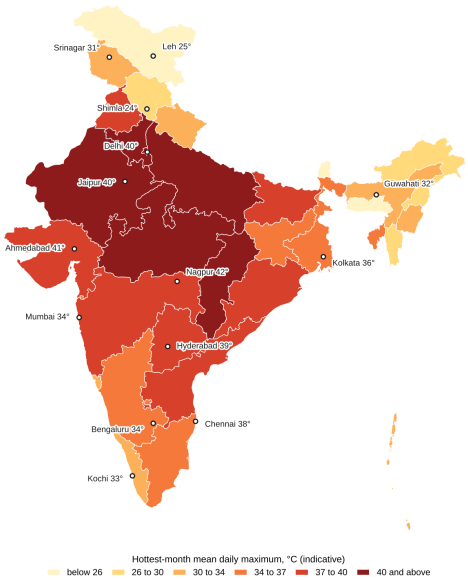
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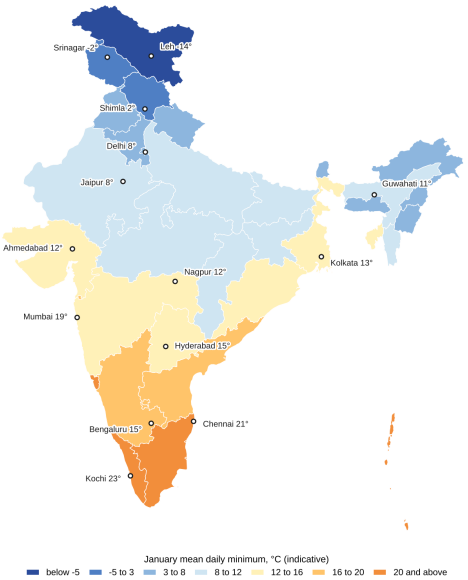
Heat, Cold and the Electric Vehicle

How regional temperatures shape efficiency, range and emissions across India

Includes temperature and air quality heat maps, energy use versus temperature data, and a regional playbook for riders and fleets.



Hottest-month afternoon highs



January early-morning lows

Free resource | November 2026

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About this report

This report looks at one question that every rider, fleet owner and manufacturer in India eventually asks: **what do heat and cold do to an electric vehicle?** India has some of the widest temperature differences of any large EV market, from sub-zero winter mornings in Ladakh to afternoon highs above 40 °C across the north and centre. It also has some of the world's most polluted urban air, which is where electrification can matter most.

All temperature, range and air quality figures are **indicative**. They are intended to show patterns, not to replace measured data. Please read **Method and data notes** before quoting any number.

Key findings

The headline findings below come from the regional data and an illustrative range model described later in the report.

1 **India's temperature spread is unusually wide.**

January early-morning lows run from about **-14 °C** in Ladakh to about **25 °C** in the islands, while hottest-month afternoons reach roughly **40 to 42 °C** across Rajasthan, Madhya Pradesh, Gujarat and Uttar Pradesh.

2 **Range is highest between about 15 and 35 °C.**

In our illustrative model an electric two-wheeler keeps about **85%** of its 25 °C range at 5 °C, about **79%** at 0 °C and about **65%** at -10 °C. In extreme heat it keeps about **94%** at 40 °C and about **90%** at 45 °C.

3 **For most Indians the effect is modest.**

Winter-morning range retained is about **89%** in Delhi, **96%** in Hyderabad and **100%** in Chennai. The cold-range effect is concentrated in the Himalayan belt, where it falls to about **76%** in Srinagar and **59%** in Leh on a typical January morning.

4 **Emissions stay lower even in the cold.**

Operational CO_2 is about **29 g per km** at 25 °C and about **34 g per km** at 5 °C for an electric two-wheeler, against about **51 g per km** for a petrol two-wheeler at 45 km per litre, assuming a grid factor of 0.75 kg CO_2 per kWh.

5 **The cold north is also the most polluted north.**

The northern plains pair cool winter mornings with the highest indicative PM2.5 levels in the country. This is where local air quality benefits of electric two-wheelers are largest, and where the cold-range penalty is manageable.

6 **Plan for the season, not the brochure.**

Plan range with a buffer, charge in shade in summer and indoors in winter, and use telematics to learn your own seasonal pattern.

1. Why temperature matters to an electric vehicle

An electric vehicle is a chemical device that happens to move. The battery, the motor and the controller each have a temperature range where they work best, and India regularly takes vehicles outside it in both directions.

The battery

Lithium-ion cells work by moving ions through an electrolyte. In the cold the electrolyte becomes more resistant, so less of the stored energy is available and the battery cannot deliver or accept power as freely. Battery management systems also limit charging current in the cold to protect the cells. In the heat, reactions speed up, which can help short-term performance but accelerates ageing, and the battery management system will reduce power to protect the pack if temperatures climb too high. Engineers call this **thermal derating**.

The motor and controller

Motors and controllers lose efficiency as they heat up and may reduce output if they overheat. A heavy load, steep gradients and high ambient heat together are the hardest case for a two-wheeler's drivetrain.

The vehicle and the road

In cold weather the air is denser, so aerodynamic drag rises, and tyres are stiffer, which raises rolling resistance. Both increase energy use per kilometre.

> **Why two-wheelers behave differently from cars**
>
> Heating and air conditioning are a large reason cars lose range in extreme weather. Electric two-wheelers have no cabin to heat or cool, so temperature effects come mainly from the battery, the drivetrain and the riding conditions. That is one reason the modelled range swings in this report are smaller than the figures often quoted for cars.

Battery chemistry matters

Lithium iron phosphate (LFP) and related chemistries such as LMFP are valued for thermal stability and cycle life, but they tend to lose more usable capacity and charge acceptance in the cold than nickel-based chemistries. Pack design, insulation, cell placement and battery management strategy can change the outcome considerably, which is why two vehicles with the same chemistry can behave differently in the same weather.

These are general engineering principles. Actual behaviour depends on the specific vehicle, so always check the manufacturer's guidance.

2. India's temperature landscape

India's climate is not one climate. A rider in Leh in January and a rider in Nagpur in May are facing different conditions. The two maps in this section show the heat side and the cold side.

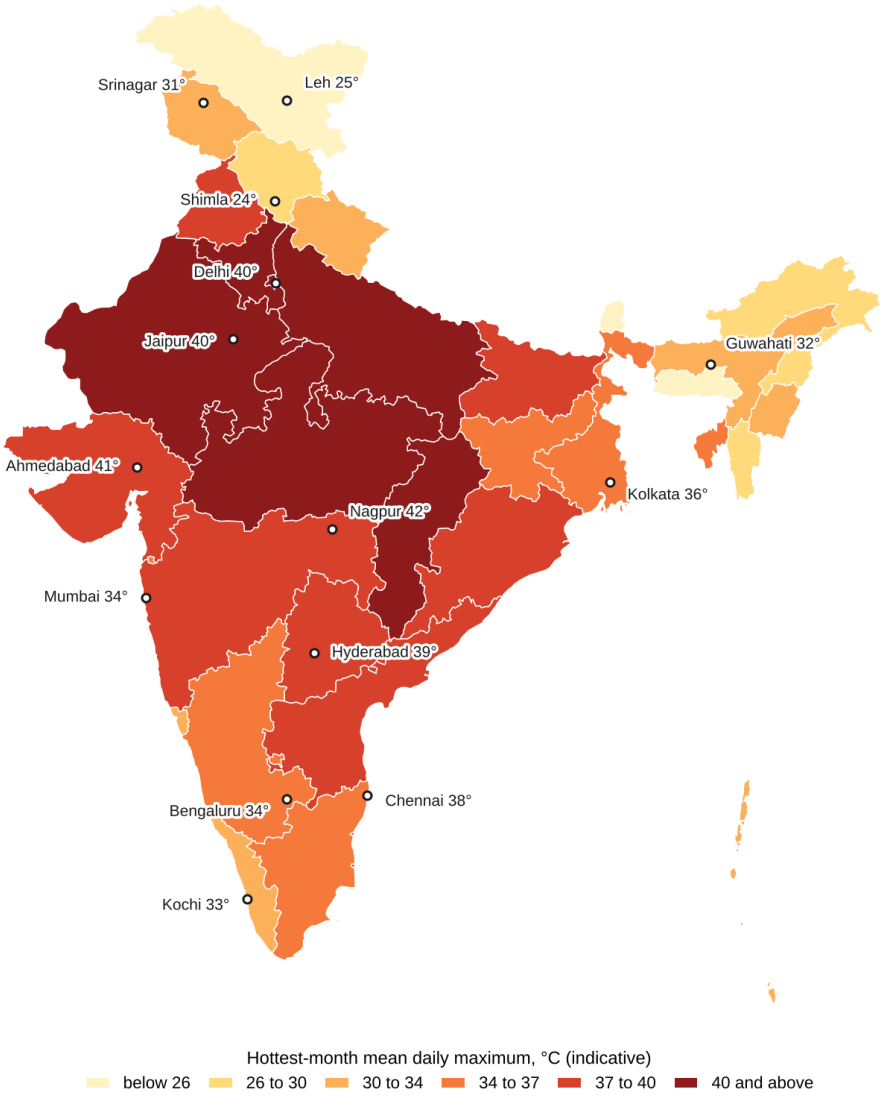


Figure 1. *Indicative hottest-month mean daily maximum temperature by state and union territory, with reference cities. Values are rounded and indicative.*

What the heat map shows. The hottest belt runs across Rajasthan, Madhya Pradesh, Gujarat, Chhattisgarh and Uttar Pradesh, where typical hottest-month afternoons sit around 40 °C and above. Coastal and southern states are milder because of the sea and monsoon influence, and the Himalayan states stay cool even in summer.

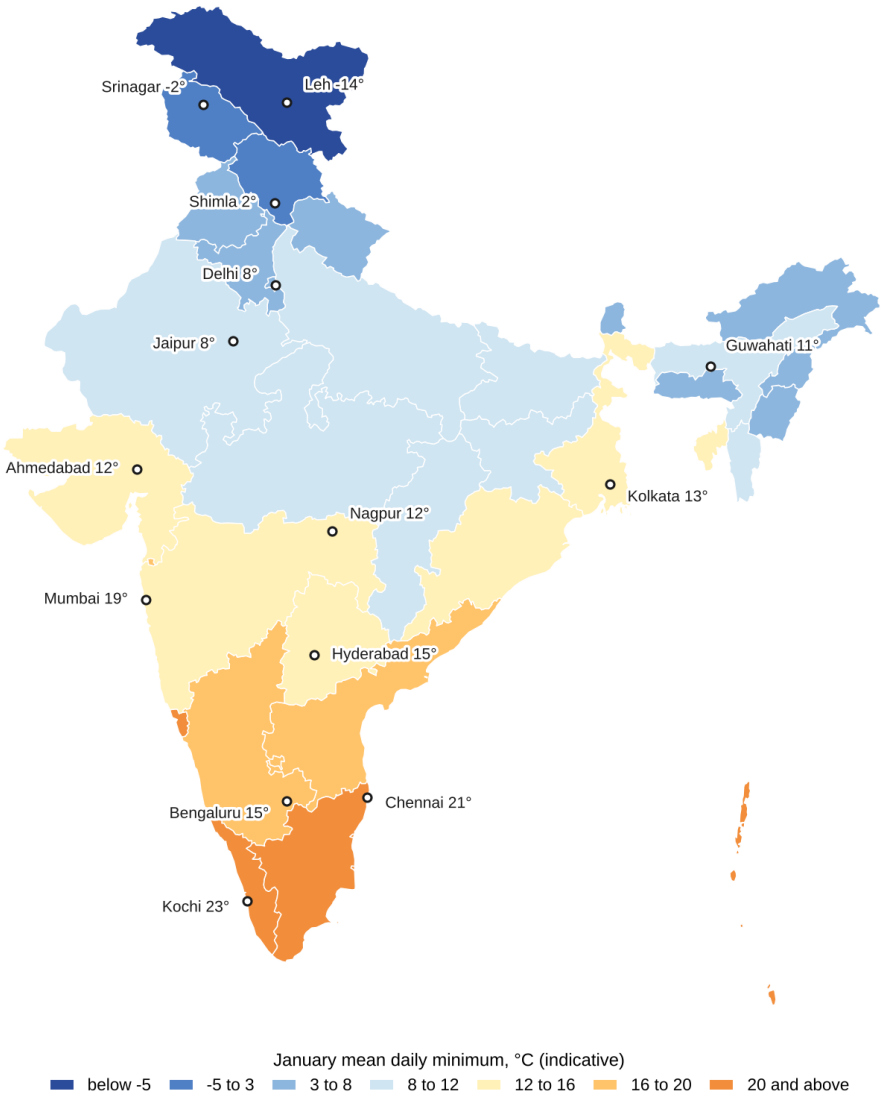


Figure 2. *Indicative January mean daily minimum temperature by state and union territory, with reference cities. Values are rounded and indicative.*

What the cold map shows. Most of peninsular India stays warm through winter. The northern plains see single-digit mornings, and the Himalayan belt, led by Ladakh, drops well below freezing.

Cold in India is mostly a morning problem

The map shows early-morning minimums. On a typical January day in the northern plains, the afternoon is far warmer than the dawn, so cold-weather effects are concentrated in early morning riding, in the hills and at altitude. This matters for riders who commute at first light and for fleets that start shifts early.

3. Temperature, efficiency and range

To make the effect concrete, we built a simple range model for a typical electric two-wheeler that uses 35 Wh per km at 25 °C. Figure 3 shows how range and energy use change with ambient temperature.

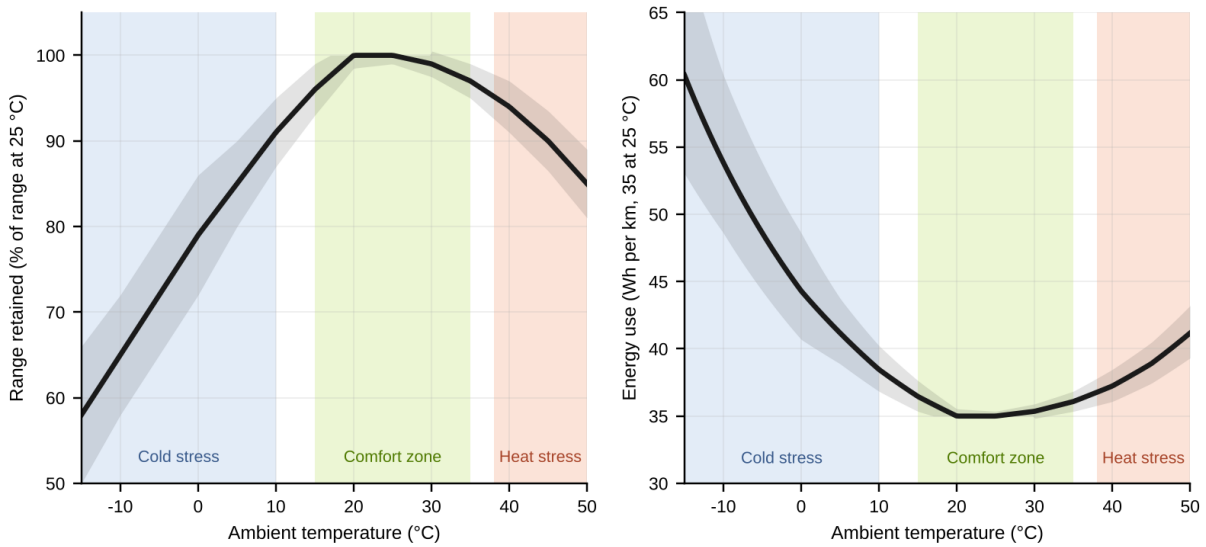


Figure 3. Illustrative range retained and energy use versus ambient temperature. The shaded band shows the plausible spread across chemistries and vehicle designs. This is an engineering model, not Gravton test data.

Ambient temperature	Range retained	Energy use (Wh per km)	Energy cost per km at ₹8 per kWh	Change vs 25 °C
-10 °C	65%	53.8	₹0.48	+54%
0 °C	79%	44.3	₹0.39	+27%
5 °C	85%	41.2	₹0.37	+18%
10 °C	91%	38.5	₹0.34	+10%
15 °C	96%	36.5	₹0.32	+4%
25 °C	100%	35.0	₹0.31	baseline
35 °C	97%	36.1	₹0.32	+3%
40 °C	94%	37.2	₹0.33	+6%
45 °C	90%	38.9	₹0.35	+11%

Energy cost assumes home electricity at ₹8 per kWh and 90% charging efficiency. Petrol at ₹115 per litre and 45 km per litre costs about ₹2.56 per km for comparison.

Reading the table. Even at 5 °C, energy use per kilometre rises by roughly one sixth, which adds only a few paise to the cost of each kilometre. The bigger practical effect is less range available on a cold morning, which matters most to riders who use most of the battery in a day.

Important: how to read the curve

- The curve shows the typical shape of how lithium-ion vehicles respond to temperature. It is an illustrative model built for this report and is not measured test data from any specific vehicle, including Gravton vehicles.
- Real behaviour varies with chemistry, pack insulation, battery management software, load, speed and how long the vehicle has been parked in the heat or cold.
- If you operate a fleet, the best curve is your own: log distance and battery use across seasons.

4. What this means region by region

Applying the curve to the temperatures in each part of India shows where the effect matters. Figure 4 compares estimated range retained on a typical winter morning and a typical hot-season afternoon for 14 reference cities.

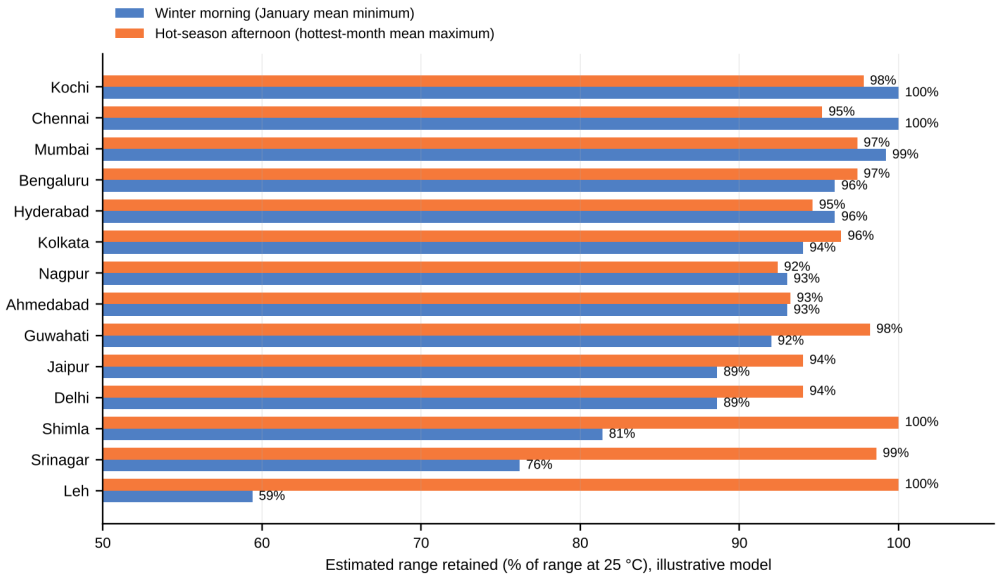


Figure 4. *Estimated range retained for reference cities, using indicative January minimum and hottest-month maximum temperatures and the illustrative model. Worst-case windows, not daily averages.*

Region	Winter morning: range retained	Hot afternoon: range retained	Main effect
Northern plains	about 86 to 90%	about 93 to 96%	Heat in summer, cold mornings in winter, and the highest pollution levels
Hot and dry west and centre	about 89 to 93%	about 93 to 94%	Prolonged peak heat; battery cooling and thermal derating matter most
Deccan and southern plateau	about 95 to 98%	about 94 to 96%	Warm all year; heat is the main stress in April and May
Coastal and humid tropics	about 89 to 100%	about 96 to 99%	Warm and humid all year; temperature has the smallest effect
Himalayan cold	about 59 to 84%	about 99 to 100%	Cold and altitude dominate; winter range and cold charging need planning
North-east hills	about 86 to 93%	about 97 to 100%	Mild temperatures with humidity and rain; gradients matter more than temperature

Ranges show the spread across the states in each group, using indicative state values and the illustrative model.

5. Emissions and air quality

Emissions have two sides for an electric vehicle. There are no tailpipe emissions, which is what improves the air people breathe in a city. And there are the emissions from generating the electricity it uses, which depend on the grid.

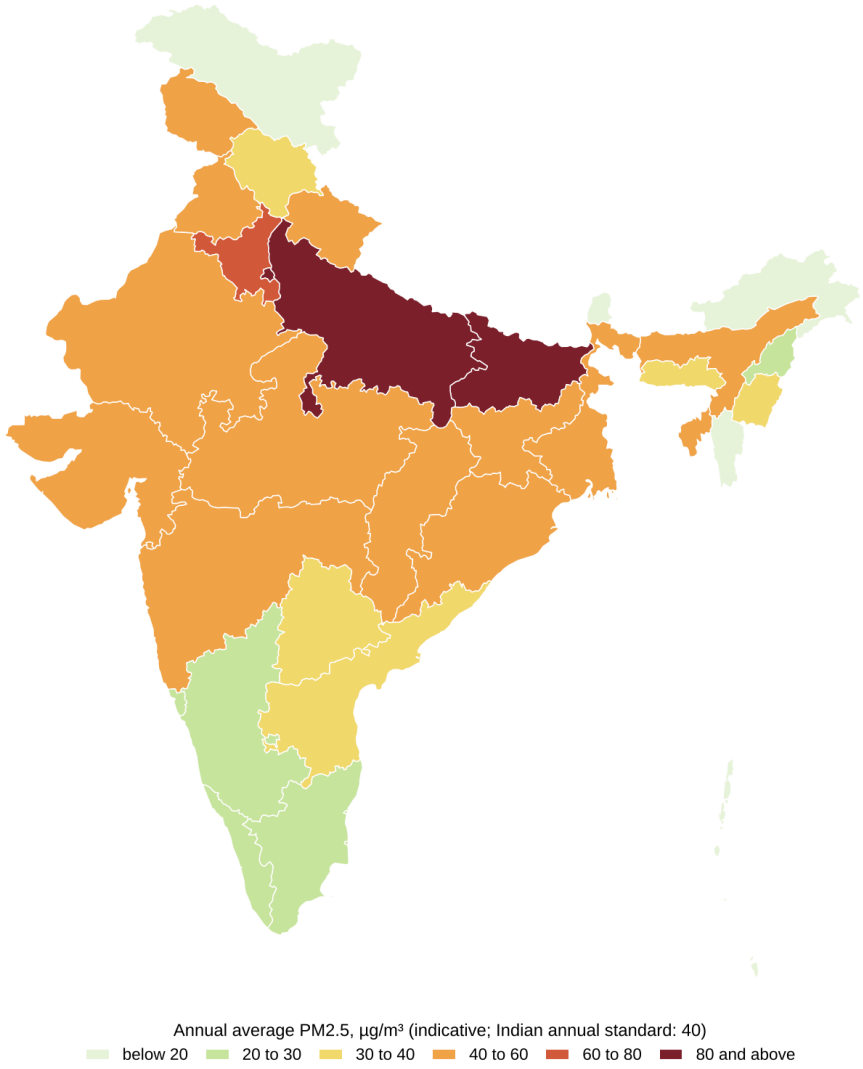


Figure 5. *Indicative annual average PM2.5 by state and union territory. This shows ambient air quality, which is the exposure that cleaner vehicles help reduce. It is not a vehicle emissions inventory.*

Where cleaner vehicles matter most. The Indo-Gangetic Plain, from Punjab and Haryana through Delhi, Uttar Pradesh and Bihar, carries the highest indicative PM2.5 levels. For comparison, the Indian annual standard for PM2.5 is 40 µg/m^3, and the World Health Organization's 2021 guideline is far lower at 5 µg/m^3. Peninsular and island regions generally sit lower. Two-wheelers are a very large share of vehicles on Indian roads, so replacing petrol two-wheelers with electric ones removes tailpipe emissions where people live and breathe.

Temperature and carbon emissions

Because an electric vehicle uses more energy per kilometre in the cold and the heat, its operational carbon emissions per kilometre also vary with temperature. Figure 6 compares an electric two-wheeler with a petrol two-wheeler across the temperature range.

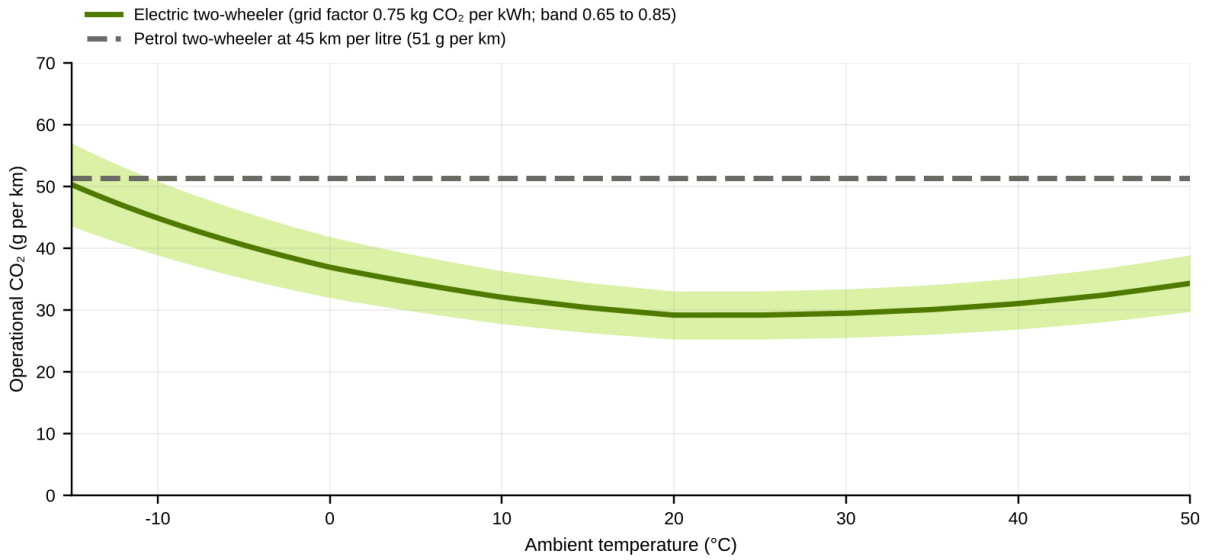


Figure 6. *Operational CO_2 per kilometre versus ambient temperature. Electric: illustrative model with a grid factor of 0.65 to 0.85 kg CO_2 per kWh (central 0.75) and 90% charging efficiency. Petrol: 2.31 kg CO_2 per litre at 45 km per litre. Operational emissions only.*

Reading the chart. At 25 °C the electric two-wheeler emits about 29 g of CO_2 per kilometre at the grid, against about 51 g for the petrol bike, a reduction of roughly 43%. At 5 °C the electric figure rises to about 34 g, still about 33% lower. Only in very cold conditions, with a coal-heavy grid, does the gap narrow. As the grid adds more renewable power, the electric line moves down and the gap widens.

What this chart leaves out

- Manufacturing emissions, including the battery, which add to an electric vehicle's lifecycle total.
- Regional differences in the grid mix, which can make some states cleaner than others.
- Differences in real-world petrol mileage, which also changes with temperature and traffic.

Use the grid factor published by the Central Electricity Authority for current figures.

6. A regional playbook

Grouping states by climate makes the guidance easier to apply. Figure 7 shows the six groups used in this report.



Figure 7. *Six climate groups used for the regional guidance. Groupings are simplified, and conditions vary within states, especially in hilly states.*

Region	What to expect	Riders	Fleets and manufacturers
Northern plains	Hot afternoons in summer, cold and foggy mornings in winter, and high pollution.	Charge in shade in summer. In winter, charge indoors and allow a warmer start. Expect less range on early mornings.	Plan shift starts around cold mornings, and plan cooling and derating for peak summer afternoons.
Hot and dry west and centre	Long stretches of extreme heat from April to June.	Park in shade, avoid charging a hot battery straight after a long ride, and keep a larger range buffer on hot afternoons.	Prioritise thermal management and test for derating under load.
Deccan and southern plateau	Warm all year, with a hot April and May and a monsoon season.	Use normal planning with a buffer, and be careful with water exposure and gradients.	Test sustained high-load performance in heat, and plan service around the monsoon.
Coastal and humid tropics	Warm and humid, with rain and salt air near the coast.	Temperature barely changes range. Protect connectors and charge in dry, shaded spots.	Focus on corrosion, water ingress and humidity as much as temperature.
Himalayan cold	Sub-zero winters, altitude and steep gradients.	Plan range with a large buffer. Store and charge the battery indoors. Charge before the battery gets cold, not after.	Insulated or heated packs, cold-charging limits and altitude testing matter most.
North-east hills	Mild temperatures, heavy rain and steep roads.	Gradients and wet roads affect range more than temperature. Allow for regen and brake carefully on wet slopes.	Prioritise waterproofing, braking and hill performance.

7. Practical guidance

For riders

- **In hot weather:** park in the shade, avoid fast charging a hot battery straight after a long ride, and let the battery cool before charging if the manufacturer advises it.
- **In cold weather:** charge indoors where possible, charge before the battery has cooled overnight, and expect a lower range on the first ride of the day.
- **All year:** keep tyre pressure correct, avoid unnecessary load, and use the manufacturer's charger on a properly earthed socket.
- **Plan a buffer:** plan with about 25% less than the claimed range, and more in the cold or with a heavy load.

For fleet owners

- Use telematics to compare energy use per kilometre across seasons, routes and drivers. Gravton's GOTAC platform, for example, includes battery analytics and reports.
- Schedule the longest or heaviest routes for the milder parts of the day.
- Plan swap or top-up points for cold-morning starts and hot-afternoon peaks.
- Track charging patterns, because charging a hot or cold battery is where avoidable wear happens.

Questions to ask a manufacturer

- What range retention does the vehicle show at 5 °C and at 40 °C?
- How does the battery management system handle charging in the cold and thermal derating in the heat?
- Is the battery pack insulated, and how is the pack cooled or heated, if at all?
- What does the warranty say about temperature extremes and commercial use?
- Can I test the vehicle on my own route in my own season?

Measure your own pattern

Record distance and battery percentage used on a regular route once a month through the year. Within a few months you will see your own seasonal curve, which is more useful than any general figure.

8. Looking ahead

Three developments are likely to reduce temperature effects over time. First, better thermal management and battery chemistries that perform better in the cold. Second, more connected-vehicle data, which will let manufacturers and fleets publish real seasonal curves for Indian conditions. Third, a cleaner grid, which lowers the operational emissions of every kilometre in every season.

Open, India-specific datasets on real-world range across seasons are still scarce. If you operate vehicles at scale, sharing anonymised seasonal data with researchers or industry groups would help every rider and fleet.

9. Gravton in conditions that vary

Gravton Motors designs and builds electric two-wheelers in Hyderabad, with in-house motors, controllers and batteries, including an LMFP battery. Gravton also developed GOTAC, an edge AI telematics platform with live tracking, geofencing, anti-theft, driver scoring, battery analytics and reporting.

The Gravton Quanta completed what the company describes as the first and only electric two-wheeler journey from Kanyakumari to Khardung La: **4,011.9 km across 11 states in 6.5 days, reaching about 18,000 ft**, using roughly ₹400 of electricity, according to the company. The route crossed the tropical south, the hot central plains and the cold high Himalaya, a good illustration of how varied Indian riding conditions are. This report does not draw conclusions about temperature effects from that ride, because no controlled temperature data is presented here.

10. Method and data notes

Please read before quoting any figure.

- **Temperature values** are rounded, indicative state-level and city-level figures for hottest-month mean daily maximum and January mean daily minimum. They reflect general climatological patterns and are not a direct extract from official data. Verify against the India Meteorological Department's climate normals before external use.
- **PM2.5 values** are rounded, indicative state-level annual averages that reflect general patterns in public monitoring. They are not a direct extract from official data. Verify against Central Pollution Control Board and state pollution control board data, which are the authoritative sources.
- **The range and energy model** is an illustrative engineering model for a typical electric two-wheeler using 35 Wh per km at 25 °C. It is not measured data from Gravton or any specific vehicle. The shaded bands show a plausible spread, not a statistical confidence interval.
- **CO_2 figures** use a grid factor range of 0.65 to 0.85 kg CO_2 per kWh (central 0.75) and 2.31 kg CO_2 per litre of petrol. Check the Central Electricity Authority's current published grid factor for up-to-date calculations. Operational emissions only.
- **Winter and summer windows** use the January minimum and the hottest-month maximum, which are worst-case windows. Daily averages are milder.
- **Maps** are illustrative. They are not to scale and are not an authoritative depiction of boundaries. Refer to the Survey of India for official maps.
- **Rupee figures** assume electricity at ₹8 per kWh and petrol at ₹115 per litre and 45 km per litre. Local prices and tariffs vary.

Appendix: indicative state and union territory data

The values below underpin the maps. They are indicative and may be updated as verified data becomes available.

State or union territory	Hottest-month mean max (°C)	January mean min (°C)	Annual PM2.5 band (µg/m3)	Climate group
Andaman and Nicobar Islands	31	23	below 20	Coastal and humid tropics
Andhra Pradesh	38	18	30 to 40	Deccan and southern plateau
Arunachal Pradesh	28	7	below 20	North-east hills
Assam	32	10	40 to 60	North-east hills
Bihar	37.5	9	80 and above	Northern plains
Chandigarh	38	6.5	40 to 60	Northern plains
Chhattisgarh	40	11	40 to 60	Hot and dry west and centre
Dadra and Nagar Haveli and Daman and Diu	34	17	40 to 60	Coastal and humid tropics
Delhi	40	7.5	80 and above	Northern plains
Goa	33	20	20 to 30	Coastal and humid tropics
Gujarat	39.5	12	40 to 60	Hot and dry west and centre
Haryana	40	6.5	60 to 80	Northern plains
Himachal Pradesh	29	2	30 to 40	Himalayan cold
Jammu and Kashmir	31	0	40 to 60	Himalayan cold
Jharkhand	36	8	40 to 60	Coastal and humid tropics
Karnataka	36	16	20 to 30	Deccan and southern plateau
Kerala	33.5	22	20 to 30	Coastal and humid tropics
Ladakh	24	-14	below 20	Himalayan cold
Lakshadweep	32	25	below 20	Coastal and humid tropics
Madhya Pradesh	41	9	40 to 60	Hot and dry west and centre
Maharashtra	38	14	40 to 60	Deccan and southern plateau
Manipur	30	6	30 to 40	North-east hills
Meghalaya	25	6	30 to 40	North-east hills
Mizoram	28	11	below 20	North-east hills
Nagaland	28	7	20 to 30	North-east hills
Odisha	37	14	40 to 60	Coastal and humid tropics
Puducherry	37.5	21	20 to 30	Coastal and humid tropics
Punjab	39	5.5	40 to 60	Northern plains
Rajasthan	41	8	40 to 60	Hot and dry west and centre
Sikkim	22	4	below 20	Himalayan cold
Tamil Nadu	36.5	20	20 to 30	Coastal and humid tropics
Telangana	39.5	15	30 to 40	Deccan and southern plateau
Tripura	34	12	40 to 60	North-east hills
Uttar Pradesh	41	8	80 and above	Northern plains
Uttarakhand	31	4	40 to 60	Himalayan cold
West Bengal	35.5	12	40 to 60	Coastal and humid tropics

About Gravton Motors

Gravton Motors Pvt. Ltd. is a Hyderabad-based electric two-wheeler manufacturer. Its flagship, the Quanta, is a step-through electric motorcycle built around an in-house battery and BLDC hub motor, with variants claimed at up to 125 KM (S) and up to 165 KM (S+) of range. Gravton also builds the QRX, and has built India's first BIS certified hub motor and the first rib cage chassis on an electric two-wheeler.

Talk to Gravton

Visit **www.gravton.com** to explore the Quanta and book a test ride.

Fleet and business enquiries: **connect@gravtonmotors.com** | Phone: **7995252220**

Careers: **careers@gravtonmotors.com**

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