India Energy Transition Dashboard (2000–2025)

Power BI Dashboard

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1 Project Overview

This project develops an interactive Power BI dashboard to analyse India's installed capacity, generation, energy mix, renewable share, and emissions at national and state levels (2000–2025) & to provide insights useful for energy policy, planning, and consulting.

2 Objectives

- Understand the progress of India's energy transition from fossil fuels to renewables by combining domain expertise in the energy systems with Power BI data analytics skills.
- Visualize capacity addition, generation trends, and RE share at both national & state level.
- Quantify emissions from fossil generation and avoided emissions from renewable energy.
- Build interactive dashboards with filters and drilldowns for decision-making.
- Demonstrate data cleaning, modelling, and visualization skills in Power BI.

3 Repository Structure

India_Energy_Transition/

- README.md
- Data/
    - raw/ # Original downloaded datasets
    - processed/ # Cleaned & structured Excel files
- Docs/
    - Data_model_diagram
    - DAX_measures
- pbix/
    - India_Energy_Transition.pbix

- Output docs/ # Final outputs (Report PDF)

4 Data

4.1 Data Sources

Datasets	Source
Electricity Installed Capacity (State/national, by source)	NITI Aayog Energy Data Portal (ICED) https://iced.niti.gov.in
Electricity Power Generation (State/national, by source)	NITI Aayog Energy Data Portal (ICED) https://iced.niti.gov.in
Emission factors	CEA Baseline CO_2 factors (https://cea.nic.in)
India States Locations (Longitude, Latitude)	https://www.kaggle.com/

4.2 Assumptions & Limitations

- Year Ranges: Multi-year blocks (e.g., 2002–07) converted to single-year data at range-end.
- Renewable Definition: Solar, Wind, Small-Hydro, Bio Power.
- Capacity Factor: Derived directly from reported generation values.
- Missing Data: year gaps data filled using interpolation.
- Scope: Only national level & Indian states considered (Union Territories excluded).
- India Map: Used ArcGIS (only visible in online mode) because of Power BI desktop version limitation

4.3 Data Preparation

- **Source Data**: Downloaded raw datasets from NITI Aayog Energy data portal & CEA.
- **Restructuring Years:** Where only 5-year cumulative values were given, disaggregated into single years by interpolation. Renamed all "March-end" columns to reflect the corresponding year.
- **Renewable Energy (RE) Consolidation:** Created RES Total (2009–2025). Grouped sub-categories into Solar (all types combined) and Biopower for consistency (2014–2025).
- **Back casting (1997, 2002, 2007):** Derived missing values using multiplying factors based on 2009 shares: Multiplying factor = year 2009 specific row value/ Total RES for year 2009
- **Interpolation:** Estimated annual values between plan-period years (1997, 2002, 2007) by dividing differences equally across intervals.
- **Validation**: Cross-checked reconstructed yearly series with India's 5-Year Plan periods for consistency.
- **Final Transformation:** Clean dataset structured into columns: Year | State | Source | Capacity (MW) | Generation (GWh) | Emissions (tCO_2 per MWh)
- **Cleaning Tools:** MS Excel (pre-processing), Power BI (pre-processing, modelling & visualization).

4.4 Standardization:

- Units: Capacity (MW), Generation (GWh).
- Source names harmonized: Coal, Oil & Gas, Nuclear, Hydro, Solar, Wind, Small-Hydro, Bio Power
- Added "All India" rows in fact tables for direct national-level KPIs.
- Excluded Union Territories for simplification

5 Methodology & Calculation:

- Data Collection & Integration
- Data Cleaning and Transformation
- Data Modelling
- KPI & Metric Calculation
- Dashboard Development
- Validation & Cross-Check

5.1 Emission Factors & Calculations

Emission Factors (CEA Baseline Database, FY 2023–24):
EF_{Coal} = 0.97 tCO_2/MWh
$EF_{Oil\ \&\ Gas}$ = 0.45 tCO_2/MWh
Nuclear, Hydro & Renewables = 0
EF_{source} = Emission factor of a particular fuel source
$EF_{fossil,\ avg}$= weighted average emission factor of fossil fuels (Coal, Oil & gas)

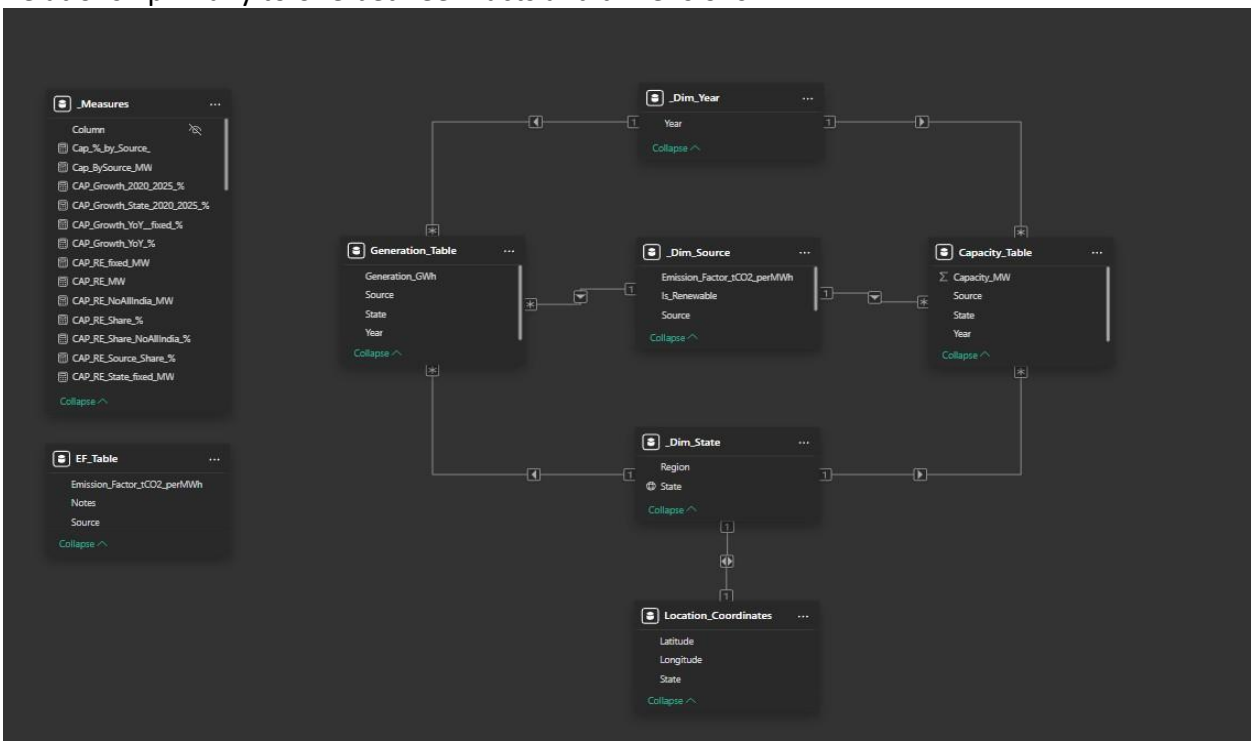
$EF_{fossil,\ avg} = \frac{\sum_{Fossil\ sources}(Generation_{Source} * EF_{source})}{\sum_{fossil\ sources}(Generation_{sources})}$

5.2 Efficiency, Utilization and Emission Calculation

- Total Emissions = $\sum_{all\ sources}(Generation_{Source} * EF_{source})$
- Avoided Emissions = Total Renewable Generation * $EF_{fossil,\ avg}$
- Grid Emission Intensity gCO2 per kWh = $\frac{\text{Total Emission}}{\text{Total Generation}}$
- Avoided Emission = Total Renewable Generation $*$ $EF_{\text{fossil,avg}}$
- Capacity Factor = $\frac{Total\ Generation}{Total\ Capacity * Yearly\ Hours}$

6 Data Model & Tables

- The model follows a Star Schema design in Power BI for efficient querying and flexible analysis.
- Fact tables store the main quantitative data for capacity, generation & emission factors
- Dimension tables provide descriptive attributes (state, region, source, year) to allow easy filtering/slicing
- Relationship: Many to one between facts and dimensions



6.1 Fact Tables

- **Generation_table:** Year, State, Source, Generation (GWh)
- **Capacity_table:** Year, State, Source, Capacity (MW)
- **EF_Table:** Source, Emission Factor (tCO2 PER MWh), notes
- **Location_Coordinates:** State, Latitude, Longitude

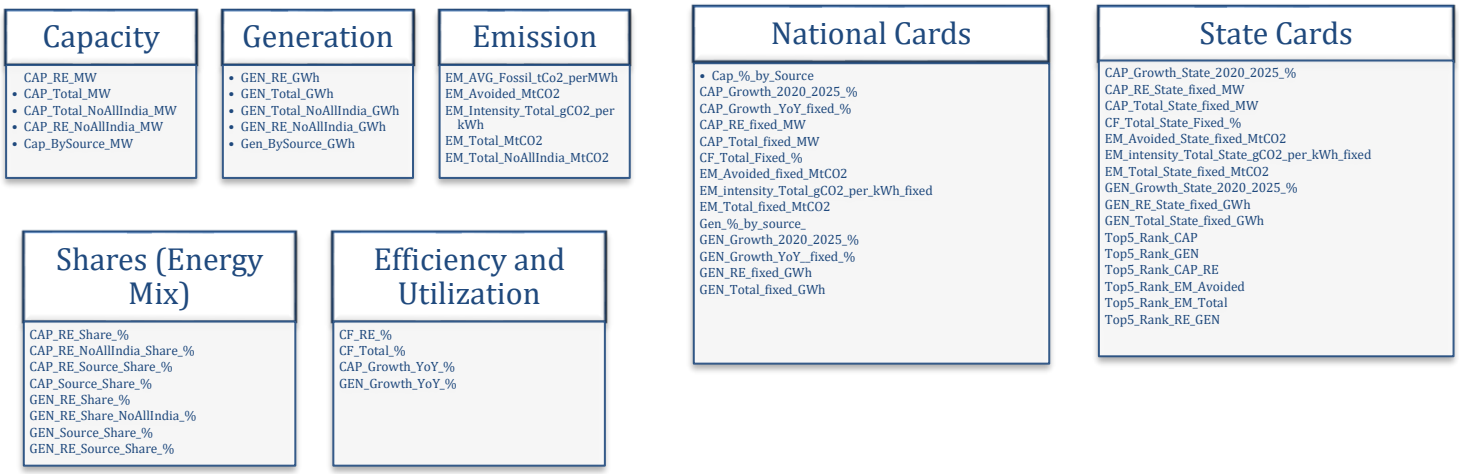
6.2 Dimension Tables

- **DimYear:** Calendar year (2000–2025)
- **DimState:** State, Region
- **DimSource:** Source, Source group, Is_Renewable (True/False), Emission_Factor_tCO_2/MWh

7 Key Measures & KPIs

Core metrics developed in DAX, designed to work at both state and national levels:
_Measures: Logical grouping of all KPIs

- Capacity Share (%)
- Generation Share (%)
- Renewable Energy Share
- Capacity Factor
- Grid Emission Intensity
- Avoided Emission
- Growth metrics (2020-25)
- Top 5 States by different metrics\



8 Dashboard Layout

8.1 Page 1 – National Level Energy Summary

- **Cards (2025 baseline):** Renewable capacity, Renewable Generation, Total Capacity, Total Generation, avoided emissions, Total CO2 emissions, Grid emission intensity, capacity factor (%), 2020–25 capacity and generation growth.
- **Graphs:** Total capacity & generation trends, emissions trends, avoided emissions, Capacity and Generation share by source for year 2000-2025
- **Slicers:** Year, source, source Type, Is Renewable.

8.2 Page 2 – State Level Energy Summary (1/2)

- **Cards (2025):** Same KPIs as national but state-specific.
- **Graphs:** Same trends but state-specific for year 2016-2025
- **Slicers:** Year, state, region, source, source type, Is renewable

8.3 Page 3 – State Level Energy Summary (2/2)

- Graphs: Top 5 states by capacity, Renewable capacity, generation, Renewable generation, emissions, avoided emissions.
- Map: State-wise total & Renewable generation.
- Slicers: Year, state, region, source, source type, Is renewable

9 Analytical Use Cases

- **National-level insights:** Track India's RE transition, fossil reliance, and emissions avoidance.
- **State benchmarking:** Compare states by generation, capacity mix, and emission.
- **Top performers:** Identify top 5 states driving the Renewable energy push.
- **Scenario testing:** Use slicers to dynamically see year-wise, source-wise, and region-wise shifts.

10 Key Insights

- India's Renewable share in capacity is significantly higher than in generation shows utilization challenge.
- Coal remains the backbone of power generation (~70%), driving emissions.
- Avoided emissions from Renewable Energy are growing rapidly, reducing around 240 $MtCO_2$ in 2025.
- State-level variations: Southern & Western states dominate in solar and wind, while Eastern India is still coal-heavy.
- Rajasthan and Gujarat lead in Renewable generation while Chhattisgarh and Uttar Pradesh lead in Emissions.

11 Technical Skills Demonstrated

- **Power BI:** Data transformation (Power Query), star schema modelling and dimension design, DAX, measure, Dashboard design principles, interactive map
- **Excel:** Data cleaning & transformation
- **Analytics:** KPI design, Emission modelling, actionable insights
- **Energy Domain:** Knowledge of India's power sector, emissions accounting, RE integration.

12 Business Value

- Helps policymakers assess progress toward renewable targets.
- Provides state-level insights for investment prioritization.
- Quantifies emission reduction benefits of RE adoption.

13 Future Scope

- Integrate Real-time data APIs
- Add Financial Metrics – LCOE, tariff data etc.
- Scenario Analysis – Add projections for 2030/2070 net zero
- Automate updates via Power Query
- Benchmarking - Compare India with global Renewable/CO_2 intensity benchmarks

14 How to Use

- Download the .pbix file from repository link
- Open file in Power BI Desktop.
- Keep Internet ON to view India map
- Use slicers to explore national/state data