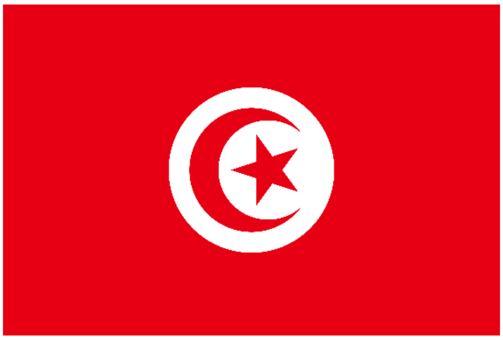
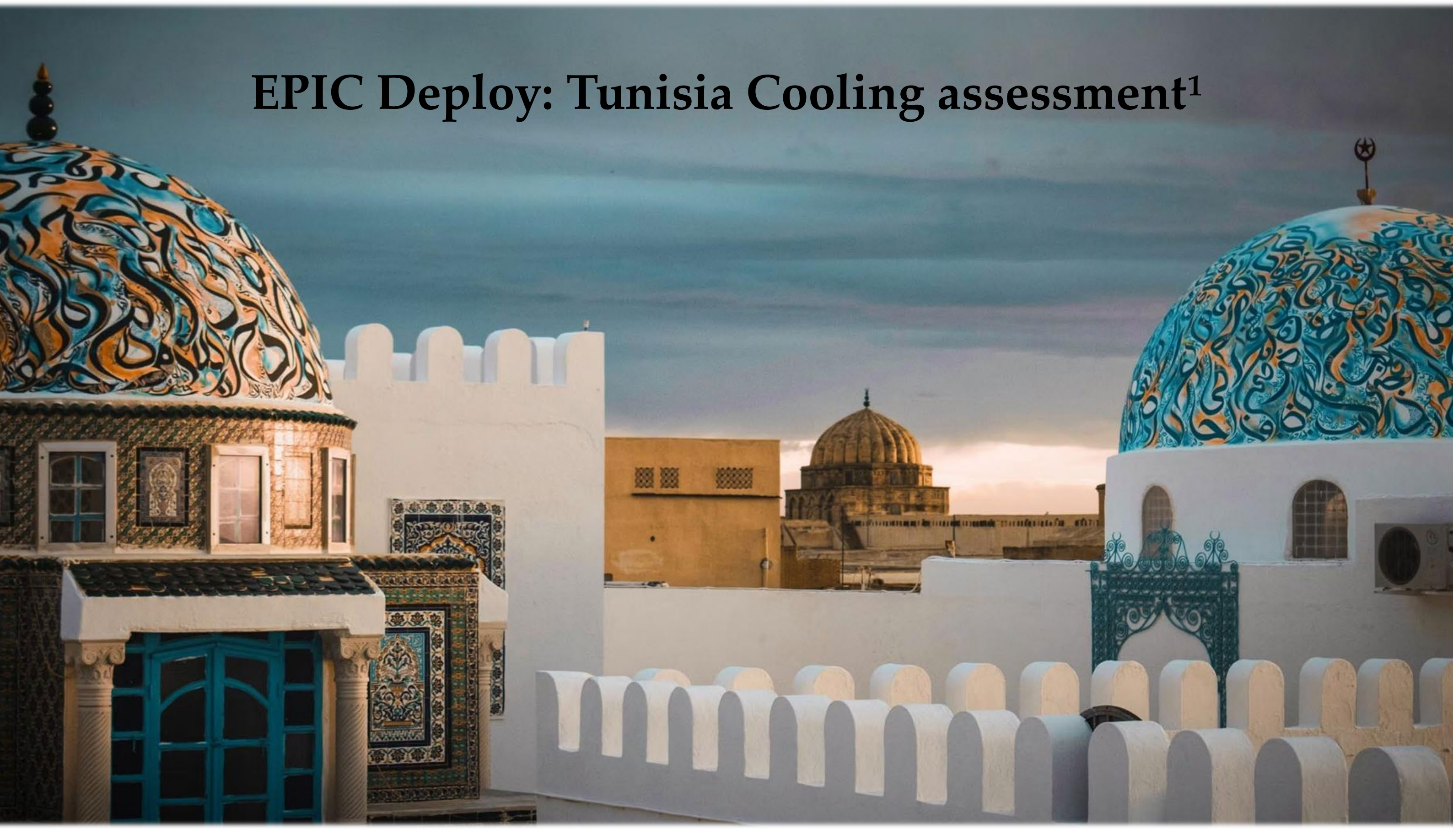
Tunisia



EPIC Deploy: Tunisia Cooling assessment[1]



POLITECNICO MILANO 1863

Ministero dell'Ambiente e della Sicurezza Energetica

UN environment programme

[1] **Scope and use:** This report provides contextual and screening-level information to support the preparation of applications. It is not a technical design standard, legal opinion, official national inventory or substitute for site-specific due diligence. Applicants remain responsible for validating demand, baseline conditions, equipment sizing, regulatory compliance and expected emission reductions for the proposed project.

Cooling Demand Taxonomy

Tunisia's cooling landscape reflects a Mediterranean-to-Saharan climate gradient, a comparatively small, urbanized and slow-growing population, a lower-middle-income economy with regulated electricity tariffs, an electricity system that is almost entirely gas-fired, and a regulatory framework that is well established on appliance energy labeling and the ozone and HFC agenda. A dedicated National Cooling Action Plan is not yet adopted, but ANME launched the technical-assistance process for its preparation in March 2026 [1]. The principal country framework conditions are summarized in Table 1 for quick reference, and each dimension is developed in the sections that follow.

Table 1 – Tunisia: key cooling taxonomy data

Economics and demographics		**Climatic conditions**	
GDP (2026, nominal)	≈ USD 60 bn (2026 IMF forecast) [2]	National avg. Cooling Degree Days (18 °C base)	1,739 °C·day/yr [4]
GDP per capita (nominal / PPP)	≈ USD 4,900 / 15,800 (2026 forecast) [2]	CDD range across the country	≈ 1,450 – 2,170 [4]
GDP growth (medium-term)	≈ 2.1%/yr (2026 forecast) [2]	Mean annual temperature range	Station-specific ANME/INM cooling-design conditions [5]
Total population (2025)	≈ 12.35 M [6]	Projected warming by 2050	≈ +1.6 to +1.9 °C, depending on scenario [7]
Population growth rate	≈ 0.6%/yr (slow growth) [6]	Climate gradient	Mediterranean north to Saharan south
Urban population share	≈ 70% [8]	AC share of summer peak demand (2021)	≈ 44% [9]
Income group	Lower-middle income [3]		
Energy infrastructure		**Regulatory framework**	
National electrification rate	≈ 99.8% [10]	MEPS for cooling appliances	In force (ANME label, individual room AC below 12 kW) [11][12]
Total electricity generation (2023)	≈ 19,313 GWh [10]	R-22 (HCFC) phase-out	HPMP Stage II final tranche through 2026; subsequent controls continue [13]
Natural-gas share of generation	≈ 95% [15]	HFC phase-down (Kigali Amendment)	Electronic HFC licensing and quotas since 2024; Stage I milestones to 2030 [14]
Renewable share of generation	≈ 3-5% [15]	National Cooling Action Plan	Under preparation since March 2026 [1]
Total electricity-network losses	≈ 20.9% of electricity transformation output (2023 energy-balance loss line) [15]	NDC targets	−46.4% by 2030; −62% by 2035; 2050 neutrality objective [16][17]

Economics and demographics		Climatic conditions	
Residential tariff	Regulated tariff schedule administered by STEG [18]	EU trade regime	Preferential treatment subject to origin rules and valid EUR.1 [19][20]
Grid emission factor	0.468 kgCO2eq/kWh (IEA screening average) [21]	Conformity	INNORPI / CETIME; ANME label [22][23][12]

General Overview

Geography and climate

Tunisia occupies the north-eastern tip of the Maghreb, with a long Mediterranean coastline and a territory that grades from a sub-humid north to a hyper-arid Saharan south. Three broad climatic zones structure the country's cooling needs:

- A Mediterranean north (the Tell and the coastal plains), with mild wet winters and hot dry summers and the bulk of the population;
- A semi-arid centre (the high steppe and the Sahel) with hotter, drier conditions;
- An arid Saharan south, with extreme summer heat and a sparse, oasis-based population.

The zone breakdown in Table 2 and the map in Figure 1 provide a reference framework used throughout the assessment.

Figure 1 – Tunisia: geography and climate zones [4]

Table 2 – Tunisia: climatic zones general data

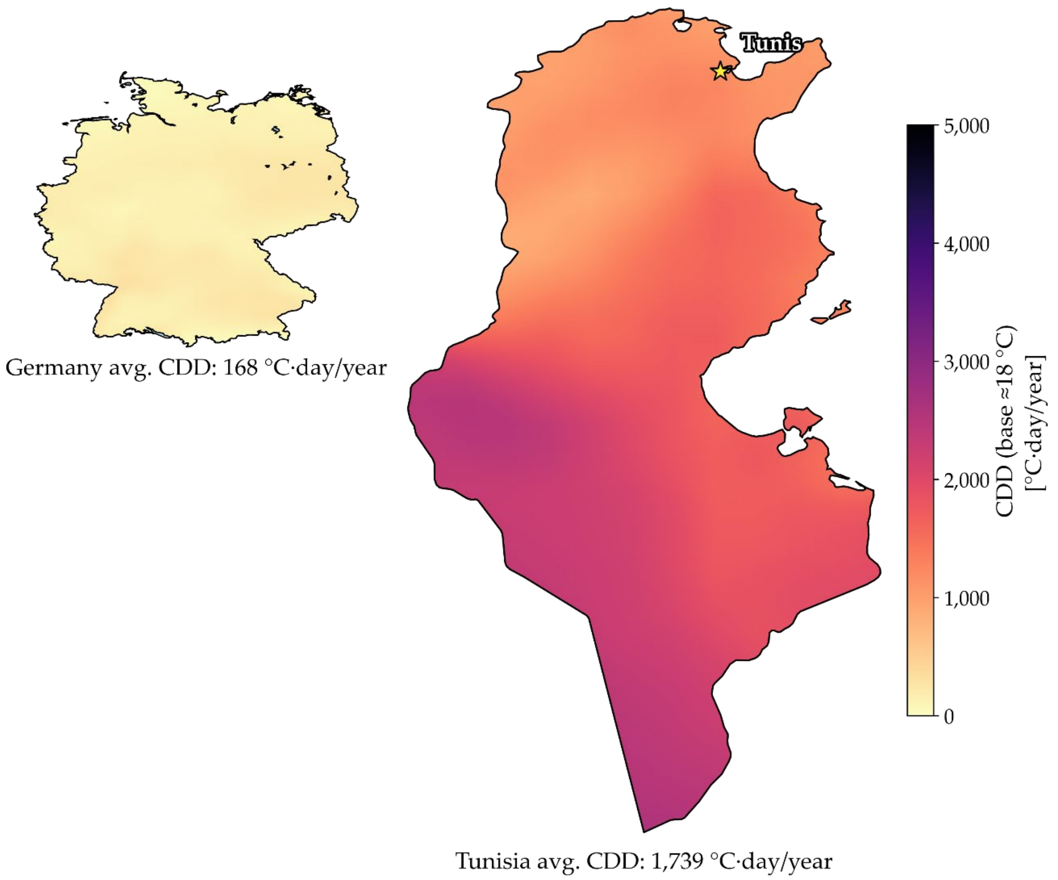
Zone	Approx. area / population	Climate	Key cooling relevance
North (Tell, coastal plains)	≈ 20% area; majority of population	Mediterranean; mild wet winters, hot dry summers	Largest cooling market; Greater Tunis, Bizerte; urban heat islands; moderate but rising loads

Zone	Approx. area / population	Climate	Key cooling relevance
Centre (high steppe, Sahel)	≈ 30% area; ≈ a third of population	Semi-arid; hotter, drier	High sensible cooling demand; Sousse, Sfax, Kairouan; agriculture and cold-chain activity
South (Saharan, pre-Saharan)	≈ 50% area; sparse population	Arid desert; extreme summer heat	Highest per-capita thermal stress; oases (dates); lower incomes; concentrated vulnerability

Climate projections raise cooling requirements across every zone. Tunisia's national climate documents project mean warming of approximately +1.6 to +1.9 °C by 2050, depending on scenario, with more frequent and intense heat waves, a longer hot season and the strongest effects in the interior and south [7]. The national-average Cooling Degree Days on an 18 °C base, calculated for this assessment from gridded historical climate data, are around 1,740, ranging from roughly 1,450 in the cooler north to about 2,170 in the south [4]. These CDD values are screening indicators rather than design conditions; project sizing should use the station-specific ANME/INM design data [5].

A visual representation of the spatial distribution of this indicator is provided in Figure 2.

Figure 2 – Tunisia: cooling degree days (18 °C) spatial distribution [4]



Cooling demand is unevenly distributed across the country. The Mediterranean coast and the north record comparatively moderate cooling-degree-days, whereas the central and southern interior, including Kairouan, Gafsa, Tozeur, Kebili and Tataouine, records substantially higher values. Cooling need, and the associated heat stress, is therefore concentrated in the hotter and generally less-served interior and southern governorates, a mismatch that matters for siting and prioritising investment [4].

Population, urbanisation and vulnerability

Tunisia is already highly urbanized, with roughly 70% of the population living in cities [8]. Its population is small and growing slowly, at about 12.35 million in 2025, with annual growth of approximately 0.6% [6][8]. Under the United Nations medium variant, the population continues to grow slowly through 2050 rather than peaking in the mid-2040s. The dominant cooling-relevant dynamic is therefore not rapid urban immigration but the thermal vulnerability of an established, coastally concentrated and ageing population.

Key demographic indicators are reported in Table 3.

Table 3 – Tunisia: general demographic data

Indicator	Value	Source
Total population (2025)	≈ 12.35 M	[6]
Population growth rate	≈ 0.6%/yr (slow growth)	[6]
Urban population share	≈ 70%	[8]
Population distribution	Concentrated on the coast (Greater Tunis, Sfax, Sousse); sparse interior/south	[8]
Income group	Lower-middle income	[3]

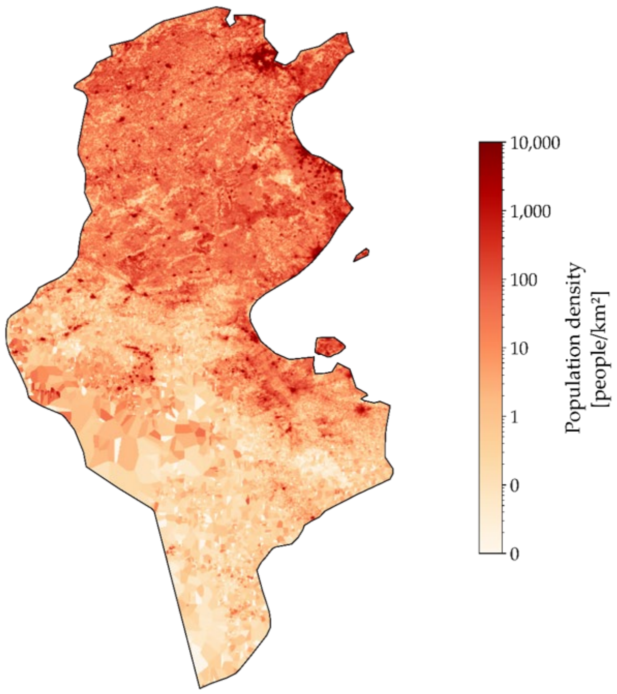


Figure 3 – Tunisia: population distribution

As can be seen, the population is concentrated along the north and east coasts. Greater Tunis, Sfax and Sousse account for a large share of the population and of economic activity, while the vast Saharan south remains sparsely settled. This concentration places the largest cooling market in the temperate north, even though per-capita thermal stress is highest in the under-served interior and south.

Building stock and thermal exposure

The built environment is a primary determinant of heat risk. Tunisia's building-efficiency framework identifies thermal-envelope performance as an important issue in the residential and tertiary stock [24]. Older urban housing, rural schools and lower-cost buildings may combine limited insulation and external shading, but the prevalence of these characteristics is not quantified nationally. Passive measures - reflective or insulated roofs, external shading, cross-ventilation, night cooling and vegetation - should therefore be assessed first at site level, particularly in the hotter interior and south. These measures are developed in the sectoral chapters that follow, where they are the first-order response for schools in particular.

Economy and energy poverty

Tunisia is a lower-middle-income economy [3], with nominal GDP forecast at about USD 60 billion in 2026; services are the largest sector, followed by industry and agriculture [2][3]. Near-universal electrification coexists with regulated electricity tariffs and affordability constraints that fall most heavily on lower-income, interior and rural households. The SEforALL Chilling Prospects framework classifies lower-middle-income populations as a medium-risk profile for access to efficient cooling, but its 2023 country analysis does not publish a Tunisia-specific result [25]. Applicants should therefore use the framework only as a contextual lens and should assess first-cost constraints, life-cycle operating costs and equitable access at project level.

Table 4 – Tunisia: main economic indicators

Indicator	Value	Source
GDP (2026, nominal)	≈ USD 60 bn (2026 forecast)	[2]
GDP per capita (nominal / PPP)	≈ USD 4,900 / 15,800 (2026 forecast)	[2]
GDP composition	Services are the largest sector; industry and agriculture account for smaller shares	[3]
Cooling-access context (SEforALL framework)	Medium-risk lower-middle-income profile used as a contextual lens; not a published Tunisia-specific estimate	[25]
AC share of summer peak electricity demand (2021)	≈ 44% of a 4,472 MW August peak	[9]
Agriculture share of employment	≈ 13% (latest modeled ILO/World Bank estimate)	[3]

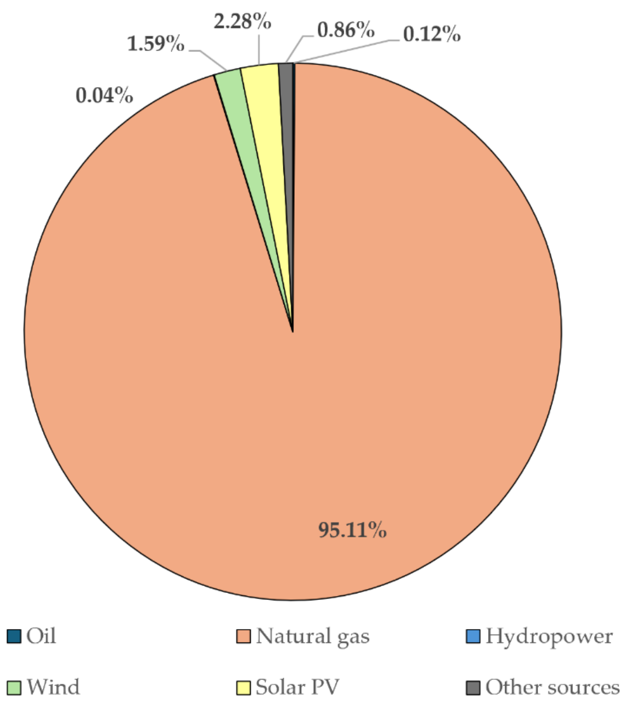
Electricity system

The Tunisian electricity system is vertically integrated under the public utility STEG and remains overwhelmingly gas-fired. National electricity production was 19,313 GWh in 2023; official energy-balance data indicate that natural gas supplied about 95% of generation and renewables only a few percent [10][15]. For screening calculations, this assessment uses an average grid electricity emission factor of 0.468 kgCO2eq/kWh from the IEA Emissions Factors 2023 data product [21]. The value is a consistent national screening factor rather than a project-specific baseline; applicants should use the factor required by the financing program and disclose its reference year and accounting boundary. The 2023 national energy balance records electricity-system losses of 367 ktoe against transformation output of 1,758 ktoe, equivalent to approximately 20.9%; this aggregate loss line should not be confused with a transmission-only technical-loss indicator [15]. Air conditioning is a major and growing driver of the summer peak: STEG attributed about 44% of its record August 2021 peak of 4,472 MW to air-conditioner operation [9]. Cooling efficiency is therefore a peak-management and energy-security issue as well as an emissions issue. Key indicators are reported in Table 5.

Table 5 – Tunisia: electricity system key indicators

Indicator	Value	Source
National electrification rate	≈ 99.8%	[10]
Total electricity generation (2023)	≈ 19,313 GWh	[10]
Natural-gas share of generation	≈ 95%	[15]
Renewable share of generation	≈ 3 – 5%	[15]
Total electricity-network losses	≈ 20.9% of transformation output (2023 energy-balance loss line)	[15]
AC share of summer peak demand (2021)	≈ 44% of 4,472 MW (August)	[9]
Residential tariff	Regulated tariff schedule administered by STEG	[18]
Grid emission factor	0.468 kgCO2eq/kWh (IEA screening average)	[21]
Interconnection	ELMED HVDC link with Italy under development	[26]

Figure 4 – Tunisia: electricity generation mix



The domestic RAC market

Unlike countries with a large domestic appliance-manufacturing base, Tunisia's room air-conditioner market is supplied largely through imports and local assembly, with the appliance stock dominated by split units and a refrigerant mix weighted toward higher-GWP fluids [9][14]. The installed base of room air-conditioners was about 1.68 million units in 2019, with close to half of all households already owning at least one unit, and the wider stock of refrigeration and air-conditioning appliances is larger and rising steadily on current trajectories [9][27]. Because much equipment enters as finished or semi-finished imports, the principal policy levers act at the point of import and sale, energy labeling, minimum performance requirements and conformity assessment, rather than on domestic production lines. This shapes the regulatory and market-entry framework set out below, in which energy labeling for room air-conditioners and import conformity are the binding requirements.

Regulatory Framework

Key legislation

Tunisia has a comparatively mature framework for appliance energy efficiency and for the ozone and HFC agenda, anchored in its energy-management legislation and delivered through the national energy-efficiency agency, ANME, with refrigerant control operating under the Montreal Protocol and its Kigali Amendment. A dedicated National Cooling Action Plan is under preparation: ANME launched a technical-assistance procurement in March 2026 to develop the data, scenarios and strategic studies forming its technical basis [1]. Energy efficiency rests on the energy-management law [28] and on ANME's mandatory energy-labeling programme for household appliances [11][12], while refrigerant control runs through the HCFC Phase-out Management Plan (HPMP) [13] and the Kigali Implementation Plan administered with UNIDO and the Multilateral Fund [14].

The principal instruments are summarized in Table 6.

Table 6 – Tunisia: list of administrative key provisions

Instrument	Year	Key provision
Energy-management law (maîtrise de l'énergie)	2004 (amended)	Legal basis for energy efficiency, audits and the energy-transition fund [28]
Arrêté on AC energy labeling (below 12 kW)	2009; revised 2023	Mandatory bilingual energy label for individual air conditioners below 12 kW; updated class-performance thresholds [11][29]
ANME energy-certification program	ongoing	Energy labeling and minimum classes for household appliances [12]
Restriction of low-efficiency room ACs	2012	Only label classes 1–3 permitted on the market; class 1 requires EER > 3.38 under the 2023 order [12][29]
HCFC Phase-out Management Plan (HPMP)	Stage II final tranche scheduled through 2026	Continued HCFC control and R-22 phase-out under the Montreal Protocol; final-tranche completion remains subject to implementation milestones [13]
Kigali Implementation Plan (HFC phase-down)	Stage I: 2024–2030	Electronic HFC import licensing and quotas from 2024; 10% reduction by 2029 and 23.8% by 2030 relative to the Kigali baseline [14]
Fonds de Transition Énergétique (FTE/FNME)	ongoing	Financial support for energy-efficiency actions and investments [30]
Nationally Determined Contribution (updated)	ongoing	−46.4% carbon intensity by 2030 and −62% by 2035; long-term carbon-neutrality objective for 2050 [16][17]

MEPS in force for cooling appliances

Mandatory energy labeling applies chiefly to individual room air conditioners with a cooling capacity below 12 kW, which must carry the ANME energy label [11][12]. The label is bilingual (French and Arabic) and uses an eight-class scale; current ANME program documentation indicates that only classes 1, 2 and 3 are market-eligible, with a class-1 threshold above EER 3.38 [12][29]. CE marking alone does not satisfy the applicable Tunisian labeling and conformity requirements. For larger or industrial HVAC&R equipment, the applicable standards, conformity documents and approvals are product-specific. Foreign CE and EN/ISO documentation may support the technical review, but it should not be assumed to provide automatic market access or legal mutual recognition.

The applicable provisions are set out in Table 7.

Table 7 – Tunisia: MEPS in force for cooling appliances

Product	Instrument	Key requirement
Individual room air conditioners (below 12 kW)	ANME energy label (2009 order, revised 2023)	Bilingual eight-class label; current program documentation indicates classes 1-3 are market-eligible; class-1 threshold EER > 3.38; CETIME testing [11][12][29]
Household refrigerating appliances	ANME energy-certification program	Energy label and minimum classes [12]
Larger / industrial HVAC&R	Product-specific Tunisian requirements; foreign EN/ISO and CE documentation may support review	Do not assume automatic market access or legal mutual recognition; confirm applicable standards and approvals [22][31]
Conformity / market entry	CETIME testing; INNORPI; TUNAC accreditation	Model testing and label before sale of regulated products [22][23][32]

Refrigerant transition timeline

Tunisia follows the Montreal Protocol and has ratified the Kigali Amendment. The final tranche of HPMP Stage II is scheduled for implementation through 2026, while subsequent controls continue toward the complete HCFC phase-out [13]. For HFCs, Tunisia has operated an electronic import-licensing and annual-quota system since 1 January 2024. Stage I of the Kigali Implementation Plan runs to 2030 and targets a 10% reduction from the Kigali baseline by 2029 and a 23.8% reduction by 2030 [14]. The KIP also records a government commitment to introduce, by 1 January 2027, restrictions on selected high-GWP equipment, including residential air conditioners using refrigerants with GWP above 700. The KIP itself does not establish that the corresponding national implementing regulation is already in force; applicants should verify its legal status and scope at the time of procurement and importation [14]. R-32, R-454B, R-290 and CO2 are potential technology pathways rather than blanket legal prescriptions, and their use remains subject to product-specific safety, charge-limit, installation and service-capacity requirements.

The milestones are set out in Table 8.

Table 8 – Tunisia: refrigerant transition targets

Milestone	Target
HCFC (R-22) phase-out	Under the HPMP; Stage II final tranche scheduled through 2026, with subsequent controls continuing toward complete phase-out [13]
HCFC import control	Licensing/notification through the National Ozone Unit [13]
HFC phase-down (Kigali): status	Kigali Amendment ratified; Stage I runs from 2024 to 2030, with a 10% reduction milestone in 2029 and a 23.8% reduction by 2030 [14]
HFC licensing and quota system	Electronic import licensing and annual quotas in force since 1 January 2024; nationally administered and structurally distinct from the EU F-gas regime [14]
Potential transitional option (split ACs)	R-32 (GWP 675) where the model is ANME-compliant and safety and servicing requirements are met [14]
Potential lower-GWP options (commercial / industrial)	Application-appropriate options include R-454B, R-290 and CO2, subject to safety codes and demonstrated local O&M capacity [14]

Key institutions

Oversight is distributed across several national authorities, summarized in Table 9.

Table 9 – Tunisia: cooling key authorities

Authority / body	Role for cooling
ANME (Agence Nationale pour la Maîtrise de l'Énergie)	Energy labeling and efficiency programmes; the energy-transition fund (FTE/FNME) [12][30]
CETIME	Testing laboratory for ANME energy labels, especially individual room ACs below 12 kW [23]
INNORPI	National standards body; adoption of EN/ISO and Tunisian standards [22]
TUNAC	Accreditation of laboratories and conformity-assessment bodies [32]
Direction Générale des Douanes / TradeNet	Customs tariffs, import processing and HS-code verification [19]
Ministry of Environment / National Ozone Unit	HCFC import notifications and Montreal Protocol obligations [13]
STEG	Electricity supply, grid connection and electrical-installation approval [18]
Ministry of Industry, Mines and Energy	Energy policy and the energy-transition fund [30]

Market entry: what to do before importing or installing equipment

Imported cooling equipment is subject to product-specific documentary, customs and conformity requirements. Qualifying EU-origin goods may receive preferential duty treatment only when the applicable rules of origin are met and valid EUR.1 or equivalent origin documentation is provided; treatment must be confirmed by HS code before procurement [19][31]. VAT applies to imports, with 19% used only as a budgeting assumption pending product-specific confirmation [31]. Individual room air conditioners below 12 kW require the applicable ANME energy label and CETIME testing. For larger industrial equipment, foreign CE and EN/ISO documentation may support the technical file but should not be treated as automatic evidence of Tunisian market authorization or mutual recognition [22][31].

Table 10 – Tunisia: import and market-entry requirements

Item	Working assumption
Import duty, EU-origin equipment	Qualifying EU-origin goods may benefit from a 0% preferential customs duty when supported by valid EUR.1 or equivalent origin documentation; confirm by HS code and applicable rules of origin [19][20]
Import duty, non-EU equipment	MFN tariff by HS code; confirm against the current customs tariff [19]
Value-added tax (TVA)	Standard VAT applies on the customs value (19% working assumption); confirm the current rate and tax base by HS code before procurement [31]
Individual room AC below 12 kW	Mandatory ANME energy label; current program documentation indicates classes 1-3 are market-eligible; class-1 threshold EER > 3.38; CETIME testing [12][29]
Core documents	Commercial invoice (French, CIF, HS codes); packing list; bill of lading; EUR.1; CE Declaration of Conformity; technical datasheet; ANME label certificate; customs declaration D.16 [19][31]

Item	Working assumption
Customs clearance timeline	Transaction-specific; confirm the expected clearance period with the customs representative before shipping [19][31]
First-time ANME label timeline	Allow sufficient lead time for first-time model testing and approval; confirm the current schedule directly with CETIME and ANME before procurement [23][12]
Refrigerant import	HCFCs require licensing/notification; HFC imports are subject to the electronic licensing and quota system [13][14]
Importer of record	A Tunisian-registered entity or licensed customs representative is normally required for the import declaration [20][31]
Financing / incentives	FTE/FNME co-financing possible for efficiency actions; confirm with ANME [30]
Local partner and O&M	Local distributor/EPC, named technicians, spare-parts and maintenance plan advisable [20]

In practice, the import declaration normally requires a Tunisian-registered entity or licensed customs representative. Foreign suppliers without a local entity therefore generally work through a Tunisian distributor, EPC contractor or authorized service firm. Regulated room air conditioners must carry the ANME label before sale, and CE marking is not accepted in its place, although foreign test data may support the conformity file. A local technical partner is not necessarily a statutory requirement for every transaction, but proposals should demonstrate adequate local commissioning, maintenance, spare-parts and refrigerant-handling capacity. Competence requirements should be assessed for the refrigerant and application proposed, including A2L, hydrocarbon and high-pressure systems where relevant [20].

Behavioral Context

Cooling in Tunisia is shifting in perception from a comfort and status good toward a necessity, driven by hotter and longer summers, but it does so within a lower-middle-income market where affordability and regulated electricity tariffs shape behavior [18][25]. Air-conditioner ownership, though still below the levels of higher-income Mediterranean countries, is rising quickly and is already the single largest contributor to the summer electricity peak, accounting for roughly 44% of the record August 2021 maximum [9]. Regulated tariffs can weaken the financial signal to choose efficient equipment and moderate use, so demand-side and labeling policy carry particular weight. Heat exposure falls disproportionately on elderly people, lower-income and informally housed households, outdoor workers, and populations in the hotter interior and south. Tunisia's Mediterranean-to-Saharan climate, slow-growing and coastally concentrated population, gas-heavy grid and import-based appliance market together set the conditions for the sectoral demand examined in the following chapters.

Tertiary-Sector Cooling

Healthcare

System infrastructure and facility inventory

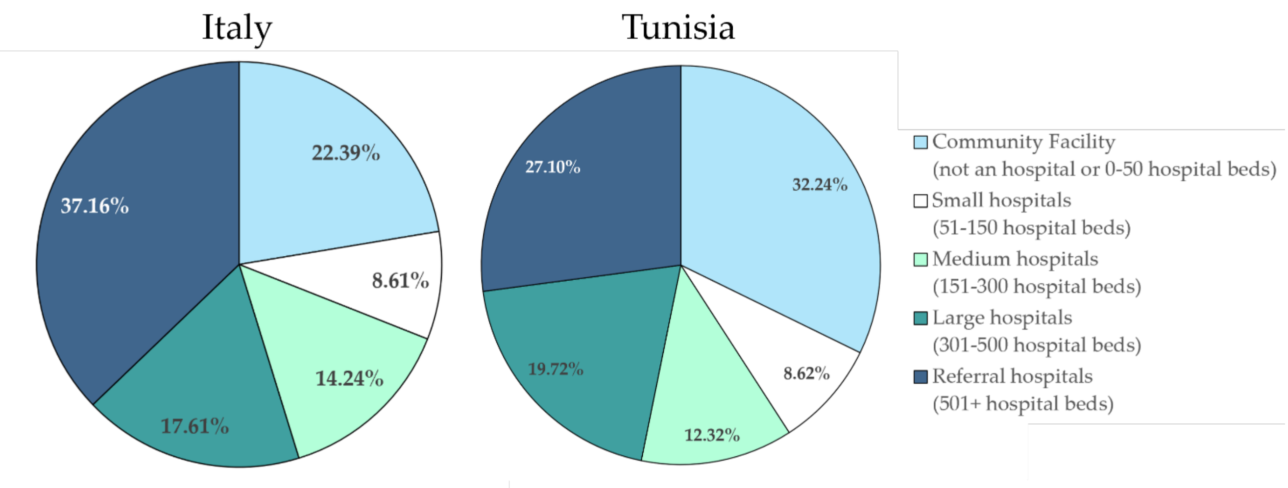
The public hospital network analysed here comprises 164 establishments holding about 20,400 inpatient beds, to which the private sector adds roughly 98 hospitals and 5,600 beds, for a modeled national total of approximately 26,000 beds [33][34]. Combining this facility inventory with the 2025 population estimate gives an indicative ratio of about 2.1 beds per 1,000 inhabitants. This is not directly comparable with the latest harmonised WHO/World Bank indicator because the years and coverage differ [35]. High-complexity capacity is concentrated in Greater Tunis and the coastal governorates. A facility-type breakdown of the public network by size band is set out in Table 11.

Table 11 – Tunisia: public healthcare facilities classification (elaboration on the Ministry of Health public-hospital inventory [33])

Healthcare Facility Type	Description	Facilities	Total capacity	Average capacity
Community hospital	Local facilities, hospital beds ≤ 50 (excl. primary-care health centres)	98	2,269	23.2
Small district hospital	50 < hospital beds ≤ 150	27	2,304	85.3
Medium hospital	150 < hospital beds ≤ 300	15	3,291	219.4
Large hospital	300 < hospital beds ≤ 500	14	5,267	376.2
Referral / Tertiary sector hospital	Hospital beds > 500	10	7,241	724.1

Below this hospital network sits a capillary primary-care tier of roughly 2,100 basic health centres (centres de santé de base) that hold few inpatient beds and are excluded from the facility-energy assessment. The distribution of the hospital estate is strongly skewed: a large number of small district facilities hold a minority of beds, while a handful of large and referral hospitals, predominantly the CHUs of Tunis, Sousse, Sfax and Monastir, concentrate most of the inpatient and specialised capacity. For cooling, this implies that basic-comfort and vaccine-storage needs are dispersed across many small facilities, whereas clinical-grade air treatment and chilled-water plant are concentrated in the larger hospitals. The contrast with a developed-system benchmark is shown in Figure 5.

Figure 5 – Tunisia vs Italy: percentage of total hospital beds by facility size [36]



The facility-size distribution differs from the Italian benchmark, with a larger concentration of beds in a relatively small number of large and referral hospitals. Facility size alone is not a direct measure of clinical complexity; the comparison is used only to indicate where chilled-water plant and precision air-treatment loads are likely to be concentrated.

Cooling applications and clinical consequences

In healthcare, cooling is an operational requirement rather than a matter of comfort, and its functions fall into the three domains summarized in Table 12.

Table 12 – Tunisia: healthcare cooling applications

Domain	Impact	Evidence / response
Vaccine cold chain (2 – 8 °C)	Continuous temperature control from central stores to vaccination rooms across the national immunisation programme	Assessments conducted in 2018-2020 found that approximately 98% of vaccine refrigerators were domestic, non-WHO-PQS appliances. UNICEF delivered 184 PQS refrigerators, three freezers and 955 temperature data loggers in 2021; the present composition of the complete fleet requires verification [37].
Medical storage & laboratories	Pharmaceuticals, blood products and diagnostic reagents require uninterrupted 24-hour climate control	Facility-level reliability depends on application-specific equipment, monitoring and backup power [38][42].
Clinical thermal comfort	Stable temperature and humidity in wards, ICU and operating theatres, with rising summer load	A population-weighted summer-to-winter temperature swing drives a measurable cooling signal in hospital electricity [4][34]; national projections indicate approximately +1.6 to +1.9 °C warming by 2050, depending on scenario [7].

The vaccine cold chain is the most safety-critical cooling application. Assessments conducted in 2018-2020 found that approximately 98% of vaccine refrigerators were domestic appliances rather than WHO-PQS prequalified immunisation equipment. In 2021 UNICEF delivered 184 PQS refrigerators, three freezers and 955 temperature data loggers, but the current composition of the full national fleet still requires verification before procurement [37]. The clinical estate imposes requirements that go beyond temperature setpoints: operating theatres, intensive-care units and isolation rooms require controlled humidity, defined air-change rates and, in several cases, room pressurisation. For these reasons, latent capacity and air quality, not temperature alone, drive equipment sizing in the larger hospitals.

Cooling technology and efficiency

Large Tunisian hospitals typically rely on central chilled-water plants serving air-handling units and fan-coils, with variable-refrigerant-flow and direct-expansion split units used in wards, clinics and smaller hospitals [9]. The installed base is weighted toward fixed-speed equipment, and the transition to inverter-driven units and lower-GWP refrigerants is at an early stage. Indicative efficiency benchmarks for the dominant equipment classes are reproduced in Table 13.

Table 13 – Tunisia: healthcare cooling technology benchmark

Equipment class	Typical application	Indicative efficiency
Fixed-speed split / packaged AC	Wards, offices, smaller facilities	EER ≈ 2.6 – 3.0; dominant installed base [9][38]
Inverter split / VRF	Wards and clinics in newer facilities	SEER ≈ 5 – 7; minority but growing [9][38]
Air-cooled chiller (fixed speed)	Medium and large hospitals	COP ≈ 2.8 – 3.2 [38][39]

Equipment class	Typical application	Indicative efficiency
Water-cooled / variable-speed chiller	Large and referral hospitals (best practice)	COP ≈ 4.5 – 6.0 [38][39]

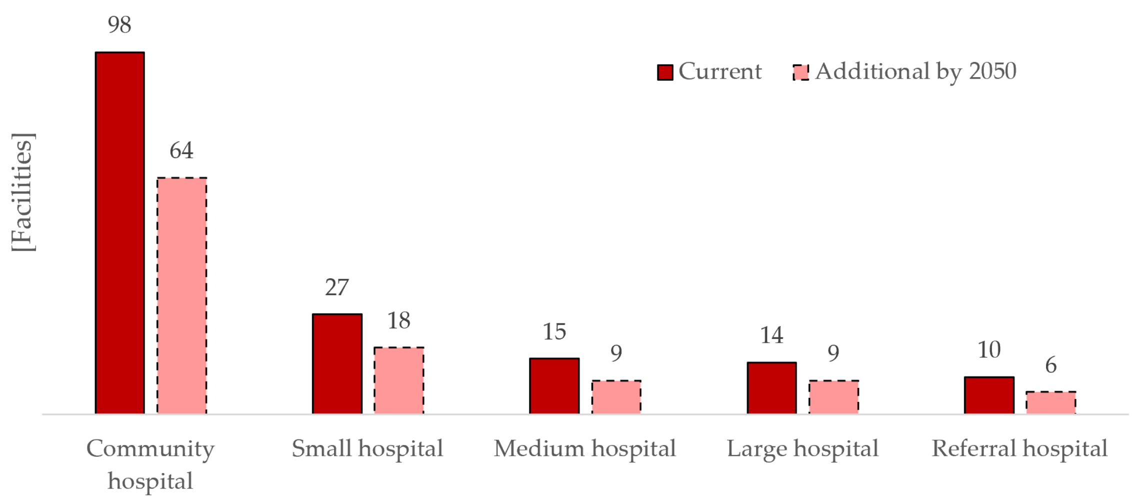
Infrastructure demand projections

Projections of new hospital capacity follow a consistent bottom-up logic, applying expected population change to the current beds-per-capita and facility-type ratios:

new facilities = population growth × current beds per capita × facility-type ratio ÷ average facility size

Tunisia's demographic trajectory is the starting point for the cooling outlook. Under the United Nations medium variant, the population rises from approximately 12.35 million in 2025 to 12.63 million in 2030 and 13.15 million in 2050 [6]. Holding the current bed ratio constant, this trajectory implies approximately 590 additional beds by 2030 and about 1,680 by 2050. Because demographic growth is slow, the decisive driver of future hospital cooling load is not population increase but the modernization and possible expansion of the hospital system. Figure 6 also shows a separate sensitivity case that assumes 3.3 beds per 1,000 people by 2050. This is an illustrative planning assumption - not a Tunisian policy target, an international standard or a forecast - and would imply approximately 17,400 additional beds. Actual requirements depend on occupancy, length of stay, outpatient care, clinical service models and health-system organization. Rising cooling intensity per bed, driven by warming, higher clinical standards and greater comfort expectations, would compound this effect.

Figure 6 - Tunisia: current facilities and illustrative hospital-capacity sensitivity by size band



Current market conditions and technology

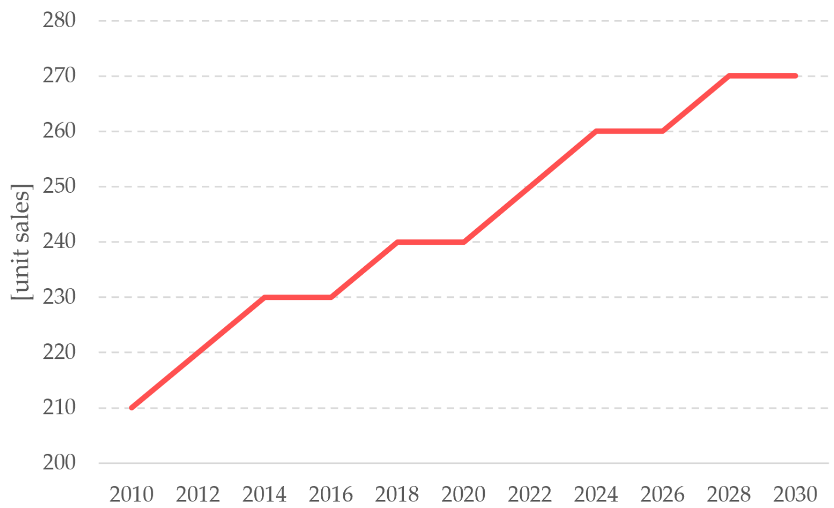
The technology baseline in Tunisian healthcare cooling reflects the national air-conditioning and refrigeration (RAC) market, which is dominated by split air-conditioners and a refrigerant mix still weighted toward higher-GWP fluids [9][14]. Minimum energy-performance standards and energy labeling for air-conditioners and household refrigerators have been in force since 2009–2011, but a substantial informal segment bypasses them [9][12]. Facility-level indicators relevant to healthcare cooling are summarized in Table 14.

Table 14 – Tunisia: healthcare-relevant cooling technology indicators

Indicator	Value	Source
Dominant AC type (clinical settings)	Single-split, mostly fixed-speed	[9]
Reported national HFC consumption by substance (CO_2-eq, Article 7 data)	R-404A 40.4%; HFC-134a 29.0%; R-410A 28.2%	[14]
National HFC consumption baseline	≈ 2,367,840 tCO_2-eq	[14]
RAC share of national electricity	≈ 28%	[14]
Vaccine-refrigerator fleet	2018-2020 assessment: ≈ 98% domestic (non-PQS) type; UNICEF supplied 184 PQS refrigerators, three freezers and 955 data loggers in 2021; current full-fleet share unverified	[37]
MEPS / labeling for ACs & refrigerators	In force since 2009 – 2011	[12]
Target refrigerants (low-GWP pathway)	HFC-32, R-290, R-600a, CO_2 and application-specific HFO/HFC alternatives	[14]

Although split units dominate, the centralized-chiller segment is expanding as new and refurbished hospitals adopt chilled-water plant [27]. The indicative trend in centralized-chiller uptake in Tunisia across all sectors is illustrated in Figure 7.

Figure 7 – Tunisia: centralized chillers: estimated unit-sales trend [27]

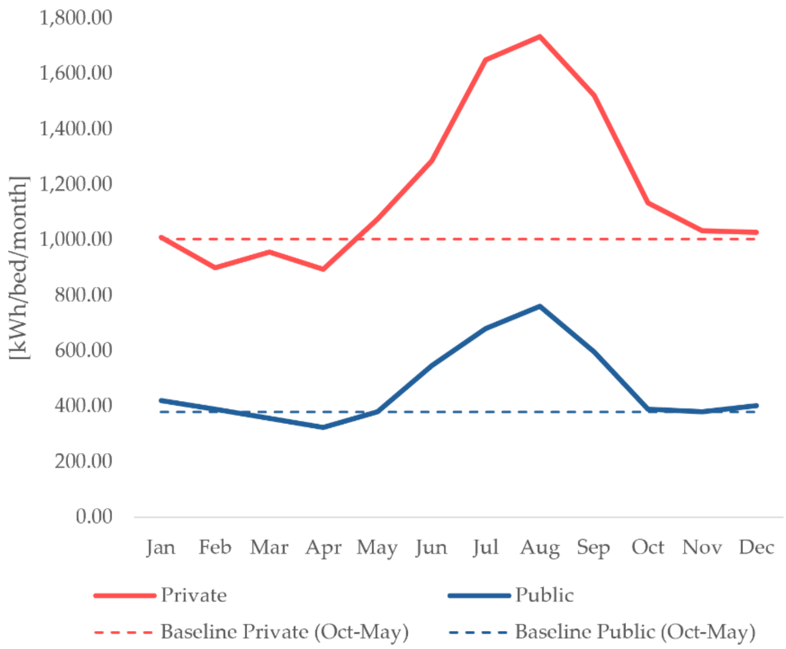


Energy implications

Applying the public- and private-sector electricity intensities in Table 15 to approximately 20,400 public and 5,600 private beds gives a screening estimate of about 195 GWh of hospital electricity use per year, equivalent to approximately 1.0% of national generation. Cooling accounts for about 98 GWh/yr, or roughly 0.5% of national generation. At the adopted grid factor and under the differentiated refrigerant assumptions below, the sector's electricity-and-refrigerant footprint is approximately 0.109 Mt CO2eq/yr, comprising about 0.091 Mt of electricity-related emissions and 0.018 Mt of direct refrigerant emissions. The cooling-attributable share is approximately 0.064 Mt CO2eq/yr [10][21][34][40]. These figures are a screening baseline for investment planning, not a current national inventory.

The energy estimates combine 2017 aggregated monthly electricity-consumption records and bed-normalized intensities for the public and private hospital fleets with the current bed-stock model [34]. The internal project dataset is not a facility-level public inventory and does not cover every establishment individually. Figure 8 shows a clear separation between summer and winter consumption. The measured load is decomposed into a winter baseline and a summer excess; HVAC consumption is taken as the summer increment above the winter baseline plus a constant share of the baseline representing year-round ventilation and air handling. The resulting totals should therefore be interpreted as an order-of-magnitude screening baseline.

Figure 8 – Tunisia: monthly hospital specific energy consumption (STEG billing data, 2017 [34])



On this basis, HVAC systems are estimated to account for around 50% of total hospital electricity consumption.

The measured specific consumption also reveals a wide public–private gap, reproduced in Table 15.

Table 15 – Tunisia: measured hospital specific energy consumption (STEG billing data, 2017 [34])

Hospital segment	Hospital electricity [kWh/bed·yr]	Cooling electricity [kWh/bed·yr]	Notes
Public hospitals	≈ 5,636	≈ 2,890	Measured fleet average; HVAC share ≈ 51%.
Private hospitals	≈ 14,234	≈ 7,000	Higher comfort/technology and continuous climate control; HVAC share ≈ 49%.
Combined	≈ 7,490	≈ 3,775	Weighted using ≈ 20,400 public and ≈ 5,600 private beds; combined HVAC share ≈ 50.4%.

Facility-level emissions are assessed as the sum of indirect electricity emissions and direct refrigerant leakage. Indirect emissions apply the screening-level average grid factor of 0.468 kgCO2eq/kWh [21]. For direct emissions, split/VRF systems use a representative initial charge of 0.27 kg/kWth and a 10% annual service emission factor, while chilled-water plant uses 0.137 kg/kWth and 22%. These benchmarks are derived from a documented African RAC inventory (5.75 kg per 21.31 kW for multi-split/VRF systems and 12.68 kg per 92.72 kW for chillers) [40]. They are not measurements of the Tunisian hospital stock, so project appraisal must replace them with equipment schedules, nameplate charges and service records.

Table 16 – Tunisia: reference healthcare cooling-plant characteristics [40]

Healthcare Facility Type	Typical cooling system	Modeled plant size [MWth]	Charge [kg/kW]	Leakage
Community hospital (≤ 50 beds)	Split / DX units; vaccine storage and basic comfort	0.20	0.27	10%
Small district hospital	VRF / DX split; small modular chiller for OT and ICU	0.74	0.27	10%
Medium hospital	Chilled-water plant	2.7	0.137	22%
Large hospital	Chilled-water plant	5.8	0.137	22%
Referral / Tertiary sector hospital	Chilled-water plant + AHUs; precision cooling for labs/imaging	14.9	0.137	22%

The plant sizes in Table 16 are modeled representative capacities calibrated by facility size, equivalent to approximately 8.6–20.6 kWth per bed across the five bands; they are not measured national values. A ±30% capacity sensitivity is therefore appropriate at country-screening stage, while hospital design must follow room-by-room clinical load, ventilation and redundancy requirements [38][39]. On this basis, the public stock comprises approximately 39.6 MWth of split/VRF-dominated capacity and 270.7 MWth of chiller-dominated capacity, for about 310 MWth in total. Scaling by the additional 5,600 private beds gives an indicative national stock of about 50.4 MWth of split/VRF capacity and 345.0 MWth of chiller capacity, or 395 MWth overall. Because private hospitals use substantially more electricity per bed, bed-only scaling may understate their installed cooling capacity and should be regarded as a conservative central case. Using R-410A as the representative legacy split refrigerant (GWP 2,088), the split/VRF component emits about 0.0028 Mt CO2eq/yr. Using R-134a (GWP 1,430) for the representative chiller case gives about 0.0149 Mt CO2eq/yr. Direct emissions total approximately 0.0177 Mt CO2eq/yr; the cooling-attributable footprint is about 0.064 Mt CO2eq/yr and the total hospital electricity-and-refrigerant footprint remains about 0.109 Mt CO2eq/yr [14][40].

Structural barriers to investment

Several structural barriers constrain the deployment of efficient cooling solutions across the healthcare sector. The principal ones are identified in Table 17.

Table 17 – Tunisia: barriers to the deployment of cooling technologies in the healthcare sector

Barrier	Detail
Carbon-intensive grid	≈ 95% gas-fired generation makes every kWh of inefficient cooling carbon-heavy, so efficiency gains carry an outsized emissions benefit [10][21].
Regulated tariffs and utility finance	Regulated electricity prices can weaken the operating-cost case for efficient equipment, while STEG's financial constraints limit public capital for retrofits [9][18].
Regional concentration and unequal service access	Specialized capacity is concentrated in coastal urban areas, while hotter interior regions face additional access and heat-resilience challenges [7][33][41].
Cold-chain fragility	The 2018-2020 assessment identified heavy reliance on domestic-type vaccine refrigerators; subsequent equipment deliveries reduce but do not quantify the current national gap [37].
Informal appliance market	A substantial share of AC sales bypasses MEPS and labeling, including some institutional procurement, locking in low-efficiency, high-GWP equipment [9][12].

Barrier	Detail
Refrigerant transition	The HFC phase-down under the Kigali Implementation Plan requires fleet and servicing changes in clinical equipment [14].
National cooling policy under development	ANME launched preparation of the National Cooling Action Plan in March 2026; final sector priorities and implementation arrangements remain under development [1]

Technology pathways

The pathway toward sustainable healthcare cooling combines equipment efficiency, application-specific refrigerant selection, resilient power supply and strong operation and maintenance, prioritized by facility type and clinical criticality, as set out in Table 18.

Table 18 – Tunisia: technology pathway for healthcare cooling applications

Application	Recommended pathway
Central plants and critical areas (ICU, operating theatres) in medium and large hospitals	High-efficiency variable-speed chillers or other application-appropriate systems with heat recovery and thermal storage; refrigerant selected through a whole-life climate, safety and serviceability assessment; room-specific temperature, humidity, ventilation, filtration and pressure requirements to be established for each clinical function [14][38][39]
Wards and clinics in smaller facilities	Inverter split / VRF units meeting or exceeding MEPS [12], replacing fixed-speed stock; commissioning and maintenance regimes.
Vaccine cold chain reliant on domestic, non-PQS refrigerators (accidental-freezing and excursion risk)	Replacement of domestic appliances with WHO-PQS prequalified medical (ice-lined) refrigerators [37][42]; continuous and remote temperature monitoring adopted as standard practice, demonstrated in Tunisia to sharply reduce accidental-freezing excursions [37][43]; adoption of freeze-free packing and transport procedures [43].
Sector-wide enablers	Solar cooling and solar-assisted cold storage exploiting Tunisia's high irradiation; enforcement of MEPS/labeling; and alignment with the emerging NCAP, KIP and NDC [1][14][16]

Quick summary

The table below condenses the healthcare-cooling assessment into its headline figures, bringing together the current stock and energy use, the resulting emissions, and the principal levers identified above. It is intended as a one-page reference to the analysis developed in this section.

Table 19 – Tunisia: healthcare cooling quick summary

Dimension	Finding	Implication / response
Provision	≈ 26,000 modeled beds, or ≈ 2.1 per 1,000 under the assessment inventory boundary; capacity concentrated on the coast [33][34]	A separate sensitivity case assumes 3.3 beds per 1,000 and implies ≈ 17,400 additional beds by 2050; it is not a policy target, standard or forecast
Energy	≈ 195 GWh/yr hospital electricity; ≈ 98 GWh/yr cooling (≈ 50.4%); cooling equals ≈ 0.5% of national generation [10][34]	Measured cooling share corroborates the 0.5 HVAC assumption; efficiency gains are high-value

Dimension	Finding	Implication / response
Emissions	≈ 0.109 Mt CO2eq/yr (≈ 0.091 indirect + ≈ 0.018 direct); cooling-attributable ≈ 0.064 Mt [21][34][40]	The gas-heavy grid and high-GWP legacy stock make efficiency, low-GWP refrigerants and leak management central to the 2030/2035 NDC and 2050 strategy [16][17]
Cold chain	2018-2020 assessment: ≈ 98% domestic-type vaccine refrigerators; UNICEF supplied 184 PQS refrigerators, three freezers and 955 data loggers in 2021 [37]	Verify the current fleet; prioritise digital monitoring, reliable backup and WHO-PQS equipment
Market & governance	Split-AC dominance, higher-GWP legacy refrigerants and an informal market segment; the NCAP is under preparation [9][14][1]	MEPS enforcement, HFC phase-down and alignment with the emerging National Cooling Action Plan

Education

System structure and context

Tunisia's school system enrols about 1.34 million pupils in primary education and roughly 1.05 million in lower- and upper-secondary education, while higher education adds about 0.31 million students [44]. The statistical observations used by the assessment do not all refer to the same year; Table 20 therefore reports them as approximate latest-available indicators rather than as a single-year administrative inventory. The public primary network operates on the order of 48,700 classrooms in the statistical series used by the model [45]. A national inventory of mechanically cooled classrooms is not available. The analysis therefore treats present-day school cooling as a low-adoption scenario rather than asserting a measured national penetration rate.

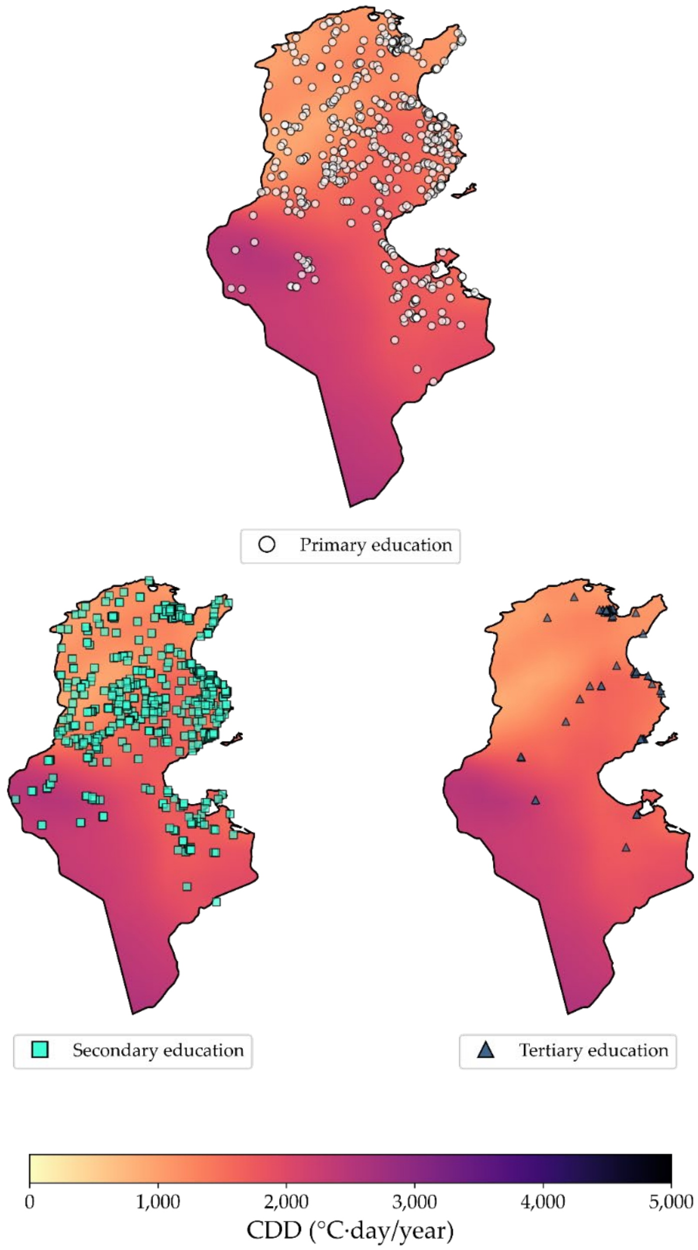
The headline indicators are summarized in Table 20.

Table 20 – Tunisia: education sector key indicators

Indicator	Value	Source
Primary (basic, first cycle) enrollment - latest available observation	≈ 1.34 M	[44]
Lower- and upper-secondary enrollment - latest available observation	≈ 1.05 M	[44]
Tertiary (higher-education) enrollment - latest available observation	≈ 0.31 M	[44]
Primary classrooms (public; statistical year used in the model)	≈ 48,700	[45]
Primary pupil–teacher ratio	≈ 17	[44][45]
Classroom mechanical cooling	No national inventory; low adoption assumed for screening	Assessment assumption; no measured national AC-penetration dataset
Basic infrastructure (electricity)	Near-universal; the deficit concerns thermal comfort, not electrification	[10]

A feature of the Tunisian calendar mitigates the exposure: the school year runs from September to June and the two hottest months, July and August, fall in the long summer break, so classrooms are largely unoccupied during the annual peak in cooling-degree-days. Heat stress is concentrated instead in the shoulder-hot months of June and September, and in early-autumn and late-spring heat waves, when occupancy and high outdoor temperatures coincide. The geographic distribution of schools against thermal stress is shown in Figure 9.

Figure 9 – Tunisia: education facilities location vs cooling-degree-days (18 °C) distribution



The thermal problem

Classrooms can experience pronounced overheating during the warm parts of the school year. The screening model assumes high occupant density, limited external shading and relatively weak envelope performance; these conditions increase indoor heat gains, but their national prevalence has not been measured [24][38]. A national inventory of mechanically cooled classrooms is not available, so the prevalence of natural ventilation in the public estate is treated here as a modeling assumption rather than an observed national statistic.

International evidence shows that exposure to hot school days can reduce learning rates and worsen educational inequality; the magnitude and adaptation response remain context-specific [47]. National climate projections indicate an increase in mean annual temperature of approximately 1.6-1.9 °C by 2050, depending on scenario, increasing the need for heat-resilient school design [7].

Market trajectory

Where mechanical cooling is installed in schools and higher-education buildings, split air-conditioners are used as the representative technology in the model, consistent with the structure of the wider Tunisian room-AC market [9].

Indicative efficiency benchmarks for the relevant equipment classes are given in Table 21.

Table 21 – Tunisia: education cooling technology benchmarks (indicative)

Technology	EER [W/W]	Notes
Modern inverter split	3.5 – 4.5	Indicative EER range; the cited field study found inverter units using 34-68% less energy than fixed-speed units in mixed-mode buildings outside Tunisia [9][46]
Conventional split (on/off)	2.6 – 3.0	Common in lowest-price procurement [9]
Ceiling fans	n/a	Low-energy air movement and comfort measure; not a refrigeration load [38][46]
Evaporative cooler	n/a	Effective in the dry interior; limited in humid coastal air [48][49]

Demand for classroom cooling is likely to rise as warming intensifies and as comfort expectations converge with regional norms. The procurement model will shape the outcome: tenders awarded on lowest purchase price tend to select on/off units, locking in low efficiency and high-GWP refrigerants for the full service life of the equipment, so efficiency and refrigerant criteria in procurement design are a decisive lever. In the Tunisian climate, however, and given the summer-break calendar, the first response is passive rather than mechanical.

Demand estimation methodology

Cooling energy demand is estimated with a bottom-up screening model that distinguishes school classrooms using split systems from tertiary facilities with centralized plant. Classroom peak load is represented as $Q = U_{eq} \cdot A_{env} \cdot \Delta T + Q_{solar} + Q_{occupants} + Q_{ventilation} + Q_{lighting/equipment}$. The representative classroom has 50 m² floor area, 3.2 m height, 90 m² of exposed envelope and 8 m² of glazing. These geometry and envelope inputs are explicit screening assumptions, not measurements of a nationally representative school sample. Outdoor conditions are selected from the ANME/INM climate-design framework, while the outdoor-air component follows the ASHRAE 62.1 classroom basis of 5 L/s per person plus 0.6 L/s per m² [5][50].

The resulting plant sizes by level are reported in Table 23, and the design parameters in Table 22.

Table 22 – Tunisia: assumed design parameters for an education plant

Parameter	Value	Reference
Ventilation rate	5 L/s-person + 0.6 L/s-m² (≈ 6.1–6.2 L/s-person for the model classrooms)	ASHRAE 62.1 classroom basis [50]
Indoor set-point temperature	26 °C	Design assumption (warm-climate comfort)

Parameter	Value	Reference
Outdoor design temperature	37–40 °C central model range; station-specific in design	ANME/INM design-climate framework [5]
Equivalent whole-envelope heat-transfer coefficient	4 W/m²K (sensitivity: 2.5–5.0 W/m²K)	Equivalent UA/A screening assumption; not a measured national average
Average split system COP	3.1	Central screening assumption informed by RAC inventory benchmarks [40]
School year / building hours	Official term spans September-June; 180 days x 8 h/day used in the model	Official calendar plus assessment assumptions [51]
Annual cooling hours	≈ 400 operating h/yr (sensitivity: 200–600 h/yr)	Assessment scenario informed by July-August closure [51]
Representative classroom geometry	50 m² floor area; 3.2 m height; 90 m² exposed envelope	Assessment assumption
Representative glazing area	8 m²	Assessment assumption

Table 23 – Tunisia: classroom characteristics (from the classroom thermal model)

Level	Occupants per classroom [45]	Total thermal load [kWth]	Electrical plant size [kWel]
Primary	25	≈ 10.9	≈ 3.5
Secondary	28	≈ 12.4	≈ 4.0

Annual cooling hours are the critical climate and calendar parameter. The official 2025-2026 calendar places the school term between September and June, with July and August outside term [51]. The model uses 180 teaching days and eight building-hours per day as explicit assessment assumptions, rather than as figures taken directly from the calendar. The central scenario uses 400 operating hours during the warmer parts of term and a 0.7 part-load factor, equivalent to 280 full-load hours. Because neither value is a measured national average, results should be scaled using the stated 200-600 operating-hour sensitivity range and site-specific operating schedules.

Mechanical cooling in schools is not systematically tracked, and no nationally representative survey supports a current penetration estimate. Table 24 therefore uses 3%, 8% and 15% solely as illustrative low, central and high adoption cases. The 8% central case is not a measured baseline and is not derived from private-school enrollment. The full air-conditioning scenario remains an upper-bound mechanical-response case, not a demand forecast or recommended policy pathway.

Table 24 – Tunisia: assumed cooling adoption and utilization scenarios

Scenario	Classroom AC adoption	Annual cooling hours	Interpretation
Illustrative central adoption scenario	8% central assumption (sensitivity: 3-15%)	≈ 400 h/yr	Scenario assumption, not observed AC penetration

Scenario	Classroom AC adoption	Annual cooling hours	Interpretation
Full classroom air-conditioning (upper bound)	100%	≈ 400 h/yr	Upper-bound mechanical-response scenario; not a forecast

Given these figures, the annual energy consumption can be estimated as:

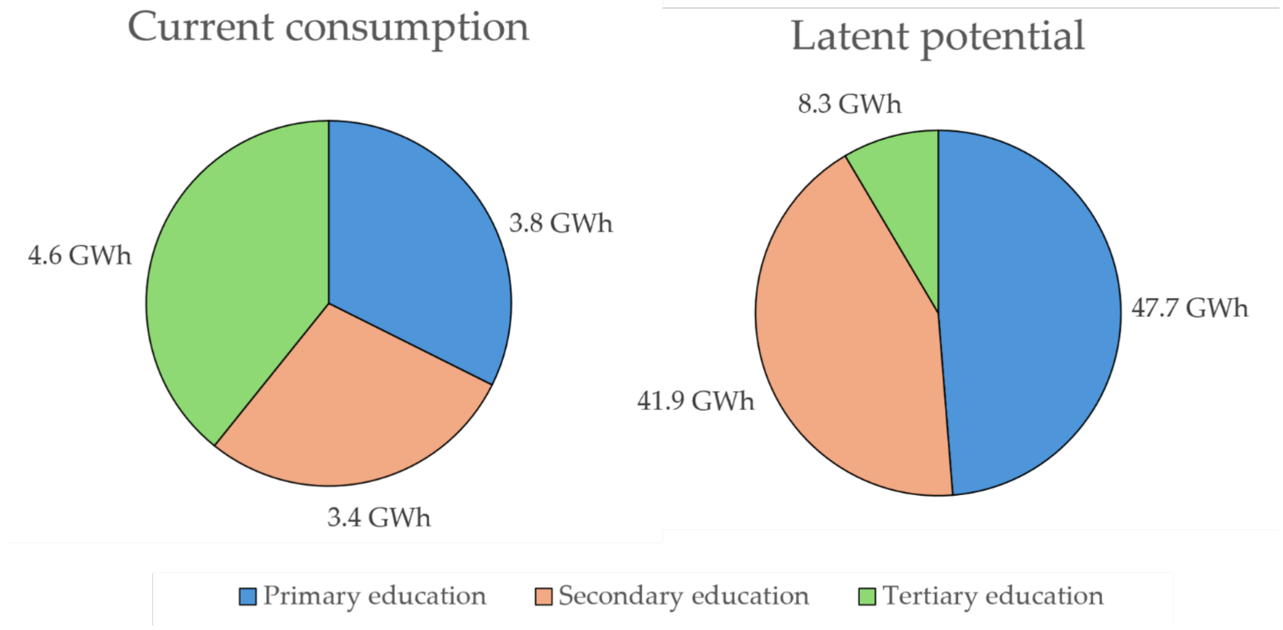
Energy [GWh] = No. classrooms × adoption rate × electrical plant size [kWel] × annual cooling hours [h] × load factor

where the load factor (0.7) reflects compressor cycling below nameplate output during operating hours.

Tertiary education is treated separately since measured 2017 electricity data for the higher-education estate are available as an internal project dataset [52], rather than estimated from floor area or enrollment.

The resulting cooling-energy distribution by education subsector is presented in Figure 10 for both scenarios, current adoption and latent demand.

Figure 10 – Tunisia: cooling energy demand by education subsector



Under the illustrative 8% central adoption case, education cooling electricity is on the order of 12 GWh per year, with the greater part in higher education because measured tertiary-estate data are included. The full classroom air-conditioning case is far larger, at about 97.7 GWh per year, equivalent to about 0.5% of national electricity generation [10]. The implied average of about 1,040 kWh per air-conditioned classroom per year is consistent with a single split unit operating during the limited Tunisian cooling season within the school year. The gap between the cases illustrates latent service demand, but it should not be interpreted as a forecast of future equipment adoption.

Emissions estimation

Total emissions are the sum of indirect electricity emissions and direct refrigerant leakage. Indirect emissions apply the national screening-level average grid factor [21]. Direct emissions use 0.27 kg/kWth and a 10% annual service emission factor for split/VRF systems, and 0.137 kg/kWth with 22% for centralized tertiary plant [40]. Because no national school-equipment bank is available, the central existing-stock scenario uses R-410A, which dominates reported residential AC use in the KIP data, and Table 25 also shows the GWP alternatives that applicants should assess [14]. Direct-emission results are therefore scenario values, not a measured inventory.

Table 25 – Tunisia: split-system refrigerant adoption share (indicative, KIP-informed [14])

Baseline scenario	Representative refrigerant	GWP (AR4)
Legacy existing-stock baseline	R-410A	2,088 [14]
Transitional alternative	R-32	675 [14]
Very-low-GWP alternative	R-290, where safety limits permit	3 [53]

The resulting emissions are summarized in Table 26. Under the illustrative 8% central adoption case, cooling emissions are approximately 12.7 ktCO2eq/yr. Under full classroom air-conditioning they reach approximately 104.5 ktCO2eq/yr in the R-410A legacy baseline, comprising about 45.8 kt of electricity emissions, 55.9 kt of school-refrigerant emissions and 2.8 kt from tertiary plant. Replacing R-410A with R-32 would reduce the school direct-emission component by about two-thirds, while very-low-GWP refrigerants would reduce it almost entirely, subject to safety and charge-limit requirements.

Table 26 – Tunisia: education cooling emissions summary

Emission component	Illustrative central scenario [kt/yr]	Full air-conditioning [kt/yr]
Indirect electricity emissions	≈ 5.5	≈ 45.8
Direct leakage, schools (R-410A legacy baseline)	≈ 4.4	≈ 55.9
Direct, refrigerant leakage (tertiary)	≈ 2.8	≈ 2.8
Total estimated emissions	≈ 12.7	≈ 104.5

The resulting energy-consumption and emissions estimates for both scenarios are summarized in Table 27.

Table 27 – Tunisia: education cooling demand and emissions by scenario

Scenario	Cooling consumption [GWh/yr]	Total emissions [ktCO₂eq/yr]
Illustrative central scenario (8% assumed classroom adoption + measured tertiary)	≈ 12	≈ 13 (R-410A legacy baseline)
Full classroom air-conditioning (upper-bound mechanical scenario)	≈ 98	≈ 105 (R-410A legacy baseline)

Intervention logic

Because most heat stress falls in the shoulder months and the peak-summer weeks are outside term, Tunisia's school estate is unusually well suited to a passive-first response, meaning that the priority across the network is to reduce the load before considering mechanical cooling. Reflective or insulated roofing to cut transmission gains through lightweight roofs, external shading of glazing, cross-ventilation and ceiling fans, and vegetation in school grounds are all valuable solutions. These measures cost a fraction of mechanical cooling per degree of indoor temperature reduction, remain effective during outages, and their investment case rests on learning outcomes and resilience rather than on energy savings. They also align with the regressive geography of the deficit, since the hottest interior and rural schools have the poorest fabric.

For the smaller segment of schools where passive measures are insufficient, the most exposed interior facilities and specialised higher-education spaces, efficient mechanical cooling is the second step. Fitting applications include inverter split or VRF units meeting or exceeding minimum energy-performance standards, with low-GWP refrigerants such as R-32, procured on life-cycle cost and seasonal efficiency rather than purchase price, and maintained to limit refrigerant leakage. On-site solar generation is a natural complement, since Tunisia's high irradiation and the daytime coincidence of generation with the cooling peak make rooftop photovoltaics well matched to school loads. The sequencing matters: passive measures first, since they shrink the plant that every subsequent investment must serve; efficient equipment second; on-site generation third.

Quick summary

A quick summary of education-sector cooling in Tunisia is provided in Table 28.

Table 28 – Tunisia: education sector cooling quick summary

Dimension	Barriers	Enablers
Technology	Mechanical cooling in public schools is not systematically tracked and is assumed to be limited; lowest-price tenders may entrench on/off splits	Passive envelope measures; inverter splits and VRF; R-32 transition; evaporative cooling in the dry interior [14][38]
Economics & procurement	Constrained education budgets; awards on purchase price ignore life-cycle cost	Life-cycle and efficiency criteria in tenders; aggregated purchasing; development finance
Regulation & data	No national classroom-AC inventory or systematically tracked thermal-comfort dataset; the NCAP is under preparation [1]	MEPS and labeling in force; school-level monitoring and alignment with the emerging NCAP [14][1]
Heat exposure during term and future warming	Overheating risk is concentrated in warm shoulder months; projected warming increases future load [7][51]	Peak-heat months (July–August) fall outside term, favoring passive solutions and limiting cooling hours [51]
Envelope and resilience assumptions	Weak envelope performance and limited shading are model assumptions requiring site verification [24][38]	Reflective roofing, shading and ceiling fans; rooftop PV matched to the cooling peak [4]

Food Cold Chain

Structure: an ambient-dominated export trade and a fragmented domestic chain

Tunisia's food cold chain has a distinctive profile. Olive oil is the country's leading agri-food export and is stored and transported mainly at ambient temperature, so it creates little refrigeration demand [54]. The refrigerated export segment is smaller and includes dates, fish and seafood, citrus and other fresh produce [54][55][56]. Alongside it is a domestic chain for fruit, vegetables, dairy, fish and meat that reaches consumers mainly by road through wholesale markets and retail. FAO programmes in Tunisia have identified cold-chain and food-loss reduction opportunities in horticultural value chains, including potatoes and tomatoes [57].

A 2016 industry survey reported approximately 784 cold stores and more than 10,000 temperature-controlled vehicles, with only about 40% of the latter described as insulated [58]. These figures are retained solely as a historical baseline and must not be read as a current national inventory; project preparation should verify the present fleet and capacity.

The export, industrial and domestic segments are contrasted in Table 29.

Table 29 – Tunisia: export/logistics vs domestic cold chain

Dimension	Export / maritime segment	Domestic segment
Maturity	Small by tonnage; the largest export (olive oil) is ambient, not refrigerated	Fragmented; high losses at farm and retail; cold storage sparse for horticulture
Key products	Dates, fish and seafood, citrus and fresh produce [54][55][56]	Fruit, vegetables, dairy, fish, meat and retail-ready food
Logistics	Ports, reefer containers and refrigerated road transport	Road-dominated distribution through wholesale markets, small cold rooms and retail
Post-harvest losses	Handling and dwell-time risks; route-specific data required	Material but incompletely measured; FAO programmes identify priority value chains, but no comprehensive public national baseline was identified [57][59]
Refrigerants	HFCs remain in transport equipment; lower-GWP transition requires equipment-bank and servicing data [14]	Refrigerant choice varies by plant size and application; ammonia, CO_2 and hydrocarbons require safety and O&M capability [14]

Under the full-processing assumptions used below, chilling, freezing and cold storage at meat, poultry and fish processors form the largest modeled electricity stream. This is an addressable-demand scenario, not evidence that every tonne currently passes through an industrial refrigerated process. The domestic distribution chain remains the main development gap: fragmented aggregation, limited temperature control and post-harvest losses create a climate and food-security case for targeted cold-chain investment.

Export and domestic cold-chain vulnerabilities

Several infrastructure constraints introduce systematic cold-chain risks that individual operators cannot resolve alone. The principal vulnerabilities, their impact on cargo integrity and the recommended interventions are identified in Table 30.

Table 30 – Tunisia: cold-chain infrastructure bottlenecks [58]

Bottleneck	Impact	Addressable solution
Limited and poorly documented cold-storage coverage for domestic horticulture [57]	High post-harvest losses; produce sold quickly or spoiled	Modular cold rooms and aggregation centres at production hubs
Ageing refrigerated road fleet (historical 2016 evidence) [58]	Temperature excursions in transit; product loss	Fleet renewal to ATP standard; insulation retrofit; telemetry [58]
Insufficient public data on reefer-plug and shore-power availability	Potential terminal bottlenecks and auxiliary-energy use	Verify terminal loads and provide metered reefer connections where justified
Fragmented smallholder supply and weak aggregation [57]	Small lots, inconsistent cold handling, capital constraints	Cooperative aggregation and cooling-as-a-service models
No comprehensive public national baseline for losses or current cold-store capacity identified	Poor basis for capacity planning	Food-loss measurement using FAO methods and a national cold-store/equipment registry [59][60]

Energy footprint of cold chain operations

Cold-chain operations generate an electricity load that is modest relative to national generation but potentially material for individual projects. Table 31 reports a defined screening boundary comprising (i) operational electricity under explicit coverage and processing assumptions and (ii) food-loss-associated emissions. Direct refrigerant leakage is not included in the country total because a Tunisia-specific equipment bank, refrigerant charge and servicing dataset is unavailable. For internationally circulating maritime reefers, allocating annual leakage solely to cargo handled in Tunisia could double count emissions attributed by the container owner, operator or servicing jurisdiction; IPCC methods require an attributable equipment bank [60]. This rationale does not apply to stationary cold stores, processing plants or domestic refrigerated vehicles, whose direct emissions are attributable to Tunisia but remain unquantified because of the data gap. Every project proposal should therefore report energy use, refrigerant type and charge, annual leakage, recovery and end-of-life emissions over the project life.

Table 31 – Tunisia: food cold chain estimated energy demand and GHG footprint

Segment	Modeled electricity / impact	Notes
Domestic cold storage: full-throughput addressable case	Up to ≈ 27.1 GWh/yr	Illustrative inventory-equivalent calculation: 5.0 Mt/yr x 100% coverage x 12/365 x 165 kWh/t-yr; denominator comparability is limited and project sizing requires operator data [61]
Export pre-shipment storage: full-throughput case	Up to ≈ 2.1 GWh/yr	Illustrative inventory-equivalent calculation: 0.23 Mt/yr x 100% coverage x 20/365 x 165 kWh/t-yr [61]
Maritime reefers: in-country operating scenario	≈ 7.5 GWh/yr	230,000 t/yr ÷ 12 t/TEU × 2.7 kW/TEU × 144 h; load and in-country hours are logistics assumptions [62]
Industrial process refrigeration: full-processing case	Up to ≈ 42 GWh/yr	Meat ≈ 26.1 GWh and fish ≈ 15.9 GWh, each assuming 100% of stated production passes through the benchmark process [56][63][64][65]
Total addressable electricity under stated full-coverage assumptions	Up to ≈ 78.6 GWh/yr	≈ 0.40% of 2023 national generation; not a measured current national consumption [10]
Spoilage (food-waste) emissions	≈ 0.84 Mt CO_2eq/yr	≈ 1.26 Mt lost × 0.67 tCO_2eq/t; loss rate and emissions factor are screening assumptions with sensitivity [59][66]
Separate screening indicators (not an inventory total)	Electricity: ≈ 0.0368 Mt CO2eq/yr; food-loss proxy: ≈ 0.84 Mt CO2eq/yr	Report separately because the indicators have different boundaries and meanings; stationary refrigerant leakage and road fuel are not quantified [60]

The cold-chain electricity estimate is built from four transparent streams: maritime reefers serving exports, export pre-shipment storage, domestic perishable storage and industrial refrigeration in the meat and fish sectors. It should be interpreted as addressable demand under the stated coverage and processing assumptions, not as metered current national consumption. For storage, the general equation is $E = Q \times s_{cold} \times d/365 \times SEC$, where s_{cold} is the share of throughput actually entering refrigerated storage. For industrial processing, $E = Q \times s_{process} \times SEC \times$ refrigeration share. Because reliable national values for s_{cold} and $s_{process}$ are unavailable, Table 31 reports the 100% upper-bound cases and requires project appraisal to replace them with operator data.

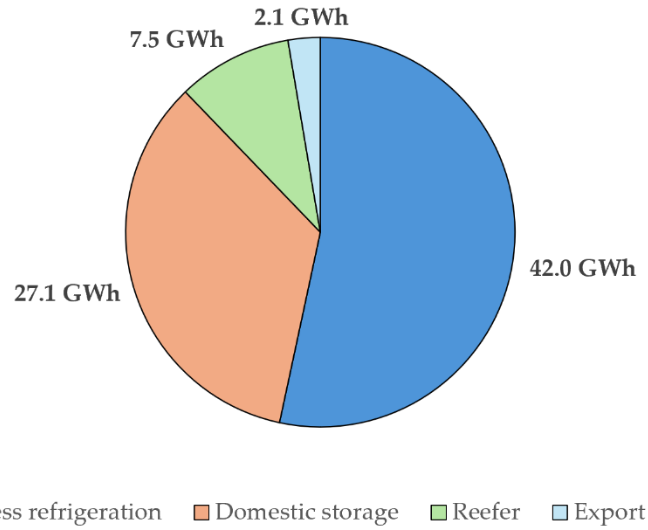
Maritime reefer demand starts from an indicative refrigerated-export flow of about 230,000 tonnes per year, assembled from the principal date, fish, citrus and fresh-produce streams [54][55][56]. The calculation converts this flow at 12 tonnes per TEU and applies 2.7 kW/TEU for 144 refrigerated hours attributed to Tunisia: 230,000/12 x 2.7 x 144 ≈ 7.45 GWh/yr. The 2.7 kW/TEU value is the mean reported by a peer-reviewed analysis of integral refrigerated containers, while the 12 t/TEU load and 144-hour allocation are explicit logistics assumptions [62]. The cited study reports variability of approximately +/-60% around the mean; applying that range to the same activity assumptions gives roughly 3.0-11.9 GWh/yr. Only electricity supplied within Tunisia should be attributed to the Tunisian grid; shipboard and foreign-terminal energy require separate allocation.

Cold-storage electricity is calculated through an illustrative inventory-equivalent method rather than from metered facilities. For domestic perishables, the upper-bound equation is 5.0 Mt/yr x s_cold x 12/365 x 165 kWh/t-yr; setting s_cold = 100% gives 27.1 GWh/yr. For exports, 0.23 Mt/yr x s_cold x 20/365 x 165 gives 2.1 GWh/yr at full coverage. The central benchmark lies within the wide range reported for refrigerated stores, including 85-512 kWh per tonne of processed product per year for fruit and berry facilities [61]. However, published studies use different denominators - nominal capacity, average inventory or annual processed throughput - and the 165 kWh/t-yr value cannot be treated as a universally transferable tonne-year factor. The estimate is therefore retained only for national screening. Project analysis should derive demand from measured storage volume or capacity, average inventory, product temperature, temperature lift, equipment efficiency and operating hours. A 100-250 kWh/t-yr sensitivity produces 18-44 GWh/yr for the two streams at full coverage; actual current consumption is lower in direct proportion to the share of product refrigerated. The 12- and 20-day dwell times are transparent assumptions to be replaced by operator records.

The 20% post-harvest loss rate is the most consequential assumption because food-loss-associated emissions dominate this illustrative comparison. It is below the global Food Loss Index estimate of approximately 25.4% for fruits and vegetables in 2023, but it is not a measured Tunisia-wide rate [67]. The sensitivity is linear: a 30% loss rate increases the spoilage term by 50%, a 35% rate by 75%, and a 40% rate doubles it relative to the 20% case. Project applications should measure baseline loss for the relevant commodity and value-chain stage using FAO-compatible methods [59].

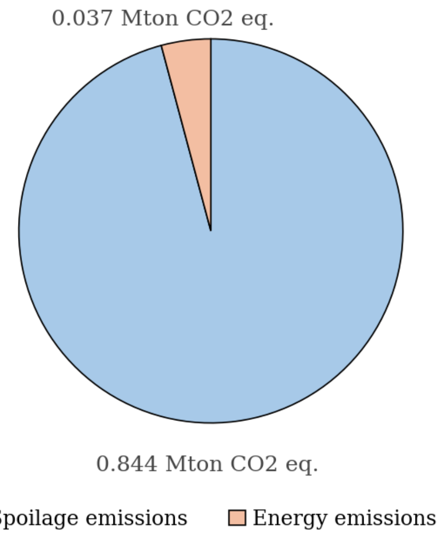
Industrial refrigeration is estimated separately for meat and fish. FAOSTAT data aggregated for the selected meat categories give approximately 0.35 Mt/yr, while official Tunisian fisheries statistics report 158.5 thousand tonnes of fish and aquaculture production in 2022 [63][56]. The meat upper-bound applies 149 kWh of total slaughterhouse electricity per tonne and allocates 50% to refrigeration, producing 26.1 GWh/yr. The 50% allocation is an explicit screening assumption: the cited BAT reference document identifies refrigeration as a material energy use but does not prescribe one universal share [64]. The fish upper-bound applies 100 kWh/t, the midpoint of the 70-130 kWh/t industrial-freezer range reported in the cited study, giving approximately 15.9 GWh/yr; the same study's measured whole-factory average is higher and should not be confused with the freezer benchmark [65]. Both values assume s_process = 100%; current demand scales with the actual industrial-processing share. Dairy, further-processed foods, retail refrigeration and road-fuel use remain outside the quantified boundary. Under the full-processing assumptions, the combined stream is approximately 42.0 GWh/yr and total addressable electricity is about 78.6 GWh/yr.

Figure 11 – Tunisia: addressable cold-chain electricity under the stated full-coverage assumptions



Electricity emissions and food-loss-associated emissions are reported as separate screening indicators and should not be combined into a national inventory total. The full-coverage electricity case of 78.6 GWh/yr produces about 0.0368 Mt CO2eq/yr at the adopted grid factor [21]. Applying the assessment factor of 0.67 tCO2eq per tonne lost to 1.26 Mt gives about 0.84 Mt CO2eq/yr. The factor is an assessment proxy informed by the IFC Food Loss GHG Tool methodology and lies within published cradle-to-retail fruit-footprint ranges; it is not a Tunisia-specific measured factor [66]. The two values have different analytical meanings: one is an operational electricity footprint and the other is an illustrative avoided-loss benefit. Neither demonstrates that all food losses are caused by inadequate refrigeration. Project appraisal must use commodity-, location- and stage-specific loss and GHG factors. Reducing the assumed loss rate from 20% to 9% would avoid about 0.46 Mt CO2eq/yr under the same factor; this remains an illustrative scenario.

Figure 12 - Tunisia: separate screening indicators for operational electricity and food-loss-associated emissions



Market drivers and projections

Several structural forces are converging to expand the addressable cold-chain market over the coming decade. The key drivers and their expected impact are summarized in Table 32.

Table 32 – Tunisia: food cold chain market drivers

Driver	Detail
Loss-reduction and food-security finance	FAO/EBRD work assesses cold-chain solutions and business cases for Tunisian potato and tomato value chains [57]
Export quality requirements	EU market access for dates, fish and produce raises cold-chain and traceability requirements [54][55][56]
Aquaculture growth	Growth in fisheries and aquaculture can increase chilled and frozen throughput; project-specific volumes require verification [56]
Urbanisation-led domestic demand	Demand for fresh, retail-ready and processed food expands refrigerated retail and distribution; no national demand projection is asserted
Climate adaptation	Projected warming of approximately +1.6 to +1.9 °C by 2050 can compress the harvest-to-spoilage window and widen the addressable market [7]

Barriers and technology priorities

The principal barriers constraining cold-chain development are identified in Table 33.

Table 33 – Tunisia: food cold chain investment barriers

Barrier	Detail
High post-harvest losses in the domestic chain	FAO work identifies cold-chain and food-loss opportunities in specific horticultural value chains; no comprehensive public Tunisia-wide baseline was identified in the sources reviewed [57][59]
Ageing refrigerated fleet (historical evidence)	The often-cited fleet figures date from a 2016 industry survey and require current verification [58]
Capital constraints at the smallholder end	Upfront capital and aggregation remain material constraints in smallholder-oriented cold-chain projects [57]
Refrigerant transition under Kigali	The Kigali Implementation Plan introduces HFC licensing, quotas and progressive reduction milestones, requiring compatible equipment and service capacity [14]
Weak data on losses and cold-store capacity	The absence of a comprehensive public current equipment bank and measured national loss baseline weakens capacity planning [59][60]

Technology and intervention priorities

The recommended technology and intervention priorities, organised by axis and target segment, are set out in Table 34.

Table 34 – Tunisia: cold chain technology and intervention priorities

Technology / intervention axis	Target segment	Key design requirements
Solar and hybrid modular cold rooms; cooperative aggregation; cooling-as-a-service	Domestic smallholder and horticulture	Hybrid/off-grid power where justified; low-GWP refrigerant; simple O&M; metering; output-linked financing; measured baseline losses
Fleet renewal and insulation; reefer telemetry; technician training on leak reduction	Refrigerated road transport	ATP-compatible insulated bodies; temperature monitoring; leak-tight maintenance; fuel and refrigerant reporting [58][60]

Technology / intervention axis	Target segment	Key design requirements
Natural refrigerants in industrial plants; shore power and reefer plugs at ports	Meat/fish processing and export	Application-specific ammonia/CO2/HFO solutions; safety assessment; heat recovery; leak detection and end-of-life recovery [14]
Food-loss monitoring and a cold-store registry	Sector governance and policy	FAO-compatible loss measurement, equipment-bank registry, submetering and refrigerant records [59][60]

Quick summary

To conclude, a quick summary of the food cold chain sector in Tunisia is provided in Table 35.

Table 35 – Tunisia: food cold chain quick summary

Dimension	Barriers	Enablers
Market structure and food loss	Material but incompletely measured horticultural losses; food-loss-associated emissions dominate the selected screening boundary [57][59][66]	Measured loss reduction as a first-order project outcome; FAO/EBRD cold-chain business cases [57]
Energy & refrigerants	Gas-heavy grid; incomplete stationary-equipment bank; HFC transition under Kigali [10][14]	Up to ≈ 78.6 GWh/yr addressable demand under full-coverage assumptions; solar potential and low-GWP options
Logistics & infrastructure	Historical evidence of fleet and insulation gaps; current condition requires verification [58]	Fleet renewal to ATP standard; modular and solar cold rooms; reefer-plug provision [58]
Financing & affordability	Upfront capital for smallholder cold rooms; fragmented demand	Cooling-as-a-service, cooperative aggregation and development finance, subject to measured baselines [57]
Governance & data	No comprehensive public current food-loss baseline, cold-store registry or refrigeration equipment bank identified [59][60]	FAO-compatible monitoring, cold-store/equipment registry and coordinated cooling policy

References

[1] Agence Nationale pour la Maîtrise de l'Énergie (ANME). (2026, 24 March). Avis à manifestation d'intérêt: Assistance technique de la Tunisie pour la mise en place du Plan d'actions National du Froid (NCAP). https://anme.tn/fr/news/avis-manifestation-dinteret-assistance-technique-de-la-tunisie-pour-la-mise-en-place-du-plan

[2] International Monetary Fund. (2026). World Economic Outlook Database, April 2026: Tunisia country profile. https://www.imf.org/external/datamapper/profile/TUN

[3] World Bank. (2026). Tunisia country overview and World Development Indicators: sectoral value added and employment in agriculture; World Bank country and lending groups. https://www.worldbank.org/ext/en/country/tunisia; https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS?locations=TN; https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=TN; https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=TN; https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=TN; https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[4] World Bank. Climate Change Knowledge Portal: Tunisia - historical climate data. The cooling-degree-day values and maps in this report are assessment calculations from gridded historical data using an 18 °C base. https://climateknowledgeportal.worldbank.org/country/tunisia

[5] Agence Nationale pour la Maîtrise de l'Énergie (ANME) and Institut National de la Météorologie (INM). Données climatiques de base pour le dimensionnement des installations de chauffage et de refroidissement. https://anme.tn/fr/guide/donnes-climatiques-de-base-pour-le-dimensionnement-des-installations-de-chauffage-et-de

[6] United Nations, Department of Economic and Social Affairs, Population Division. (2024). World Population Prospects 2024, medium variant: Tunisia. https://population.un.org/wpp/

[7] Republic of Tunisia. (2023). Quatrième Communication Nationale à la Convention-cadre des Nations Unies sur les changements climatiques. https://unfccc.int/sites/default/files/resource/Tunisia-4th%20National%20Communication.pdf

[8] World Bank. Urban population (% of total population) - Tunisia. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=TN

[9] de la Rue du Can, S., Agarwal, S., Letschert, V., and Khalfallah, E. (2023). Tunisia Air-Conditioner Market Assessment. Lawrence Berkeley National Laboratory. https://eta-publications.lbl.gov/sites/default/files/ac_market_assess_tunisia_may_2023.pdf

[10] Société Tunisienne de l'Électricité et du Gaz (STEG). STEG en chiffres and Produire: 2023 electricity and electrification indicators. https://www.steg.com.tn/fr/steg-en-chiffres; https://www.steg.com.tn/fr/page/produire

[11] Republic of Tunisia. (2009). Arrêté du 21 avril 2009 relatif à l'étiquetage des appareils de climatisation individuelle de puissance frigorifique inférieure à 12 kW. Journal Officiel de la République Tunisienne, No. 32; as amended by the Arrêté du 23 mars 2023. https://rise.esmap.org/sites/default/files/library/tunisia/Energy%20Efficiency/Tunisia_Decision%20of%2021%20Avril%202009%20-%20Labelling%20air%20conditioners%20-%20%20FR.pdf

[12] Agence Nationale pour la Maîtrise de l'Énergie (ANME). Programme de certification énergétique des équipements électroménagers. https://anme.tn/fr/project/programme-de-certification-energetique-des-equipements-electromenagers

[13] United Nations Industrial Development Organization and Multilateral Fund for the Implementation of the Montreal Protocol. (2025). HCFC Phase-out Management Plan, Stage II, third tranche: Project proposal - Tunisia (UNEP/OzL.Pro/ExCom/97/80). https://downloads.unido.org/ot/40/04/40045874/1.Tunisia%20-%20HPMP%20Stage%20II%2C%20third%20tranche%20-%20project%20document.pdf

[14] United Nations Industrial Development Organization and Multilateral Fund for the Implementation of the Montreal Protocol. (2024). Kigali HFC Implementation Plan, Stage I, first tranche: Project proposal - Tunisia. https://downloads.unido.org/ot/34/69/34698146/2.%20Tunisia%20-%20KIP%2C%20first%20tranche%20-%20project%20document.pdf

[15] Ministry of Industry, Mines and Energy, Observatoire National de l'Énergie et des Mines. (2024). Rapport sur le bilan énergétique 2023, Version 2. https://www.energiemines.gov.tn/fileadmin/docs-u1/Bilan_National_de_l_Energie_2023.pdf

[16] Republic of Tunisia. (2026). Contribution Déterminée au niveau National de la Tunisie - CDN 3.0, version finale. https://unfccc.int/sites/default/files/2026-04/Document%20CDN3.0%20-version%20Finale.pdf

[17] Republic of Tunisia. (2022). Stratégie de développement neutre en carbone et résilient aux changements climatiques à l'horizon 2050. United Nations Framework Convention on Climate Change. https://unfccc.int/documents/620592

[18] Société Tunisienne de l'Électricité et du Gaz (STEG). Electricity supply, tariff schedules and grid-connection information. https://www.steg.com.tn/

[19] Direction Générale des Douanes, Tunisia. Origine des marchandises: EUR.1 et EUR-MED; official customs portal. https://www.douane.gov.tn/origine-des-marchandises/; https://www.douane.gov.tn/

[20] U.S. International Trade Administration. (2026). Tunisia - Import Requirements and Documentation; Tunisia - Trade Agreements. Country Commercial Guide. https://www.trade.gov/country-commercial-guides/tunisia-import-requirements-and-documentation; https://www.trade.gov/country-commercial-guides/tunisia-trade-agreements

[21] International Energy Agency. (2023). Emissions Factors 2023: electricity supplied from the grid, Tunisia. Screening value used in this assessment: 0.468 kgCO2eq/kWh. https://www.iea.org/data-and-statistics/data-product/emissions-factors-2023

[22] Institut National de la Normalisation et de la Propriété Industrielle (INNORPI). Official standards-body information. https://www.innorpi.tn/

[23] Centre Technique des Industries Mécaniques et Électriques (CETIME). Official testing and conformity-assessment information. https://www.cetime.ind.tn/

[24] Ministry of Industry, Mines and Energy and Agence Nationale pour la Maîtrise de l'Énergie. Building-sector energy-efficiency framework, thermal regulation and EcoBat programme. https://www.energiemines.gov.tn/fr/themes/energie/efficacite-energetique/projets-et-programmes/secteur-du-batiment-residentiel-et-tertiaire/

[25] Sustainable Energy for All. (2023). Chilling Prospects: Global Access to Cooling Gaps 2023 - risk profiles and income groups. Tunisia is not included in the published country list; the framework is used only as a contextual lens in this report. https://www.seforall.org/our-work/research-analysis/chilling-prospects-series/chilling-prospects-global-access-to-cooling-gaps-2023; https://www.seforall.org/chilling-prospects-access-to-cooling-gaps-2023/risk-profiles

[26] World Bank. (2023, 22 June). World Bank approves $268.4 million project linking Tunisia's energy grids with Europe. https://www.worldbank.org/en/news/press-release/2023/06/22/world-bank-approves-268-million-project-linking-tunisia-s-energy-grids-with-europe

[27] Green Cooling Initiative, GIZ Proklima. Tunisia country data: refrigeration and air-conditioning stock and emissions scenarios. https://www.green-cooling-initiative.org/country-data

[28] Republic of Tunisia. (2004). Loi n° 2004-72 du 2 août 2004 relative à la maîtrise de l'énergie. Journal Officiel de la République Tunisienne, No. 63, 2231-2234. https://www.anme.tn/sites/default/files/2024-09/loi_2004_72.pdf

[29] Agence Nationale pour la Maîtrise de l'Énergie (ANME). (2024). Réponses aux demandes d'éclaircissements - programme TEEP: application of the Arrêté du 23 mars 2023 and class-1 threshold EER > 3.38. https://anme.tn/sites/default/files/2024-10/reponses_aux_demandes_d_eclaircissements_dao_clim_juin_2024.pdf

[30] Ministry of Industry, Mines and Energy and Agence Nationale pour la Maîtrise de l'Énergie. Fonds de Transition Énergétique (FTE/FNME). https://www.energiemines.gov.tn/fr/themes/energie/efficacite-energetique/fonds-de-transition-energetique-fte/; https://www.anme.tn/index.php/fr/plateform/fonds-de-transition-energetique

[31] European Commission and International Trade Centre. Guide to Import and Export Procedures in Tunisia. https://api.tradehelpdesk.org/downloads/trd-proc-guides/import-export/788_en.pdf; Tunisian TradeNet. Trade procedures portal. https://www.tradenet.com.tn/; U.S. International Trade Administration. (2026). Tunisia Country Commercial Guide. https://www.trade.gov/country-commercial-guides/tunisia-import-requirements-and-documentation

[32] Conseil Tunisien d'Accréditation (TUNAC). Official information on accreditation of laboratories and conformity-assessment bodies. https://www.tunac.tn/

[33] Ministry of Health, Tunisia. Santé Tunisie en chiffres 2017: public-facility and hospital-bed inventory. Project source document; current facilities should be checked against the Ministry's Carte Sanitaire. https://santetunisie.rns.tn/fr/carte-sanitaire/structures-publiques-de-sante-en-tunisie

[34] Société Tunisienne de l'Électricité et du Gaz (STEG). (2017). Aggregated monthly electricity-consumption records and bed-normalized intensities for public and private hospitals. Unpublished project dataset; not a public facility-level inventory.

[35] World Bank and World Health Organization. Hospital beds (per 1,000 people) - Tunisia. https://data.worldbank.org/indicator/SH.MED.BEDS.ZS?locations=TN

[36] Italian Ministry of Health. Posti letto per struttura ospedaliera dal 2010 al 2019: open-data dataset, 2019 reference year. https://www.dati.salute.gov.it/it/dataset/posti-letto-struttura-ospedaliera-dal-2010-al-2019/

[37] Kimball, S., and González, P. (2022, 23 March). Keeping vaccines safe in Tunisia: Cold chain equipment for all in Tunisia. UNICEF Tunisia. https://www.unicef.org/tunisia/recits/keeping-vaccines-safe-tunisia

[38] ASHRAE. (2025). ASHRAE Handbook - Fundamentals, chapters on cooling-load calculations. ASHRAE. (2013). HVAC Design Manual for Hospitals and Clinics (2nd ed.). International Energy Agency. (2018). The Future of Cooling. https://www.iea.org/reports/the-future-of-cooling

[39] ANSI/ASHRAE/IES. (2019). Standard 90.1-2019: Energy Efficiency Standard for Sites and Buildings Except Low-Rise Residential Buildings. Air-Conditioning, Heating, and Refrigeration Institute. (2023). AHRI Standard 550/590 (I-P): Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle. https://www.ashrae.org/technical-resources/standards-and-guidelines; https://www.ahrinet.org/search-standards

[40] Papst, I. (2022). Greenhouse Gas Inventory for the Refrigeration and Air Conditioning Sector in Kenya. GIZ Proklima / Green Cooling Initiative, Tables 6 and 26. https://www.green-cooling-initiative.org/fileadmin/user_upload/2022_GIZ_GCI_Greenhouse_Gas_Inventory_RAC_Kenya.pdf

[41] World Health Organization, Regional Office for the Eastern Mediterranean. (2013). Health System Profile: Tunisia. https://applications.emro.who.int/docs/Country_profile_2013_EN_15402.pdf

[42] World Health Organization. Performance, Quality and Safety prequalification: E003 - refrigerators and freezers for vaccine storage. https://extranet.who.int/prequal/immunization-devices/e003-refrigerators-and-freezers

[43] Lloyd, J., Lydon, P., Ouhichi, R., and Zaffran, M. (2015). Reducing the loss of vaccines from accidental freezing in the cold chain: The experience of continuous temperature monitoring in Tunisia. Vaccine, 33(7), 902-907. https://doi.org/10.1016/j.vaccine.2014.10.080

[44] UNESCO Institute for Statistics. UIS Data Browser: Tunisia - enrollment by education level, teaching staff and pupil-teacher ratio, latest available observations used in the assessment. https://databrowser.uis.unesco.org/

[45] Institut National de la Statistique. (2026). Annuaire Statistique de la Tunisie 2019-2023, education tables. https://www.ins.tn/publication/annuaire-statistique-de-la-tunisie-2019-2023; https://www.ins.tn/sites/default/files-ftp3/files/publication/pdf/annuaire-2023avec%20lien.pdf

[46] Gokarakonda, S., van Treeck, C., Rawal, R., and Thomas, S. (2023). Energy performance of room air-conditioners and ceiling fans in mixed-mode buildings. Energies, 16(19), 6807. https://doi.org/10.3390/en16196807

[47] Park, R. J., Behrer, A. P., and Goodman, J. (2021). Learning is inhibited by heat exposure, both internationally and within the United States. Nature Human Behaviour, 5, 19-27. https://doi.org/10.1038/s41562-020-00959-9

[48] Ben Amara, M., Trabelsi, I., and Balghouthi, M. (2025). Implementing evaporative desiccant cooling in Tunisia: A climate-adapted approach for sustainable thermal comfort. Euro-Mediterranean Journal for Environmental Integration, 10, 321-336. https://doi.org/10.1007/s41207-024-00647-4

[49] Choubani, K., Almeshaal, M. A., Balghouthi, M., and Ben Rabha, M. (2023). Investigation of a solar-powered evaporative cooling system under Tunisian climate. Coatings, 13(11), 1901. https://doi.org/10.3390/coatings13111901

[50] ANSI/ASHRAE. (2022). Standard 62.1-2022: Ventilation and Acceptable Indoor Air Quality, Table 6-1 classroom outdoor-air rates. https://www.ashrae.org/technical-resources/standards-and-guidelines

[51] Ministry of Education, Tunisia. (2025). Ouverture et clôture de l'année scolaire 2025-2026 et calendrier des vacances scolaires. Official ministry publication. https://education.gov.tn/?lang=fr&page_id=14207

[52] Société Tunisienne de l'Électricité et du Gaz and Ministry of Higher Education. (2017). Consommation électrique, GN enseignement supérieur 2017. Unpublished project dataset containing aggregated higher-education energy-consumption data.

[53] Intergovernmental Panel on Climate Change. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report, Table 2.14. Cambridge University Press. https://www.ipcc.ch/report/ar4/wg1/

[54] U.S. International Trade Administration. (2024). Tunisia - Agricultural Sectors. Country Commercial Guide. https://www.trade.gov/country-commercial-guides/tunisia-agricultural-sectors

[55] World Bank, World Integrated Trade Solution, based on UN Comtrade. (2023). Tunisia exports of dates, fresh or dried (HS 080410), all partners. https://wits.worldbank.org/trade/comtrade/en/country/TUN/year/2023/tradeflow/Exports/partner/ALL/product/080410

[56] Observatoire National de l'Agriculture, based on Direction Générale de la Pêche et de l'Aquaculture data. La filière pêche et aquaculture en Tunisie: indicateurs clés, 2022 data. https://www.onagri.nat.tn/uploads/filieres/Fiche-peche-et-aquaculture-version-actualisee.pdf

[57] Food and Agriculture Organization of the United Nations and European Bank for Reconstruction and Development. Food Security Package SEMED - Improving market opportunities of domestic production; Cooling the chain, cutting the waste: Tunisia potato and tomato value chains. https://www.fao.org/energy/projects/project-details/fao-ebrd-food-security-package-semed---improving-market-opportunities-of-domestic-production/en

[58] International Institute of Refrigeration. (2017, 15 March). Tunisian cold chain status. Historical industry survey. https://iifiir.org/en/news/tunisian-cold-chain-status

[59] Food and Agriculture Organization of the United Nations. Technical Platform on the Measurement and Reduction of Food Loss and Waste: Tunisia country profile, projects and measurement resources. https://www.fao.org/platform-food-loss-waste/in-action/countries/country-profile/TUN/en/

[60] Intergovernmental Panel on Climate Change. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 7: Emissions of Fluorinated Substitutes for Ozone-Depleting Substances. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_7_Ch7_ODS_Substitutes.pdf

[61] Evans, J. A., Foster, A. M., Huet, J.-M., Reinholdt, L., Fikiin, K., Zilio, C., Houska, M., Landfeld, A., Bond, C., Scheurs, M., and van Sambeeck, T. W. M. (2014). Specific energy consumption values for various refrigerated food cold stores. Energy and Buildings, 74, 141-151. https://doi.org/10.1016/j.enbuild.2013.11.075; Indergård, E., Svendsen, E. S., and Köster, L. (2024). Industrial cold storage of fruit and berries - specific energy use and operational processes. 8th IIR International Conference on Sustainability and the Cold Chain. https://doi.org/10.18462/iir.iccc2024.1009

[62] Fitzgerald, W. B., Howitt, O. J. A., Smith, I. J., and Hume, A. (2011). Energy use of integral refrigerated containers in maritime transportation. Energy Policy, 39(4), 1885-1896. https://doi.org/10.1016/j.enpol.2010.12.015

[63] Food and Agriculture Organization of the United Nations. FAOSTAT: Crops and livestock products, Tunisia - production quantities for the selected meat categories aggregated in this assessment. https://www.fao.org/faostat/en/#data/QCL

[64] Nunes, J., da Silva, P. D., Andrade, L. P., Domingues, L., and Gaspar, P. D. (2016). Energy assessment of the Portuguese meat industry. Energy Efficiency, 9, 1163-1178. https://doi.org/10.1007/s12053-015-9414-7; European Commission, Joint Research Centre. (2024). Best Available Techniques Reference Document for the Slaughterhouses, Animal By-products and/or Edible Co-products Industries. https://publications.jrc.ec.europa.eu/repository/handle/JRC135916

[65] Terehovics, E., Soloha, R., Veidenbergs, I., and Blumberga, D. (2018). Analysis of fish refrigeration electricity consumption. Energy Procedia, 147, 649-653. https://doi.org/10.1016/j.egypro.2018.07.084

[66] International Finance Corporation and Global Agriculture and Food Security Program. (2023). Food Loss GHG Tool Methodology. https://www.gafspfund.org/sites/default/files/2023-10/Food%20Loss%20GHG%20Tool%20Methodology-2023.pdf; Subedi, S., Dent, B., and Adhikari, R. (2024). The carbon footprint of fruits: A systematic review from a life cycle

perspective. Sustainable Production and Consumption, 52, 12-28. https://doi.org/10.1016/j.spc.2024.10.014. The 0.67 tCO2eq/t value used in the report is an assessment scenario parameter, not a Tunisia-specific measured factor.

[67] Food and Agriculture Organization of the United Nations. SDG Indicator 12.3.1: Global Food Loss Index - fruits and vegetables, 2023. https://www.fao.org/sustainable-development-goals-data-portal/data/indicators/1231-global-food-losses/en