*Research Paper*

# De-carbonization and Environmental Planning Roadmap for Rourkela Steel City

## -a city under transformation

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### Abstract

*Rourkela, a tier-II steel township in eastern India is the industrial capital of the state of Odisha. Apart from being home to the oldest integrated steel plant of the country, the city is home to two major universities and a private airport belonging to the Steel Authority soon to be upgraded to a domestic airport. The opening of the airport is likely to improve employment opportunities increasing population growth along with increased travel and housing demands. Also the city has pledged to reduce 30% of its emissions in the UN Energy Compact by 2030. The current Comprehensive Development Plan for 2031 was drafted before the airport up-gradation plan and the city level de-carbonization pledge. Hence our current study is aimed at analysing the impact of the upcoming airport oriented development, identifying strategies in the building sector and exploring scenarios in the transport sector towards decarbonisation pledge put forward by the city. The study also outlines an environmental planning roadmap in the city level considering the gap areas identified in the existing comprehensive development plan.*

### Keywords

*De-carbonization strategies, Environmental planning roadmap, Airport oriented development, Green infrastructure, District energy, Scenario analysis*

## 1. Introduction

Rourkela is a steel township and the industrial capital of the state of Orissa in east India, classified as a tier-II town owing to a population of about 0.645 million people within its planning area according to Census 2011. The city comes under the "Smart Cities Mission" of the Government of India, having won various awards like "Global Mayors Challenge" by the Bloomberg's City Network or the "Nurturing Neighbourhoods" program by the Ministry of Housing and Urban Affairs of the country. The city also aims at targeting to meet 30 percent of its energy needs from clean energy sources by 2030 according to its pledge in the UN Energy Compact. Even though the city is classified under Koppen Aw warm humid tropical climate zone, it experiences composite climate characters, such as, a very hot and dry summer, warm and humid monsoons and cold winter seasons. Summer temperatures are unbearable during the months of April and May before the onset of monsoon, and these two months record the maximum amount of cooling energy expenditure in built environments. The city is home to the oldest integrated steel plant of the country and experiences power deficits during the peak summer months. The activities of the steel plant cause high emissions and also impact the pollution level of the city. Moreover the waste heat available at various locations of the steel plant from its activities is re-utilizable towards energy efficient operations (Sen et al, 2021). The current Comprehensive Development Plan of the city contemplated till 2031 lacks a roadmap to achieve its goals of de-carbonization and mitigation of its environmental problems in buildings and transportation sector. Also, Rourkela would host the 2023 Hockey World Cup Tournament with a proposed up-gradation plan of the existing airport privately operated by the Steel Authority to a public airport in place. Hence the city is already at the onset of a rapid transformation as the public airport would come up, the city would be likely to be impacted upon by the airport driven urban development.

Our current study projects the growth of the city driven by the upcoming airport. We define strategies in building sector that help de-carbonizing its energy use in the built environment and explore some alternative scenarios of multi-modal scenarios towards the de-carbonization potential in the transport sector. We also outline an environmental planning roadmap considering lacunae in the existing Comprehensive Development Plan.

## 2. Background of Rourkela Steel city- a city under transformation

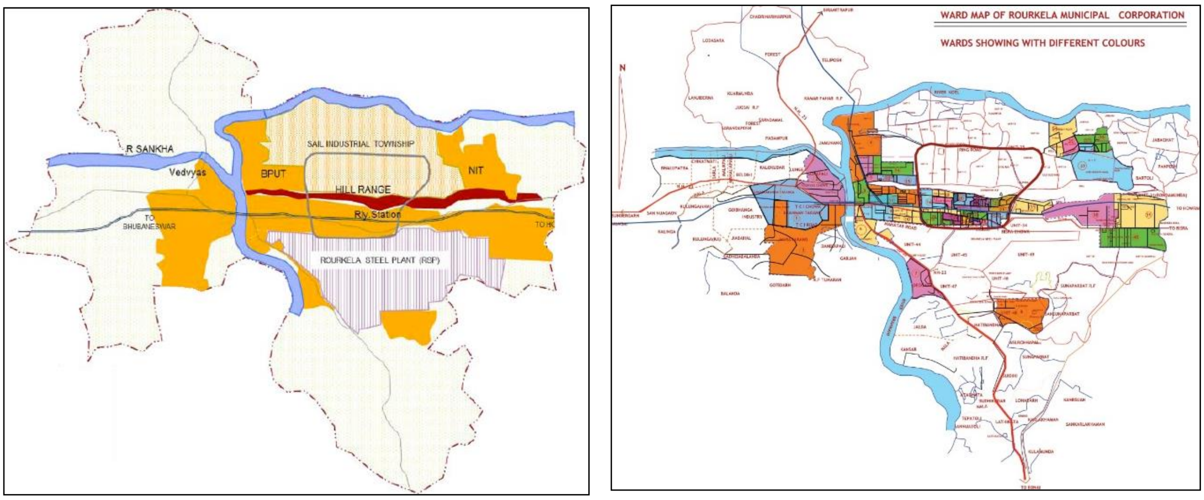
### 2.1. Existing and proposed land use in Comprehensive Development Plan till 2030

The existing Comprehensive Development Plan (CDP) 2031 of Rourkela has been contemplated in 2015 when many of the current policies and goals- such as Rourkela airport up-gradation plan or the de-carbonization pledge taken at the UN Energy Compact- were non-existent. The CDP comprises of a development planning area of 279.55 Sq. km, referred to as Rourkela Planning Area (RPA) that includes (a) the Rourkela Steel Plant and the Steel Township area under the Steel Authority of India-developed in the form of sectors, (b) the Civil Township area-more or less unplanned even though covered under a masterplan in 1982- which comes under the Rourkela Municipal Corporation and (c) adjoining blocks of Lathikata, Kuramunda and Bisra comprising of 40 villages and peri-urban zones. The CDP aims at a balanced community development accompanied by sustainable development of the industrial activities providing local employment opportunities and inclusion of the tribal population in the mainstream economic growth process of the city. The CDP has allocated land for various types of land uses apparently interrelated to each other as shown in Table 1 and Figure 1. However the planning synthesis of the various land uses does not consider the land use impact of the airport up-gradation plan proposed in later years.

**Table 1. Existing and proposed land use of RPA**

| Sl. no | Land Use type | Existing Area (Sq. Km) | Area (%) | Proposed Area (Sq. Km) | Total (Sq. Km) | Total Area (%) |
|---|---|---|---|---|---|---|
| 1 | Residential | 39.11 | 15.09 | 46.64 | 85.75 | 30.67 |
| 2 | Commercial | 1.40 | 0.54 | 4.74 | 6.14 | 2.20 |
| 3 | Industrial | 21.45 | 8.28 | 7.93 | 29.38 | 10.51 |
| 4 | Recreational | 2.81 | 1.08 | 14.51 | 17.32 | 6.20 |
| 5 | Public and Semi Public | 10.13 | 3.91 | 11.53 | 21.66 | 7.75 |
| 6 | Transportation | 11.76 | 4.53 | 16.81 | 28.57 | 10.22 |
| 7 | Agricultural/vacant/waste land | 112.28 | 43.32 | 46.17 (-66.11) | 46.17 | 16.52 |
| 8 | Forest | 16.11 | 6.22 | - | 16.11 | 5.76 |
| 9 | Water bodies/ wet land | 24.26 | 9.36 | - | 24.16 | 8.65 |
| 10 | Others/ mixed land use | 19.87 | 7.67 | 4.29 (-15.58) | 4.29 | 1.53 |
| | **TOTAL** | 259.18 | 100 | | **279.55** | 100 |

*Source: Rourkela Comprehensive Development Plan 2031*




*(a)* *(b)*

**Figure 1. Existing development mapped- (a) Schematic demarcation of the Rourkela Steel Plant, Steel Township and Civil Township in Map, (b) Existing ward map of Civil township delineated in different colours. Source: Rourkela Municipal Corporation**

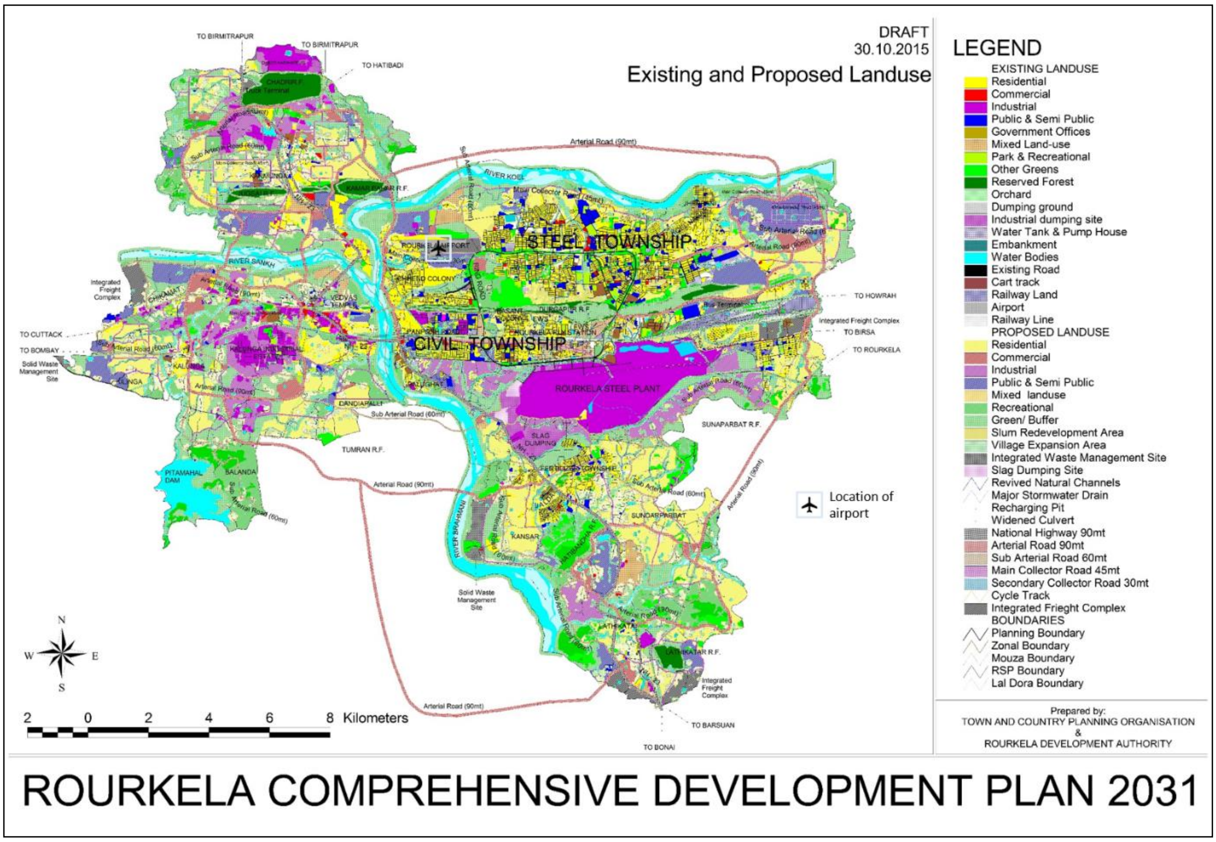



**Figure 2. Existing and proposed land use for RPA. Source: Rourkela CDP 2031.**

## 2.2. The new airport region and projected urban development by 2030

Rourkela airport is soon going to be open for civil aviation (AAI, 2022) before the upcoming Men's Hockey World Cup in 2023 from code B2 to C3 category of ICAO Aerodrome Reference code (SKYBary, 2022). The opening of the airport is going to bring about a number of opportunities for the surroundings and the regions linked to the airport in terms of commercial and spatial development, as observed in past studies (Kasioumi, 2015), (Freestone and Baker, 2011).

Several typologies of spatial planning models are in practice for airport-oriented developments emphasizing the airport as an economic gateway for urban development as delineated by (Freestone and Baker, 2011). The 'Airfront' model is identified as a suitable planning model for Rourkela acting as a potential growth driver of the urban area. It is defined as an airport related commercial zone located in the airport fringe area. The characteristic land use mix of such an airport fringe area is likely to include hotels, rentals, freight and cargo services, warehousing and manufacturing. However, it is observed in the proposed Rourkela Comprehensive Development Plan 2031 that a major area surrounding the west of the airport is residential. On the northern side a green buffer area is present while the Steel Township is located on the eastern side of the airport. Only towards the airport's entrance, on its southern side, is the land reserved for public and semi-public space. This land in the airport fringe area may be suitable to be planned and developed as an 'Airfront' model having a high potential towards community renewal or business regeneration. As a business district improvement model, the Airfront is retrofitted to the existing neighbourhoods. It has the local inhabitants and public-private partnerships as the lead actors (Freestone and Baker, 2011) towards developing innovative strategies and policies for coordinated infrastructure and land-use plans. It could be of the scale of a business district model and governed by a special planning organization inclusive of all stakeholders. Such planning would result in an efficient urban system taking a forward-thinking and cooperative approach where airport planning, spatial planning, and economic development would function together in a synergized manner. Though an airport is a carbon-intensive infrastructure, a planned development around it is likely to help bringing down the levels of emissions substantially.

While data on airport related in-migration to cities is rare in Indian context, it has been found that small and medium sized airports have contributed to growth of population and employment in United States over 60 year period. An airport on average contributes to 0.2-0.4% population or employment growth annually, even though there is substantial observed heterogeneity in the outcomes (McGraw, 2017). Also the study (McGraw, 2017) illustrates that among many factors, the proximity to a research university, generation of human capital, climatic factors, proximity to a capital city and city size contribute to the success of airport driven developments. Even though Rourkela is small compared to most major growth centres in India, it is categorized as a tier-II city and meets most of the above mentioned criteria. Hence the airport up-gradation program is likely to increase the population growth and have a positive impact upon employment generation.

## 2.3. Current power consumption of the urban area

Rourkela urban area is broadly divided into the civil township and the steel township. Power is supplied by Tata Power Western Odisha Distribution Limited (TPWODL) which is a mix of thermal and hydro-electric power. The total power consumption of the civil township varies between 80-85 MW in a day (The New Indian Express, 2021) and that of the steel township as approximately 25 MW in a day as per survey data from Rourkela Steel Authority. Partial data obtained so far from TPWODL confirms that in the month of July 2022, the total power consumption of the RPA has been 80MU (MU refers to million units where 1 unit=1kWh). This consumption value for the month of July-a month with moderate to high energy consumption- more or less authenticates the above range of figures considering the power consumed by the steel plant.

## 2.4. Projected power consumption in 2030 and upcoming solarisation plan

The Rourkela CDP 2031 predicts an annual population growth rate of 1.57% based upon the past trend of population growth from census of India data. Considering the upcoming airport oriented development, we assume an additional 0.3% annual population growth rate from the year 2023 and project the population of the RPA to be around 0.9 million in the year 2031. Assuming average power consumption of

110 MW per day (85 MW for Civil Township and 25 MW for the Steel Township) for the year 2022, the projected average consumption for the year 2030-31 can be taken as 130 MW per day.
The Rourkela Municipal Corporation has demarcated an adjacent area to the Lathikata block included inside the RPA for setting up a 30 MW solar plant and also has been encouraging rooftop solar campaigns for the city dwellers day (The New Indian Express, 2022). If the entire power generated in this solar park is provided to the city, it would help offsetting only about 10-23 % of average daily power consumption, considering an average daily power requirement of 130 MW for the city in 2030 and expansion of the steel plant activities (The New Indian Express 2022a). Hence it is important to lay a decarbonisation roadmap for 2030.

## 3. Literature reviews

A roadmap is a process of creating flexible guidelines in support of various strategic aims in planning practice in a flexible manner (Pereira and Azambuja, 2022) such as-planning, implementing, adopting, monitoring and evaluating. The study (Ibrahim et al, 2018) in city level proposes a smart sustainable city transformation roadmap through six steps. An interesting study (Jenkins et al, 2018) analyzes a collective of studies that evaluate two overall paths to de-carbonize electricity- the one that relies primarily or entirely on variable renewable energy sources –chiefly wind and solar power supported by energy storage and expansion of transmission grid; and the other relying upon a wider range of low carbon resources or “firm” resources along with wind and solar, such as, geothermal, biomass and fossil fuels with carbon capture and storage. The study infers that strategies that expand the portfolio of available low-carbon resources rather than restrict it to a few are more likely to achieve deep de-carbonization using affordable means.

## 4. Delineating de-carbonization strategies and scenarios in built environment and transport sector

The land use goals of the existing Rourkela CDP 2031 considers protection of valuable natural resource and attempts to design future developments in the RPA in a sustainable manner and synchronized with the existing development. However, even though the land use planning goals aim to minimize the travel distance of residents and promote compact growth, the CDP does not provide guidelines to allow convenient or local shopping centres in large areas of proposed residential zones located far away from commercial zones, that might favoured compact development and low transport emissions. Also the CDP fails to identify appropriate land use around the upcoming airport region and its environmental impact. Purpose of a CDP is not to freeze the built environment in certain point of time or in certain style, but to express a vision and direction to future growth (Daniels and Daniels, 2003). In the light of the above context, we aim at imparting a vision towards an environmentally sustainable future growth. We analyse alternative scenarios in the transport sector and propose de-carbonization strategies for the built environment.

### 4.1. Building sector and neighbourhood scale de-carbonization strategies

The building sector consumes 40 percent of energy and is responsible for 33 percent of carbon dioxide emissions globally (WEF, 2014). The consumption and emissions of this sector is also largely dependent upon the climatic context of a geographical location. The CDP 2031 proposes about 15% expansion of residential land use, 4% public semi-public and 1.5% commercial land use to the existing vacant land in RPA, implying to a large volume of newer constructions upcoming at RPA.
Primary strategic goals for a sustainable energy plan can be categorized under four components (Pollalis, 2016) interpreted and elaborated below in the given context-

(i) *Energy conservation and efficiency in building sector*- In order to understand the energy conservation and efficiency measures in built environments for both end users and city planners, it is important to bring to mainstream the idea of whole building life cycle assessment (LCA), a powerful tool delineated in ISO standards 14040 and 14044 accounting for the total energy consumption in the whole life of a product or a system, as outlined in *figure 3.* Even though it is hard to carry out an accurate LCA in real life projects, the concept of performing LCA imparts a clear understanding of 'conservation' and 'efficiency' measures in a construction project. Considering the building construction sector in Indian context, the following strategies may be adopted for energy conservation and efficiency in each stage of a new constructions-

a) Design stage-
   - *Site selection* - even though the choice of site selection is not in the hands of an architect or builder at the time of project allocation, compact urban planning plays a big role in preventing urban sprawl, developing green open space or protecting natural resources
   - *Choice of building geometry* - low surface to volume ratio of building mass imparts thermal efficiency towards heating and cooling during operation stage of the building
   - *Site planning and orientation* – appropriate 'sol-air' orientation for the building considering the sun path diagram and the air movement is important, use of low albedo pavement or site hardscape would result into urban heat island effect, whereas cool pavements with high albedo is seen to have imparted high building energy demand in places with high incident radiation exposure (Zafari et al, 2021), such as the case of Rourkela city in summer months. Therefore the best strategy is to retain as much as natural vegetation on site.
   - *Earth sheltered or bermed construction*- Bermed construction refers to part of the building constructed below ground level, naturally reducing cooling energy cost in hot summer seasons. However the initial construction cost can be about 20-30 percent more compared to conventional construction.

b) Construction stage-
   Choice of building materials in the construction is important to bring down energy consumption during both construction and operation stages of the building life. While low embodied energy building materials are desired, the thermal properties would affect the air-conditioning energy consumption during building operation. Locally sourced building materials would help in bringing down transportation energy in this stage.

c) Operation stage-
   This stage accounts for the energy consumed while the building is occupied by the end user in fully functional form; accounting for the electricity consumption due to the building operation. In developing countries, buildings are catered with split AC and temporal mixed mode ventilation where air conditioning is available only for a part of the building contributing to 50% energy utility billing as compared to about 40% for centralized cooling in developed countries, the operation of split ACs being energy intensive. Such cooling means may be replaced by more centralized systems and radiant cooling technologies. Also, renewables such as solar thermal or roof-top PV installations may offset operating energy usage.

d) Demolition stage-
   The stage accounts for energy expended during building demolition activities per unit volume at the end of building life in a linear economy. In an ideal and sustainable circular economy model, the building is carefully deconstructed and the building materials are attempted to be salvaged for recycling and reuse

e) Green building rating compliance-

The Indian green building code GRIHA manual lays down guidelines for construction of environmentally sustainable buildings. The Energy Conservation Building Code (ECBC) is a manual that guides the construction of energy efficient building envelopes. A new building performance analysis tool- the ECO-NIWAS – helps to compare building envelopes in initial stage of design and also helps achieve ECBC compliance along with star labelling of homes

*(ii) Expansion of the supply of renewable energy and other on-site distributed energy-*

a) *Steel plant waste heat utilization-* The Rourkela Steel Township is home to one of the largest steel plants of India, generating waste heat from its various activities, hence suited for combined cycle technology towards electricity generation (Pollalis, 2003) or directly utilizing its waste heat towards air conditioning (Sen et al, 2021).

b) *District energy systems-* The proposed land use of the CDP 2021 with the upcoming new constructions along with the airport based developments have high potentials towards investment of district energy infrastructures. The new growth centers at RPA can be brought under the ambit of district energy infrastructure for which agent based model simulations may be applied as illustrated in the study (Busch et al, 2017)

c) *Renewable technology integration in district energy systems-* District energy systems such as district cooling is having the potential not only to centralize and render upto 40% cooling efficiency but also can be easily offset by renewable energy generation in the centralized arrangement (Sen et al, 2017).

*(iii) Integrated energy infrastructure for sustainable practices-*

Integrated infrastructure planning involves co-location, co-development of services and sustainable design (Pollalis, 2003) towards compact city planning. Such multi-purpose infrastructure are applicable in the up-coming proposed growth centers of RPA.

*(iv) Leveraging advanced technology-*

Compared to current practice, the cleaner energy technologies such as district energy systems or air conditioning through radiant cooling are still new to a large extent in context of developing country like India- could be explored to set examples of good practice for future developments in urban areas.

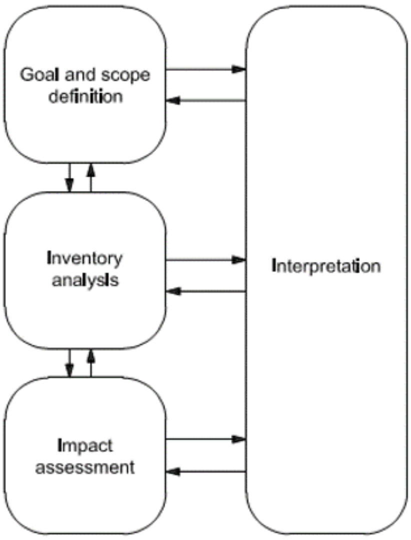



**Figure 3. Life Cycle Assessment framework as explained in ISO 14040**

*Case study of Rourkela Municipal Corporation (RMC) building – LCA towards rooftop PV potential*

Rooftop PV with net metering system is already been advocated by municipal body in its solarisation campaign day (The New Indian Express 2022b). Case study of a typical public building is done for understanding and reporting rooftop PV potential towards offsetting operating energy consumption. Architectural drawings as shown in *figure 4* are collected from RMC building along with monthly energy consumption data is collected for 3 consecutive years and the LCA analysis is performed.


**Figure 4. RMC building plans and view for a public building life cycle analysis study**

The RMC building is a reinforced cement concrete structure with solid cement concrete block walls. The windows are having steel frame and glass panels. The entrance doors have aluminium frame and glass panels. The doors in the indoor spaces are flush door with medium density fibre board. The embodied energy (MJ/cum) and emissions (kgCO2/cum) calculations have been done with Auroville Earth Institute database (Maini and Thautam, 2011). Considering 125 kW capacity of roof top solar panel, solar PV is able to offset 42% of annual operating energy consumption considering the net metering system, the RMC being a two and half storied building. However, considering the annualized embodied energy and a building life of 60 years, the initial embodied energy constitutes 76% of the energy consumption and 98% CO2 emissions, while rooftop PV offsets only around 10% energy consumption and 0.84% CO2 emissions in the entire building life. The *figure 5* illustrates the results.

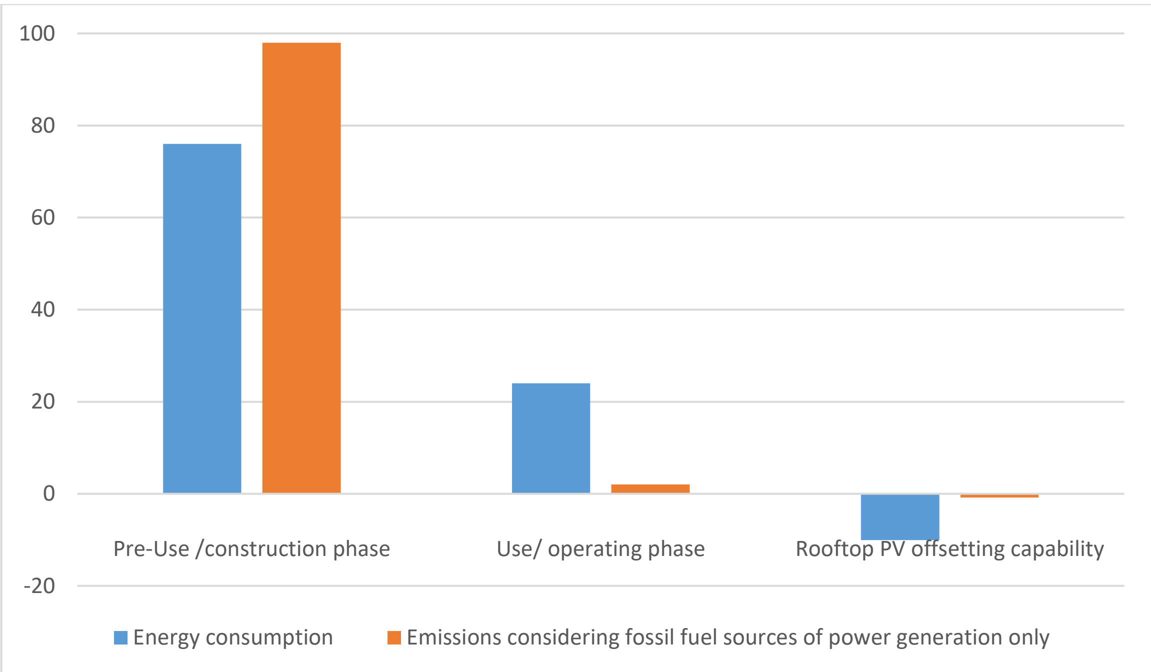


**Figure 5. Trade-offs between the initial embodied energy, operating energy and energy offset by rooftop PV in RMC building**

## 4.2. Transportation sector decarbonisation scenarios

The core city area included inside the RPA has a current population of just over three lakhs expects a population growth of 1.87% per year and a growth in vehicle ownership with road infrastructure and industry development plan in place. The population is taken as a predictor of number of trips expected and may be estimated using trip generation model developed for other Indian cities. Here trip generation model calibrated for a similar Tier-II city of India- Patna, India is used and is given in Equation 1 (CMP-AA, 2018) -

$$N_{TRIPS} = 0.927 \text{ X } Population - 5140 \qquad (1)$$

The expected number of trips per day from existing population of the city limits is around 2.8 lakhs which is distributed over the whole city with 40 wards or zones. The hourly trip expected, considering 15-hour travel duration, is around 18,796. The maximum expected trip from a particular zone is 644 (estimated from zonal population level). The projected demand for year 2030 from the zone may be estimated as 690 trips and these trips are allocated to bus, auto, personal car and bicycle.

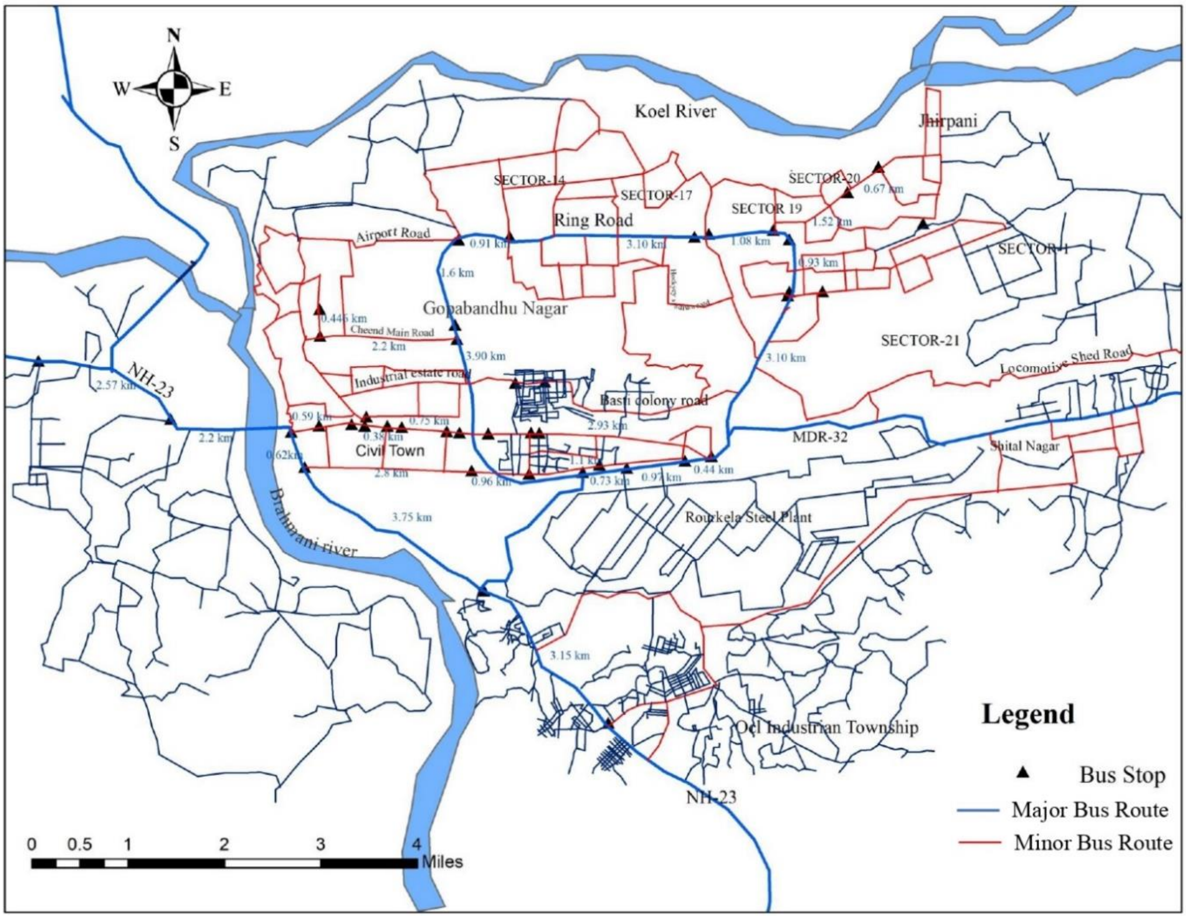



**Figure 6. Road map of Rourkela city with demarcated bus routes in green and blue and bus stops**

The Bus routes present in the city of Rourkela city, shown in *figure 6*, caters to all wards. With the current transport infrastructure and availability of bus as public transport, only 20% of the trips move by public transport i.e., bus and the rest use para-transits like auto or personalized vehicles like motorcycles and cars.

The Rourkela CDP 2031 has proposals for six bicycle tracks totalling to 13.5 Km in discontinued stretches. In the city, only around six months i.e., September to February are favourable for cycling. The rest of the time of the year either record intense summer or rains. Here we attempt to analyse emission effects of alternative scenarios of mode shift from personalised vehicles. *Table 2* presents alternative possible scenarios of mode choice from personalized vehicles. The scenario is defined with shift of personalized vehicle trips by car to bus and bicycle modes.

**Table 2. Scenario designs for alternative modal shifts**

| Scenario design | Total shifted trip % from personalized vehicle | Shift to Bicycle (shifted trip %) | Shift to Bus/Transit (shifted trip %) | Remarks |
|---|---|---|---|---|
| 1 | 70 | 50 | 50 | Pleasant weather |
| 2 | | 75 | 25 | Optimistic assumption in very pleasant weather |
| 3 | | 25 | 75 | Normal weather with improved bus service |
| 4 | 50 | 50 | 50 | During Rainy Season |
| 5 | | 75 | 25 | Optimistic assumption in when rain is less |
| 6 | | 25 | 75 | Normal weather with improved bus service |
| 7 | 30 | 50 | 50 | Summer Season |
| 8 | | 75 | 25 | Optimistic assumption on warmer days in summer |
| 9 | | 25 | 75 | Very hot season with improved bus service |

The comparative emission for different trip choice scenarios as percentage of current emission level considered as 100 % is shown in *figure 7.* The comparative emission of CO2 and PM for bus is 0.16 times that of car, $NO_X$ for bus is 0.205 times that of car. This is estimated considering occupancy and emission levels. It may be observed that greater the shift from personalised vehicle greater the saving in emission. The saving in emission when compared for variation of modal shift between bus and bike is very small.

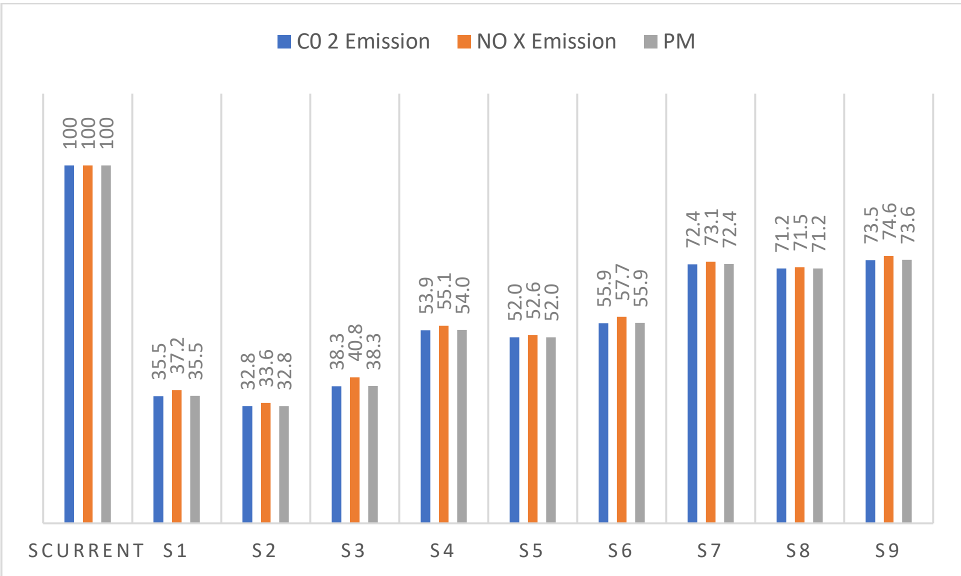



**Figure 7. Emission scenarios with alternative modal shifts**

The CDP 2031 has proposals for six biking tracks totalling to 13.5 km in discontinuous stretches. Modal shifts to cycling can be made possible by integrating these tracks and thereby providing continuous separate biking track in the inner city, accompanied by bike parking zones and policies that would make driving expensive in the central cities during bike friendly seasons as found in the study (Pucher and Buehler, 2008).

## 5. Delineating an Environmental Planning Roadmap in holistic city level

The proposed land use plan in CDP 2031 of RPA identifies four ecological development goals- to achieve environmental equilibrium by conserving natural resources, to identify eco-sensitive and no development zones along river edge, hills, natural forests etc. to optimally utilize developable land to prevent urban sprawl and to promote use of public transport and renewable and non-polluting sources of energy. However, the environmental considerations are yet to be integrated with the planning process. There is a lot more to be achieved when it comes to air-quality monitoring around the Rourkela Steel Plant area, a holistic city level solid waste management, city level low emission transport planning strategies in city scale or compact land-use planning to cut down emissions in transport sector. According to the Municipal Commissioner, Rourkela lacks a Construction and Demolition (C and D) waste recycling plant due to very high upfront investment costs where C and D waste forms around 4% of daily municipal solid wastes. The city needs to innovate a downscaled C and D waste recycling plant for such purpose. Also most of the solid wastes end up in landfilled sites as designated by the CDP and the full recycling potentials are yet to be explored. In the following sub-sections we delineate an environmental planning roadmap that may be considered as a basis of any future Environmental Action Plan for the city along with funding avenues for such environmental planning initiatives.

### 5.1. Environmental planning road-map

**City Vision** STEP-1

- Objectives- (1) Pollution mitigation plan around steel plant area by planned plantation zones with air purifying vegetation as buffer landscapes (2) Integrated solid waste management and waste recycling plan (3) Downsized C and D waste management plan (4) Land use change near the airport region and integrated land use planning guidelines to enable compact urban development lowering emissions
- Stakeholder identification and citizen participation for the above objectives

**City Readiness** STEP-2

- Current conditions of tangible structures- roads, green areas, buildings, infrastructures etc
- Assessing Information and Communication Technology based infrastructure readiness- hardware and software infrastructure, effect of digital literacy etc. in meeting objectives mentioned in city vision, Internet of Things.
- Checking with previously implemented green initiatives, conducting expert opinion surveys and learning from past experiences

**City Plan** STEP-3

- Identifying key performance indicators (KPI) for each objective
- Identifying constraints and allocating needed resources for each activity under each objective
- Engage relevant stakeholders
- Create a financial feasibility study and create an action plan for transformation

**City Transformation** STEP-4

- Develop an integrated platform for green infrastructure, monitoring of air quality and inventory for waste recycling as per objectives outlined in the city vision
- Design and implement short term solutions and reiterate the practicability of the integrated platform, add additional initiatives

**Monitoring and Evaluation** STEP-5

- Monitor and evaluate the proposed transformations keeping in reference the KPIs as reference
- Carry out detailed documentations, analysis and feedback so as to improve the previous step

**Sustain Change** STEP-6

- Learn from previous experiences, continue improvements and announce achievements
- Update the system based upon changing scenarios and introduce more changes

**Figure 7. Environmental planning roadmap in city level**

The Environmental Action Plan for a city can be derived from a step by step road map. We derived the roadmap from smart sustainable city roadmap by (Ibrahim et al, 2018), defined as a continuous and longdawn process. The roadmap has been adopted in environmental planning context for Rourkela, a tier II city in developing country as illustrated in *figure 7,* based upon the lacunae observed in the CDP 2031.

### 5.2. Financial viability model- who would pay and why?

Environmental planning actions along with green infrastructures can be funded in a public private partnership model where private developer can derive profits from energy saving utility billing. An Energy Service Company (ESCO) may help the private developer in setting up the business model for such projects. The Rourkela Steel Plant Authority is having a huge potential to fund green infrastructure projects and carry forward the responsibility of air quality monitoring and improvement around the steel plant area. Governmental support can act in the form of incentives, tax exemptions and subsidies.

## 6. Conclusions

India pledges to be a net zero economy by 2070 and the city of Rourkela pledges to reduce 30 percent of its emissions by 2030. The given study analyses the de-carbonization strategies in the building sector and compares scenarios in the transport sector, additionally also outlines a holistic environmental planning roadmap in city level. A case study of a typical institutional building is taken up and it is found that even though rooftop PV offsets around 42% annual operating energy, it contributes to only about 10% of the energy savings in the whole building life cycle analysis framework as the operating phase constitutes only around 24% of life cycle energy consumption in this case study. Scenario analysis in transport sector reveals that modal shifts to biking and bus transit from personalized vehicle considerably contribute towards bringing down carbon footprints. The proposed solar park around Lathikatha would cater to 10-23% of future daily requirements of the city dwellers and the industrial zones considering future expansion of the city and the activities of the steel plant. Hence a combination of strategies would be needed to achieve city level de-carbonization goals along with the proposed solar energy policies.

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