

Net Zero Gujarat: Linking State and City-Level Action

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Project Approach

Evidence Base

1. **Net zero scenario-based assessment covering key mitigation sectors using energy system models**
 - Updation of state-level CO₂ inventory
 - Desk review of scenario-based assessment for of low carbon and Net Zero Scenarios
 - Analysis of Net Zero CO₂ emission pathways at state level till 2070 using LEAP & GCAM model
2. **Sustainable Development Impact assessment** of Net Zero pathway using a qualitative approach (quantitative assessment wherever possible).



Roadmaps

3. **Prepare technology roadmaps** to guide the implementation of the Net Zero strategy, including
 - **Prioritise the technologies** relevant to the state based on Net Zero Assessment and SD impact assessment
 - **Barrier analysis and measures** to address barriers for the technologies
 - Prepare a draft roadmap with actions needed in the short term (until 2030) and thereafter to achieve Net Zero by the target year
 - Organise a **workshop for validation** of the roadmap

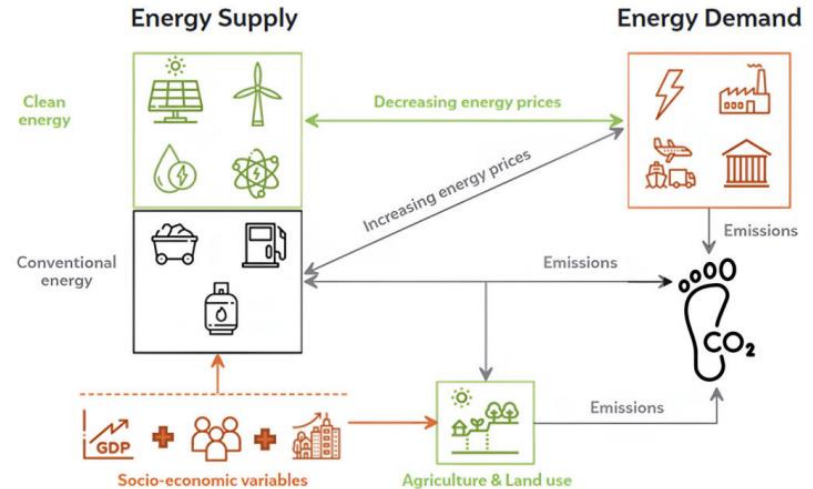
Stakeholder consultations and capacity building within line ministries on net-zero pathways

GHG Emissions for Gujarat

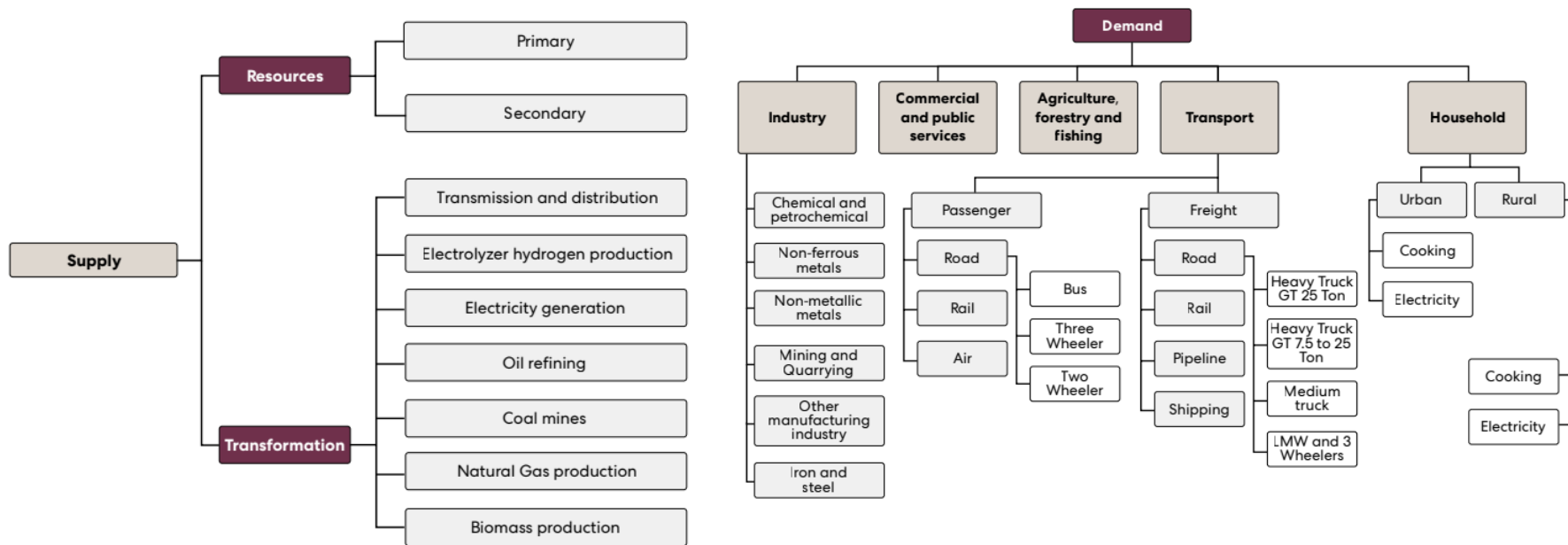
SECTOR	2018	2019	2020	2021	2022
Agriculture	1.13	1.22	1.27	1.32	1.32
Captive Electricity Generation	17.18	18.46	19.54	17.11	17.96
Commercial	0.40	0.35	0.38	0.40	0.42
Industry	101.06	97.87	95.91	104.43	114.53
Residential	3.47	3.38	3.40	3.53	3.70
Transport	24.06	25.82	23.93	26.22	29.91
Utility Electricity Generation	91.42	94.92	90.67	68.86	63.73
Grand Total	238.74	242.02	235.10	221.68	231.59

GCAM Model

- Global Change Analysis Model (GCAM) developed by JGCRI
- GCAM is an Integrated Assessment Model used at global / national level
- GCAM India
- GCAM Gujarat a subset of GCAM India



LEAP Model : Reference energy system – Supply & Demand



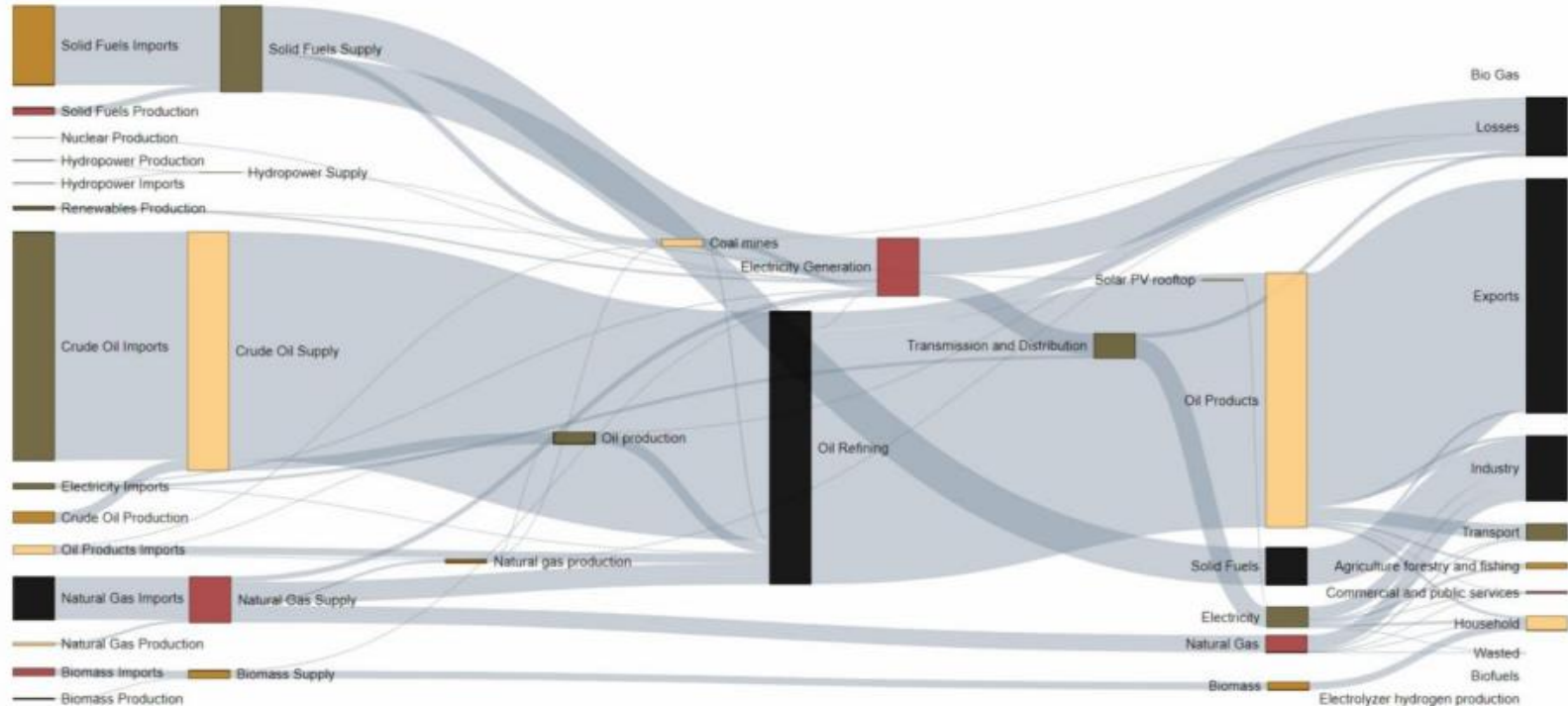
Energy Balance for Gujarat 2018

	Solid Fuels	Natural Gas	Crude Oil	Renewables	Biomass	Electricity	Oil Products	Total
Production	126.1.	51.8.	197.4.	52.5.	0.9.	-	-	431.3.
Imports	1,446.0.	789.1.	4,173.3.	-	141.2.	105.8.	144.1.	6,801.9.
Exports	-56.8.	-	-	-	-	-	-4,228.7.	-4,285.5.
Total Primary Supply	1,515.3.	840.9.	4,370.7.	52.5.	142.1.	105.8.	-4,084.6.	2,947.7.
Bio Gas	-	-	-	-	-	-	-	-
Biofuels	-	-	-	-	-	-	-	-
Natural gas production	-	-2.9.	-	-	-	-	-0.1.	-3.0.
Oil production	-	-11.7.	-	-	-	-	-0.4.	-12.2.
Coal mines	-0.0.	-0.0.	-	-	-	-	-0.2.	-0.3.
Oil Refining	-26.5.	-420.0.	-4,370.7.	-	-	-18.2.	4,517.3.	-318.0.
Electricity Generation	-866.5.	-95.6.	-	-48.6.	-0.7.	369.0.	-7.3.	-654.9.
Electrolyzer hydrogen production	-	-	-	-	-	-	-	-
Transmission and Distribution	-	-	-	-	-	-87.2.	-	-87.2.
Solar PV rooftop	-	-	-	-3.9.	-	3.9.	-	-
Total Transformation	-893.0.	-530.3.	-4,370.7.	-52.5.	-0.7.	267.5.	4,509.2.	-1,075.6.
Industry	622.3.	274.8.	-	-	-	234.0.	62.2.	1,193.4.
Commercial and public services	-	0.1.	-	-	-	23.0.	8.5.	31.6.
Agriculture forestry and fishing	-	-	-	-	-	58.0.	42.6.	100.6.
Transport	-	31.8.	-	-	-	4.1.	256.4.	292.3.
Household	-	3.9.	-	-	141.4.	54.1.	54.8.	254.2.
Total Demand	622.3.	310.6.	-	-	141.4.	373.3.	424.6.	1,872.1.
Unmet Requirements	-	-	-	-	-	-	-	-

Energy Balance for Gujarat for the base year (2018) was estimated using several sources of information:

- **GHG Platform India**
<https://www.ghgplatform-india.org/>
- Annual Reports of the Central Electricity Authority
- Annual Data from the Ministry of New and Renewable Energy
- Annual Survey of Industries
- Annual report of the Ministry of petroleum and natural gas
- Annual report of the Ministry of coal

Sankey Diagram



- Large share of energy imports and exports
- Industry and Transport are the largest end use demands

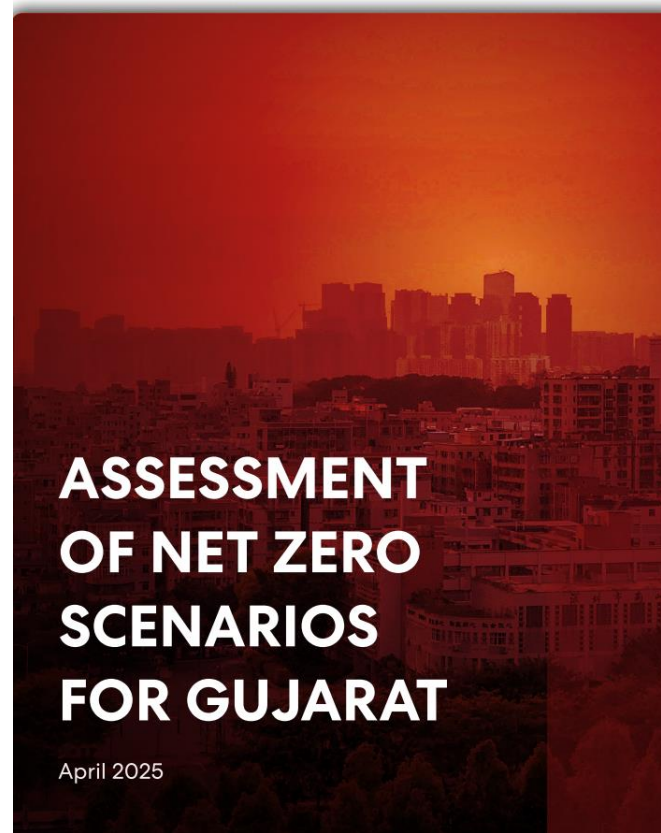
Scenario assumptions

	GCAM		LEAP	
Assumptions	Reference scenario	Conventional NZ scenario	Reference scenario	Structural shifts NZ scenario
Population	Population increases until 2035 in line with the projections from Ministry of Health and Family Welfare. After 2035, similar growth rates as before. GJ population peaks in 2055.			
GDP growth	The state's GDP will grow at a CAGR of 7.2% from 2020-2070, reaching 137.2 Trillion INR (constant 2011-2012) in 2050 and 361.1 Trillion INR (constant 2011-2012) in 2070.			
Structural changes in the economy	Share of manufacturing decreases from 37% in 2020 to 34% in 2070, whereas share of service increases from 32.9% in 2020 to 52% in 2070		Share of services in GDP increases to 57% in 2070, and manufacturing reduces to 29% in 2070	

Model Results

Acknowledgement

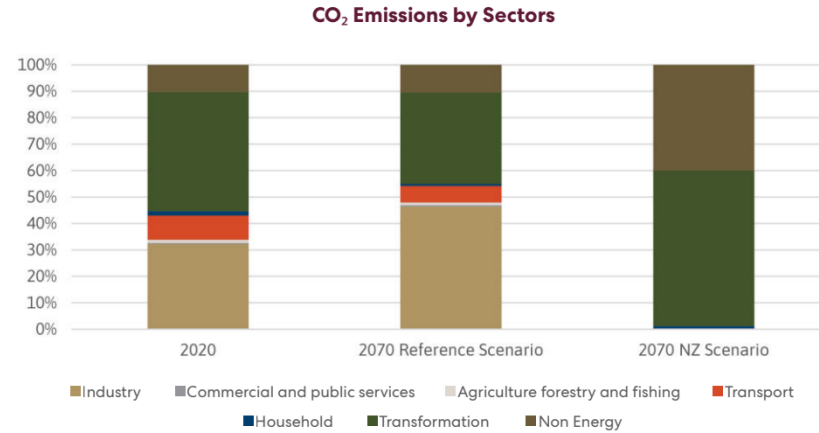
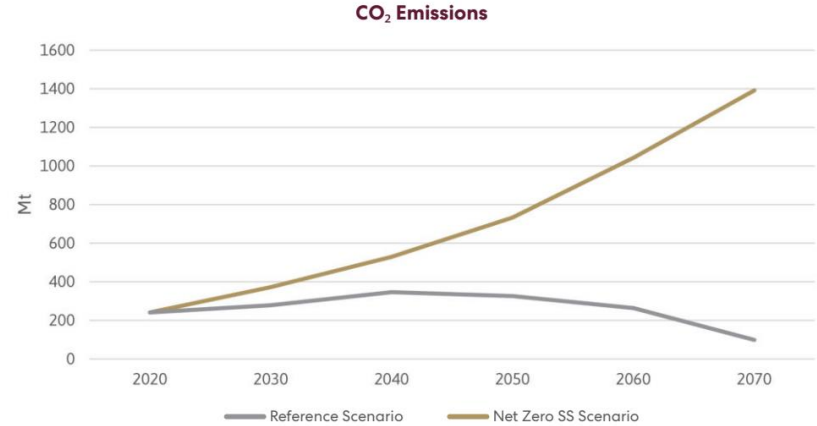
- Climate Change Department, Govt of Gujarat
- Energy & Petrochemicals Department, Govt of Gujarat
- Gujarat Energy Transition Research Institute
- Ministry of Foreign Affairs, Denmark



<https://unepccc.org/publications/assessment-of-net-zero-scenarios-for-gujarat/>

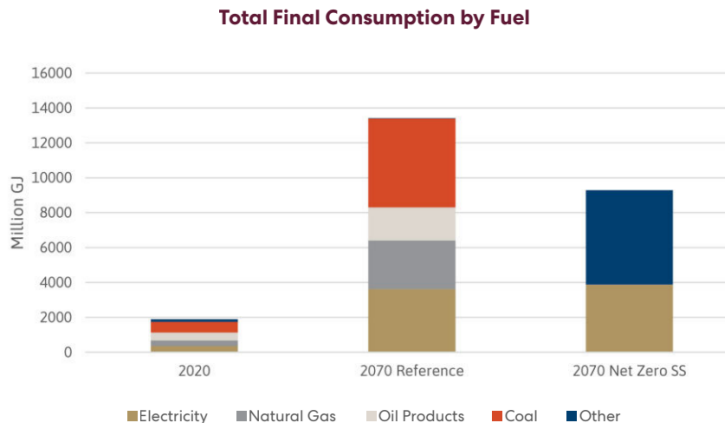
Total CO2 emissions

- In the reference scenario, CO2 emissions to rise from 241 Mt in 2020 to 1391 Mt by 2070, with a **CAGR of 3.6%**.
- In the Net Zero SS Scenario, **CO2 emissions peak in 2040**, then gradually decline to **98 Mt in 2070**.



Fuel Transition

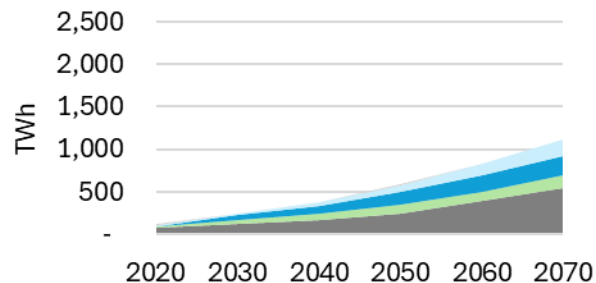
- In the Reference Scenario, total final consumption increases **7.1 times compared to current levels**
- In the Net Zero SS Scenario, this consumption is reduced by 31% compared to the Reference Scenario in 2070.
- To achieve the net zero target, the fuel shares in total final consumption change significantly:
 - Coal, natural gas, and oil products are gradually reduced, reaching 0% in 2070.
 - **Electricity's share increases from 20% to 42% in 2070.**
 - The share of “other” fuels increases from 8% in 2020 to 58% in 2070. **These “other” fuels include hydrogen, biomass, biogas, and methanol.**



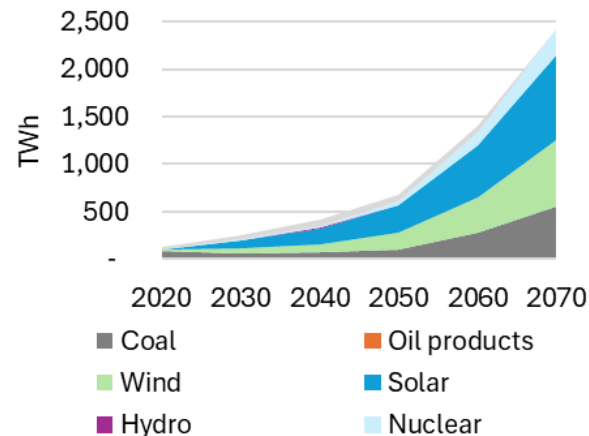
Electricity generation

- Electricity generation increases by 9.5 times in the Reference scenario and by **18.8 times in the Net Zero SS Scenario** by 2070 compared to 2020.
- In the Reference scenario, the share of coal for power generation decreases slightly from 63% in 2020 to 49% in 2070, with coal remaining a major energy source of energy generation.
- In the Net Zero SS Scenario, **coal's share gradually reduces and reaches 23% in 2070.**
- Renewable power generation (solar and wind) increases from 15% in 2020 to 33% in 2070 in the Reference Scenario, and to **66% in the Net Zero SS Scenario.**

Electricity generation in the Reference Scenario

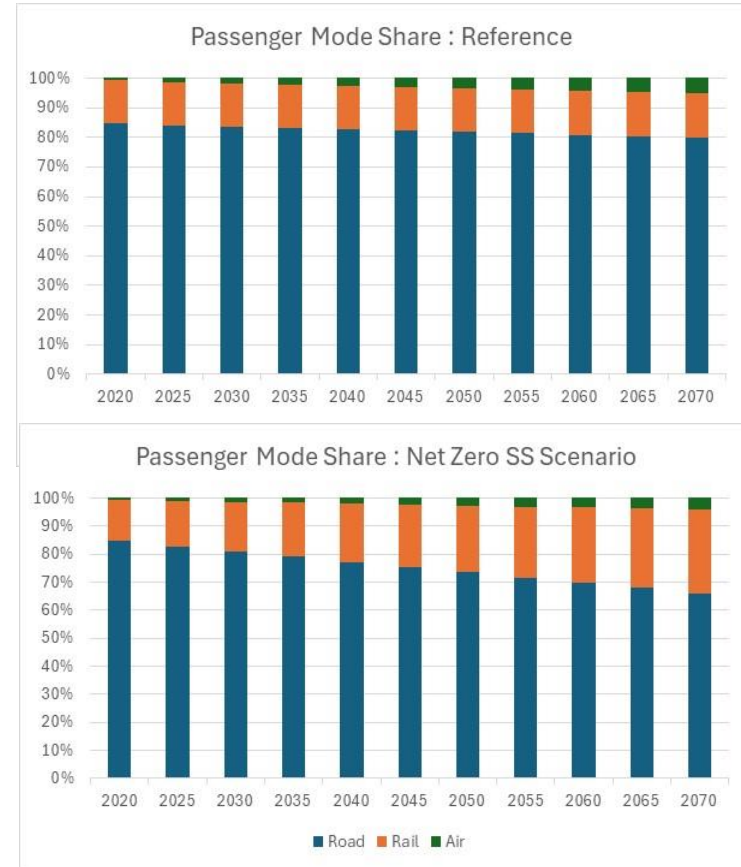


Electricity generation in the Net Zero SS Scenario



Transport Demand

- Transport sector energy demand in 2020 was 312.6 million GJ (16.5% of final demand)
- **Reference scenario**
 - Overall passenger demand **increases by 3.1 times** between 2020 and 2070
 - Overall freight demand **increases by 9.8 times** between 2020 and 2070
- **Net Zero SS Scenario**
 - Overall passenger demand **increases by 2.1 times** between 2020 and 2070
 - Overall freight demand **increases by 8.5 times** between 2020 and 2070



Transport Energy

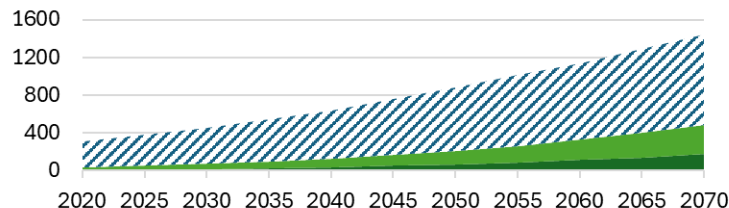
- **Reference Scenario**

- Overall demand for energy increases by **4.6 times from 313 million GJ in 2020 to 1445 million GJ in 2070**.
- The share of **oil reduces to 66.6% by 2070**, whereas the share of **CNG increases to 21.5%**, and the share of **electricity increases to 11.9%**.

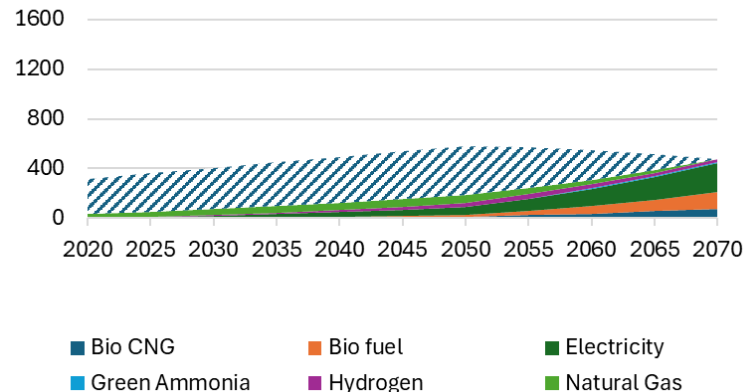
- **Net Zero SS Scenario**

- Stronger energy efficiency improvements, **a stronger shift towards EVs** and a greater role of **alternative fuels (bio CNG, biofuels, green ammonia, and green hydrogen)**.
- Overall demand for energy increases slowly and, in fact, declines from 2050 onwards, **and in 2070 is 475 million GJ or only 1.3 times of 2020**.
- Energy mix is **completely fossil-free**, with **electricity taking 50%** of the final energy demand, followed by **biofuels and bio-CNG. Green ammonia and green hydrogen**.

Energy Demand Reference (Million GJ)



Energy Demand Net Zero SS Scenario (Million GJ)



Bio CNG
 Bio fuel
 Electricity

Green Ammonia
 Hydrogen
 Natural Gas

Net Zero Transport Rajkot

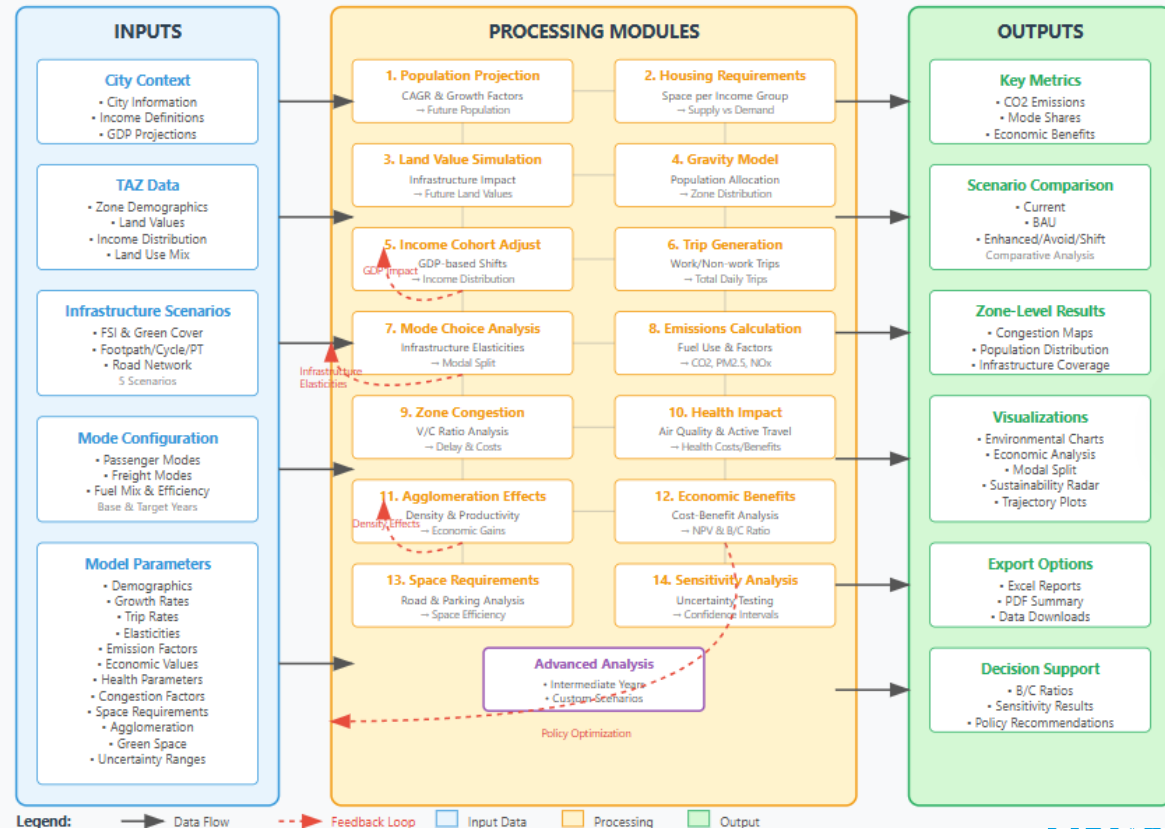
Framework for Net Zero

BAU	Enhance	Avoid	Shift	Improve
• Continuation of current trends	• Improve work opportunities for women and the physically challenged	• Reduce travel demand through urban design and remote options	• Transition trips to low-carbon modes like walking, cycling, and transit	Increase vehicle and fuel efficiency to lower emissions.

Models

- Climate City Transparency Tool
- TransCAD / Arc GIS Model Builder for Rajkot – IIT Delhi
- LEAP Rajkot Model
- Capacity Building
 - GUDI Workshop for 8 Municipal Corporations
 - Rajkot City Workshop

City Transparency Tool - System Architecture

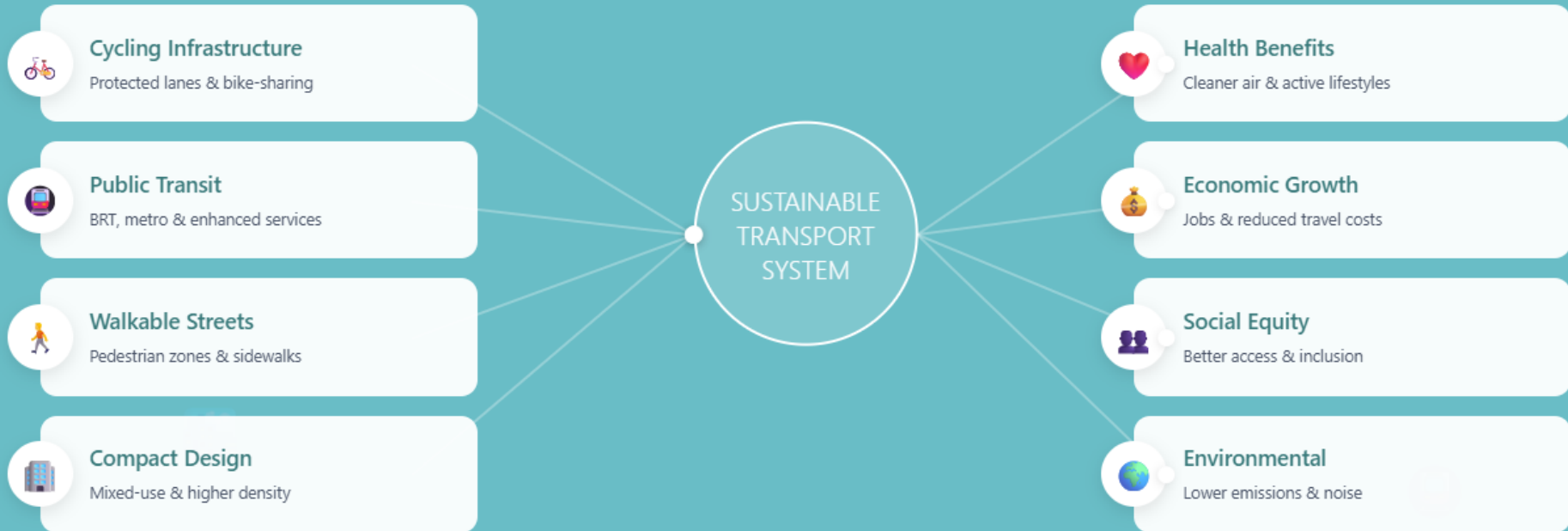




TRANSPORT CO-BENEFITS

INTERVENTIONS

CO-BENEFITS



Modal Shift Scenario: From Policy to Impact

Detailed Cause-Effect Chain for Sustainable Transport Transformation

POLICY INTERVENTIONS



Cycling Infrastructure

100km protected lanes
5,000 bike stations



Transit Enhancement

85% area coverage
Frequency + 40%



Road Space Reallocation

30% parking to green
Congestion pricing



Pedestrian Priority

50km pedestrian zones
3m min sidewalks

IMMEDIATE EFFECTS



Modal Shift

Car trips down 25%
Cycling up 300%
Transit use up 45%



Travel Time Changes

Commute time - 15 min
Reliability improved 30%



Traffic Flow

Peak congestion - 40%
Vehicle speed + 20%

Timeline: 6-12 months

MEDIUM-TERM IMPACTS



Environmental

CO₂ down 35%
PM2.5 down 40%
Noise down 6 dB



Public Health

Respiratory illness down 20%
Active minutes + 45/day
Accidents down 50%



Economic Activity

Business revenue + 15%
12,000 green jobs
Property values + 8%

Timeline: 1-3 years

LONG-TERM BENEFITS



Quality of Life

Life expectancy + 2.5 years
Happiness up 18%
Better social cohesion



Urban Resilience

Heat island reduced by 3°C
Green space up 40%
Better climate adaptation



Social Equity

Transport poverty down 60%
Better access to opportunities
Reduced inequality gap

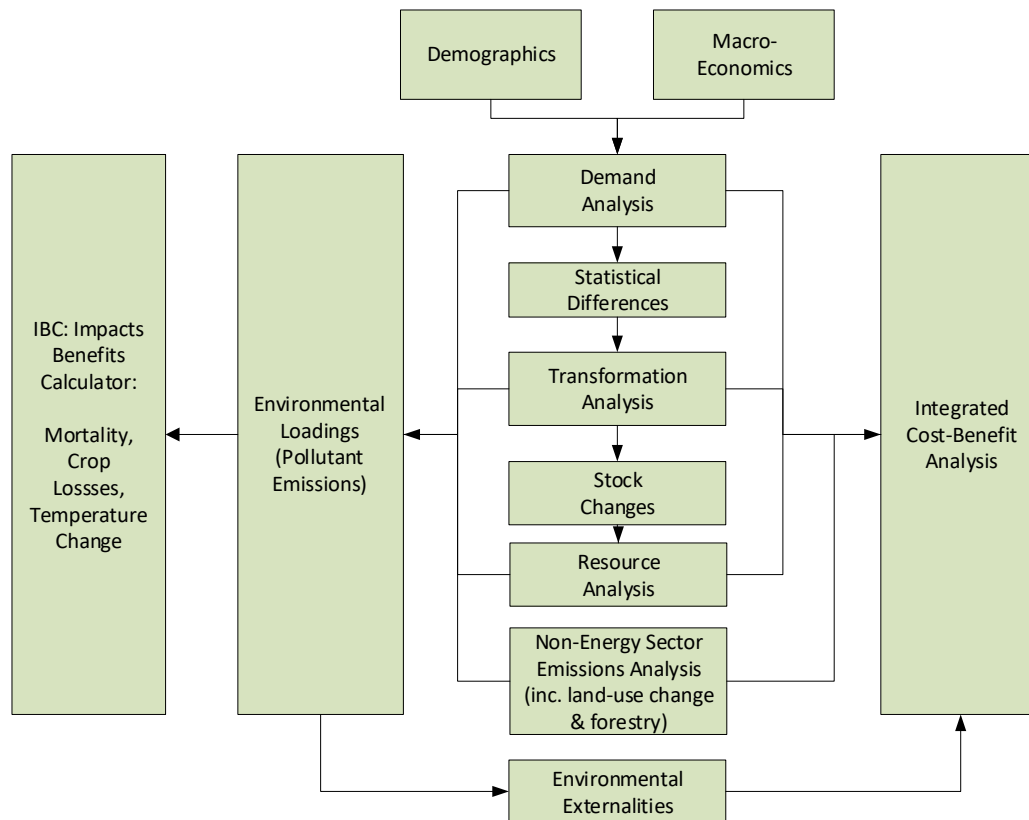


Economic Returns

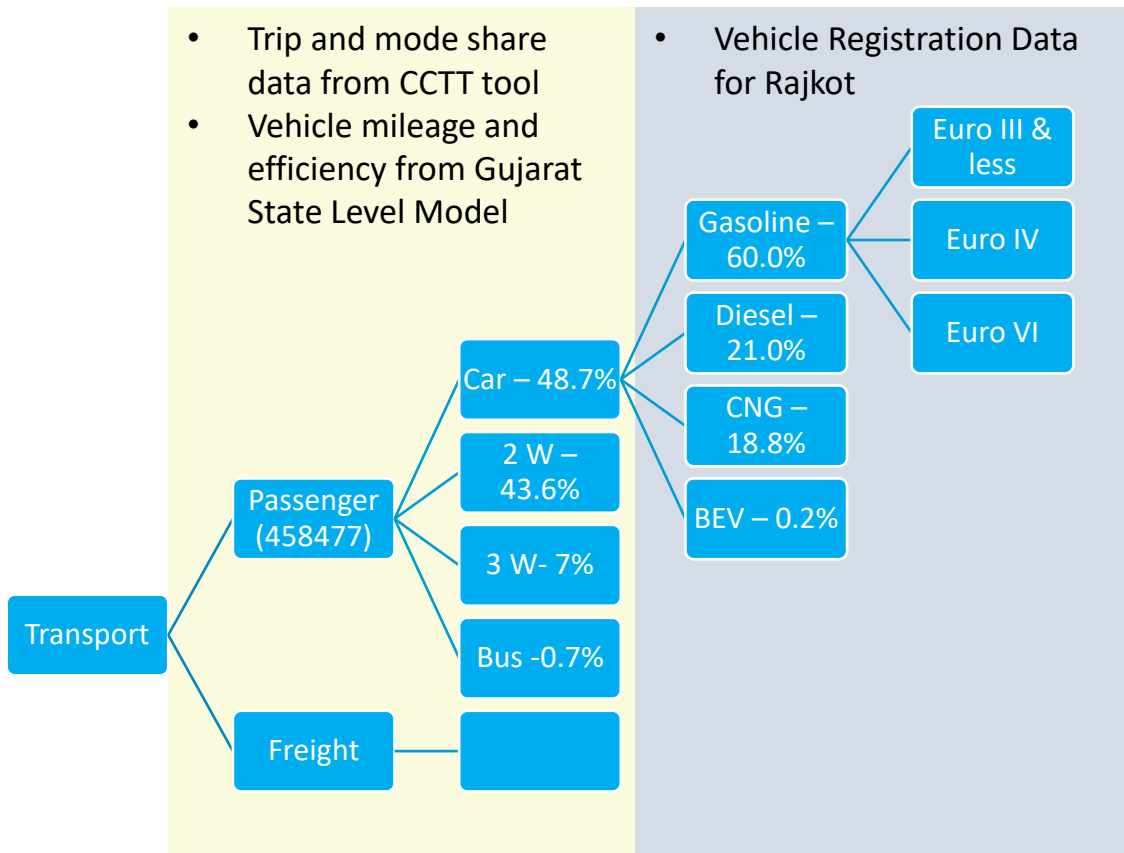
Healthcare savings: \$500M/yr
Productivity: \$300M/yr
ROI: \$4.50 per \$1

Timeline: 3-10 years

LEAP Structure



Modelling approach in LEAP



Modelling Vehicle Stock

