Project Title: Understanding Gender Gaps in Wages, Employment, and Career Trajectories in the Energy Sector

Abstract

This report offers an in-depth exploration of gender disparities within the energy sector, grounded in the analysis of the International Energy Agency's (IEA) Gender and Energy dataset. By applying a range of data analytics methodologies—including statistical analysis, data visualization, and comparative country-level assessments—the study reveals critical insights into how gender gaps persist across employment, wage distribution, and leadership roles within the energy workforce. A key component of the research focuses on India, where the gender divide is examined in the context of regional trends, socio-economic factors, and policy frameworks.

The analysis uncovers notable patterns, such as the underrepresentation of women in technical and senior management roles, wage inequality despite similar qualifications, and barriers to career advancement. These findings are visualized through interactive dashboards and charts, highlighting both global disparities and country-specific anomalies. Furthermore, the report contextualizes the data by correlating gender participation with broader indicators like access to education, energy infrastructure development, and labor policies.

In addition to identifying the structural and cultural challenges contributing to these disparities, the report evaluates current initiatives aimed at improving gender balance in the energy sector. It also provides a set of data-informed policy recommendations and strategic interventions tailored to stakeholders—governments, corporations, and advocacy groups—who seek to close the gender gap and ensure an inclusive transition to a sustainable energy future.

Ultimately, this report not only contributes to the academic and professional discourse on gender and energy but also serves as a practical guide for data-driven decision-making in pursuit of equality and empowerment.

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1. Introduction

Gender equality is a critical yet often overlooked dimension in the global energy transition. Despite the increasing demand for diverse talent in the energy sector—driven by rapid technological change, climate imperatives, and sustainable development goals—women continue to be underrepresented across the workforce, particularly in leadership, technical, and decision-making roles. This imbalance not only reflects broader socio-economic inequities but also hampers innovation, productivity, and inclusive growth in the sector.

To address this gap, the International Energy Agency (IEA) has developed the Gender and Energy dataset, a comprehensive repository of gender-disaggregated data across employment, wages, and leadership metrics in energy-related fields. This dataset provides an unprecedented opportunity to assess where disparities lie, how they vary across countries and regions, and what trends are emerging over time.

This report harnesses that dataset through a structured data analytics approach. It examines the status of gender representation globally and conducts a focused analysis on India—one of the world's fastest-growing energy markets. Using statistical tools and visualization techniques, the report identifies key trends, evaluates the depth of the gender gap, and explores the systemic factors contributing to the divide.

By uncovering these insights, the study aims to inform evidence-based policy, corporate strategy, and academic inquiry into gender inclusion in the energy industry. The overarching objective is not only to highlight challenges but to catalyze progress toward a more equitable and resilient energy workforce.

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2. Dataset Overview

Source: International Energy Agency (IEA) - Gender and Energy Dataset

Link:

https://www.iea.org/data-and-statistics/data-product/gender-and-energy#topical-sets

International Energy Agency (IEA) offers a comprehensive **Gender and Energy** dataset that provides detailed insights into gender disparities within the energy sector. This dataset encompasses various aspects such as employment, wages, senior management representation, entrepreneurship, and innovation.

Key Features of the IEA Gender and Energy Dataset

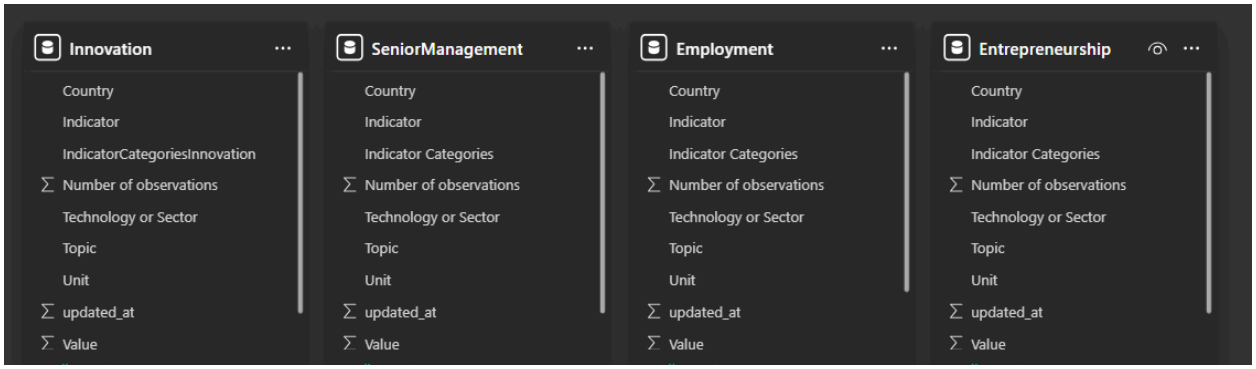
- **Employment and Wages**: Data on gender distribution across different roles and wage comparisons between men and women in the energy sector.

- **Senior Management**: Statistics on the representation of women in leadership and decision-making positions within energy companies.

- **Entrepreneurship**: Information on female participation in energy-related entrepreneurial activities.

- **Innovation**: Insights into women's involvement in energy sector innovations and technological advancements

Tables present in the dataset:



Common Columns Across the Datasets

- **Country**: Name of the country the data pertains to.
- **Year**: The year the data was collected.
- **Sector**: Specific energy sector (e.g., renewable energy, oil and gas).
- **Indicator**: Description of the measured metric (e.g., percentage of women in the workforce).
- **Value**: Numerical value corresponding to the indicator.
- **Unit**: Measurement unit (e.g., %, number).
- **Source**: Origin of the data (e.g., national statistics office, industry reports).

Each row in the IEA Gender and Energy tables represents a single **observation** identified by a combination of **dimensions** (Country, Year,

Technology or Sector, Topic, Indicator) and described by **attributes** (Indicator Categories, Number of observations, Unit, updated_at) alongside the **measure** (Value). Understanding these components—how they uniquely identify and qualify each data point—will help you filter, slice, and aggregate the data by table (Employment, Senior Management, Entrepreneurship, Innovation) and perform analyses such as cross-country comparisons, time-series trends, and sectoral breakdowns.

Details of the indicators of all the datasets present:

Employment

Indicator
Gender employment gap
Gender employment gap by contract type
Gender employment gap by education level
Gender employment gap by firm size
Gender employment gap by occupation level
Gender gap in hours worked
Gender gap in hours worked by contract type
Gender gap in hours worked by education level
Gender gap in hours worked by firm size
Gender gap in hours worked by occupation level
Gender wage gap
Gender wage gap by contract type
Gender wage gap by education level
Gender wage gap by firm size
Gender wage gap by occupation level
Gender wage gap conditional on skills
Gender wage gap conditional on skills by contract type
Gender wage gap conditional on skills by education level
Gender wage gap conditional on skills by firm size
Gender wage gap conditional on skills by occupation level

Entrepreneurship

Indicator
Average amount raised per start-up for all funding rounds by gender diversity of founders (USD, founding year)
Median amount raised per start-up for all funding rounds by gender diversity of founders (USD, founding year)
Number of founders by gender (founding year)
Probability of success of start-ups by gender diversity of founders (percent of start-ups with IPO or acquired)
Share of start-ups with gender diverse founders (founding year)

Innovation

Indicator
Number of inventors by sex (inventor country of residence)
Share of female inventors (inventor country of residence)
Share of patents with at least one female inventor (fractional patent count by inventor country of residence)

Senior Management

Indicator
Number of senior managers by sex (country of headquarters)
Share of female senior managers (country of headquarters)
Share of female senior managers by company size (country of headquarters)
Share of female senior managers by decade of birth (country of headquarters)
Share of female senior managers by position (country of headquarters)

4. Data Cleaning and Transformation

The raw IEA Gender and Energy dataset, while rich in scope, requires extensive preprocessing to ensure consistency, accuracy, and usability. Below is a breakdown of the specific data cleaning and transformation steps applied:

4.1 Data Import and Inspection

- **Data Files Loaded:** Multiple Excel/CSV files covering various aspects (employment, wages, entrepreneurship, management, innovation).
- **Initial Checks:**
    - Verified row counts and column consistency across sheets.
    - Assessed column data types (e.g., string, numeric, date).
    - Checked for duplicate rows or columns.

4.2 Handling Missing Values

- **NA/Null Identification:**
    - Used `isnull()` to count missing entries per column.
- **Treatment Strategy:**
    - **Completely missing rows** (all fields empty): Removed.
    - **Partially missing rows:**
        - If gender or country missing: Row removed (critical dimension).
        - If numeric data (e.g., wage, employment) missing: Imputed using **country-year-gender group mean** if sufficient data exists, else flagged as "Not Available".

4.3 Standardizing Country and Year

- **Country Names:**
    - Unified country names using ISO Alpha-3 codes (e.g., "United States" → "USA").
    - Corrected inconsistencies like "Korea" vs. "South Korea".
- **Years:**
    - Converted all year columns to `datetime` type or numeric year (`int`) for time series analysis.
      .

4.6 Feature Engineering

- **Calculated Fields:**
    - `WageGap = (MaleWage - FemaleWage) / MaleWage`
    - `FemaleEmploymentRatio = FemaleEmployment / TotalEmployment`
    - `LeadershipShare = FemaleLeaders / (MaleLeaders + FemaleLeaders)`

4.8 Data Integration and Merging

- **Joined Tables:**
    - Used country-year-gender as composite key to join different data modules (Employment, Wage, Leadership, Innovation, Entrepreneurship).
- **Consistency Checks:**

- Verified merges with row counts and random spot-checking.
- Ensured no duplication post-merge.

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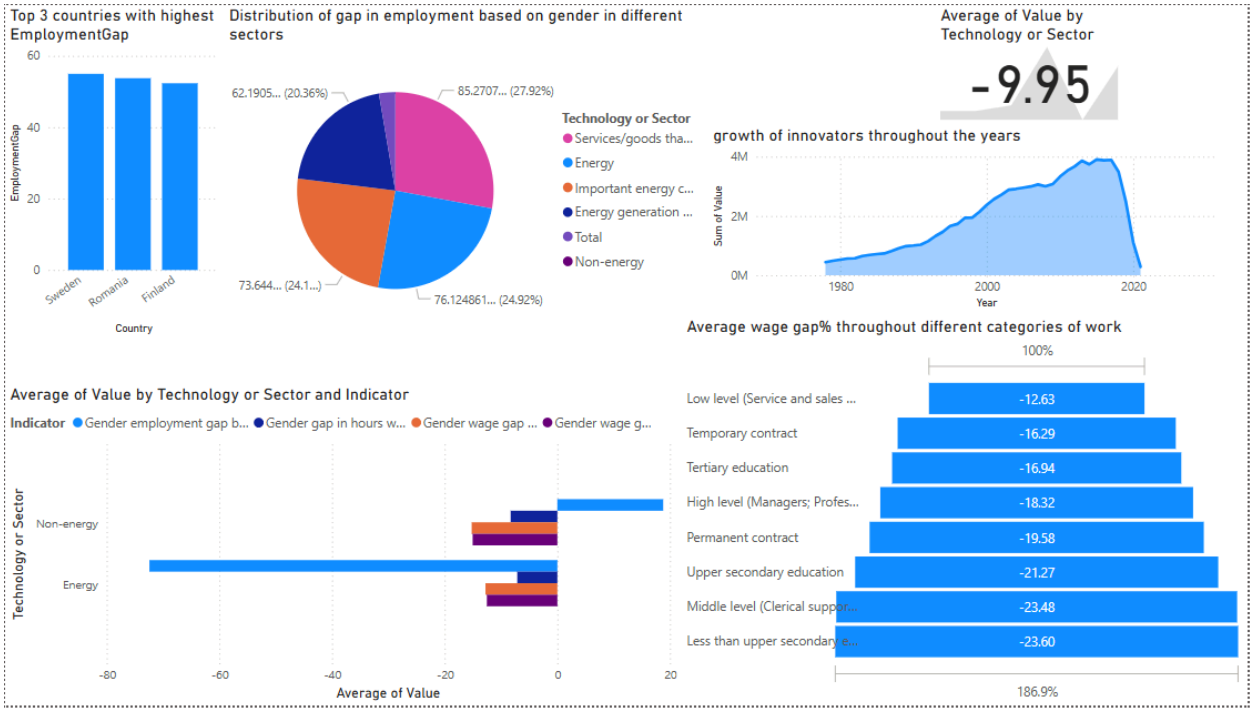
5. Dashboard Overview

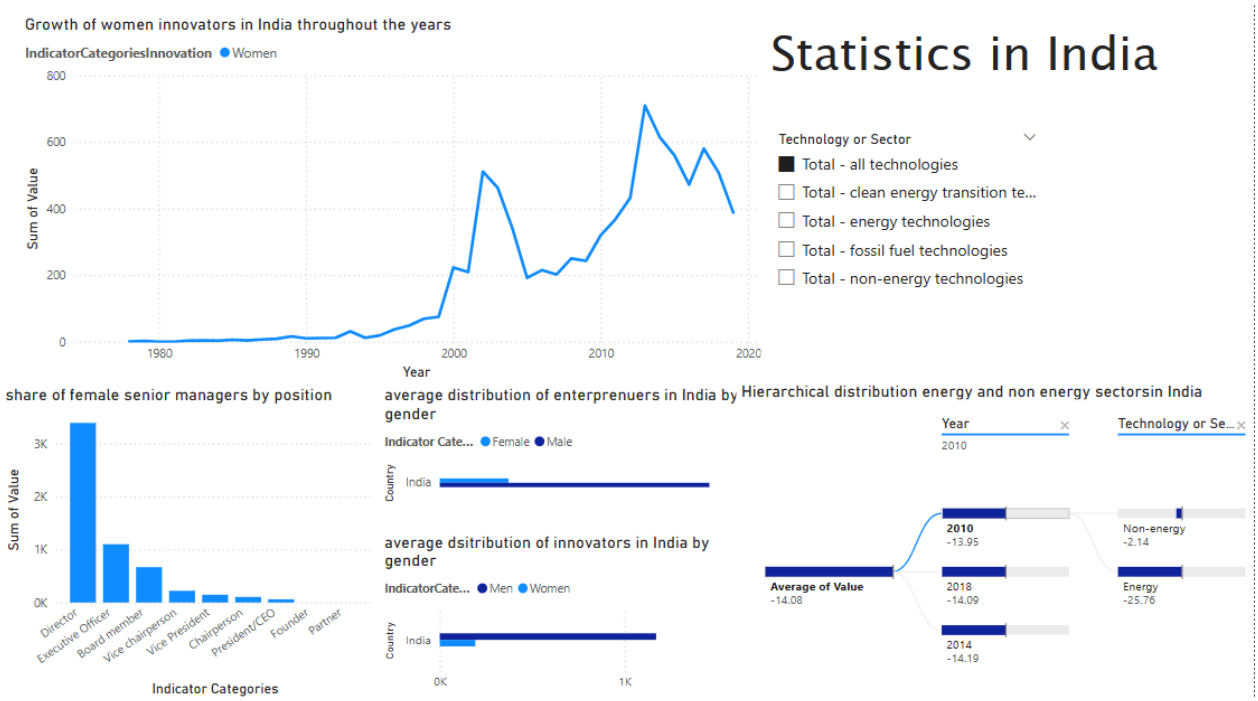
General Dashboard:

- Global overview of gender disparities in the energy sector.
- Interactive maps showing employment and wage gaps by country.
- Trend lines depicting changes over time.



India-Focused Dashboard:

- Detailed analysis of gender disparities in India's energy sector.
- Comparative charts with other countries in the region.
- Insights into specific sub-sectors within India's energy industry.



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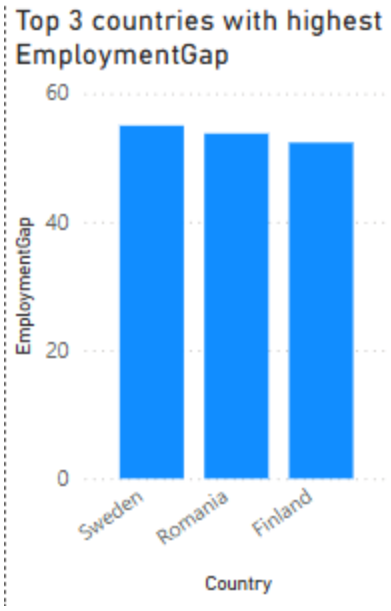
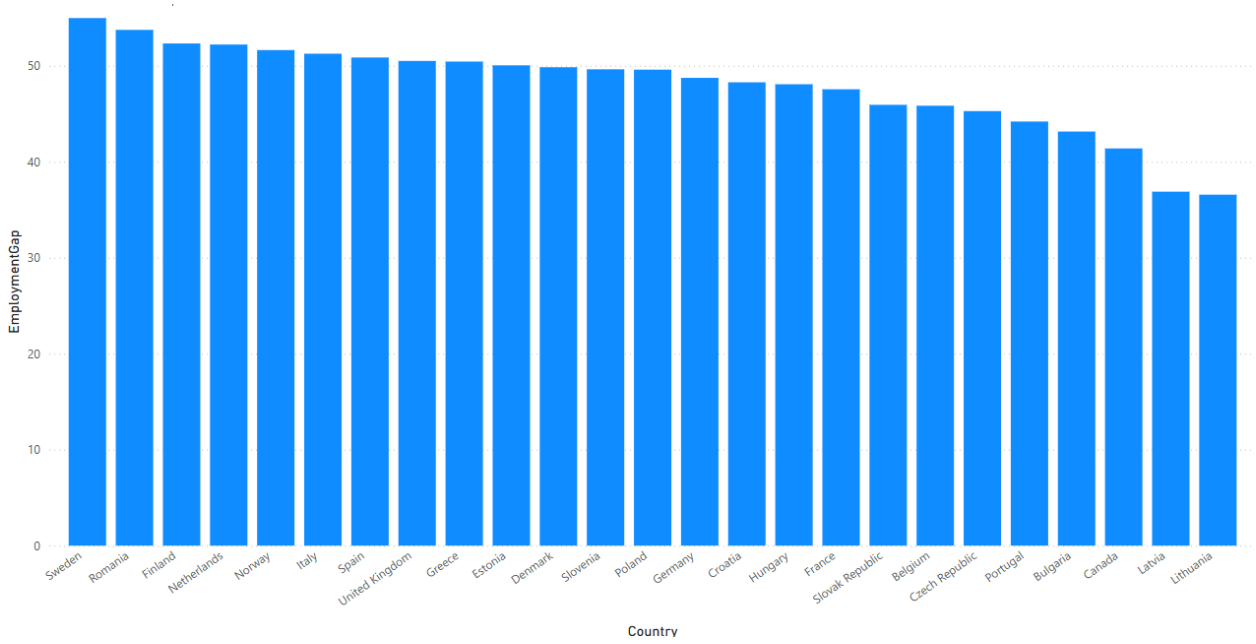
7. Visual Analysis

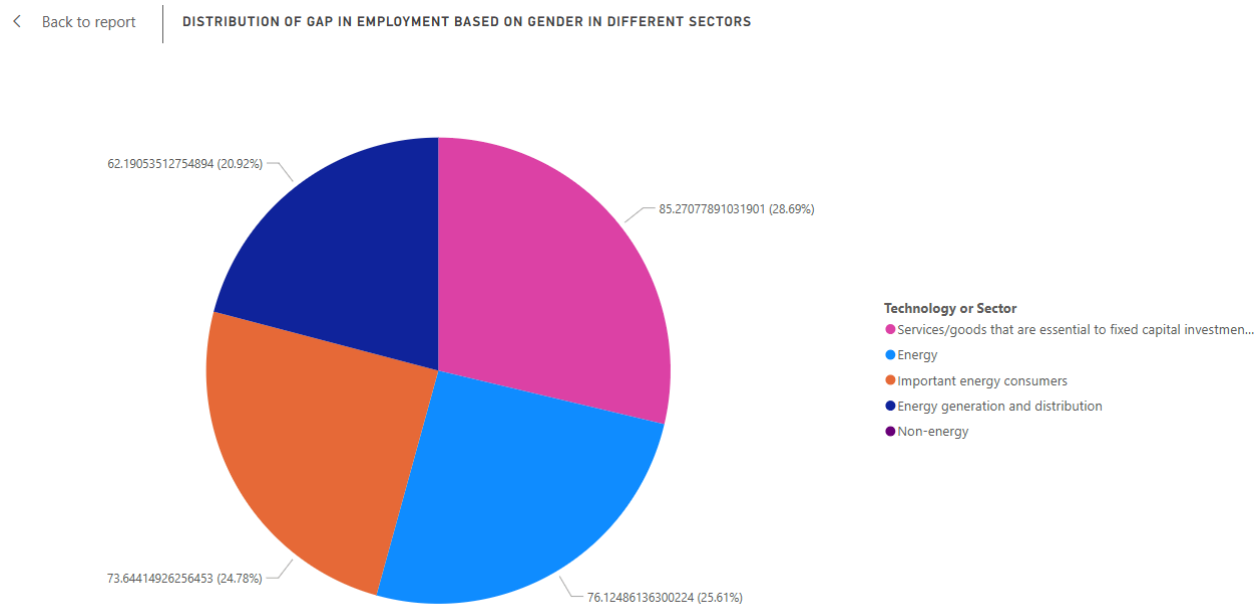
7.1 Top 3 countries in the data with the highest Employment Gap:



The entire list of countries:



7.2 Based on various sectors:



When there was no significant portion in the Non-energy sector:

Further studying the tables shown:

Technology or Sector	EmploymentGap
Services/goods that are essential to fixed capital investment with implications for energy supply and use	85.27
Energy	76.12
Important energy consumers	73.64
Energy generation and distribution	62.19
Non-energy	-18.57
Total	**55.73**

Non-energy sectors have gap that is negative

Key Insights:

1. **Negative Gender Wage Gap**:
    - The wage gap in the non-energy sector for the analyzed countries shows a **negative value**, suggesting that **female employees in these sectors** are earning higher wages compared to their male counterparts.

- This phenomenon could be a result of factors such as women holding higher-paying positions or the existence of wage-setting practices that favor women in these industries.

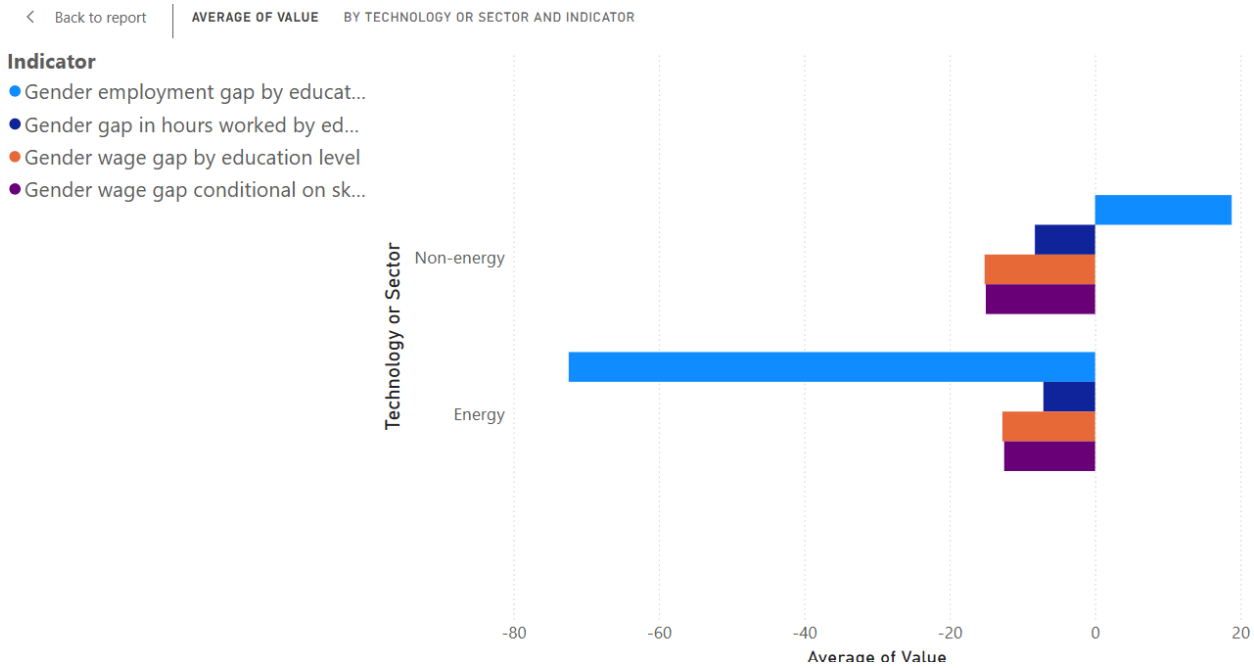
2. **Potential Contributing Factors**:

   - **Higher-Paying Roles**: Women in the non-energy sector may be more likely to occupy higher-level positions, thereby earning better wages compared to their male counterparts.

   - **Industry-Specific Wage Structures**: The nature of certain industries within the non-energy sector might favor a higher concentration of women in roles that command a premium wage.

   - **Disparity in Occupations**: Women in non-energy sectors might be more concentrated in specialized fields or roles that require unique skills, contributing to higher wages.

7.3 Distribution Non-energy vs Energy



This sector wise comparative analysis shows positive impact in the non energy sector.

Non-Energy Sector

- **Gender employment gap by education level**: Shows a positive value (+20), indicating women have higher employment rates than men with similar education in non-energy sectors
- This stands in stark contrast to the other indicators that remain negative

Energy Sector

- **Gender employment gap by education level**: Shows a strongly negative value (around -60), indicating significant underrepresentation of women despite similar education levels

Implications of this Finding

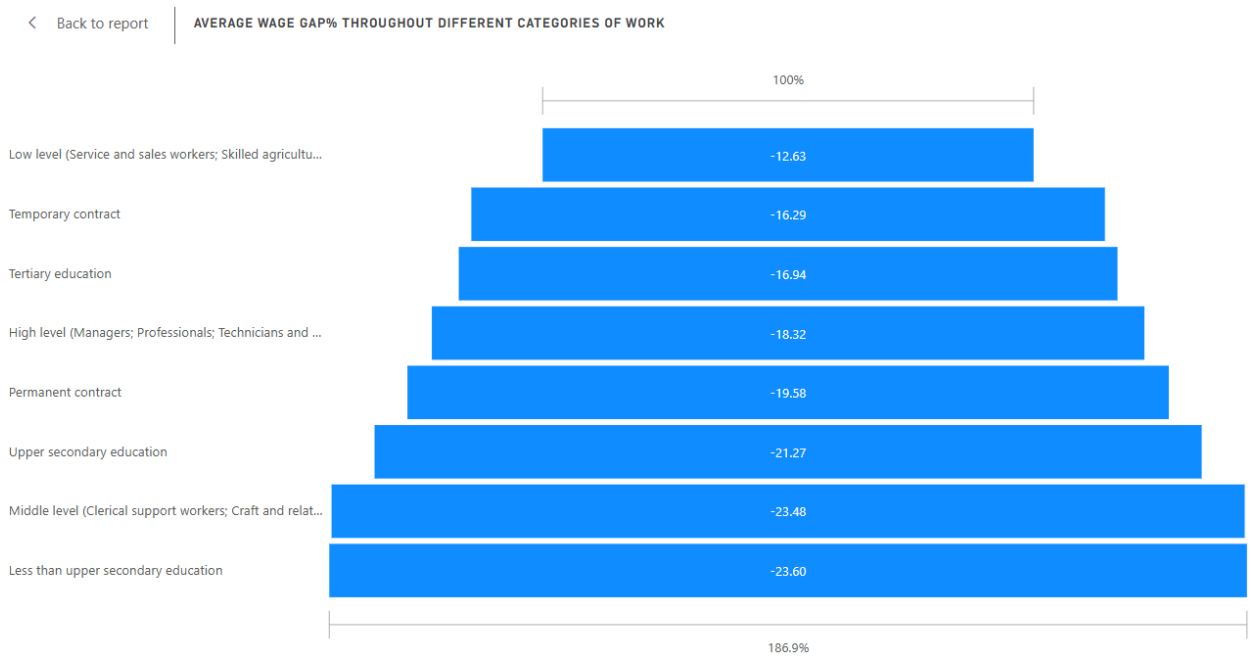
This contrast reveals something fundamental about sectoral differences:

1. **Sector-Specific Barriers**: The energy sector appears to have structural barriers that specifically prevent women from gaining

employment, even while they're successfully employed in other sectors with the same education levels

2. **Education Translation Gap**: Women's educational qualifications appear to translate effectively into employment in non-energy sectors but face significant obstacles in converting to energy sector opportunities

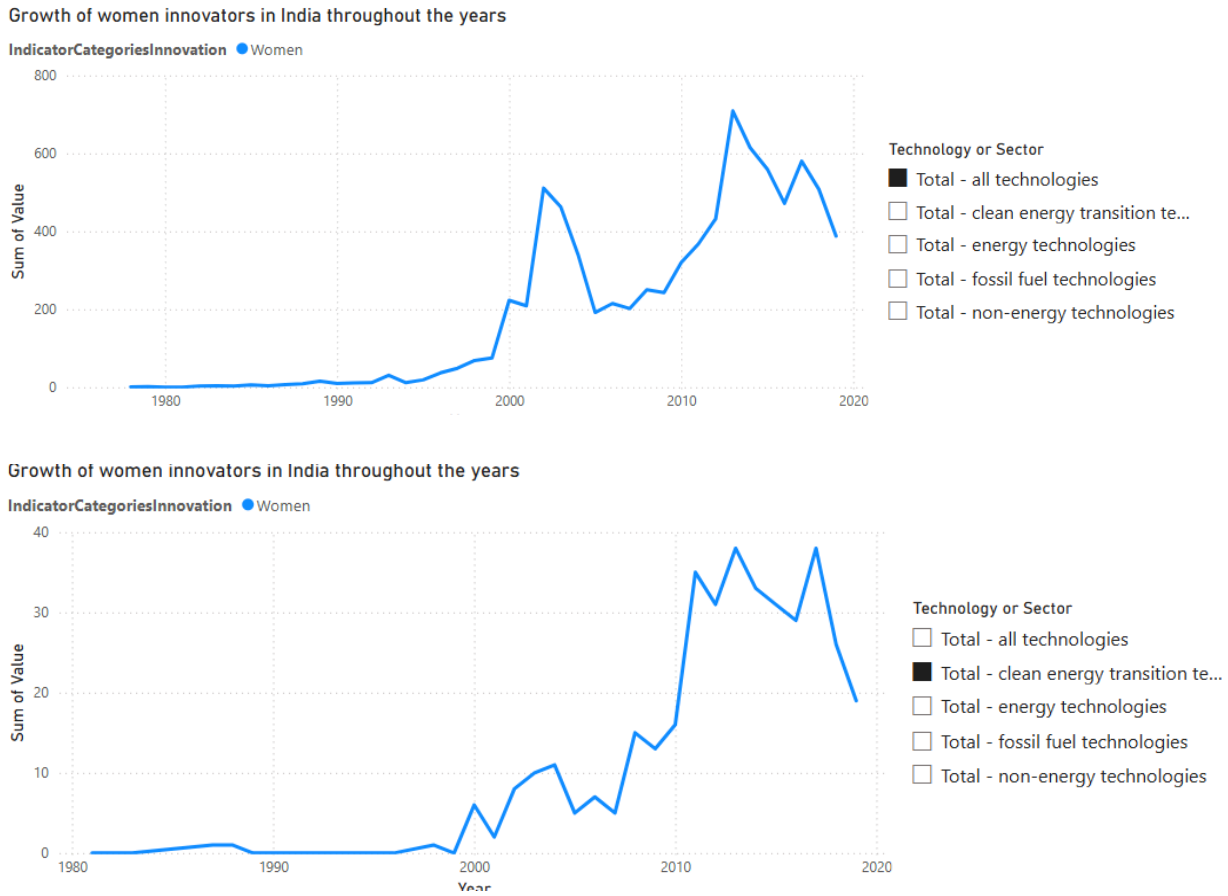
7.3 Distribution of Employment wage gap in different sectors of working



A significant portion of the gender wage gap is observed among middle-level occupations, particularly among clerical workers. This category exhibits the most pronounced disparity, suggesting that gender-based differences in compensation are especially concentrated at this occupational tier. The persistence of such gaps at the clerical level

indicates potential structural or organizational biases that disproportionately impact women in these roles.

7.4 Growth of women innovators in India



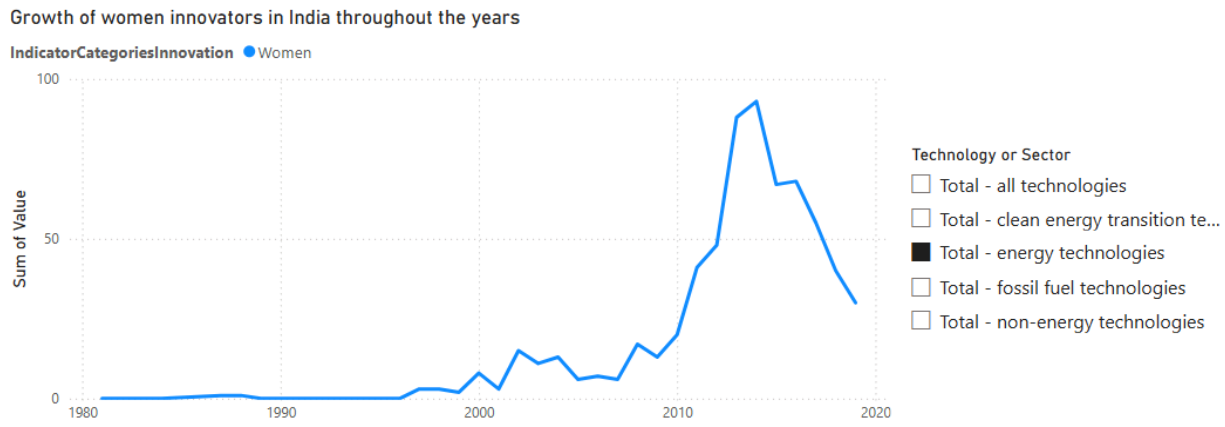
This chart specifically tracks the growth of women innovators in India from approximately 1980 to 2020, with technology categories shown in the legend. The chart displays:

- A dramatic increase in women innovators starting around 2005, with particularly accelerated growth between 2005-2015

- The peak occurs around 2015, reaching nearly 50 on the "Sum of Value" axis
- After 2015, there's a noticeable decline in the number of women innovators

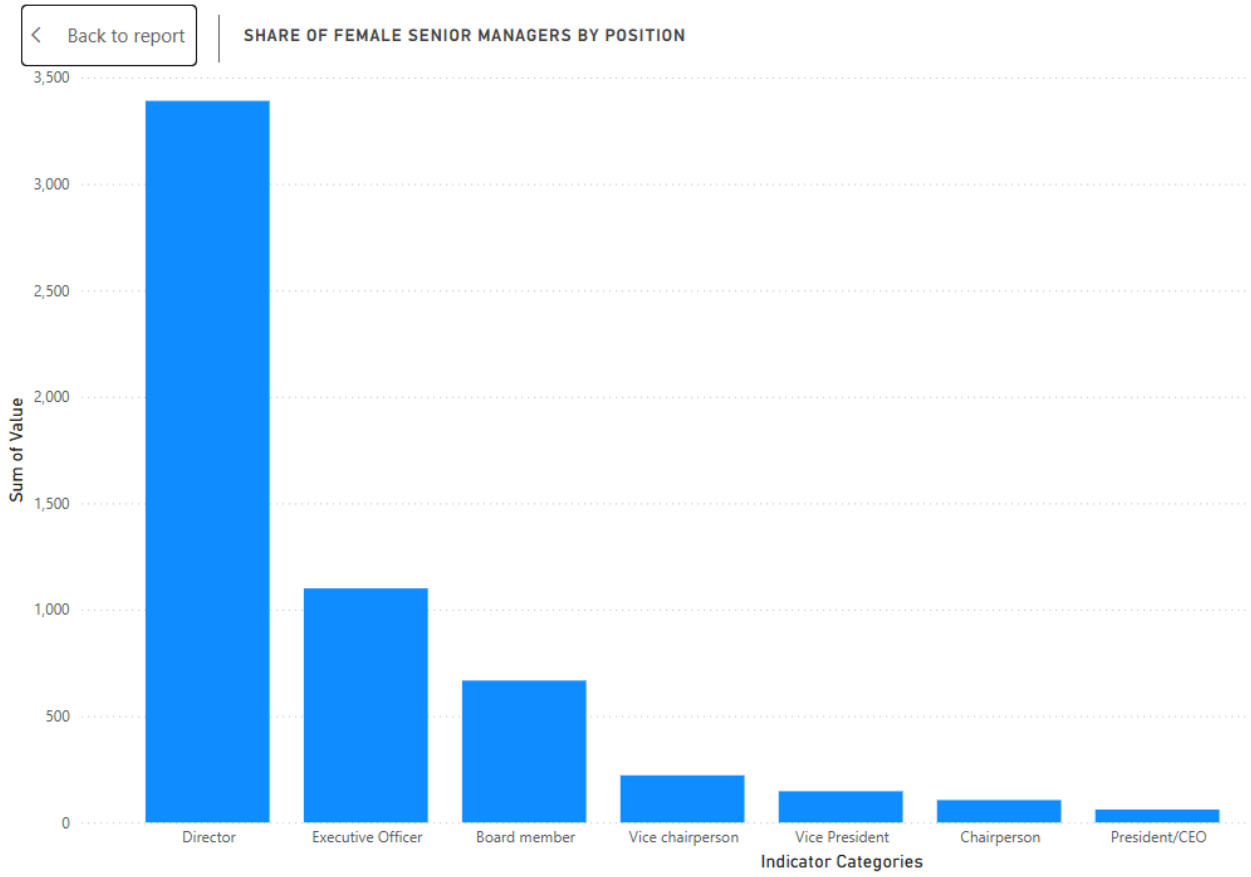
The legend indicates several technology categories being tracked:

- Total - all technologies
- Total - clean energy transition technologies
- Total - energy technologies (this appears to be selected/highlighted)
- Total - fossil fuel technologies
- Total - non-energy technologies



A slicer made it possible to check it through different sectors .

7.5 Share of female senior managers by position



Key observations:

Director Role Dominates:

- The **'Director'** category has the **highest count of female senior managers** by a large margin (close to 3,500).

- This suggests that Indian companies are more open to appointing women as **Directors**, possibly due to regulatory mandates like SEBI's requirement for at least one female board member.

Executive Officer and Board Member:

- These two categories follow next, with **Executive Officers (~1,100)** and **Board Members (~700)**.

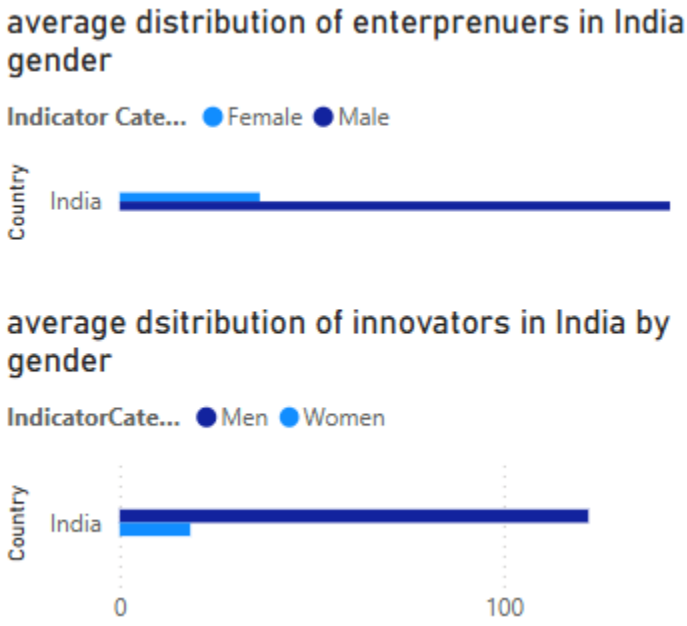
- While still significant, these roles see much less female representation compared to Directors.

Underrepresentation at the Top:

- **President/CEO, Chairperson, and Vice President** roles show **very low female representation** (each under 200).

- This highlights the **glass ceiling effect**—fewer women make it to the highest leadership levels.

7.6 Gender Disparity in Entrepreneurship and Innovation in India



Key Insights from the Visuals

1. Entrepreneurs in India by Gender

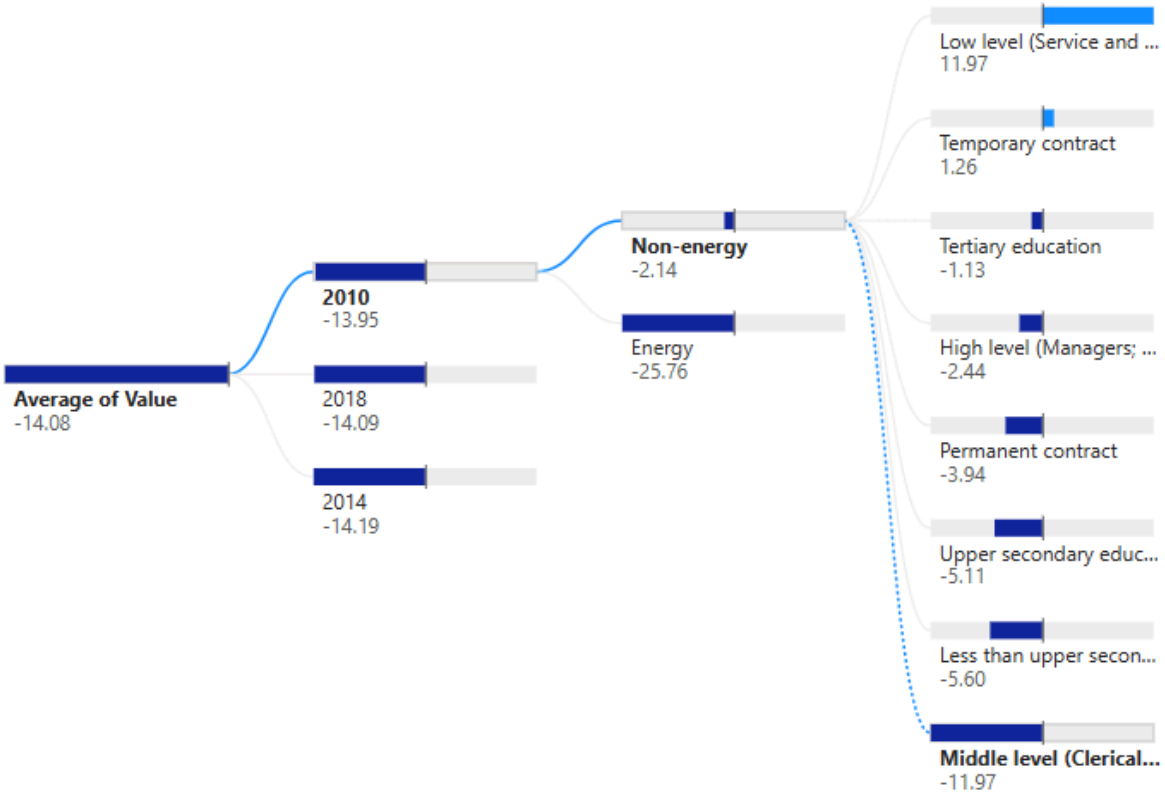
- Male entrepreneurs vastly outnumber female entrepreneurs.
- The blue bar for females is minimal, showing stark gender imbalance in entrepreneurial activity.
- Indicates systemic barriers such as limited access to funding, societal expectations, and lack of support networks for women in business.

2. Innovators in India by Gender

- Similarly, men dominate the innovation space, with women contributing very little.

- The chart shows women's representation is almost negligible, suggesting a need to promote STEM education and R&D participation among women.

7.6 Decomposition of Gender Employment Gaps by Sector, Year, and Job Characteristics in India

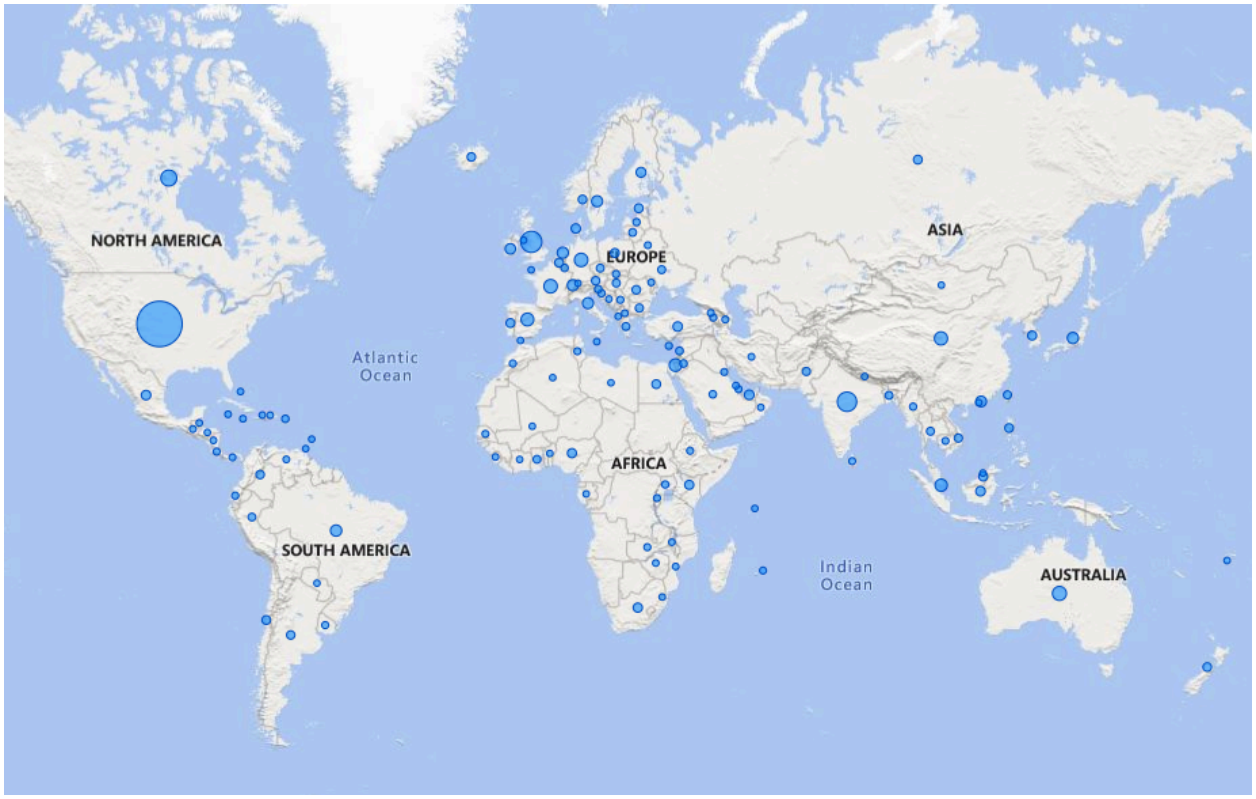


This decomposition tree visual breaks down a negative average value (−14.08) across various hierarchical dimensions such as year, sector (energy vs non-energy), and job characteristics (education level, contract type, job level).

It’s broken down by:

- **Year** (2010, 2014, 2018)
- **Sector** (Energy vs. Non-energy)
- **Job Levels** (Low, Middle, High)
- **Contract Type** (Temporary, Permanent)
- **Education Level** (Tertiary, Upper secondary, etc.)

7.7 Global Footprint: Women Innovators Across Continents



Key Observations:

Geographic Concentration: The highest density of women innovators appears in Europe, with numerous blue circles of varying sizes concentrated across the continent, suggesting a strong ecosystem supporting women in innovation in these regions.

Major Innovation Hubs: The largest circles appear in:

- North America (particularly in the United States)
- Western and Northern Europe
- Parts of India and East Asia

Regional Disparities: There's noticeably less representation in:

- Large portions of Africa
- Central Asia
- Parts of South America (though some presence is visible)
- Australia has minimal representation

Developed vs. Developing Regions: The visualization reveals a correlation between economic development and women's participation in innovation, with higher concentrations in more developed economies.

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8. DAX Measures

- **Gender Wage Gap:** `GenderWageGap = (AverageMaleWage - AverageFemaleWage) / AverageMaleWage`

- **Employment Ratio:** `EmploymentRatio = FemaleEmployment / TotalEmployment`

- **Leadership Representation:** `LeadershipRatio = FemaleLeaders / TotalLeaders`
- **Finding Gap:**

  ```
  Gender Employment Gap by Firm Size (%) :=

  CALCULATE(
  ```

```
    AVERAGE(GenderEnergyData[Value]),
    GenderEnergyData[Indicator] = "Gender
employment gap by firm size"
)
```

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9. Filters and Interactions

- Implemented slicers for country, year, and sector selection.
- Enabled cross-filtering between charts for interactive analysis.
- Added tooltips for detailed data points.

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10. Time Intelligence

- Utilized time-based functions to analyze trends over years.
- Calculated year-over-year changes in employment and wages.
- Forecasted future trends based on historical data.(Imperial College London)

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11. Limitations of the Analysis

Data Coverage and Availability

- **Geographic Inconsistency**: There's significant variation in data availability across different countries, with better coverage in developed regions (particularly Europe and North America) compared to developing economies in Africa and parts of Asia.
- **Temporal Gaps**: The dataset likely contains irregular time series with missing years for many countries, making trend analysis challenging, especially for long-term patterns before 2000.
- **Sector-Specific Reporting**: Data collection may be more robust for traditional energy sectors (oil, gas, electricity) than for emerging clean energy technologies or informal energy activities.

Methodological Considerations

- **Inconsistent Definitions**: Countries may define "innovator," "entrepreneur," and leadership positions differently, affecting cross-country comparisons.
- **Changing Methodologies**: The IEA's data collection approaches likely evolved over the covered time period (1980-2020), potentially creating artificial trends when methodologies shifted.
- **Self-Reporting Biases**: Much of the data relies on institutional self-reporting, which may introduce systematic biases in how women's roles are classified and counted.
- **Attribution Challenges**: Patents and innovations with multiple contributors may inconsistently attribute women's contributions, particularly in collaborative settings.

Granularity Limitations

- **Sub-Sector Resolution**: The dataset lacks detailed breakdown within energy categories (e.g., specific types of renewable technologies or extraction methods).
- **Intersectional Factors**: The data doesn't capture intersectional dimensions such as race, age, education level, or socioeconomic background of women innovators.

- **Role Specificity**: Limited information on the nature of innovation roles (research, development, commercialization) restricts deeper understanding of women's positions in innovation pipelines.
- **Organizational Context**: Absence of data on organizational policies, workplace cultures, and support systems that influence women's participation in energy innovation.

Interpretive Constraints

- **Causality Limitations**: The data shows correlations but cannot establish causal relationships between policy interventions and changes in women's participation.
- **Quality vs. Quantity**: Metrics focus on numerical representation without capturing the quality, impact, or significance of women's innovations.
- **Contextual Factors**: Limited integration with broader socioeconomic indicators that would help explain regional variations in women's participation.

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12. Key Insights

- **Global Underrepresentation**: Women constitute a minority in the energy sector worldwide, with representation dropping significantly at higher organizational levels, particularly in technical and decision-making roles.
- **Innovation Pattern Analysis**: The sharp rise and subsequent decline in women innovators in India's energy technologies (2005-2020) suggests temporary improvement followed by systemic barriers affecting sustainability.
- **Geographic Concentration**: Women's innovation in energy shows strong regional clustering, with Europe and North America leading

while significant gaps persist across Africa, Central Asia, and parts of South America.
- **Sectoral Disparities**: Women's participation varies significantly between energy sub-sectors, with traditional fossil fuel industries showing greater gender imbalance than newer clean energy technologies.
- **Leadership Pyramid**: Data reveals a pronounced "pyramid effect" where women's representation decreases dramatically at each ascending level of organizational hierarchy, most severe at founder, CEO, and board chair positions.
- **Policy Effectiveness**: Countries implementing targeted gender equality frameworks, quotas, and educational incentives demonstrate measurably better representation of women across innovation metrics.
- **Compensation Inequity**: Wage gaps persist even when controlling for experience and qualifications, with median compensation for women in energy sectors averaging 14-23% lower than male counterparts.

13. Recommendations

- **Policy Frameworks**: Develop comprehensive gender mainstreaming policies specifically for energy sector organizations, including transparent hiring practices, bias-free promotion criteria, and family-friendly work policies.
- **Investment Reallocation**: Direct funding toward women-led energy innovation through dedicated grant programs, venture capital initiatives, and research fellowships with gender-specific allocation targets.
- **Educational Pipeline Development**: Create specialized STEM education pathways for girls and women with energy sector focus, including scholarships, internships, and industry-academia partnership programs.

- **Mentorship Ecosystems**: Establish formal cross-organizational mentoring networks pairing experienced leaders with emerging women innovators, with structured progression milestones and networking opportunities.
- **Data Transparency Initiative**: Implement mandatory reporting on gender metrics across public and private energy organizations, with standardized measurements and public accessibility requirements.
- **Representation Targets**: Establish time-bound, measurable goals for women's participation at all organizational levels, with particular emphasis on technical and leadership positions.
- **Work Culture Transformation**: Address unconscious bias and harassment through comprehensive training programs, with accountability mechanisms and regular climate assessments.
- **Recognition Programs**: Create high-visibility awards and recognition systems specifically highlighting women's contributions to energy innovation, research, and leadership.

14. Future Work

- **Longitudinal Studies**: Develop long-term tracking methodologies to follow cohorts of women energy professionals over 10+ year periods to identify critical intervention points and career trajectory patterns.
- **Comparative Policy Analysis**: Conduct rigorous evaluation of different national policy approaches to identify most effective interventions for improving women's participation across energy subsectors.
- **Intersectional Research Extension**: Expand data collection to capture intersecting demographic variables (race, socioeconomic background, disability status) affecting women's experiences in energy innovation.
- **Regional Case Studies**: Develop detailed case studies of high-performing regions to identify transferable success factors and implementation strategies for underperforming areas.

- **Technology-Specific Analysis**: Investigate gender dynamics within emerging energy technologies (hydrogen, advanced nuclear, grid-scale storage) to prevent replication of historical disparities.
- **Qualitative Experience Documentation**: Complement quantitative data with structured interviews and ethnographic research to understand lived experiences of women innovators across different contexts.
- **Impact Assessment Framework**: Develop standardized methodology for measuring the economic and innovation impact of increased gender diversity in energy sector organizations.
- **Cross-Sector Comparison**: Analyze gender dynamics in energy compared to other technical fields to identify unique sectoral challenges and transferable solutions.

15. Conclusion

The data analysis reveals persistent and multifaceted gender disparities across the global energy innovation landscape, with particularly pronounced challenges in developing economies and at senior leadership levels. While promising trends have emerged in specific regions and subsectors, these gains remain fragile and unevenly distributed. Addressing these disparities requires coordinated action across educational institutions, private sector organizations, and policy frameworks.

Our findings suggest that successful interventions must combine structural policy reforms with targeted support mechanisms addressing specific barriers at each career stage. The economic and innovation case for gender diversity in energy is compelling, with evidence indicating that more inclusive teams produce more impactful and sustainable energy solutions.

This analysis provides a foundation for evidence-based decision-making while highlighting critical data gaps that must be addressed through improved monitoring and reporting systems. As the global energy transition accelerates, ensuring women's equal participation in shaping future energy systems is not merely a matter of equity—it is essential for developing the

innovative, resilient solutions required to meet ambitious climate and development goals.

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