals **7.51** metric tonnes.
- Overall, the hospital’s total CO2-e emissions for the six-month period amount to **80.32** metric tonnes.
- Travel and Purchased and consumed grid electricity make up the majority of emissions (**35% and 45%,** respectively).

Emission Overview: Scope Distribution & Major Contributors



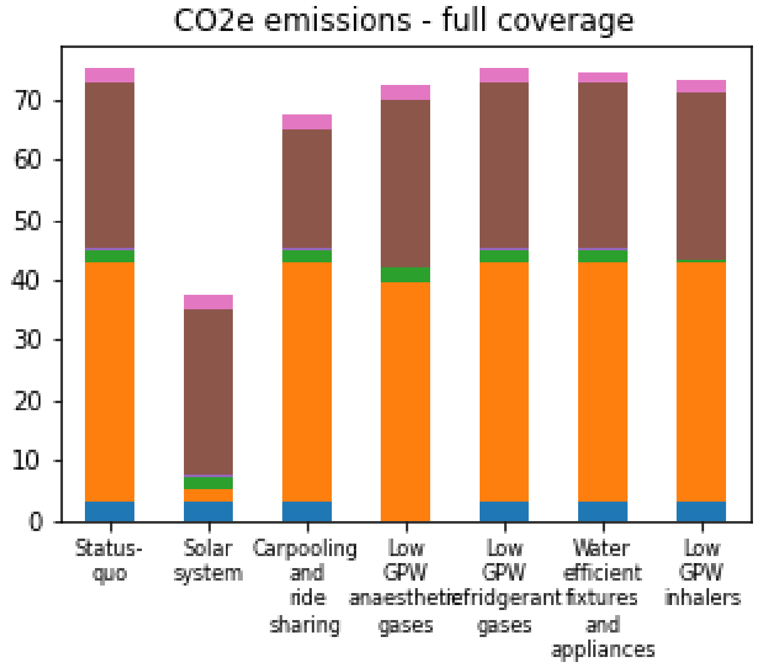


Interventions in the Study

Emission Source		Units	Annual usage	Intervention	Size	Unit Cost	Costs
Energy	*Grid electricity*	kWh	61474	Solar system	50kVa	12500	62500
	Solar system	kWh	18650				
	Generator (diesel) - 5kVa	l	1530				
	Wood	kg	210				
	LP Gas	kg	1138				
Transport & Travel	*Vehicles*	Light trucks	24	Hybrid car	2 cars	9400	18800
	Motorbike	# of people	44				
	Vehicles	Medium car	8				
Refrigerant gases	*R1234yf*	kg	180	There are already low emitting			
	R32 Diflurone	kg	0.192	There are already low emitting			
	HCF 141B	kg	570	There are already low emitting			
Water	*Water*	l	1712842	Water efficiency and fixture appliance	1 program	1100	1100
Waste	*Pharmaceutical waste*	kg	1170	Waste management program			
	Mixed clinical and non clinical	kg	2462	Waste management program			
	Mixed clinical infectious	kg	1674	Waste management program			
	Mixed recyclable	kg	2890	Waste management program			
Inhalers	*Inhalers*	Units	598	Low GPW inhalers	598 inhalers	33	19734
Building & Construction	*Plastic cables*	Units	4000				
	Asbestos	Units	1700				
	Metals	Units	400				
Anaesthetic gases	*anaesthetic gases*	ml	3.5	Low GPW emitting anaesthetic gases	3.5l	102.2714286	357.95

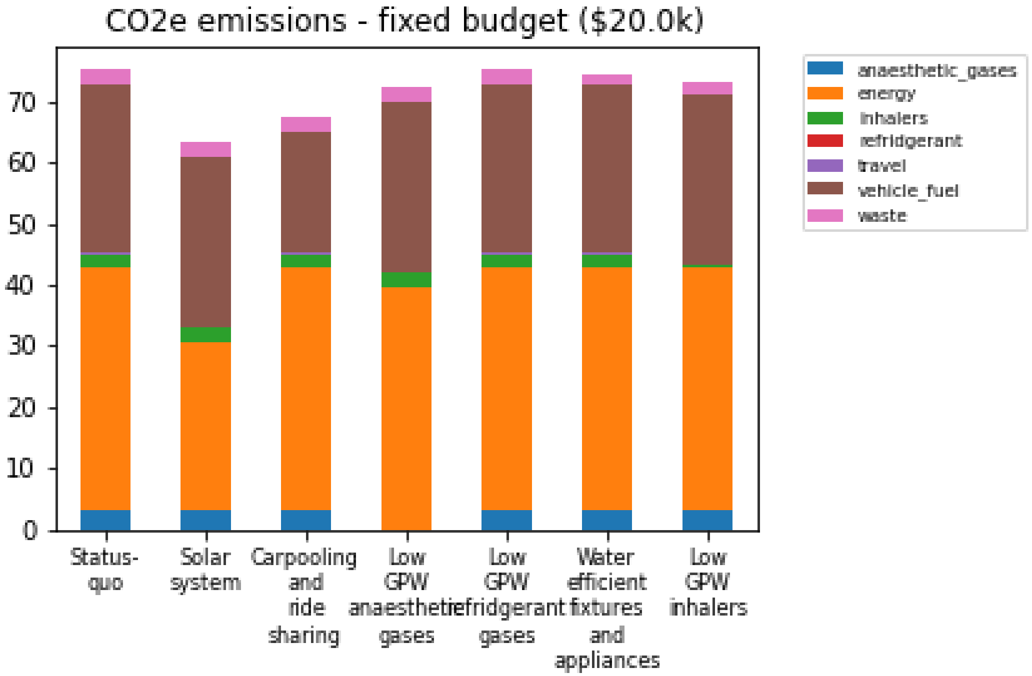
Coverage & Budget Scenarios & Optimization

- **Full Coverage Scenario**: Interventions are implemented across all facilities, each scaled to its maximum potential without considering cost. This showcases the fullest potential impact of each intervention.



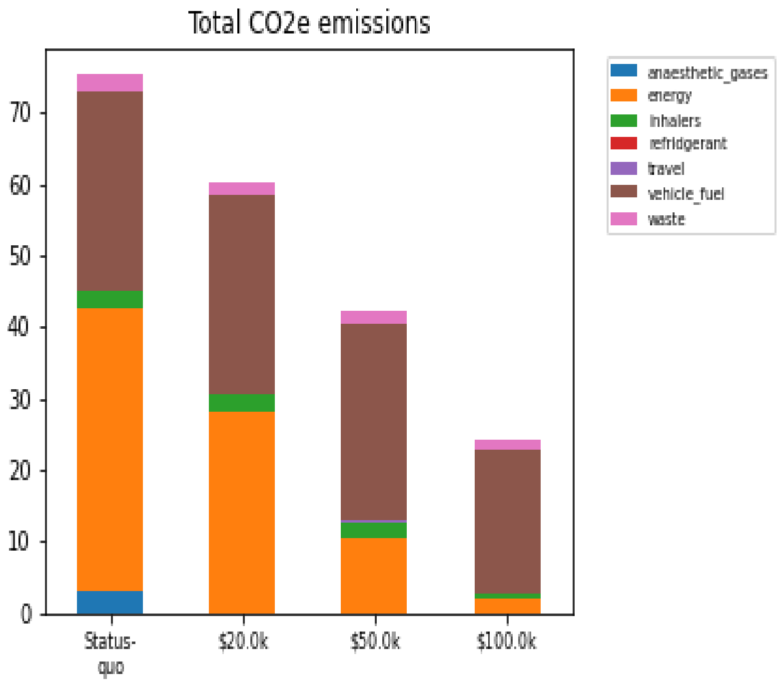
Impact of scaling up each intervention individually to full coverage

Full coverage	Total emissions	% change
Status-quo	75.28	
Solar system	37.54	-50%
Carpooling and ride sharing	67.47	-10%
Low GPW anaesthetic gases	72.26	-4%
Low GPW refridgerant gases	75.28	0%
Water efficient fixtures and appliances	74.48	-1%
Low GPW inhalers	73.31	-3%



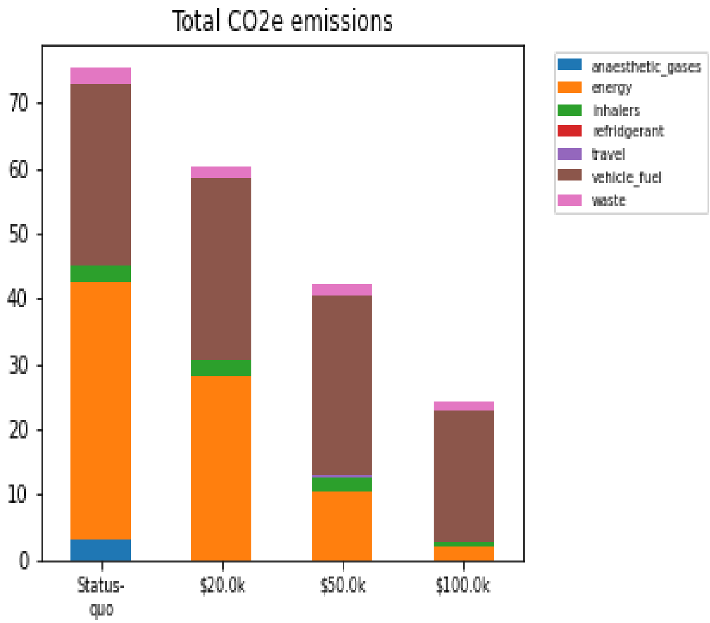
In the fixed budget scenario, interventions are scaled up individually within the constraints of a specified budget ($20,000 here).

Fixed budget	Total emissions	% change
Status-quo	75.28	
Solar system	63.20	-16%
Carpooling and ride sharing	67.47	-10%
Low GPW anaesthetic gases	72.26	-4%
Low GPW refridgerant gases	75.28	0%
Water efficient fixtures and appliances	74.48	-1%
Low GPW inhalers	73.31	-3%



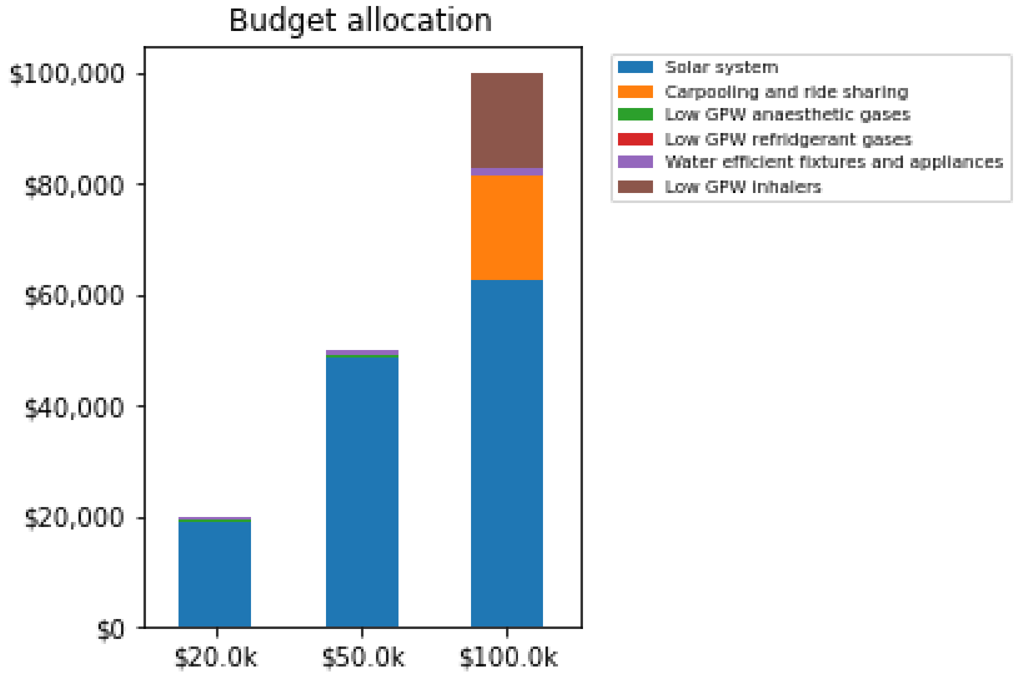
Optimization	Total emissions	% change
Status-quo	75.28	
$20.0k	60.32	-20%
$50.0k	42.15	-44%
$100.0k	24.20	-68%

With a dedicated budget allocation ranging from $20,000 to $100,000, the facility can expect to realise a significant decrease in its carbon emissions.



Optimization	Total emissions	% change
Status-quo	75.28	
$20.0k	60.32	-20%
$50.0k	42.15	-44%
$100.0k	24.20	-68%

Percentage in Carbon Emission Reduction in different budget scenarios



Optimized allocation	$20.0k	$50.0k	$100.0k
Solar system	$19,015.66	$48,547.55	$62,507.55
Carpooling and ride sharing	$ -	$ -	$18,806.65
Low GPW anaesthetic gases	$ 357.94	$ 358.14	$ 362.54
Low GPW refridgerant gases	$ -	$ -	$ -
Water efficient fixtures and appliances	$ 626.40	$ 1,094.31	$ 1,117.82
Low GPW inhalers	$ -	$ -	$17,205.44

Corresponding coverages	$20.0k	$50.0k	$100.0k
Solar system	30%	78%	100%
Carpooling and ride sharing	0%	0%	100%
Low GPW anaesthetic gases	100%	100%	100%
Low GPW refridgerant gases	0%	0%	0%
Water efficient fixtures and appliances	57%	99%	100%
Low GPW inhalers	0%	0%	87%

Reflections

- Optimization identified key priority interventions.
- Solar System:
  - Addresses sustainable energy needs.
  - Ensures consistent power for healthcare.
  - Potential for cost savings and energy independence

Reflections

- Low GPW Anaesthetic Gases:
  - Aligns with global sustainability goals.
  - Maintains quality of care.
  - Represents proactive, responsible medical practices.

Reflections

- Water-Efficient Fixtures and Appliances:
  - Addresses water scarcity challenges.
  - Strategic and sustainable choice.
  - Balances operational needs with responsible water use

Reflections

- Potential for more interventions with increased budget.
  - Carpooling and Ride Sharing:
  - Reduces carbon footprint.
  - Addresses staff commuting challenges.
  - Boosts punctuality, morale, and community feeling

Reflections

- Low GPW Inhalers:
  - Balances medical treatment with eco-friendliness.
  - Reinforces commitment to holistic healthcare.

- Overall:
  - Strategic interventions lead to sustainable, efficient healthcare.

Acknowledgements

- We gratefully acknowledge the European Union's Horizon Research and Innovation programme(Grant Agreement no 101057843) and UKRI Innovate UK for funding the HIGH Horizons project(Reference number: 10038478).

- Their support is instrumental in addressing the health impacts of extreme heat on vulnerable populations.