NSW Health

Appendix: Net Zero Roadmap

Overview

A ridge regression model was developed to estimate the projected carbon footprint for NSW Health. The model was based on carbon footprinting data from two Local Health Districts (Northern Sydney LHD and Central Coast LHD) and one Specialty Health Network (Sydney Children's Hospitals Network), and two further hospitals: one regional base hospital and one large metropolitan tertiary hospital.

This method drew available data from parts of the NSW Health system where carbon footprints had already been developed. More information on this approach is provided in the modelling approach section of this appendix.

As of FY19, the estimated carbon footprint for NSW Health was approximately 2,907 kilotonnes of carbon dioxide equivalent (CO_2e). This is roughly equivalent to the carbon sequestered by 180,000 hectares of blue gum forest, or the emissions from 410,000 around-the-world flights.

Emissions coverage

The organisational boundary for this footprinting exercise follows the Greenhouse Gas (GHG) Protocol's operational control approach. This carbon footprinting exercise includes emissions from LHDs, SHNs and affiliated facilities over which NSW Health exercises operational control (see Table 1), in alignment with the GHG Protocol.

As such, emissions from HealthShare NSW services - including those from centralised laundry, catering, and logistics - are treated as intra-health service procurement and reflected under Scope 3. These emissions are nonetheless material and recognised in this model.

Future iterations of the Roadmap will aim to incorporate more detailed, bottom-up carbon footprint data from pillar agencies such as HealthShare NSW and eHealth NSW as it becomes available. This work is aligned with the Ministry of Health's broader ambition to tackle emissions from all entities under its operational umbrella. The statewide pillars and organisations covered in the Net Zero Roadmap are outlined in Table 1.

Table 1: Key NSW Organisations included in the Net Zero Roadmap emission modelling

Organisation	Emission captured	Included in Scope 1 & 2 Modelling	Included in Scope 3	Notes
Local Health Districts	Yes	Yes	No	Directly modelled
Specialty Health Networks	Yes	Yes	No	Directly modelled
NSW Ministry of Health	Yes	No	Yes	Reported under Scope 3 (administrative overhead)

eHealth NSW	Yes	No	Yes	Captured under Scope 3 via ICT systems procurement
HealthShare NSW	Partial	No	Yes	Captured under Scope 3 via intra-health service provision (e.g. linen, catering, logistics)
Health Infrastructure	Partial	No	Yes	Captured under Scope 3 via capital works and embodied carbon from construction projects
Health Education and Training Institute	No	No	No	Minor administrative emissions; not modelled
Public-Private Partnership Hospitals	Partial	No	Yes	Scope 3: only where data was available from operators
Agency for Clinical Innovation, Clinical Excellence Commission, Bureau of Health Information, Cancer Institute NSW, Health Protection NSW	No	No	No	Not modelled
NSW Ambulance	No	No	No	Transport emissions not captured in current model; future integration planned
NSW Pathology	Yes	No	Yes	Captured under Scope 3 via intra-health service procurement

Footprint methodology

The carbon footprint of LHDs, SHN and facilities adopted a hybrid methodology:

- A top-down approach used financial expenditure data and Environmentally Extended Input-Output (EEIO) models to estimate emissions, particularly effective for Scope 3 categories such as procurement and supply chain activities.
- A bottom-up approach incorporated metered energy use, transport logs, waste records, and local activity data to capture direct emissions under operational control.

Emission factors from various sources applied across NSW Health's organisations are consolidated in Table 2. The table categorises emission sources, identifies the sources of emission factors and provides contextual examples to enhance transparency and interpretability.

NSW Health's emission profile

Standardisation across LHDs enabled the identification of 18 high-impact emissions categories, which collectively account for approximately 80% of NSW Health's total carbon footprint. As shown in Table 2, these include:

- Scope 1 and 2: Electricity, natural gas and nitrous oxide
- Scope 3: Pharmaceuticals, medical equipment, commissioned services and travel

Electricity alone contributed nearly one-third of total emissions in most districts and networks, highlighting its critical role in decarbonisation strategies. In Scope 3, procurement categories such as health-related goods and ICT equipment were major contributors; particularly in resource-intensive service delivery settings.

Although commissioned health services are captured under GHG Protocol's operational control approach for Scope 3: Purchased Goods and Services, the footprint (in line with other health systems like the NHS) explicitly includes several commissioned services—such as those provided by privately operated hospitals, nursing homes, and Public-Private Partnership (PPP) hospitals. These inclusions reflect a strategic and pragmatic interpretation of Scope 3 boundaries, acknowledging NSW Health's role in funding or commissioning these services even where it does not directly operate them.

Table 2: Key Emission Sources Across NSW Health Operations. This table summarises major emission sources by scope and category, including examples and data sources used for estimating carbon impacts in alignment with NSW Health's net zero commitments.

Key: Scope 1; Scope 2; Scope 3

Emission source	GHG protocol category	Inclusions / Examples	Emission factor source
Natural gas	Stationary combustion	Used in hospital boilers and heating systems	NGA stationary energy factors
Air ambulance service	Mobile combustion	Jet fuel and aviation gasoline used in owned air ambulances	NGA aviation fuel factors
HFC refrigerants	Fugitive emissions	Emissions from refrigerant gases used in HVAC systems	NGA refrigerant factors
Nitrous oxide	Fugitive emissions	Used as an anaesthetic gas in operating theatres and birthing suites	IPCC AR6 + PrescQIPP
Electricity	Purchased electricity	Grid electricity used across health facilities	Australian Government National Greenhouse Accounts Factors (NGAF, 2022) – state grid mix
Electronic equipment	Purchased goods and services	ICT hardware such as monitors, servers, and networking equipment	IELab Input–Output database (2019)
Staff commute*	Employee commuting	Travel to and from work using personal vehicles or public transport	Staff travel survey; NGA transport factors & UK's Department for Business, Energy and Industrial Strategy (BEIS) Greenhouse Gas Reporting Factors
Medical building construction	Capital goods	Embodied emissions in concrete, steel, and other building materials	AusLCI v1.35; Decarbonising Infrastructure Delivery Policy
Medical building repair & maintenance	Capital goods	Emissions from refurbishments and facilities	IELab construction/maintenance

		management	sector
Hospitals and nursing homes	Purchased goods and services	Private or NGO-operated facilities funded but not operated by NSW Health	IELab health services sector
Pharmaceutical goods	Purchased goods and services	Medications including injectables, oral tablets, vaccines	IELab pharmaceuticals sector
Surgical and medical supplies/devices	Purchased goods and services	Single-use and reusable items used in surgeries	IELab medical sector
GPs, dentists, optometrists, ambulance	Purchased goods and services	Primary care services commissioned by NSW Health	IELab healthcare subsectors
Hotels, clubs, restaurants, cafes	Purchased goods and services	Patient accommodation, meals, and event services	IELab hospitality sector
Textile products (linen, uniforms)	Purchased goods and services	Procured uniforms, bed linens, and cleaning cloths	IELab textiles sector
Food products	Purchased goods and services	Catering services and bulk food items procured via HealthShare	IELab food & catering sector
General waste	Waste generated in operations	Mixed municipal waste from wards, admin, and outpatient areas	NGA Waste factors; Climate Active LCI
Cleaning products/services	Purchased goods and services	Contracted cleaning services and chemical products used in healthcare	IELab cleaning/chemical sector

**Emissions associated with employee commuting include public transport, car travel, and active transport, based on available staff travel survey data reported by LHDs. In cases where survey data was incomplete, regional averages and national modal share statistics were used to model commuting emissions. These estimates were applied consistently across LHDs, as reflected in the SCHN and NSLHD consultant reports.*

Modelling approach

NSW Health developed a ridge regression model to forecast emissions trends and evaluate reduction scenarios based on operational predictors, including acute separations, National Weighted Activity Units (NWAUs), and emergency department presentations.

The ridge regression model can be expressed as:

$$\hat{y} = 4.1138 + 0.001124 \times (acute\_nwau) - 0.000144 \times (acute\_bedday) + 0.000092 \times (ed\_presentation) - 0.000120 \times (subacute\_bedday)$$

The ridge regression model was developed to estimate facility-level emissions using an 80/20 train-test split and 5-fold cross-validation across a wide range of α values (10^{-6} to 10^{6}). The optimal penalty parameter was α = 1,000,000, which provided a high predictive performance (R^2 = 0.9767, RMSE = 3.26 $ktCO_2$-e) while improving stability in the presence of multicollinearity between hospital activity indicators.

The coefficients in this model should not be interpreted as causal elasticities (e.g., 'one additional acute bed day causes X tonnes of emissions'). Instead, ridge regression shrinks coefficients toward zero to balance variance and bias, producing a stable predictive model even when predictors are

correlated. This makes the approach appropriate for extrapolating and estimating emissions across the NSW Health system, rather than attributing exact emissions values to individual service types.

By design, the methodology prioritises predictive accuracy over interpretability of coefficients, ensuring that NSW Health has a consistent, reproducible, and system-wide estimate of its carbon footprint. The use of standard model validation practices — including the 80/20 train-test split and cross-validation — confirms that this is a valid and reliable approach in line with accepted statistical methods for forecasting in complex, high-dimensional systems.

The model was then applied to 199 NSW Health sites with complete operational data for FY19–24. Future emissions projections incorporate demographic and health system trends, including population growth, aging and service demand.

Net Zero Pathway (Wedge Analysis) and Strategic Insights

The Net Zero Pathway graph wedges are based on a linear projection of total emissions under a Business-as-Usual scenario. This projection leverages the ridge regression model to estimate emissions trends across the healthcare sector. The cascade of the wedges downward represents initiatives to tackle critical emission sources identified through academic literature, government policies and grey literature. These are aligned with the Net Zero Government Operations Policy.

Several key procurement categories - pharmaceutical goods, electronic equipment and textiles - are captured within broader intervention wedges like decarbonised supply chains and investment in circular initiatives. These aggregated groupings reflect the integrated approach required to address Scope 3 emissions, largely outside NSW Health's direct control but central to overall decarbonisation efforts.

While interventions targeting Scopes 1 and 2 emissions are critical, achieving deep reductions across Scope 3 requires systemic changes and collaborative efforts with suppliers and stakeholders. The identified shortfall (Research, Innovation & Offsetting) further emphasises the need for innovation in emission reduction technologies and strategies, particularly for hard to abate sectors.

Limitations

Table 3 presents data availability for each emission source. It incorporates the 18 key emission categories from the Net Zero Roadmap, along with additional Scope 3 categories identified in consultant reports and flagged in the "Limitations and Next Steps" section. Data availability is categorised as *Available*, *Partially Available* or *Not Yet Available*, providing transparency for current readiness and improvement needs.

This classification reflects the evolving nature of carbon accounting across NSW Health. As decarbonisation plans are developed by agency leads, this appendix will be updated accordingly.

Table 1: Data availability summary for emission sources

Emission source	Status	Comments / Notes
Natural gas	Data Available	Included in Scope 1 stationary combustion.
Fleet vehicles	Data Available	Fuel-based emissions for owned transport captured.
Electricity (grid)	Data Available	Scope 2 electricity use well documented in NGA Factors.
Anaesthetic gases (e.g., N_2O)	Data Available	Desflurane and N_2O included via clinical use emission factors.
Refrigerants	Data Available	Scope 1 fugitive emissions captured via GHG Protocol.

Pharmaceuticals	Partial Data Available	Represented through IELab expenditure categories; lacking granularity.
Surgical/medical supplies	Partial Data Available	Captured through procurement data; varies by LHD completeness.
ICT equipment	Data Available	Included in purchased goods and services (ICT/telehealth categories).
Food and catering	Partial Data Available	Estimates used for major categories; supplier-specific factors vary.
Textiles and linen	Partial Data Available	Represented under purchased goods; variation in frequency and LHD-specific reporting.
Staff commuting	Data Not Yet Available	Not consistently collected across districts.
Air travel	Data Available	Business-related flights captured via expense reports.
Courier and freight transport	Partial Data Available	Captured indirectly in procurement spend; not always categorised distinctly.
Clinical waste	Data Available	Captured in waste audits and health facility data.
Water use	Partial Data Available	Reported inconsistently
PPP buildings	Partial Data Available	Emissions from Public-Private Partnership not consistently collected across districts.
Leased facilities (non-controlled)	Data Not Yet Available	Excluded due to operational control criteria per GHG Protocol.
Capital works (construction)	Partial Data Available	Building construction emissions modelled with assumptions; highly variable inputs.
Building repair & maintenance	Partial Data Available	Included under capital goods where tracked; missing in others.
Staff uniforms and PPE	Partial Data Available	Represented in expenditure categories, but disaggregated data is limited.
Outsourced services (e.g., cleaning, GPs)	Partial Data Available	Partially represented in expenditure data; complex due to indirect relationships.