State of the Industry Report 2026

Decarbonization Progress in the Apparel, Footwear & Textiles Industry

Cascale

Contents

Executive Summary

Despite ongoing effort, global greenhouse gas emissions continue to rise, reaching a new peak in 2024. The apparel, footwear and textiles industry reflect this broader trend, with emissions rising 7.5 percent during 2023. Incremental efficiency gains have been outpaced by rising production volumes, underscoring the urgency for coordinated, systemic action across the supply chain.

This report assesses the state of decarbonization in the apparel, footwear and textiles industry using verified Higg Facility Environmental Module (vFEM) data from 2023 and 2024. Focusing on Tier 1 (Finished Product Manufacturing) and Tier 2 (Material Manufacturing such as fabric mills and dyehouses), it evaluates industry performance through Cascale's Effective Energy Carbon Intensity (EECI) metric, supported by indicators on electrification and fossil fuel dependency. Together, these metrics provide insight into how effectively the industry is decarbonizing its energy use, which represents the dominant source of Scope 1 and 2 emissions.

Overall, the progress towards decarbonizing energy is slow, with only marginal improvement in EECI performance over time. While the most recent data indicates a modest shift toward lower-intensity performance categories, the pace of progress remains far below what is required to meet climate targets. Energy-related emissions continue to be driven primarily by large facilities and thermal energy use, particularly in Tier 2 facilities, where heat-intensive processes dominate. Coal remains a critical barrier to progress, accounting for 31 percent of total energy consumption and showing no meaningful decline year over year.

Despite this overall trend, significant differences exist between individual facilities, across geography, production type, and facility size. Notably, emissions are driven by a small number of large facilities that have a high reliance on thermal energy. Identifying and focusing on these facilities has the potential to scale progress more quickly than focusing equally on all facilities. Tier 1 facilities tend to show a greater degree of electrification, though there are significant differences between countries. Targeted interventions by geography is an effective lever here. It also shows the importance of deeper supply chain engagement into Tier 2, where thermal energy continues to dominate.

Electrification alone will be insufficient to achieve a 1.5°C pathway as country level grid electricity emissions in the major producing countries remain higher than needed for deep decarbonization. Increased adoption in renewable energy, through direct on-site installations and through power purchase agreements, is critical. Although a growing number of facilities report purchasing or generating renewable energy, renewables account for only a small fraction (2 percent) of total industry energy consumption and this fraction remained static between 2023 and 2024 reporting periods.

Taken together, the findings demonstrate that while pockets of progress exist, the apparel, footwear and textiles industry is not yet achieving decarbonization at the scale or speed

required. Meaningful reductions in emissions will depend on accelerating the transition away from coal, expanding electrification in large, energy-intensive facilities, and rapidly increasing the share of renewable energy. These actions must be pursued through collaborative, long-term engagement between brands and manufacturers, rather than through shifts in sourcing geography. Cascale will continue to support industry progress by expanding access to data, analytics, and targeted programs for our members, enabling the industry to better track progress and collectively advance toward a low-carbon future.

Introduction

"Off target" is what titles the 2025 Emissions Gap Report of the United Nations Environmental Programme (UNEP), published in November last year. It concisely captures where the world stands with respect to the climate goals set in the Paris Agreement, just over a decade ago. Despite major technological and regulatory advances, global greenhouse gas (GHG) emissions continue to grow, reaching a new record of 57.7 GtCO2e in 2024 (UNEP, 2025). As the mitigation efforts prescribed through current policies only limit global temperature increase at 2.8°C by 2100, collective, accelerated efforts to reduce GHG emissions are necessary to "limit the escalation of climate risks and damages that, already today, are severe, and hit the poorest and most vulnerable the hardest." (UNEP, 2025).

Recording a 7.5 percent increase in 2023 (aii, 2025), the apparel sector's GHG emissions continue to grow and move further away from the required reduction pathway to limit global warming to 1.5°C, mirroring the global trend. Increased textile production volume shows that marginal improvements to raw materials and production processes are not enough to curb carbon emissions. As a 45 percent emissions reduction by 2030 is out of reach, it is critical for the industry to obtain a shared understanding of the key drivers of carbon emissions in the supply chain, and the urgency of collectively addressing these. Cascale will therefore move to mobilize the industry around an ambitious, coordinated climate agenda to accelerate supply chain decarbonization.

By analyzing the primary causes of emissions and obstacles to progress, this report will inform that agenda for Cascale members and industry stakeholders. Using Higg Facility Environmental Module (FEM) data, it offers insight into the climate state of our industry through analysis of performance on key decarbonization metrics. The Higg FEM is the consumer goods industry's most comprehensive facility environmental assessment, relied on by tens of thousands of production facilities worldwide for environmental performance tracking. As owner and developer of the Higg Index, Cascale has access to a comprehensive and representative database of industry climate data. By detailing the specifics of key manufacturing countries and supply chain tiers, the report identifies the main levers for meaningful decarbonization progress.

This report is planned to be published each year going forward. This will enable Cascale to showcase climate performance of the apparel, footwear and textiles industry, while providing public access to the latest aggregated industry data to drive further conversation and collective action.

About This Report

To ensure the data in this report is used by organizations in a meaningful and correct way, it is important to understand the setup, scope and limitations of the report. This section discusses the report's approach and offers guidance on how its contents can be used by the industry.

Report Scope & Approach

The report focuses on the apparel, footwear and textiles industry, with primary focus on the apparel sector. Energy-related data from individual production facilities as reported in the Higg FEM is aggregated to assess the industry's climate performance in key countries and production tiers. The report uses verified FEM (i.e. vFEM) data from FEM 2023 and 2024. FEM emissions data covers Scope 1 and 2 greenhouse gas emissions, as defined by the Greenhouse Gas Protocol.

The report focuses on facilities in Tier 1 (Finished Product Manufacturing) and Tier 2 (Material Manufacturing) as the coverage of vFEM in those production tiers is of sufficient size to provide strong confidence in the representativeness of the data and the report's conclusions. Appendix A outlines the number of vFEM assessments considered.

The industry's decarbonization progress will be evaluated with Cascale's effective energy carbon intensity (EECI) metric and additional indicators covering electrification and fossil fuel dependency. The EECI metric is a unified measure of the carbon intensity of a facility's energy-related GHG emissions.

The metric combines thermal and electrical emissions and focuses on energy sources at a facility rather than how that energy is used. As a result, the EECI offers an at-a-glance understanding of overall decarbonization progress, and a fairer comparison between facilities with different final energy mixes. One limitation of this approach is that energy efficiency is not considered. However, energy efficiency is a metric that tends to relate to the proficiency of an individual factory rather than directly to decarbonization risks. Increasing energy efficiency while continuing to use high carbon intensity energy sources is not sufficient to achieve deep decarbonization. Further, energy efficiency improvements don't necessarily correlate to decarbonization since they generally result in increased production that cancels out efficiency gains (Jevon's paradox[1]). This report focuses on energy use through the aforementioned carbon intensity metrics. This methodological choice enables a streamlined assessment and clearer identification of the industry's key decarbonization levers. However, for an absolutely complete picture of the decarbonization pathway of the industry, energy efficiency should be considered in supplement. More details on the EECI methodology can be found below, as well as in Appendix D.

1 Jevon's paradox articulates the idea that increased energy (and material-resource) efficiency leads not to conservation but increased use (Clark, et al., 2010)

How to Use This Report

The report assesses the carbon performance of the apparel, footwear and textiles industry. Key producing countries and production tiers are analyzed further to identify the main drivers of GHG emissions. The aggregated facility data offers an industry-level perspective that doesn't necessarily reflect the realities of individual supply chains. Hence, organizations should be careful when evaluating their own supply chains and cannot use this report to justify a sourcing switch between countries. Meaningful reductions in emissions are only obtained by improving practices at the production level and simply moving production elsewhere jeopardizes progress and livelihoods. Cascale encourages brands and manufacturers to engage in equitable, long-term partnerships and collaborate towards decarbonization objectives.

The Industry's Climate Performance

The climate state of the apparel, footwear and textiles industry is analyzed through three performance metrics. At the core of this report sits the EECI metric, which assesses the current level of decarbonization of the industry's primary energy consumption. Supporting indicators on electrification and fossil fuel dependency are introduced later, deepening the analysis by identifying the key drivers of EECI performance across the industry.

Decarbonizing Energy

The major share of GHG emissions from apparel and footwear production is related to energy. Emissions of finished product suppliers (i.e. Tier 1 for brands/retailers) are predominantly energy-related, while the most energy-intensive production steps typically occur deeper in the supply chain at, for example, fabric mills and dyehouses (Tier 2), often beyond the visibility of brands and retailers. As attempts to align the industry with the 1.5°C trajectory of the Paris Agreement require accelerated energy decarbonization efforts in the supply chain, this report tracks progress on energy carbon intensity.

The EECI metric assesses the effective energy carbon intensity of a facility. Foundationally, it works like any carbon intensity metric, dividing the total carbon emissions by the total (energy) inputs. However, by weighting electric and thermal energy amounts using a Primary Energy Factor, it offers a more balanced perspective on electric and thermal carbon intensity. The Primary Energy Factor represents a conversion factor that quantifies the amount of primary energy required to produce one unit of final (i.e. delivered) electricity. For the EECI metric, it is set as 2.4, which equates to a powerplant efficiency of 41.7 percent. The more balanced weighting of electric and thermal energy ensures the EECI encourages electrification (instead of penalizing it) while reflecting effective fossil fuel dependency. The EECI performance can be interpreted using the ranges provided in Table 1 below. More details on the EECI methodology can be found in Appendix D.

Above 0.08	Very High	*Energy is almost fully dependent on high carbon fossil fuels*
0.06-0.08	High	*Significant opportunities for energy decarbonization*
0.04-0.06	Medium	*Tailored opportunities for energy decarbonization*
0.02-0.04	Low	*Decarbonized energy extensively used*
0-0.02	Very Low	*Energy is almost fully decarbonized*

Table 1 - EECI performance ranges

Figure 1 below outlines the average supplier performance on Cascale's EECI metric over time, showcasing a minor decrease in earlier cadences while suggesting more meaningful progress in later years. Although comparability over time may be influenced by different Higg FEM versions and the amount of included verified assessments, the decreasing EECI between FEM2023 and FEM2024 is somewhat promising as both cadences apply FEM4.0 and the cadence count is relatively stable. Between these cadences, the average EECI improves, with the proportion of facilities in the "Very Low + Low" buckets increasing and the "Very High" bucket decreasing. While hopeful, the decarbonization rate is far from the pace required to stay in line with the 1.5°C pathway.

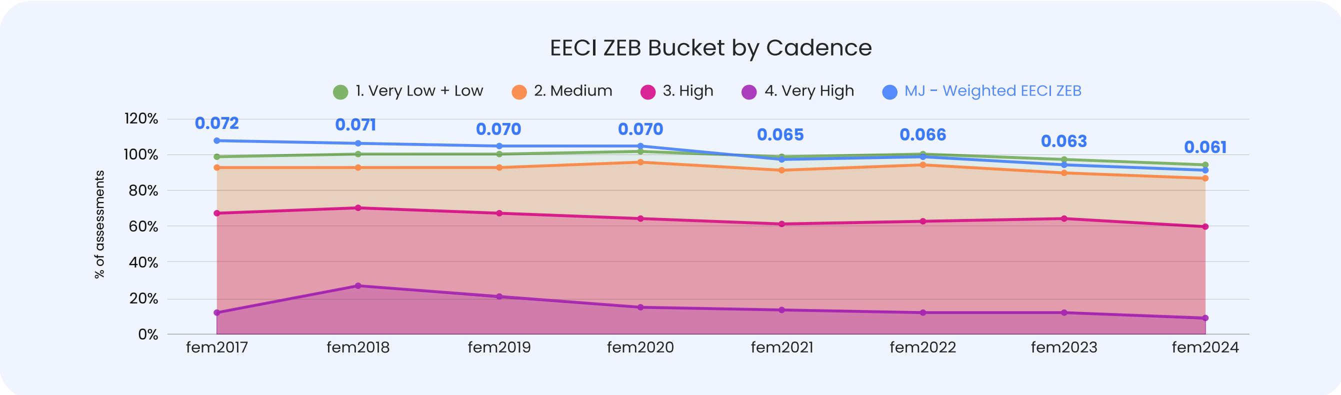

Figure 1 - Facility EECI performance in buckets.

As this report considers only Scope 1 and 2 emissions, the carbon intensities in this chapter consider biogenic emissions as carbon neutral. It must be noted that this represents an idealized scenario that does not take into account the full lifecycle of biomass production required for full Scope 3 reporting, nor the potential non-sequestered emissions from combustion (due to unsustainable use of the carbon pool). Overreliance on biomass as a solution for decarbonization comes with large uncertainties that should be reported alongside fossil carbon emissions for full conformity to Scope 1 and 2 GHG reporting. The uncertainty regarding actual biomass emissions and its effect on energy carbon intensities is further discussed in Appendix B.

Country performance on EECI varies. Figure 2 below shows the distribution of facility EECI performance by country, reflecting the share of facilities achieving a specific EECI value. The values for China, Turkey, and Vietnam are reasonably normally distributed, demonstrated by the bell-shaped curve of the area. The graph areas of India, Sri Lanka and Pakistan are flat, pointing to greater variability in individual facility performance and fewer facilities achieving the average performance.

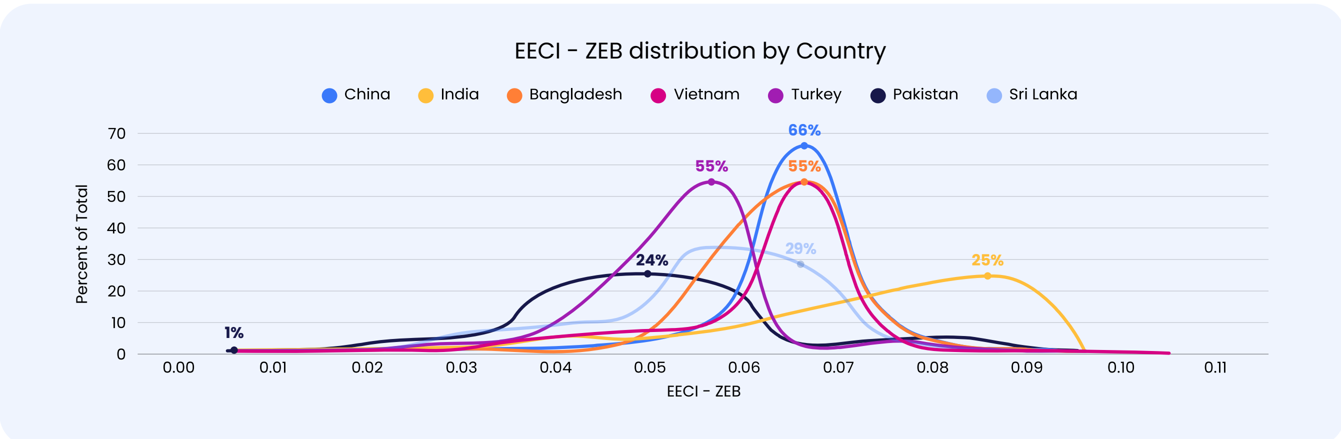

Figure 2 - EECI - ZEB distribution by Country.

The EECI metric can be split into a thermal and electric portion to understand what is driving EECI performance. Figures 3 and 4 visualize this for Tier 1 and 2 respectively. Electric carbon intensity is lower than the EECI in China, Turkey and Pakistan in both Tier 1 and 2. This signals that facilities in these countries are decreasing their GHG emission intensity by electrifying their energy use. Although the high carbon intensity of the national electricity grid requires additional renewables to be purchased to achieve a 1.5°C pathway, any electrification leads to emission reductions in these countries.

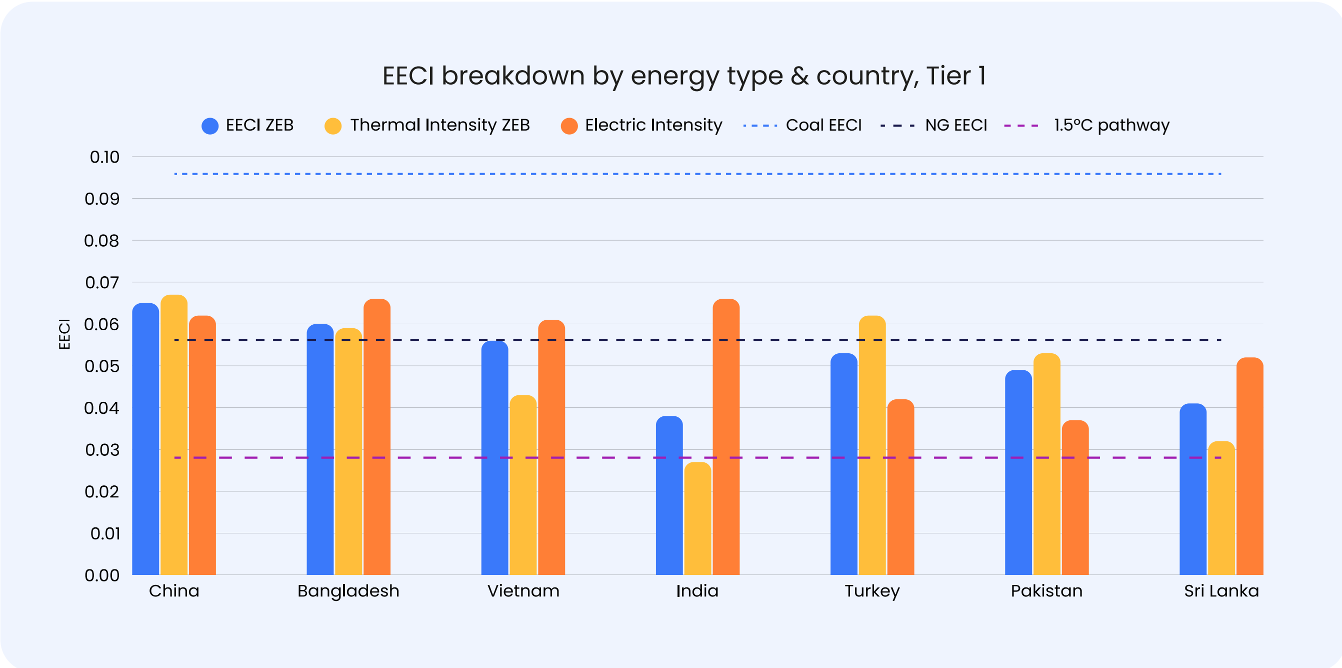

Figure 3 - EECI breakdown by energy type & country, Tier 1

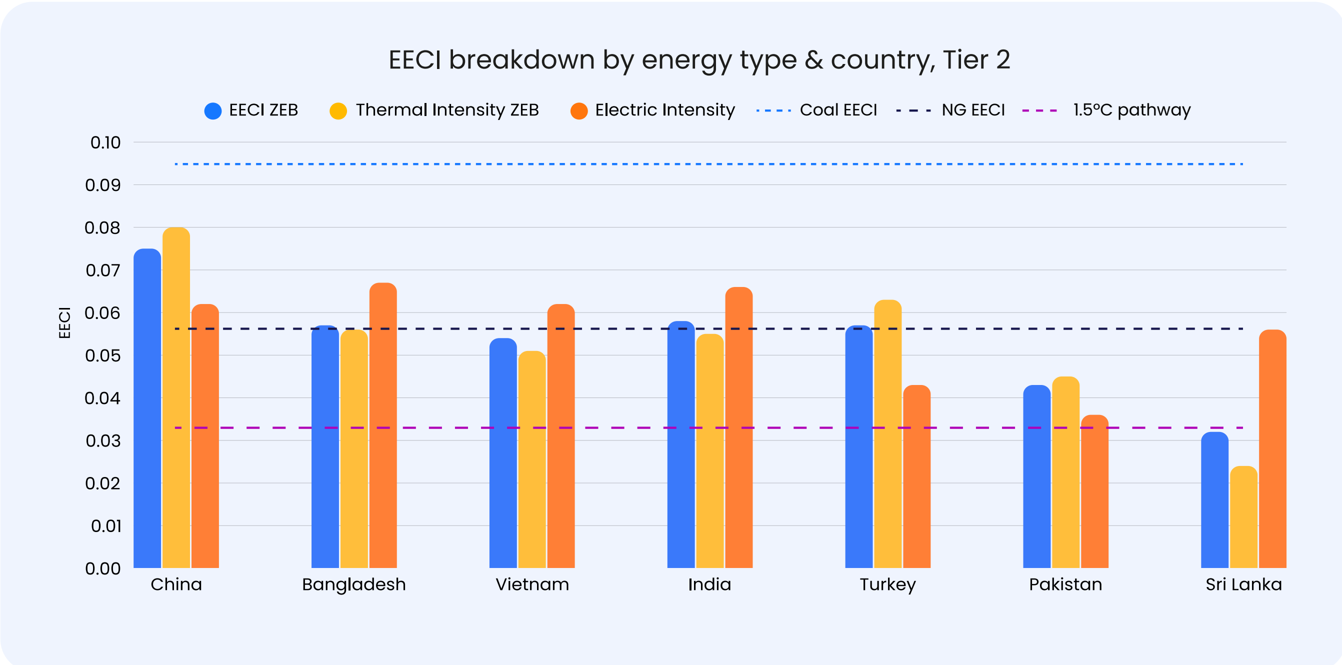

Figure 4 - EECI breakdown by energy type & country, Tier 2

Electric intensity is higher than the EECI in Bangladesh, Vietnam, India, and Sri Lanka. In these countries, the thermal carbon intensity is lower than electric due to the wide scale use of biomass (which is considered carbon neutral in the figures). Electrification and adopting renewable energy is still considered a preferred strategy to limit organizational exposure to the risk around actual biogenic emissions from thermal energy, especially from a Scope 3 perspective, and to bring the average EECI more in line with the 1.5°C pathway. For facilities reliant on biomass, the source and sustainability of these resources should be tracked and disclosed.

Most thermal carbon intensities are in close proximity to the average EECI (especially in Tier 2), demonstrating the heavy dependency of the industry on thermal energy. Coal being a dominant and carbon intensive fuel, is a key driver of industry emissions and a critical lever for progress. This is further illustrated in Figure 5 below, as it highlights the relationship between EECI performance and coal dependency.

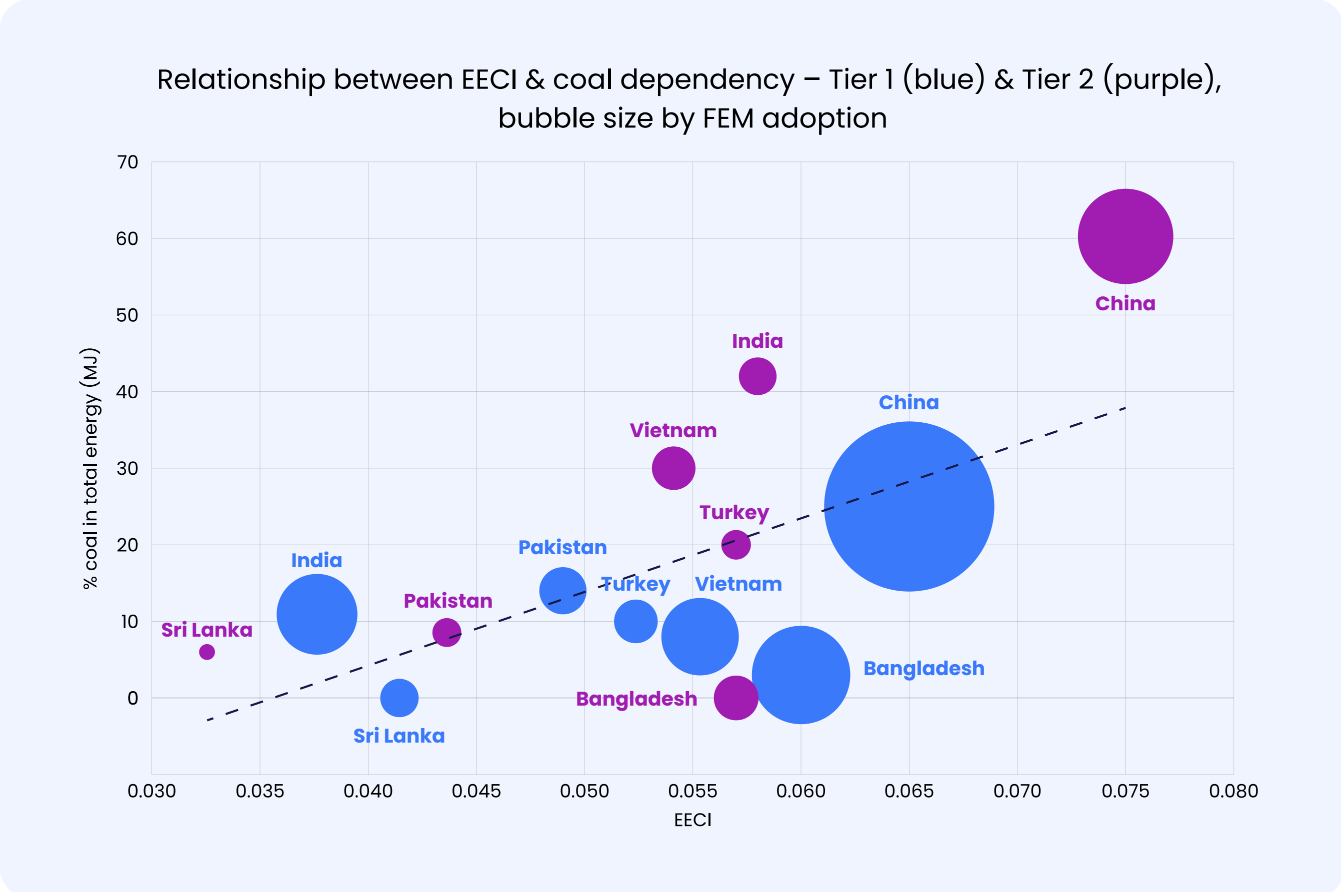

Figure 5 - The link between EECI and coal dependency

Electrification

It is critical that the energy consumption of the apparel, footwear and textiles industry is further electrified to lay the groundwork for deep levels of decarbonization. The current degree of electrification varies by country and production tier, see figure 6 below. Tier 1 facilities in Turkey, Sri Lanka and Vietnam have a greater degree of electrification, resulting in Tier 1 achieving a lower EECI compared to Tier 2.

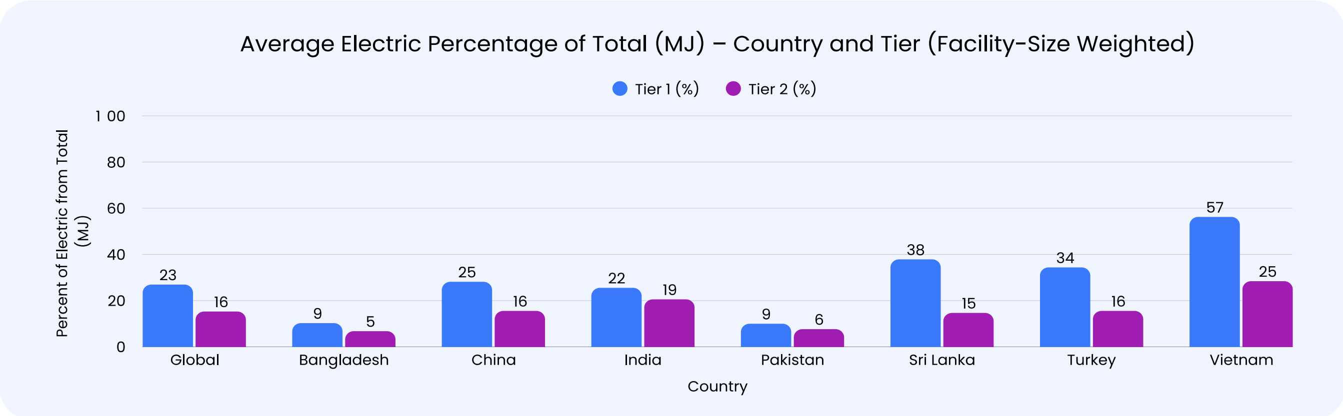

Figure 6 - Electrification as a percentage of total energy use, by country & production tier

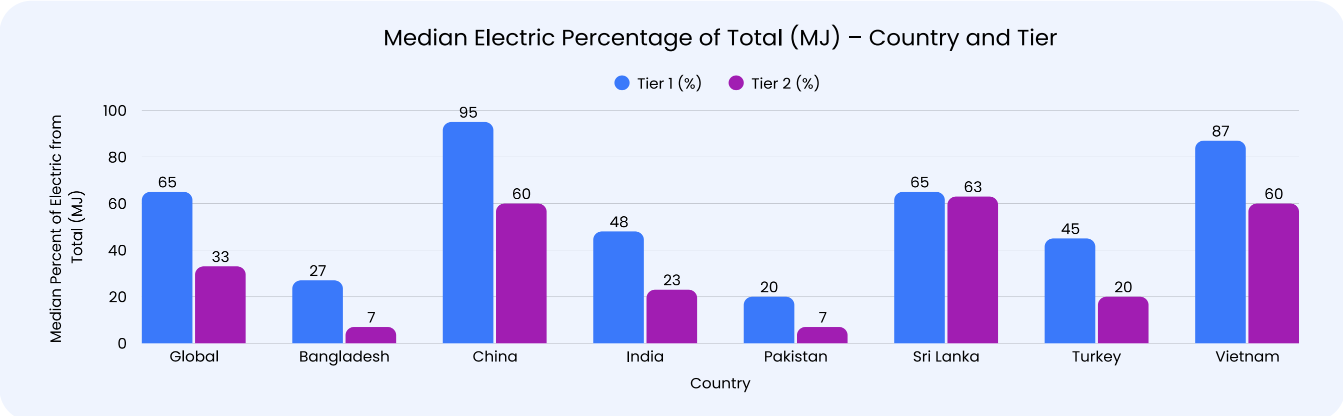

Figure 7 - Median electrification percentage of facilities, by country & production tier

The average electrification percentages shown in Figure 6 are energy consumption-weighted, meaning they are affected by facility size. Facilities that use more energy have a greater impact on the average than smaller facilities. If the median facility (the middle value after sorting facilities by electrification degree) is assessed, the picture looks very different. Figure 7 below reflects this. It clearly shows much higher percentages compared to the average, indicating that in most countries there are many facilities with very high electrification levels even if it isn't always apparent from the average. For example, the middle Tier 1 facility of China is 94 percent electrified, meaning half of China's facilities in Tier 1 are electrified to 94 percent or higher. The large difference between the median and the average suggests a large difference in size between the highly electrified facilities and the ones relying predominantly on fossil fuels. The same applies in Sri Lanka's Tier 2 facilities, where the middle facility relies mostly on electricity (59 percent) while only 15 percent of the total energy consumed by Tier 2 facilities is, in fact, electric.

Another way of visualizing this difference is shown in Figure 8. It overlays the distribution of the energy consumption-weighted and the facility-weighted electrification percentages of facilities. This offers a view into how both values are constituted with regards to their distributions. The early high concentration of the consumption-weighted distribution (in blue) reflects that most energy use is to a limited degree electrified, while the late peak of the facility-weighted average (in yellow) indicates its population contains a large number of small facilities that are almost completely reliant on electricity.

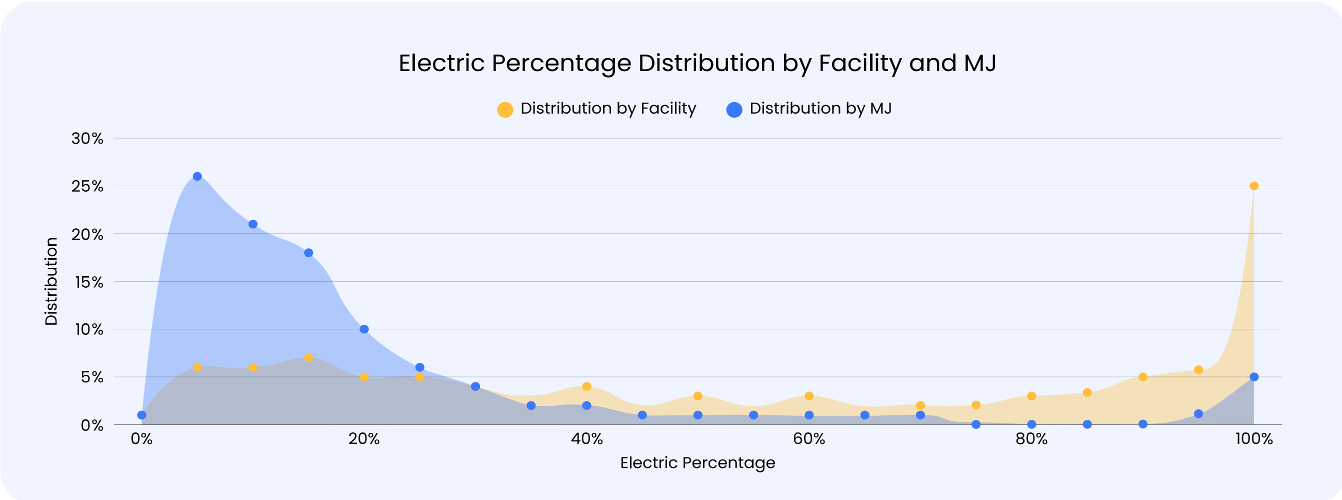

Figure 8 - distribution of electrification share by facility & by energy use

This underlines again that there is a relatively small number of very large facilities that use a high proportion of thermal energy, bringing down the consumption-weighted electrification average. For such facilities it is crucial to reduce the consumption of fossil fuels, especially coal. While upgrading thermal boilers to use lower carbon intensity fuels is possible, advancing the technology directly to electrification should be seriously considered due to the potential for deep decarbonization. However, this second point is important as few electricity grids are in line with the 1.5°C pathway, meaning more renewable energy needs to be used to accelerate decarbonization. The next section will dive deeper into this topic of fossil fuel dependency and renewables adoption.

Reducing Fossil Fuel Dependency

The previous section discussed the large difference between the degree of electrification of an average and median facility. The dominant presence of fossil fuels as demonstrated by the (often limited) electrification of energy consumption, is equally visible when zooming into renewable energy adoption. Figure 9 below demonstrates an increasing number of facilities purchasing and generating renewables in all major sourcing countries except Turkey. The share of facilities with some degree of purchased or self-generated renewables often outperforms the global average of 28 percent in FEM24. However, the overall portion of the total energy and electricity that renewables make up is much lower. Renewables failed to increase their share of global energy and electricity, and Turkey and Vietnam saw a sharp decline in FEM24 from FEM23. Purchased and autogenerated renewables constitute 13 percent of total electricity and 2 percent of global energy consumption. Only India outperforms these global averages amongst the largest production countries.

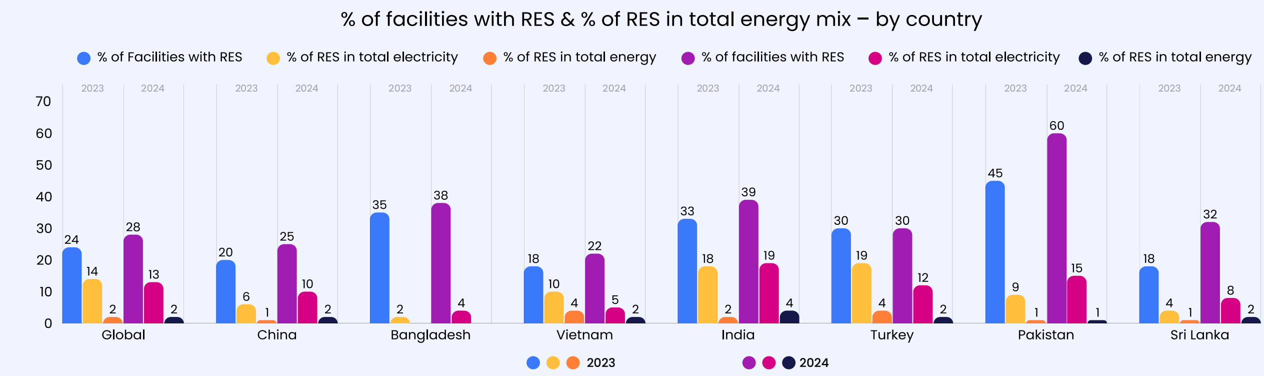

Figure 9 - Adoption of renewable energy by country

The industry's slow transition to renewables is further mirrored in the minimal transition away from coal consumption. Figure 10 below shows no reduction in coal consumption as a percentage of thermal and total energy between FEM23 and FEM24, though there was a small decrease in the number of facilities reporting direct coal use.

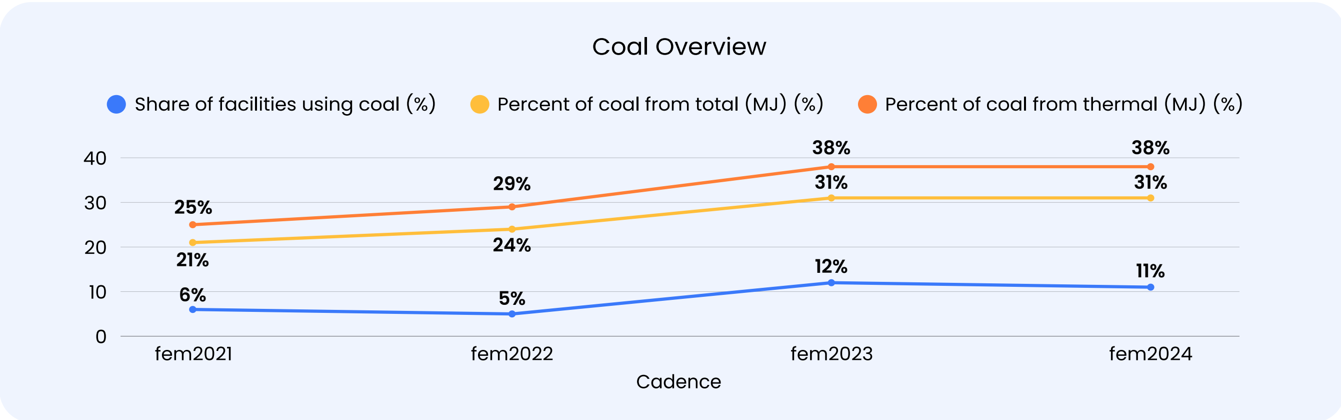

Figure 10 - Industry's dependence on coal, by FEM cadence

The limited adoption of renewable energy and the heavy dependency on fossil fuels (especially coal) is further illustrated by the energy mixes outlined below. It is important to note that purchased steam from unknown origin in this overview is considered to be generated using coal. This follows Cascale's methodology update to the Higg FEM for 2025. While this assumption is considered to be moderately conservative, it is worth noting that coal was the largest reported known energy source for purchased steam. In Tier 1, gaseous fuels[2] dominate the global energy mix, while electricity and renewables together account for 23 percent. Large differences are visible between countries. Tier 1 facilities in Bangladesh rely heavily on gas, while half of the total energy in India is generated using biomass. While most countries rely less on coal than the global average of 13 percent, China, a major apparel production country, drives up the global average considerably with 24 percent of its energy mix coming from coal. Fossil fuel use is even more dominant in Tier 2, as the use of coal increases at the expense of gas and electricity. With a 40 percent share of global energy consumption in Tier 2, coal classifies as the most widely used fuel source in that production tier.

2 Gaseous fuels include natural gas, compressed natural gas (CNG), liquefied natural gas (LNG), and liquefied petroleum gas (LPG). In this report it is often referred to as "gas" for simplicity.

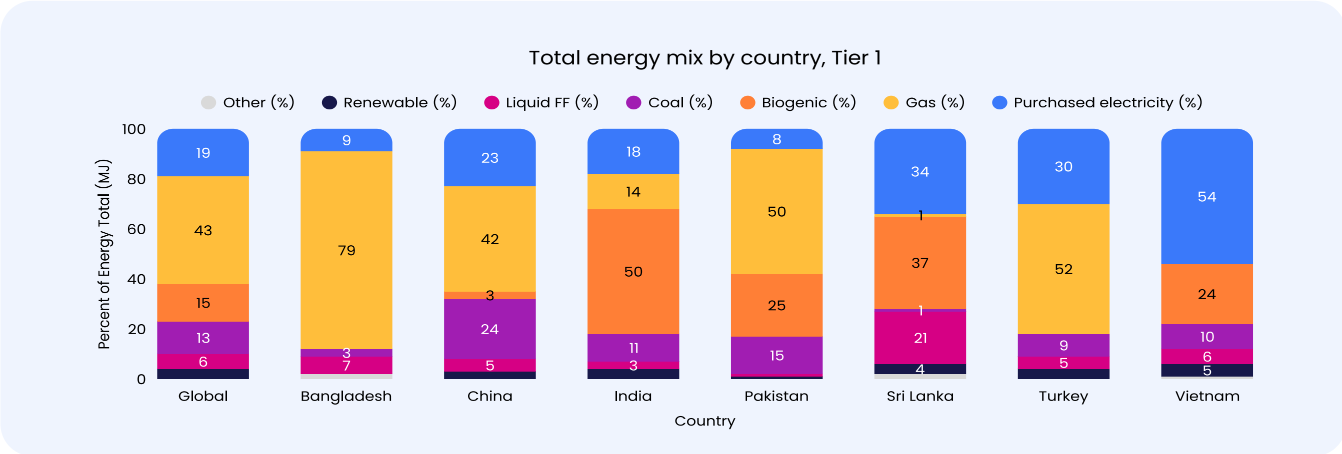

Figure 11 - Total energy mix by country, Tier 1

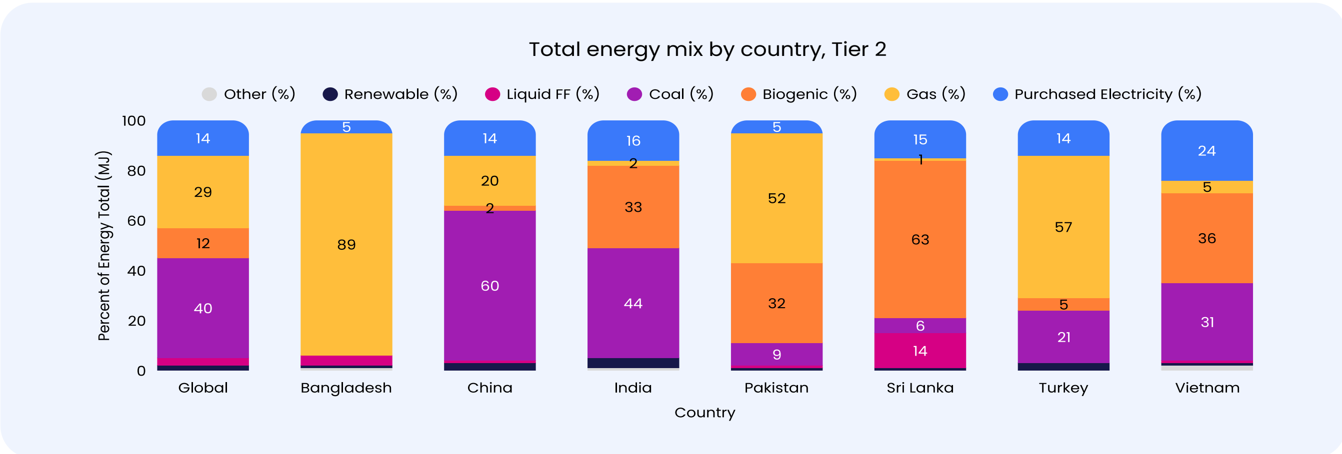

Figure 12 - Total energy mix by country, Tier 2

The EECI performance of individual countries is a direct translation of the energy mix their facilities use. The limited degree of electrification in Pakistan and Bangladesh is reflected in the close proximity of the thermal intensity and EECI in those countries. This is further amplified in Tier 2, where degrees of electrification are often below 20 percent. Despite electricity being the dominant energy source in Vietnam in Tier 1, the limited share of renewables (5 percent of electricity in FEM24) undermines the decarbonization potential of widespread electrification. A similar dynamic can be observed in the Tier 1 facilities of Sri Lanka and Turkey, where the small share of renewable energy limits the alignment of EECI with the 1.5°C pathway, despite the fact that over 30 percent of energy is electric.

Considering the dominant position of thermal energy in both Tier 1 and 2, it is worth further analyzing the thermal energy mix as well. In Tier 1, gas accounts for more than half of thermal energy globally, while coal accounts for 16 percent. China and Vietnam rely more on coal than this average with 23 percent and 33 percent, respectively. Biomass is the dominant fuel source in Sri Lanka, while Bangladesh relies almost entirely on gas (Figure 13). As shown on Figure 14, coal dependency only increases in Tier 2 as material manufacturers typically apply more heat-dependent processes (e.g. pre-treatment, dyeing) and rely less on electricity (also see Figure 12). 71 percent of China's thermal energy mix consists of coal, driving the global average up to near 50 percent. India and Vietnam follow with 55 percent and 41 percent, respectively, while Bangladesh, Pakistan and Sri Lanka have reduced coal dependency to under 10 percent of their thermal energy mix.

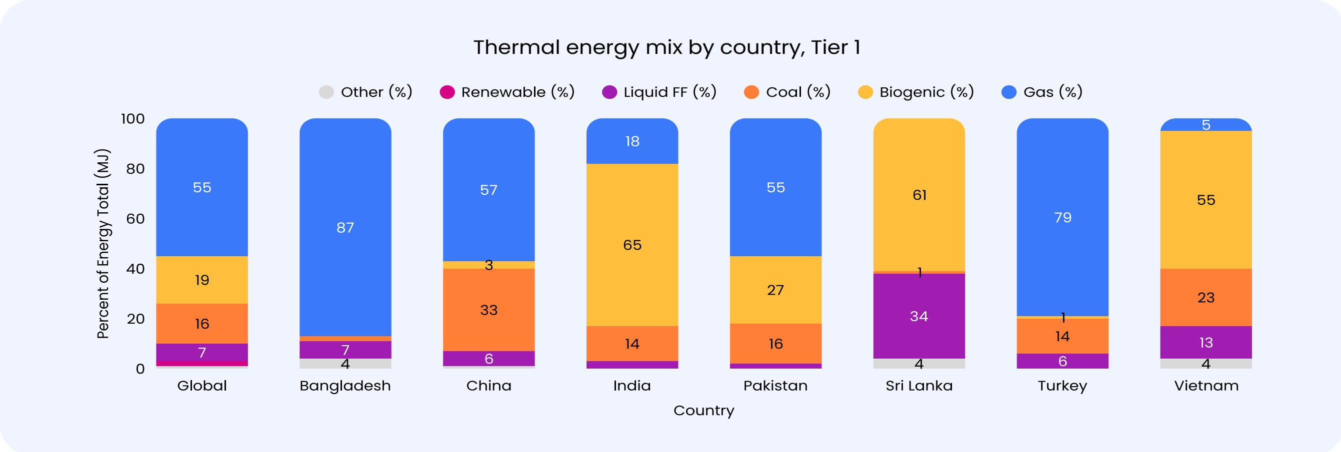

Figure 13 - Thermal energy mix by country, Tier 1

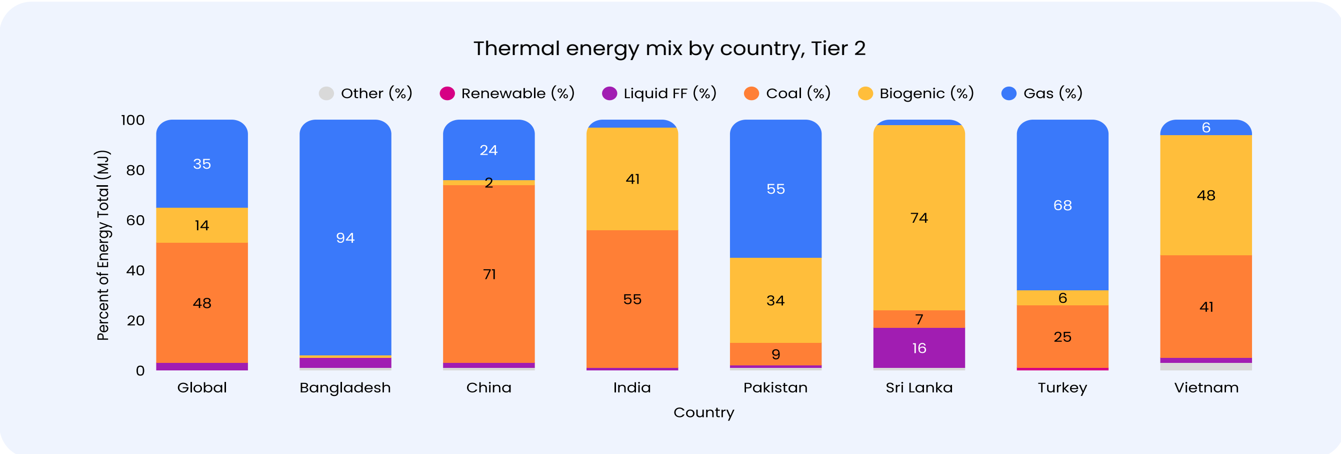

Figure 14 - Thermal energy mix by country, Tier 2

These large differences in the energy mixes of individual countries are reflected in their EECI performance (shown previously in Figures 3 and 4). For Tier 1, the thermal carbon intensity of Bangladesh and Turkey reflect their high gas consumption. The EECI of Turkey is to a lesser extent affected by this however, as its electric carbon intensity and higher degree of electrification drive its EECI down. China's high coal consumption in especially Tier 2 drives its high EECI, while Sri Lanka's heavy dependency on biomass ensures its EECI ranks lowest among the countries considered. While biomass accounts for a similar share of total energy in India, Vietnam and Pakistan, the variance between their EECIs are driven by the difference in coal consumption.

Although biomass is considered carbon neutral in the main sections of this report (which considers only Scope 1 & 2), its strong presence in the countries' fuel mixes does not necessarily provide a reliable decarbonization path when considering Scope 3 emissions. Given the large degree of uncertainty around actual biomass emissions, supply chain interventions that guarantee emission reductions are preferred. Electrification while adopting renewables therefore remains paramount to drive meaningful progress in the industry.

Conclusions & Calls to Action

While pockets of action exist, as a whole the apparel, footwear and textiles industry is demonstrating insufficient scaled decarbonization progress to meet the climate goals of the Paris Agreement. To identify the underlying causes, verified Higg FEM data fueled a comprehensive analysis of energy carbon emissions of Tier 1 and 2 facilities in seven of the largest production countries. Marginal improvements to the industry's average EECI are noted, yet are inadequate to drive meaningful emission reductions. This is primarily due to a lack of adoption of renewables and continued dependency on coal as a fuel source. Coal continues to be the dominant fuel source in Tier 2 facilities, representing 40 percent of the global energy mix and unchanged from the previous year. While an increasing number of facilities adopt renewable energy in most countries, renewables never make up more than 4 percent of the total energy mix in Tier 1 and 2.

Many differences exist in the climate state of individual production countries and facilities. As the world's largest producer of textiles, China's heavy reliance on coal and limited degree of electrification drive industry emissions. The lower EECI of Tier 1 facilities in Sri Lanka and India suggest strong decarbonization progress, which must be considered with context. Tier 1 facilities in these countries typically rely more heavily on biomass, the actual emissions of which are uncertain and highly variable (see Appendix B). While electrification progress is much further advanced in the Tier 1 facilities of Sri Lanka, Turkey, and Vietnam, electricity makes up less than 10 percent in facilities in Pakistan and Bangladesh. Moreover, Figure 8 points to the large number of small facilities that have (nearly) completely electrified their energy, while larger facilities tend to still depend more heavily on fossil fuels.

These large differences between individual countries, and production facilities warrants the need for organizations to carefully evaluate their own supply chains, as this industry-level perspective cannot reasonably be applied to individual apparel, footwear, and textiles supply chains. This underscores once more that the aggregated insights from this report cannot be used to justify procurement switching to other countries.

Cascale will further support its members to monitor and drive decarbonization progress of their supply chains. The Member Analytics Portal will be expanded with dashboards that build upon the visuals introduced in this report. In addition, Cascale's Manufacturer Climate Action Program (MCAP) supports manufacturers with developing and validating Science-Aligned Targets (SATs) to reduce Scope 1 and 2 greenhouse gas emissions.

Cascale recognizes this report does not cover all carbon emissions, nor all the tiers involved in apparel and footwear production. As Cascale plans to publish this report yearly going forward, the aim is to increase visibility of our supply chain coverage and data representation. Cascale encourages its members to engage with their manufacturers in Tier 2 and beyond to increase their visibility over critical impact drivers and to mitigate risk, and will support them on this journey.

Cascale

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Appendix A

Verified FEM Coverage - Number of Verified Assessments by Tier

Production tier	# of vFEM23	# of vFEM24
Tier 1 (Finished Product Manufacturing)	6,918	7,123
Tier 2 (Material Manufacturing)	2,187	2,916

Verified FEM Coverage - Number of Verified Assessments by Country

Country	# of vFEM23	# of vFEM24
China	4,389	4,670
India	1,136	1,413
Vietnam	1,148	1,329
Bangladesh	1,132	1,297
Turkey	622	654
Pakistan	317	354
Sri Lanka	252	267

Appendix B

A Word on Biomass

As this report analyzes the climate state of the apparel, footwear and textiles industry, it is important to explain its approach to carbon emissions from biomass, as it represents an important fuel in many production countries (see Figures 11 to 14). Carbon emissions from biological sources (like biomass) are biogenic emissions. As opposed to fossil emissions, these emissions are part of the fast carbon cycle: the fast and continuous exchanges of carbon between the atmosphere and biosphere. Because of the fast biological carbon cycle, biogenic carbon could, in theory, be considered carbon neutral when only considering Scope 1 and 2[3] as in this report. Biogenic carbon emissions emitted during combustion were previously absorbed from the atmosphere and will be sequestered in biomass again. However, the carbon neutral claim is often inappropriate when considering the full lifecycle of biomass production (US EPA, 2012) because of two primary factors:

- Feedstock type & source: The carbon neutrality claim depends on nature's ability to restore within a reasonable timeframe after the extraction in order to absorb the emitted carbon again. Cutting down forests for feedstock jeopardizes this ability considerably, while using dead organic material or compost does not.
- Production process: The applied processes between feedstock extraction and combustion affect the carbon emissions as well. Preparatory processes could lower biogenic emissions compared to burning raw, unprocessed biomass.

Recognized carbon accounting frameworks prescribe the separate reporting of biogenic and fossil emissions. For that reason, figures 15 and 16 below outline the EECI and thermal carbon intensity including and excluding (potential) biogenic emissions. Due to the complexity around determining the exact amount of biogenic emissions, the additional portion of biogenic emissions of each bar should be considered the possible range of emissions. Carbon neutral biomass would qualify as a "best case" (and zero out in the charts). A "conservative case" is presented in the charts below and applies the biomass emission factor used in the Higg FEM. While to be reported separately, biogenic emissions still contribute to climate change if not completely sequestered. The large bar size of the biogenic portion in some major sourcing countries demonstrates how relevant that is to them, emphasizing the importance of engaging with supply chain partners to ensure the sustainable sourcing of biomass.

3 The GHG Protocol dictates that CH_4 and N_2O emissions from biomass combustion are to be included in scope 1 and 2, but as these emissions are typically small (± 2.5-3%), this report excludes these for simplicity.

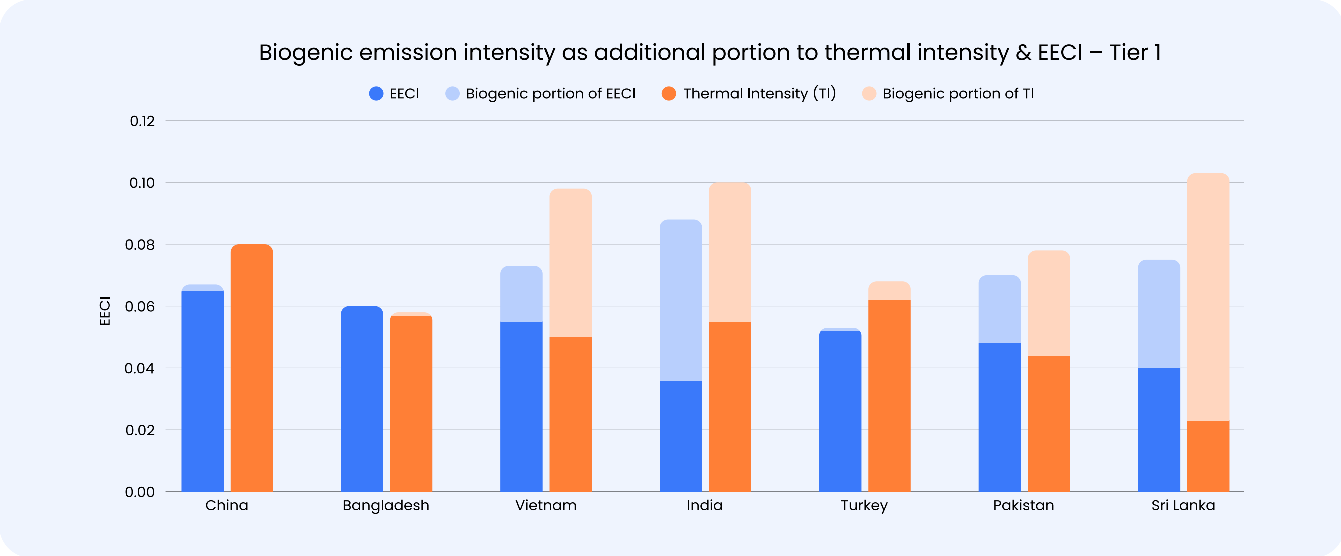

Figure 15 - Biogenic emission intensity as additional portion on top of EECI and thermal carbon intensity by country, Tier 1

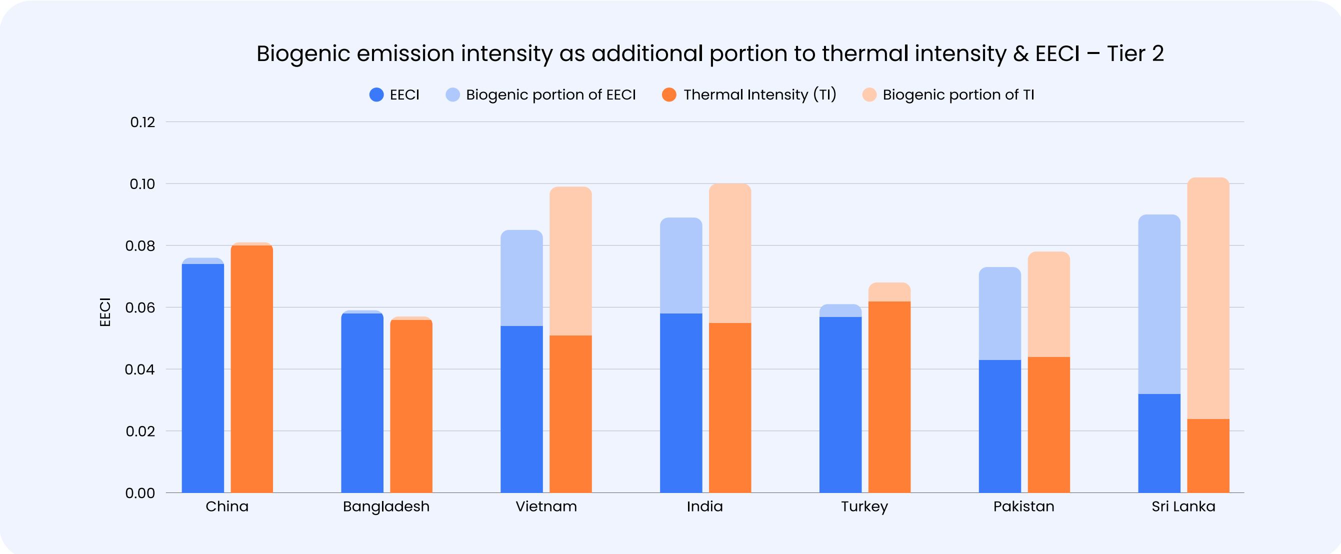

Figure 16 - Biogenic emission intensity as additional portion on top of EECI and thermal carbon intensity by country, Tier 2

The large portion of biogenic emissions in Sri Lanka, India, Vietnam and Pakistan signal their significant dependency on biomass as a fuel source. This is also highlighted in the "Reducing Fossil Fuel Dependency" section of this report. For Tier 1, the EECI could potentially increase by 34 percent to 0.074 in Vietnam, and by 136 percent to 0.09 in India. Regarding Tier 2 facilities, biogenic emissions could increase the EECI of Pakistan with 70 percent to 0.074 and with 174 percent to 0.09 in Sri Lanka. Biogenic emissions barely influence the EECI and thermal intensities of China, Bangladesh and Turkey, as very limited biomass is used in those countries.

Throughout this report, biogenic emissions are separately reported from fossil emissions, in line with the GHG Protocol. The "Decarbonizing Energy" section applies the "best case" scenario and considers biomass carbon neutral (within scope 1 and 2). Likewise, organizations are to consider the EECI and thermal intensity figures displayed in that section as "best case" results, and examine the potential impact of biogenic emissions in production countries where biomass is an important fuel source. Facilities that rely on biomass are strongly advised to track and disclose the source and sustainability of these resources.

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Appendix C

Final (i.e. Delivered) Energy Mix by Country - Tier 1

Some country mixes might not add up to 100 percent due to rounding

	Global	China	India	Bangladesh	Vietnam	Pakistan	Turkey	Sri Lanka
Natural Gas	**28%**	26%	12%	35%	0%	45%	48%	0%
Purchased Electricity	**19%**	23%	18%	9%	54%	8%	30%	34%
CNG - Compressed Natural Gas	**16%**	4%	1%	43%	0%	0%	0%	0%
Purchased Steam	**12%**	27%	3%	3%	3%	12%	4%	1%
Biomass - Without certification	**9%**	2%	49%	0%	20%	20%	0%	35%
Coal - commercial mix	**4%**	2%	8%	0%	9%	11%	7%	0%
Diesel	**3%**	2%	3%	5%	4%	1%	3%	17%
LPG - Liquid Petroleum Gas	**3%**	7%	1%	2%	2%	0%	0%	1%
Solar Photovoltaic (electricity) (Onsite)	**1%**	1%	1%	0%	2%	1%	3%	4%
Petrol/Gasoline	**1%**	1%	0%	2%	2%	0%	1%	0%
Purchased Renewables	**1%**	1%	3%	0%	2%	0%	1%	0%
Fuel Oil - Blended	**1%**	2%	0%	0%	0%	1%	0%	3%
Fabric Waste	**1%**	0%	0%	1%	2%	0%	0%	2%
LNG - Liquid Natural Gas	**1%**	2%	0%	0%	0%	0%	1%	0%
Biomass - with certification	**0%**	0%	1%	0%	2%	1%	0%	1%

Final (i.e. Delivered) Energy Mix by Country - Tier 2

Some country mixes might not add up to 100% due to rounding

	Global	China	India	Bangladesh	Vietnam	Pakistan	Turkey	Sri Lanka
Natural Gas	**24%**	16%	1%	82%	1%	47%	56%	0%
Purchased Electricity	**14%**	14%	16%	5%	24%	5%	14%	15%
CNG - Compressed Natural Gas	**1%**	0%	0%	5%	0%	1%	0%	0%
Purchased Steam	**33%**	57%	4%	1%	13%	10%	3%	3%
Biomass - Without sustainably sourced biomass certification	**8%**	1%	32%	1%	13%	29%	4%	56%
Coal - commercial mix	**13%**	9%	41%	0%	21%	6%	19%	6%
Diesel	**1%**	0%	0%	4%	1%	0%	1%	2%
LPG - Liquid Petroleum Gas	**1%**	0%	1%	1%	3%	1%	0%	2%
Solar Photovoltaic (electricity) (Onsite)	**1%**	0%	1%	0%	1%	1%	1%	1%
Petrol/Gasoline	**0%**	0%	0%	0%	0%	0%	0%	0%
Purchased Renewables	**1%**	1%	3%	0%	0%	0%	0%	0%
Fuel Oil - Blended	**0%**	0%	0%	0%	0%	1%	0%	12%
Fabric Waste	**0%**	0%	0%	0%	0%	0%	0%	0%
LNG - Liquid Natural Gas	**0%**	0%	0%	0%	0%	0%	0%	0%
Biomass - Sustainably Sourced with certification	**2%**	0%	1%	0%	19%	0%	1%	4%
Biodiesel	**0%**	0%	0%	0%	0%	0%	0%	0%
Purchased Heating (District Heating)	**0%**	0%	0%	0%	2%	0%	0%	0%

Appendix D

Methodology Document: Effective Energy Carbon Intensity (EECI) Metric for Higg FEM

Introduction

The Higg Facility Environment Module (Higg FEM) collects credible, consistent environmental impact data for thousands of facilities annually. While the Higg FEM already enables reporting of energy carbon intensity, the differences between thermal and electrical energy sources make it difficult to interpret leading practices in energy decarbonization at a facility level. The release of a new Higg FEM performance metric: "Effective Energy Carbon Intensity" (EECI) is intended to help bridge this gap to enable scalable, effective hotspotting and risk assessment using information that is already accessible and available.

Background: Higg FEM Energy Impact Data

Amongst the vast array of data that the Higg FEM collects is facility level energy consumption, broken down by a wide range of different thermal and electrical energy sources. Data collection is supported by a broad level of accessible training materials and by a robust verification program. This energy data is converted to a greenhouse gas footprint using standardized emission factors based on IPCC data sources and methodology that are reviewed annually. The Higg FEM has a longstanding recognition as a tool appropriate for measuring site and supply chain emissions.

Reporting metrics from the Higg FEM have included the ability to analyze overall facility energy carbon intensity as well as sub-metrics for facility thermal energy carbon intensity and facility electrical energy carbon intensity. These metrics are already available in various forms, including industry reports, Cascale's Member Analytics Portal, and on Worldly's Insights Hub.

Effective Energy Carbon Intensity Performance Metric

Interpreting energy carbon intensity of electrical sources and direct thermal energy sources requires an understanding of the underlying differences of primary energy factor between these sources. This is especially apparent when considering electrification of industry thermal energy processes, as it takes more primary fossil fuel energy to generate the upstream electricity than would be used in a direct thermal process. However, electrification of industry energy is an important long-term consideration when considering net-zero targets beyond our short-term 2030 commitments.

The EECI metric is intended to bridge this gap. The core of the metric is the conversion of electrical energy consumed at a facility back into the equivalent amount of primary fossil fuel energy that it takes to generate that electricity. This enables a "corrected" energy carbon intensity value that enables a direct comparison of thermal and electrical energy sources as part of overall progress towards decarbonizing energy. **The detailed version of the equation is:**

$$\text{Effective Energy Carbon Intensity} = \frac{\Sigma\,(\text{Specific Thermal Energy Amount} \times \text{Specific Thermal Energy Intensity}) + \Sigma\,(\text{Specific Electrical Energy Amount} \times \text{Primary Energy Factor} \times \text{Specific Electricity Energy Intensity} \div \text{Primary Energy Factor})}{\text{Total Thermal Energy Amount} + \text{Total Electricity Energy Amount} \times \text{Primary Energy Factor}}$$

Which further simplifies down to:

$$\text{Effective Energy Carbon Intensity} = \frac{\text{Absolute Carbon Footprint (kg CO2e)}}{\text{Total Thermal Energy Amount (MJ)} + \text{Total Electrical Energy Amount (MJ)} \times \text{Primary Energy Factor}}$$

Note that in these equations, the "Primary Energy Factor" is a value that represents the average ratio of primary fossil fuel energy used to generate a unit of electricity. For the purposes of this metric, the Primary Energy Factor is set to a value of 2.4, which equates to a powerplant efficiency of 41.7 percent.

By combining thermal and electrical emissions together using the primary energy factor, facilities with higher proportions of electrical energy use can be compared more fairly to facilities with a more direct thermal energy use. Since this metric is based around existing Higg FEM data points, it can be scaled across all reporting facilities to enable more effective scalable insights.

Using and Interpreting the EECI Metric

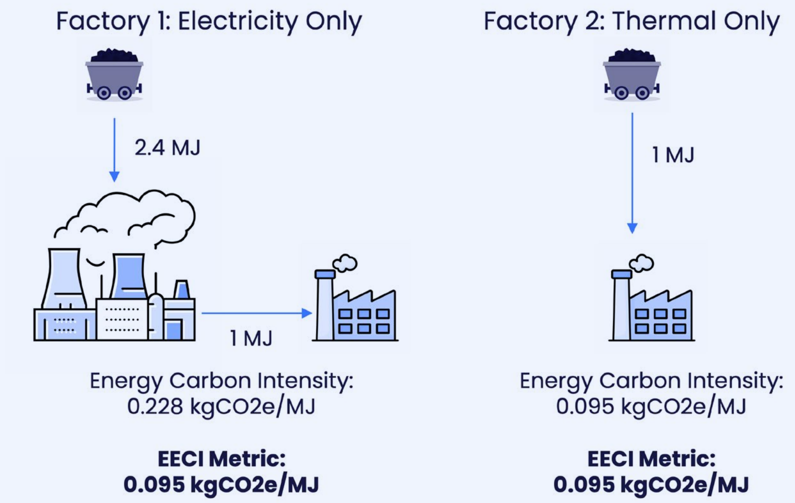
The EECI metric allows for an at-a-glance understanding of overall progress on decarbonization, irrespective of a specific facility's final energy mix. The performance metric accounts for direct decarbonization actions (replacing direct thermal sources with lower emission direct thermal sources and lowering electricity emissions through adopting renewable energy sources) as well as indirect decarbonization through the replacement of direct thermal sources with electrified processes.

Representative EECI Metric Scenarios

The following scenarios showcase how the EECI metric changes as a facility's energy mix changes. While these scenarios are simplified representations of the complexity of any facility, they serve as illustrative examples to enable a baseline understanding of how the EECI metric functions.

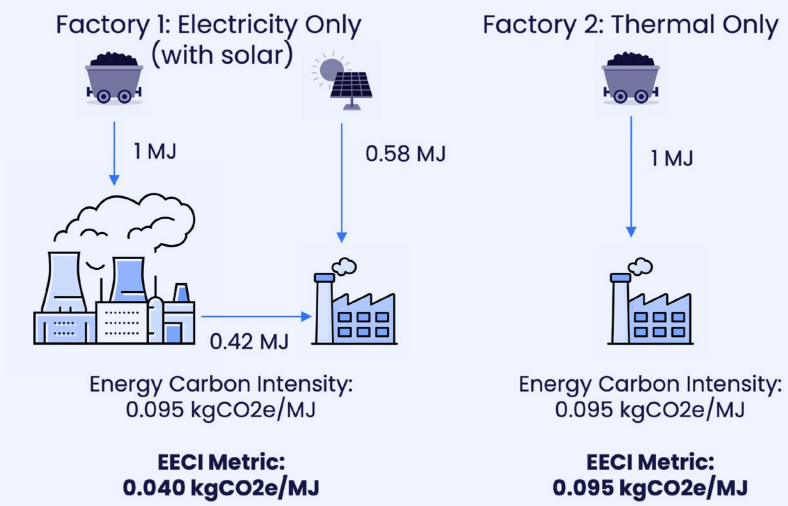
Scenario 1: Thermal vs Electrical Factory, but Same Primary Energy Type

EECI shows the same effective carbon intensity since both are reliant on coal energy



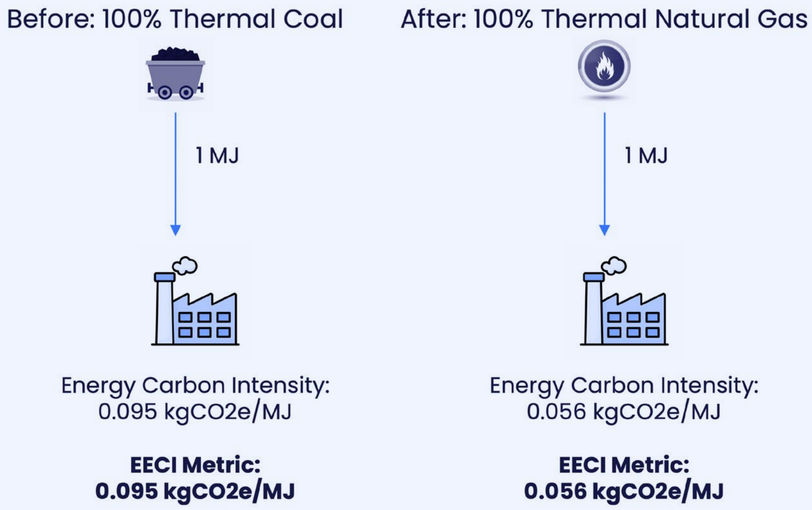
Scenario 2: Same Primary Energy Amount of Coal, but Different Electrification

EECI shows a lower value for the first factory since it is less reliant overall on fossil fuels



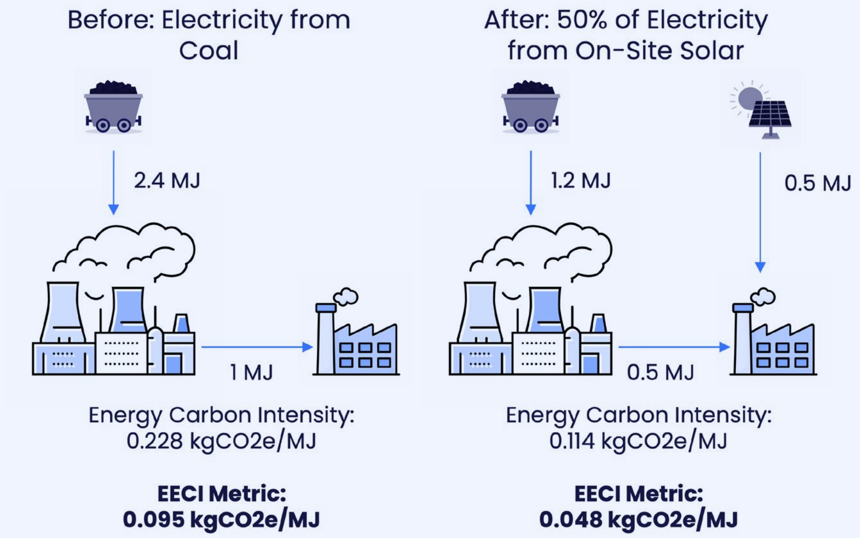
Scenario 3: Facility Replaces their Thermal Energy Source

Replacing high carbon intensity with lower carbon intensity thermal fuel sources lowers EECI



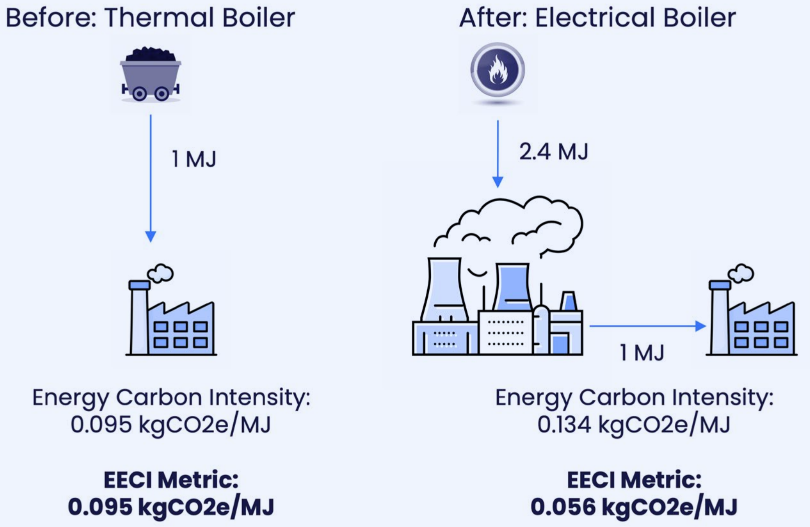
Scenario 4: Facility Adds Renewable Electricity

The effects of decarbonizing the electricity grid lowers EECI



Scenario 5: Facility Electrifies a Boiler

EECI shows a lower value when electrifying if the grid is less carbon intensive



Additional Considerations for Understanding the Effective Energy Carbon Intensity Performance Metric

- It is worth noting that primary energy factors can vary by fossil fuel electricity source and power plant efficiency, but this effect is generally small. Since Cascale does not have access to data at the level of the individual power station, a single value average is used to ensure fair comparison

- All electricity is converted by the effective fossil fuel primary energy factor, regardless of source. This means that renewable electricity adoption lowers the effective benchmark rather than trying to accurately track the primary energy factor. This is intentional given the purpose of the metric (see above note).

- This metric does not currently differentiate between sustainable biomass and conventional biomass. Practices that make a biomass source sustainable are tied to the upstream practices that are not reportable in Scope 1 & 2 emissions. Adoption of sustainable biomass should still be tracked separately through direct analysis of Higg FEM data.

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